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Some Epidemiological Aspects of Yaws Eradication

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Much has been learnt of the epidemiology of yaws during eradication campaigns in populations in which the prevalence of active yaws was high, but not all has been published. The recognition of the importance of latent cases in the maintenance of yaws has contributed to the effectiveness of these campaigns. Yaws eradication activities are extending into populations where at present active yaws is often not high. Planning of effective and economical eradication measures, especially in such populations, needs as complete a picture of the disease as possible, from its transmission and the factors that favour this until the death of the infected person, before or after cure of the infection either after chemotherapy or spontaneously.

By revealing the many gaps that still remain in our knowledge of yaws, this summary may encourage those who have gathered valuable material during field work to study and prepare it for publication.

INTRODUCTION

All activities directed to eradicating a communicable disease have for their sole purpose, directly or indirectly, the ridding of the community of the infective organism. Improvements in standards of living, including hygiene and nutrition, and all other changes for the better are effective in eradicating an infection only in so far as they serve this purpose. If the infective organism is absent no conditions, however favourable for its transmission and for the development of the resultant disease, can create it. In the tumult of the field of action the full significance of this truism may at times escape attention. To stop the transmission of an infective organism is to eradicate it: activities directed to this end must be based upon the epidemiology and the natural history of the disease. It is from existing knowledge that the present effective use of long-acting penicillin preparations in mass treatment campaigns has been developed.

FACTORS CONCERNED WITH THE EXTENT OF YAWS IN A COMMUNITY

Population groups in a yaws-endemic population

The population in a yaws-endemic area will comprise the following groups (see Fig. 1) according to a recent classification of yaws (Hackett, 1957b).

(1) Patients with active yaws lesions; which might be:

- (*a*) infectious lesions
  - (*i*) initial lesions
  - (*ii*) papillomata
- (*b*) non-infectious lesions
  - (*iii*) other early lesions—these are potentially infectious
  - (*iv*) hyperkeratoses
  - (*v*) late lesions

(2) Persons with no active yaws lesions; by serological testing (disregarding biologically false positives) they can be separated into:

- (*vi*) sero-reactors with no active yaws lesions who are in the latent early stage, latent late stage, or a residual reactive stage following treatment.

Sero-reactors, with and without active lesions, who have been infected for more than one year may be regarded as insusceptible to yaws infection whether they have been treated or not (Medina, 1954).

- (*vii*) non-reactive persons with no active yaws lesions. These are persons who have not been infected or who have undergone spontaneous or chemotherapeutic seroreversal. Persons with infections of less than one year's duration who have undergone seroreversal, as well as uninfected persons, comprise the susceptibles.

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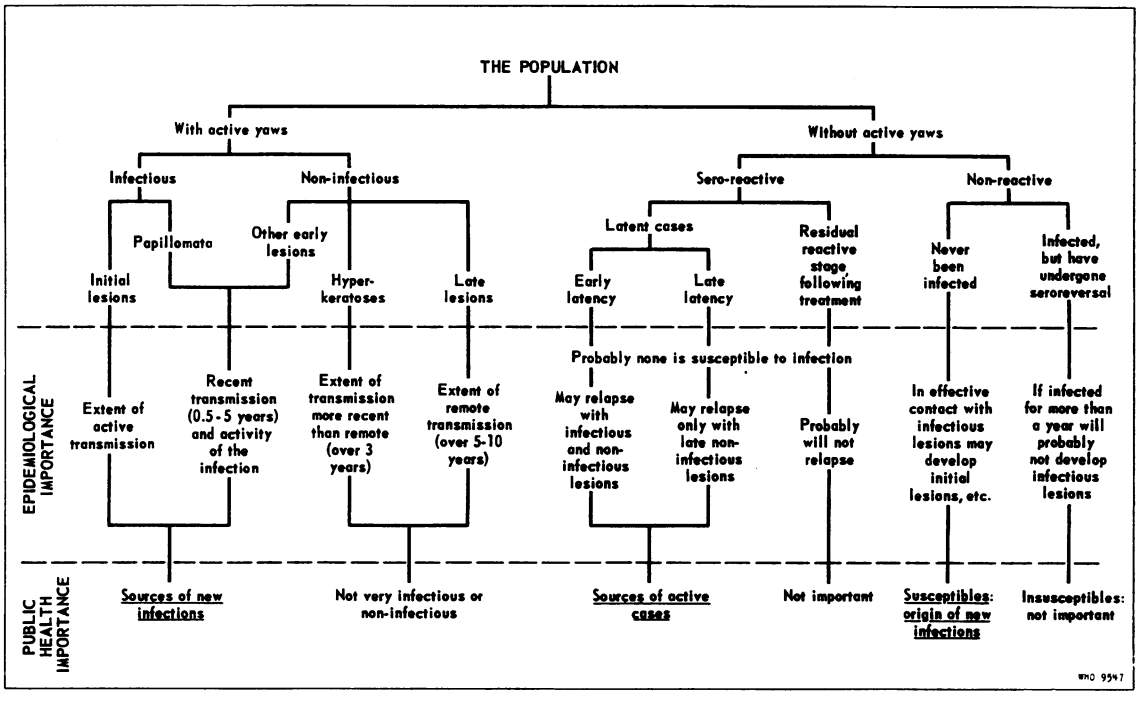
FIG. 1
POPULATION GROUPS IN A YAWS-ENDEMIC POPULATION



The significance of these population groups

(*i*) *Initial lesions.* These are evidence of recent active transmission of the disease. The incubation period may be about three weeks, and a further four weeks may be required for a luxuriant initial lesion to develop. Hence the effective contact between the infectious lesion and the susceptible person would have been at least 1.75 months before the papillomatous initial lesion is seen. Powell (1923), however, found that, of 205 yaws infections carefully observed, no initial lesion occurred in 43 in which the first manifestations were multiple papillomata with incubation periods ranging from 35 to 121 days. The incubation period in 162 patients with initial lesions ranged from 17 to 68 days.

The presence of initial lesions indicates the recent presence of susceptible persons and infectious lesions. About 80% of infections have usually occurred before the age of 15 years and most infectious patients are in the same age-groups, although infection is unusual before the age of two years.

Initial lesions are rarely seen in untreated populations of several thousand persons without numerous patients with infectious lesions also being present. In most populations in which yaws is endemic, initial lesions do not exceed a small percentage (about 2%) of all cases of yaws, This means that if the prevalence of active yaws in the population were around 20% then the prevalence of initial lesions in the population would be about 0.4%, which is not very high.

From several campaigns in different parts of the world a disproportionately high number of initial lesions relative to active cases has been reported (see page 755) among the few cases of yaws observed at later resurveys after total mass treatment (see Annex 1, page 759). Such figures as eight patients with initial lesions, 10 with infectious lesions, and none with late lesions have been reported. Studies in Indonesia indicate that at resurveys six months after the administration of PAM in doses of 2-8 ml (0.6-2.4 mega units) infectious lesions are usually absent. However, after the lower doses the number of treated patients with active late yaws lesions may be greater than after the higher doses—though it will always be low then. PAM in doses of 2-4 ml (0.6-1.2 mega units) produces serological cure in some early cases which may again become infected, whereas in the late cases the effect is more suppressive than curative, and at any rate these would be older

persons with infections of some years' duration who, even if they underwent seroreversal, would probably remain resistant to reinfection (Medina, 1959).

The time of the resurvey after the initial treatment survey should also be taken into account since the rate of seroreversal may be slow. Two years after PAM 4 ml (1.2 mega units) seroreversal may occur in more than 20%, mainly in early cases, but reduction of titre is more frequent (Kranendonk, 1956, 1958). Seroreversal in untreated seroreactors with no clinical lesions (latent cases) is much slower.

Unpublished Indonesian studies have shown that in some untreated communities with a high prevalence of total active yaws (37%) the proportion of active cases to sero-reactors was less than 1: 2, and the prevalence of initial lesions among patients with active yaws was fairly high (2%-6.4%).

(*ii*) *Papillomata*, and (*iii*) *Other early lesions*. The work of Schöbl (1928) suggests that " other early lesions " should occur in patients with more immunity than patients in whom papillomata develop but this is not very apparent in the field.

To simplify the discussion these two groups of lesions will be represented by the papillomata, which are the most important infectious lesions. The potentially infectious lesions include the early macules and papules since patients with these lesions may later develop infectious lesions. Some hyperkeratoses and bone lesions also occur in the early stage and some patients with these lesions may occasionally simultaneously have, or subsequently develop, papillomata.

In untreated communities (see Annex 1, page 759) papillomata, including those of the palm and soles, are frequent lesions and are the only important source of infection. Without papillomata (and initial lesions) transmission would stop. Their presence in over 4% of the population indicates many active infections in the community and is associated with active transmission.

In communities uninfluenced by treatment, in which yaws has been endemic for a number of years, the presence of many patients with papillomata is always associated with the presence of all the other lesions of yaws, such as early plantar and palmar hyperkeratoses, and early bone lesions in the same or other patients, and of late plantar and palmar hyperkeratoses, late bone lesions, ulcers and other late destructive lesions in other patients. The prevalence of late lesions in a community in which there are many patients with papillomata is due to the activity of the previously contracted disease in its various stages in the community, and is probably not due, to any important extent, to superinfection of persons in different stages of the infection with treponemes from the papillomata (see pages 743 and 755). This is supported by the findings in Western Samoa (Buxton, 1928).

In an untreated community of high endemicity the following prevalences of lesions, etc., might be expected:

		Percentage of total population
People with active yaws:		
20%	initial lesions	0.4
	papillomata	4.0
	other early lesions	1.6
	hyperkeratoses	12.0
	late lesions	2.0
People without active yaws:		
80%	sero-reactors	40.0
	non-reactors	40.0

The proportions of the various lesions given above have no inherent value but are mentioned merely for the purpose of discussion. Although these proportions may be found in some surveys, especially in populations where some specific treatment has been available for some years, they vary widely from area to area and with the age distribution of the population, season, previous treatment, etc. (Klokke, 1955; Kranendonk, 1958; van der Hoff, 1956). Often in high-prevalence areas infectious lesions may predominate while in low-prelvaence areas non-infectious lesions may be the more frequent. However, in low-prevalence areas after total mass treatment infectious lesions often predominate. Infectious lesions are usually most frequent in younger people and late lesions in older people. The titres of serological reactions are usually higher in young people than in older people. Although hyperkeratoses are often the most frequent lesions, in some areas they may be less numerous than either early or late lesions. However, more data are required before sound generalizations can be made, and as van der Hoff (1956) says, variations in the duration of the early stage of yaws in different countries have not been accurately determined.

To know what is the highest prevalence of active yaws that can be present in a yaws-endemic community is of importance. Careful consideration should be given to the reliability of prevalence data for yaws since different diagnostic criteria alone may limit the value of some data. If among those with active yaws are included persons saying they have had yaws then prevalences allegedly of " active

yaws" may reach 80% of the population examined, whereas patients with clinically recognizable active lesions would number perhaps a quarter of that figure. Misunderstandings arise if persons with any inactive yaws lesions are included in totals for active cases. Both these kinds of data are of limited value either as indications of prevalence or for the assessment of campaign activities, since at resurveys usually only clinically active yaws are counted so that comparison with the data including "history latent" or inactive cases is unprofitable.

Two rather sweeping generalizations may be suggested: (*a*) in areas where casual-patient treatment (see Annex 1, page 759), especially with arsenic and bismuth, has been available for some years, it is rare to find more than 15%-20% of active yaws cases; (*b*) where no treatment has been available and personal hygiene is unsatisfactory 35% or more of active yaws cases may be reported.

In both instances the number of sero-reactors in the whole community might be about 70%. The more extensive the casual-patient treatment is in the community the lower will be the prevalence of active yaws cases, but the number of sero-reactors may not decrease until a considerable amount of treatment has been available for about 10 years (Kranendonk, 1958). Any influence adverse to yaws transmission arising from improved standards of living (Hackett, 1959), or a possible endemic rise and fall of prevalence (Hackett, 1957a), and perhaps seasonal variations in some countries, might also have to be excluded. Increasingly extensive patient treatment can result in the complete disappearance of active disease while the sero-reactivity rate may remain high—for example, 35%-50%—for 10-20 years.

As stated already, usually most of the papillomatous cases will be found among children while some will occur among adolescents and young adults and a few among adults. Several observations have shown that although most initial lesions occur in the 5-9 years age-group and most papillomata are found in the 5-14 group, there may be a further slight increase in prevalence of the latter in the 20-30 group (Levitan et al., 1953; Soetopo & Wasito, 1953). This second rise in prevalence is more likely to be due to first infections, contracted from their own children, of persons not previously infected than to reinfections of persons who had overcome their previous childhood infections and then lost their effective resistance to reinfection (see page 747).

Occasionally a relatively high prevalence of infectious lesions in adults is reported. In communities of low (3%-5%) yaws prevalence a relatively high prevalence of infectious lesions in adults would not be surprising since, if the prevalence had been low for some years despite little treatment being given, many adults would be susceptible.

(*iv*) *Hyperkeratoses.* Palmar and plantar hyperkeratoses may occur in both the early and late stages of yaws. The early hyperkeratoses form a fairly uniform group and are probably usually the more frequent. They comprise most of the more readily recognized and fairly well-defined hyperkeratoses (Baermann, 1911) and respond well to treatment if the thickness of the normal skin of the sole is taken into account. The late hyperkeratoses are a much less well-defined and less easily recognizable group (Hackett, 1957b). If most of the hyperkeratoses are to be regarded as early lesions, then the early stage would need to be extended long beyond the five years at present assumed to be its usual duration. Usually hyperkeratoses, the "solitary hyperkeratoses", are the only yaws lesion present. Although some early hyperkeratoses may occur with papillomata on other parts of the body, these are usually superficial changes and do not long outlast the other lesions. Hyperkeratoses in patients with bone lesions or with ulcers are very unusual. Particular attention might be called to this absence of the association of hyperkeratoses and ulcers. If it did occur it would indicate that such hyperkeratoses belonged to the late stage of the disease. Late lesions occur in the higher age-groups as do some of the hyperkeratoses, so this association would be possible but hyperkeratoses are usually solitary.

Bone lesions are often found—in the same age-groups as are hyperkeratoses—as the only yaws lesions. Such bone lesions fall into two distinct groups. The lesions of one of these groups are identical with bone lesions found in association with early skin lesions while those of the other are identical with bone lesions associated with late skin lesions (Hackett, 1951). Since, as pointed out above, hyperkeratoses and late skin lesions are rarely observed together, it is very suggestive that most of the solitary hyperkeratoses are really early lesions; many resemble those sometimes associated with papillomata. Further careful study is needed.

The prevalence of hyperkeratoses is often high in drier tropical areas, and where there is a longish dry season they may comprise 75% of all active

lesions. The prevalence is often low—for example, under 25%—in humid tropical areas. In such areas higher prevalences have been reported in people walking on rough and rocky ground than in those living in areas having sandy soils such as are found on coasts. However, yet other factors may be important. Nevertheless, in the absence of yaws, barefooted people who live on soft sandy soil may have plantar skin as smooth and supple as many shoe-and-sock-wearing people.

Hyperkeratoses, as well as only rarely occurring simultaneously with late lesions of the skin or bones, are also probably even more unusual following the development of these late lesions.

The solitary hyperkeratoses are usually most frequent in the 18-30 years age-group. Usually most of these patients are well-developed and many also appear healthy and well-nourished. There is some evidence that injury may play a part in the production or localization of these lesions (Klokke, 1955). Certainly these patients are usually of the age-group that should be actively engaged in agriculture. Other infections or malnutrition may predispose a yaws patient to these lesions (van der Hoff, 1956).

The more definitely late yaws hyperkeratoses are usually found in older people—over 40 years of age. The palms are more often affected than the soles and widespread thickening and roughening are frequent. Pigmentary changes are usually present and digital flexor contractures, most marked in the ulnar digits, may be seen. When these lesions cease to be active the palmar surface usually becomes shiny and smooth. The thinning of the skin, contractures and depigmentations, which may extend on to the flexor surface of the wrist, are characteristic and have been epitomized by the name of " ghoul hand " (Jelliffe, 1950).

Certain other palmar and plantar changes not due to yaws and not responding to penicillin, such as keratoma plantare sulcatum (Castellani, 1910) and keratodermia punctata (Chalmers & Kamar, 1917), also occur in many yaws-endemic populations (Furnell, 1943; Jelliffe & Humphreys, 1952; Hackett & Loewenthal, 1960). The prevalence of these is usually but not always low, and until extensive treatment has greatly reduced the prevalence of active yaws they may not be numerically important. However, after mass treatment, their prevalence may assume greater relative significance and can cause confusion if they are not recognized. Their appearance is usually so different from that of yaws hyperkeratoses that no confusion should arise once it is understood that not every change of the palm or sole is due to yaws even in a community where much yaws is present.

Solitary yaws hyperkeratoses may, for practical purposes during a mass campaign, be regarded as non-infectious, and probably few, if any, of the patients with early lesions of this type will subsequently develop papillomatous relapses. It might be said that a patient with solitary hyperkeratosis will not subsequently become infectious. However, in surveillance after a mass treatment campaign caution dictates that, as regards treatment, " any yaws lesion may be infectious ". In all stages of mass campaigns " any doubtful lesion should be regarded and treated as a yaws lesion " but perhaps in the later stages the doubtful lesions, although treated as yaws lesions, should not be included in the " total active yaws " figures but may be reported under a separate heading.

Solitary hyperkeratoses are probably the result of infections contracted three or more years previously.

(*v*) *Late lesions.* For the purposes of the present discussion these will be typified by deep and localized or superficial and spreading ulcers. These lesions mainly occur in the 30-40 years age-group. However, some of the late bone lesions, such as gangosa and the localized ulcerated nodular osteoperiostitis may sometimes occur in children only 5-10 years of age (Hackett, 1951). These two lesions occur in younger people than do the less localized, more sclerosing, late bone lesions, and may occasionally follow the previous attack of papillomata by as few as 3-5 years.

All late lesions appear to be most frequent in populations where there is much active yaws—that is, where the infection is active and has not been greatly influenced by treatment. Some observers have suggested that superinfection is an important factor; it is certainly more likely under these conditions (see page 741). Such superinfection could not be as much concerned with the localization of the lesion as with the hastening of an allergic state which would make this type of lesion possible, otherwise one would expect late skin lesions to be on the same sites as initial lesions (Hackett, 1957a). Furtado (1955), however, reports that 95% of nodular and ulcerative late yaws lesions occur on the lower limbs. Experimental superinfection in man is followed by lesions only slightly resembling late yaws lesions and only at the site of inoculation (Guimarães, 1946; Medina, 1954). Also since, in the presence of many infectious cases in the com-

munity, late bone lesions are often as numerous as or more numerous than late skin lesions, an endogenous rather than an exogenous source of the treponemes is indicated. However, in "florid yaws" communities late lesions, such as ulcers, do not as a rule occur at early ages when superinfection would be most likely. Perhaps this is because in most children the allergic condition of the individual may not be favourable. Superinfection is probably not the important determining factor. It is more likely that late lesions are a manifestation of active disease arising from infections contracted 5-10 years or more previously.

The part possibly played by superinfection in the production of late lesions has been stressed by various writers (Grin, 1953). However, the presence of late lesions in a community (Buxton, 1928) in which no early lesions were observed, soon after extensive mass patient treatment (see Annex 1, page 759) had been carried out, would at least indicate that this is not always important, but some of the late lesions which Buxton saw may have been of long duration and may have arisen while infectious lesions were still frequent. Later, numerous infectious cases reappeared in the absence of further anti-yaws activities (Lambert, 1936).

Although at the first resurvey after total mass treatment late lesions may show a proportionate increase, usually at subsequent resurveys infectious lesions, though very scanty, predominate. In some field data non-yaws ulcers and certain inactive late yaws lesions may have been regarded erroneously as active late yaws. Probably, in the early stages of mass campaigns in high prevalence areas, there are about 10% of diagnostic uncertainties which are rightly regarded and treated as yaws. In the later stages of the campaign, such lesions, if they are uninfluenced by the mass treatment and are still attributed to yaws, will assume considerable relative significance, especially in the evaluation of the results of the campaign.

Late lesions alone in a community, without any other active yaws, would result from the cessation of transmission for several years either because the environmental factors favouring transmission had disappeared, or because infectious lesions had been totally suppressed by treatment. This latter sequence has been reported, following prolonged or extensive arsenical and bismuth patient therapy. It was a frequent belief of the rural people in many countries that the too early treatment of papillomata—"before the disease had come well out"—was to be avoided because it was liable to be followed by an increased risk of late lesions. If any such "increased" frequency of subsequent lesions did occur, it was more likely to be the normal evolution of the disease uninfluenced by inadequate treatment rather than any "stimulative" effect of such treatment. The evolution of untreated syphilis suggests this (Gjestland, 1955). No report has been seen that this is occurring after penicillin although some rural populations continue to avoid early treatment for the reason just given.

When arsenic and bismuth were used it was necessary to give a number of injections but usually few patients continued treatment until they had received an adequate dosage. The single adult dose of PAM (1.2 mega units or 4 ml) at present largely employed in yaws campaigns is probably more adequate than the previously recommended 4-6 weekly doses of arsenic and bismuth. With the single injection of PAM every patient receives the whole dose. Thus treatment with PAM is probably more successful than the treatment with arsenic and bismuth that was usually given, in ridding a population of all yaws lesions, including the late destructive ones.

People with no active yaws lesions may be either sero-reactors or non-reactive persons.

(*vi*) *Sero-reactors with no active yaws lesions.* In a population with 20% clinically active yaws and a proportion of active yaws to sero-reactors of 1:3 the total sero-reactors would be 60% of the population and sero-reactors without lesions would be 40% (see page 741). This relationship has been discussed by Li & Soebekti (1955), and Kranendonk (1958) and Soetopo et al. (1956) have stressed the influence of treatment on it.

These are persons who have already been infected with yaws. It is assumed that no other treponematosis is present in the community. The possible presence of biologically false-positive tests may be disregarded here. In one endemic treponematosis area in which there has not been much treatment, however, out of 20 reagin sero-reactive latent cases only one was negative to the *Treponema pallidum* immobilization test (Murray et al., 1956).

The course of yaws is characterized by prolonged latency interrupted by relapses of early or late active lesions. What precipitates a relapse is not known, but it is probably a disturbance of the antigen-antibody balance in favour of the treponemes which are lying relatively inactively in the body.

Thus there is early and late latency, depending on the duration of the infection; this is assumed to be five years (Hackett, 1957b) but is sometimes shorter and may be longer. Early latency would be interrupted by early lesions and late latency by late lesions. Since in the evolution of a case of yaws early and late lesions may, for practical purposes, be regarded as never occurring in the same patient at the same time (Hackett, 1957b), there must be a latent period separating the last early lesion and the first late lesion. It would be expected that the change from the tissue reaction which is found in early lesions (that is, hyperplasia without destruction in the presence of many treponemes) to the tissue reaction of the late lesions (that is, inflammatory cellular infiltration and destruction in the presence of scanty treponemes) would occur during this transitional latent period.

During the first five " early " years in the course of yaws, the average duration of early lesions may be assumed to be:

	Months	
Initial lesions	6	3 months' overlap
First eruption of papillomata	6	
Subsequent relapses	6	
Total	15	

This is assuming an average of one relapse in each patient, but it may be more.

These figures, which are only approximations, suggest that infectious lesions may be present during about 15 months of the infection in the patient.

During the remaining period of the infection two main types of lesions may occur, *hyperkeratoses* and *late lesions of skin and bones*, both of which tend to relapse. The *average duration* of these in the persons infected with yaws (the average duration of such lesions in a patient is about a year or more) may be assumed to be:

	Months
Hyperkeratoses	9
Late lesions	3
Total	12

These approximations stress the need for more precise data. Late lesions are usually of longer duration (12 as compared with 6 months) and less frequent than early ones (2% as compared with 6%; see page 741).

Thus every person infected with yaws might be expected to suffer active lesions for about 2.25 years. The possible significance from the points of view of morbidity and economic loss becomes apparent when one applies it to untreated communities where sero-reactor prevalences are high, for example, 40%-70% or more.

The most obvious and immediate effect of any form of extensive treatment, patient or mass (see Annex 1, page 759), is a great reduction in prevalence of active yaws. Reductions from 20% or more of active yaws to 2% or less within a year after total mass treatment may be expected (Zahra, 1956).

Before the prevalences of active yaws in different communities can be compared, and before the significance of figures for the prevalence of active yaws from the point of view of the extent of yaws infection in a community can be assessed, the extent of past treatment in the community must be known (see Annex 1, page 759). Quantitative serological survey data would greatly increase the value of prevalences of clinically active yaws.

In some areas where variations of wet and dry seasons are marked, the prevalence of active yaws in the dry season may fall to as low as one-third of what it was in the wet season (Harding, 1949). In other areas this seasonal variation has not been found. Harding observed the same population during different seasons. Other observers have studied the prevalences in different populations at different seasons. The observations of Platt (1958) suggest that seasonal variations in growth and specific mortality may be related to nutritional variations, particularly of protein adequacy. Similar factors may be important in seasonal variations of yaws prevalence.

The effects of mass treatment and casual patient treatment (see Annex 1, page 759) on the prevalence of sero-reactors are less, and more delayed, than those on the prevalence of clinically active yaws. There is a general reduction in titres and seroreversal in about 20% or more of reactors (Kranendonk, 1956, 1958) about two years after total mass treatment may occur. This seroreversal would occur mainly in patients in the early stage (Medina, 1959).

All this is of more than academic interest since the indications for treatment policies at present recommended are based upon clinical prevalence.

In communities where no treatment for yaws has been given, the ratio of the prevalence of active yaws to that of sero-reactors may be about 1 : 2 to 1 : 3. When treatment has been extensive or long-continued, this ratio may change up to 1 : 10. In certain Caribbean Island communities, after considerable patient treatment, no active yaws patients were seen, but a prevalence of sero-

reactors of 35%-50% was found. Where a mass treatment campaign against yaws has not yet been carried out, it might be unwise in the above conditions to base treatment policies upon clinical prevalences only. In such situations, unless the local conditions and medical history of the community are well known, some form of serological survey should be undertaken to ascertain the sero-reactor prevalences (Hackett & Guthe, 1956). Where the prevalence of clinically active yaws has fallen in the absence of any effective mass treatment, the clinical prevalence probably still gives a useful indication of the activity of the disease in the community for the guidance of eradication campaigns.

With the delay that may precede seroreversal, following a single injection of PAM (Medina, 1959), there is probably a residual reagin reactive stage between the complete destruction of the treponemes and the reversal of the serological tests for syphilis. This, of course, would vary with the tests used and the duration of the infection when treatment was received.

(vii) Non-reactive persons with no active yaws lesions. In the population that has been already considered, persons whose sera do not react to the reagin serological tests for syphilis would comprise 40%. Among these are the uninfected and thus the susceptible part of the population. Upon their presence depends the maintenance of the infection in the community. Experimental studies with animals (Greenwood, 1932, 1936) have clearly shown that to maintain an infection in a closed herd it is essential that uninfected susceptible immigrants be added periodically (see page 755). Thus the number of non-reactors in the community is of great importance and calls for careful consideration.

This group of non-reactive persons can be further sub-divided into smaller groups. There is a small group of persons, perhaps better regarded as patients, who have been effectively exposed to an infective dose of virulent treponemes and are thus in the incubation period. This period would be the time from the entry of an infective dose of treponemes into the skin until the resultant initial lesion appears. It is a safe assumption that initial lesions occur in a high proportion of yaws infections, perhaps 75% or more (Powell, 1923). The initial lesion, if developing in otherwise normal skin (i.e. not superimposed upon an ulcer), would commence as a papule which sooner or later would become eroded and present the characteristic appearance of a small papilloma. Such a lesion might be missed on casual inspection unless the attention of an alert observer was called to it by the patient. This lesion then enlarges until the typical large papillomatous initial lesion results. When this incubation period ends is often not clearly defined. Its duration is usually regarded as being about three weeks, and experimental inoculations in man (Guimarães, 1946; Medina, 1954) support this. The end of the incubation period should theoretically be taken as the time when the smallest indubitable papillomatous lesion is seen. To differentiate this in the field as an initial lesion, as distinct from the onset of an eruption of papillomata, it would have to be the first yaws lesion the patient had had. Such early initial lesions are rarely seen. Most initial lesions, when recognized by other observers than the patient himself, are about 2.5 cm in diameter and must have been recognizable, as defined above, at least a month previously.

For the present discussion, it may be assumed that the incubation period is three weeks and that at least another month will have passed before the early initial lesion will be recognized. In a yaws community with a clinical prevalence of 20% the percentage of the whole population who will have initial lesions has been estimated at 0.4% (see page 741).

If the average duration of an initial lesion is six months, it is possible that the average duration of those seen at an initial survey might be three months. Thus, if the rate of infection is assumed to be constant one might suspect that only a third of the 0.4%, that is 0.13% of the population, would become infected, and thus enter the incubation period, in any one month.

In addition to the papillomatous initial lesions, ulcerative ones have also been described (Montel, 1951). These are most frequent on the lower third of the leg where the skin is close to the bone, so that possibly a large papillomatous lesion, if deprived of a deep blood supply, would undergo necrosis with subsequent granulation tissue formation, while the papillomatous changes would continue in its edge. However, ulceration has not been observed in initial lesions after experimental inoculations, but this may be due to their position on the body and to their treatment before they have become large. On healing some slight scarring, at first depigmented, usually remains. At times a yaws infection may take place in an already existing ulcer; the initial lesion may heal and leave the ulcer unchanged in character, which may account for

reports of initial lesions changing into late ulcerative lesions.

Some infections may occur without an initial lesion developing or at any rate being recalled by the patient. So many factors may obscure the site of an initial lesion that it is difficult to suggest how frequently its occurrence might be missed. Usually less than 25% of patients are unable to recall the position of their initial lesion. Amnesia may account for some of these, since the lesions would have occurred in early childhood.

Thus only a small percentage of the non-reacting 40% have been accounted for as being in the incubation period. The others would comprise persons not yet infected and persons who have undergone spontaneous or chemotherapeutic cure; uninfected persons would be the more numerous. Spontaneous seroreversal, or seroreversal after chemotherapy, of infections of more than one year's duration would probably not result in the person becoming susceptible to reinfection (Medina, 1954).

The part played by climate, diet, other infections, trauma and dose of treponemes in the relationships of the above groups should also be considered, but to separate the particular effects of each is not possible at present.

DATA REQUIRED TO DETERMINE ACCURATELY THE STATUS OF YAWS IN A COMMUNITY

By this is meant the data needed to ascertain if, in a community, yaws is increasing, decreasing or static. Ordinarily such variations can be studied only when "incidence" data are collected—i.e., when the population is kept under continuous observation, and *all new cases* during a long period are recorded. But, as is shown below, in yaws some idea of disease incidence can be obtained even from prevalence data (recorded at any point of time) because the presence of active lesions and the percentage of sero-reactors indirectly indicate the extent to which yaws has been active in the recent past. Although past infection is of considerable interest, the transmission going on at the time is always more important.

If the disease is decreasing, it is important to learn whether this is due to treatment or to changes in environment which have reduced the transmission of yaws.

First it is necessary to find out the prevalence of active yaws, by sex and age groups in the community, and the prevalence of various active manifestations which would comprise initial lesions, papillomata and other early lesions, hyperkeratoses and late lesions. These data would indicate the severity of the disease in the community.

Next it would be necessary to know the serological status of the community, which would be indicated by the prevalence of sero-reactors and thus also of non-reactive persons by sex and age groups. These data would be separated into those for persons without active yaws and those for patients with active yaws. The sero-reactivity of persons with active yaws is a test of accuracy of serological technique and of clinical diagnosis. The sero-reactors would need to be divided into those with high titres (for example, 1 in 16 and above with the VDRL test) and those with low titres (for example, 1 in 8 and below). These data, obtained from serological screening of the total population or a suitably selected sample (random sample for instance), would indicate the extent of the infection in the community at the time the survey was made. The higher the proportion of high titres the more active would be the infection in the community. Sero-reactors with no active lesions would be the latent cases or latent infections. It is probable that latent yaws cases with high titres would be more likely to relapse with active lesions than those with low titres.

Other information, in addition to the presence or absence of active yaws in the persons concerned, that has been used for the purpose under discussion has been (1) the presence or absence of scars resulting from yaws lesions, and (2) the patient's statement that he had or had not had yaws.

Certain workers feel that by careful observation they can recognize many papillomata scars and differentiate them from scars arising from other causes, but it is usually impossible to do so with all scars. Many workers are not able, and do not claim to be able, to do so accurately because the criteria are too indefinite and vary from country to country.

More attempts have been made to study instead the patient's history of past yaws. Most infections with yaws occur in early childhood, and that alone might be expected to lead to many infections being unknown to or not remembered by the patient. He might recall mention of his infection by relatives but in yaws-endemic communities yaws is an everyday affair and may thus have little "news" value in the community. A history of yaws may be given merely to receive a much desired free injection of

penicillin. It is also possible that the " remembered " diagnosis is not correct.

Serological studies in several yaws-endemic areas of persons with no active yaws lesions have shown that about two-thirds of such persons who say they have had yaws are sero-reactive while one-third of such persons who say they have not had yaws are also sero-reactive (D'Mello & Krag, 1955). In a few countries much closer relationship between history and serological results has been found (Kranendonk, 1958).

It is thus seen that the presence of scars or a history of past yaws in persons without clinically active yaws lesions are usually not sufficiently reliable indicators to be of value in measuring the status of yaws in a community.

Many yaws workers during their first year or so in the field have learnt about the macular and papular lesions of early yaws from their patients; the accuracy of much of this teaching has usually been confirmed by their own subsequent observations. Although the yaws origin of hyperkeratoses is often fairly accurately recognized by patients or their relatives, confusion arises about the late destructive yaws lesions.

The accuracy of yaws diagnosis at initial treatment surveys in mass campaigns under very good conditions when checked by serological findings is about 90%. That is, when the serological work is well done, about 90% of patients diagnosed as yaws on clinical inspection in the field will give positive reagin serological tests for syphilis. This is accounted for by the lack of time for full consideration of each individual, by the occurrence of a few lesions in any peasant community that might be confused with yaws, and by the recommended practice that when in doubt the case should be regarded as one of yaws and treated accordingly.

The sex and age distributions of all clinical or serological manifestations and of the community itself indicates the status of the disease, and data on these items should be collected in respect of each person examined.

Other information that might be of value would be records of the prevalence of yaws in the community in the past. Such records will usually be only of patients seeking treatment at established treatment units. Sometimes in the past, although bismuth injections were free, patients would not present themselves until they could afford the cost of an arsenical injection. In established treatment units the accuracy of diagnosis may vary from district to district and from country to country. Factors which affect the comparison of data of one year with those of another should be carefully kept in mind. Furthermore, the returns may be given as all attendances by yaws patients or, in recent years, as first attendances by yaws patients. Since previously efforts were made to give each yaws patient 4-6 injections of bismuth and/or arsenical preparations, while with PAM as good or better results are to be expected from a single injection of an adult dose of 1.2 mega units (4 ml), it may be difficult to compare attendance data of some 20 years ago and at present. The only accurate data of disease prevalence is that resulting from surveys of the whole population concerned. Yaws is usually a visible disease, hence such clinical surveys can provide much useful knowledge. However, until the past 10 years few surveys had been carried out in most countries. A recent unpublished study, by the late Dr J. Fraisse in Nigeria, has shown no constant relationship between the annual attendances for yaws at rural dispensaries and the prevalence of clinically active yaws found at initial treatment surveys in the same areas in the following year.

The extent of yaws in a community should be indicated by the prevalence and the sex and age distribution as found at surveys of the following:

initial lesions
papillomata and other early lesions
hyperkeratoses
late lesions
persons with no active lesions
sero-reactors { with high titres / with low titres
non-reactors

In the absence of adequate local knowledge clinical data alone may be inadequate and then serological data could be very helpful. Minimal serological data would consist of numbers of sero-reactors and non-reactors, but preferably the former should be divided into those with high titres and those with low titres among persons without clinically active yaws.

Perhaps the most useful way of presenting the serological data would be:

Persons *with* clinically active lesions	sero-reactors	high titre / low titre
	non-reactors	
Persons *without* clinically active lesions	sero-reactors	high titre / low titre
	non-reactors	

The serological information about the persons without clinically active yaws would measure the extent of the "hidden" or latent infection in the community and also of the susceptibles.

It is also desirable to know what treatment (see Annex 1, page 759), if any, the community has had in the past, how recent and how extensive it was, and what drugs were used.

SIGNIFICANCE OF HIGH AND LOW PREVALENCES OF ACTIVE YAWS IN A YAWS-ENDEMIC COMMUNITY

It might be asked why the prevalence of active yaws varies so markedly in different parts of the world. The irregularity or "spottiness" of the distribution of yaws has often been remarked upon. In some communities there may be only a few active cases while in others more than 20% of the population may have active lesions and 60% may be sero-reactors. In general, however, the major foci of yaws in a country will be in the less-developed populations. The effects of previous treatment in the community, either total mass treatment, or mass or casual patient treatment (see Annexe 1, page 759) would have to be considered. Any form of modern treatment for yaws, if it is sufficiently extensive or prolonged, will cause the prevalence of clinically active yaws in a community to fall and perhaps will even result in the disappearance of active lesions, while a considerable prevalence of sero-reactors may persist for some years. But unless the factors responsible for the high prevalence are removed, the disease will tend to attain a high level once the treatment campaign has ended. However, after total mass treatment this may require some years.

If the effects of treatment are excluded, two possibilities remain that may account for a uniformly low prevalence of active yaws in a community where the prevalence had been previously high. The first is that conditions of living were improving so that, perhaps without any readily apparent improvement in the hygiene of the environment, the transmission of yaws did not occur as easily as in the past. Improved economic conditions may result in the better and earlier clothing of children, and the use of more soap and water for personal hygiene. The late Dr J. Fraisse observed in one area in northern Nigeria a high prevalence of yaws in unclothed pagan people and its absence in Moslems who were well clothed from an early age. In many communities improvements are no doubt taking place and it is to be expected that the medical facilities at their disposal will also improve. If these considerations are sound, then there will be a decrease or cessation of yaws transmission; the results in the community will depend on the completeness of this change and its duration, and would be measured by the prevalences, by age, of the various groups of active lesions and the ratio of the prevalence of active cases to sero-reactors (see page 748).

The other possibility is that different prevalences depend upon stages in an epidemiological cycle (Hackett, 1957a) lasting 40-60 years. In this cycle a stage with low prevalence of active yaws and high prevalence of susceptibles (low prevalence of sero-reactors) is followed by increased transmission so that the susceptibles are decreased and in time the effective contact of susceptibles and infectious cases is reduced, so that transmission falls. At the peak of transmission the ratio of active yaws to total sero-reactors might be 1:2 and both prevalences and titres would be high. As transmission falls this ratio might change to 1:3 or more and the clinical prevalence would be low, while the sero-reactor prevalence would be high, although the titres would be lower. After 5-10 years or more there would be low prevalences of both with a ratio of 1:2 with rising titres. Many susceptibles would now be present and transmission would again increase.

Thus to assess the status of yaws in a community not only the different types of lesions present and their frequencies and the prevalences of sero-reactors with high and low titres may need to be taken into account, but also comparable data for the previous 20-30 years and the amount of treatment that the community has received.

INTRODUCTION OF YAWS INTO A COMMUNITY

It is of interest to consider the environment in which yaws might be expected to flourish from the point of view of the introduction of the infection into a community. Powell (1923) reports what he thought was the introduction of yaws into Assam. For yaws to be endemic it is essential for the treponeme and conditions favouring its transmission to be present (Hackett, 1957a). The following suggestions are largely based on African experience.

Among these conditions an obvious, but not necessarily essential, one is climate, with warmth and humidity for about half the year and an average rainfall of over 40 inches (100 cm). The land might be hilly or rolling plains. There might be heavy forest or a mixture of smaller trees and grass, known

as woodland savanna. One would expect to find the people clothed neither very well nor very fully, and the children unclothed for the first few years of their lives. Shoes would be unusual possessions for most people although there might be some local form of protective foot covering. Washing of the body and clothes would be done when water was readily available, but this might not be throughout the year and soap would probably be scarce or absent so that neither body nor clothes, despite the best intentions, would be kept really clean. However, yaws can also occur where water is abundant and washing, usually without soap, widely practised.

Houses would be of simple stick, mud and grass, or palm-frond construction. Windows and doors would be small. The interior of the houses would be dark and more or less dry, but after heavy rains the floor might be more likely to be flooded than the roof to leak badly; however, in stable rural communities this would be unusual except among the indigent members of the community. There may or may not be overcrowding in the houses at night. Furnishings would be simple, a raised mud or wooden platform for a bed, perhaps no chairs; hence everyone from childhood squats in comfort. Possessions would be few, apart from things essential for agriculture and hunting, and perhaps a few ancestral, religious or ceremonial objects. There would be some food stores for each family or village and in some villages an alcoholic drink might be brewing.

The ground about the houses in the village would probably be bare and frequently swept clean, for it would be much used in food preparation and for the drying of food for storage. Although children may relieve themselves anywhere, a mother or a sister would usually dispose of any faeces into the nearby vegetation, while that a little more remote would serve as a communal latrine. Despite this practice, more often than not there would be no faecal smell about the smaller villages. This would probably be due partly to low population density so that a large area would be available for a relatively few people, and partly to the habit of defaecating while working in the fields, and to the effects of rain and of warmth and insects in the dry season.

At varying distances from the houses would be the gardens and fields that provide the food and cash crops of the community. There would probably be no road to the village and perhaps no good motorable road nearby; thus economic opportunities would be limited. As likely as not there would be no village school or shop, nor visiting trader; a nearby market would offer the means of selling produce, buying goods and picking up news. Villagers working away from the district would not at this stage have started to exert any recognizable influence on the life of the village. On the whole one would expect to find the villagers neither wealthy nor poverty-stricken, and "wealth" would be fairly evenly distributed although the village headman might be a little more prosperous than the others.

The community would be rather isolated. One of the bad aspects of such rural isolation is the absence of stimulus from outside which may start to break the "tradition of stagnation" (Myrdal, 1956, 1957) apparent in many isolated peasant populations. There may be little desire to improve production for which there is little need or market; the arrival of a trader may help to awaken this desire.

To sum up, the conditions favouring the presence of yaws are those found in the poor personal hygiene of an isolated peasant community in an under-developed tropical or semi-tropical country.

In the transmission of yaws (Hackett, 1957a) it may be pointed out that most infections have occurred by the age of 15 and usually by the age of 10. Possibly the hands of patients with papillomata become contaminated with treponemes, which pass to those of susceptibles. It has been suggested that when such a susceptible receives a minor injury—which must be frequent in the conditions under which peasant populations live—he would almost automatically rub the injured place to relieve the irritation. Thus although the injury might be only slight, the treponemes from his fingers would be implanted on to the injured skin, and so infection would result. The sites of such injuries and of initial lesions are most frequent about the lower leg.

At present, unfortunately, the data available are inadequate to allow the discussion of the numbers of cases that would arise from the introduction of a known number of infectious patients into a known population of susceptibles.

In dealing with the many factors that are active in producing the pattern of yaws in a community, it would be of value to take into account those that are considered by epidemiologists (Bailey, 1957) when they attempt to analyse the balance of the biological forces between the host population and the parasite population which is the basis of the extent of communicable disease in a community. This

will also indicate the information that is needed to make such analyses possible.

The introduction of an infection into a community may give rise to:

(1) an explosive outbreak in which all susceptibles are infected, after which the infection dies out;

(2) a series of cycles of high followed by low prevalences;

(3) an endemic level at which the prevalence will continue for some time if the conditions are stable.

The higher the probability of adequate contact, the more likely will be the explosive outbreaks; the lower the probability of adequate contact, the more likely it is that an endemic level will be established, for the same duration of immunity to the infection. The longer the duration of immunity and the larger the population, the greater is the tendency to develop endemic cycles; the longer the duration of immunity, the longer would be the cycles, which would tend to be longer than twice the duration of immunity. In a large population with a low probability of adequate contact and a disease with a long duration of immunity, a long cycle with a wide range between the maximum and minimum would theoretically be expected in the absence of variations in the probability of adequate contact due to changes in the infectivity of the organism, or its transmissibility, population movements, etc. The larger the population, the longer will be the period required for equilibrium to be reached. These generalizations, which are based upon the epidemic theory of Reed & Frost, have been calculated for selected population sizes, contact rates and duration of immunity (Kranendonk, 1958; Maia, 1952).

It is important to know the normal course of yaws so as to be able to assess the ultimate effects of treatment and of campaigns.

The factors that may influence the extent and pattern of yaws in a community may be considered under three main groups: (*a*) the infection and the disease; (*b*) the population; and (*c*) the climate, terrain, and other factors. These are listed in more detail in Annex 2 (see page 759). However, the most important factors are those concerned with the critical threshold of susceptibles and the characteristics of the population. Some of the data needed to define the endemic pattern of yaws are at least approximately known, but more extensive and more detailed knowledge is needed.

Burnet (1953) discusses the evolution of a communicable disease first introduced to a community. Most of the mild and invisible infections would occur in childhood (2-15 years), while infants and older people would be more severely affected, but the greatest severity would be in young adults (15-35 years). As the disease becomes established this greatest severity would no longer fall among young adults but among children. Later, however, as the disease dies out, its severity would again fall among the young adults. He also points out that the greater the ease of transmission the younger the age of highest prevalence.

Where the prevalence of yaws was high and stable (see page 741) half the persons with no yaws lesions, or 40% of the population, would be non-reactive, and would consist mostly of younger folk who are susceptible. The chances of these having sufficiently close contact with the infectious cases in the community are probably so small that only a few would be infected each year (Harding, 1949)—perhaps not more than the effective annual increase in the population.

In outbreaks of yaws in South African miners working deep underground, on two separate occasions, 10% of 3000 and 17% of 400 at risk were infected within a year (Hackett, 1953). The prevalence of sero-reactors in these populations when the infections occurred was probably about 10%. In these small populations the spread of yaws was among adults and probably started from infectious relapses. It would be interesting to know the size of population needed to produce enough susceptibles to maintain transmission among children, which is usual in yaws in natural surroundings. Since yaws may be endemic in small villages, infective contact between children must be wider than is readily apparent.

RISK OF REINTRODUCTION OF INFECTION INTO A COMMUNITY FROM WHICH YAWS HAS BEEN ERADICATED

During the progress of a yaws campaign which is expanding in a compact manner, the protection of the centre of the area from the risk of reinfection will depend upon the extent and the rapidity of the extension of the campaign activities and upon their thoroughness. However, at the same time, the longer the periphery becomes the greater will be the opportunity for reintroduction. In a community in which eradication has been established, the reintroduction

of infection will always be a risk, the importance of which will depend upon the adequacy of the surveillance. The danger of such reintroduction by visitors, returning labourers or immigrants with infectious lesions is that susceptibles in the population will be infected. The gravity of the risk will thus also depend upon the age-grouping of, and hence the prevalence of, infectious lesions in the incoming population and the extent of the entry.

In a relatively closed community with a high prevalence of active yaws, and thus few susceptibles, the number of initial lesions that develop is small and most of the infectious cases are relapses (Harding, 1949); in other words, transmission is not very active. Also in a community where the clinical prevalence had been recently high and the disappearance of clinically active cases had been due to mass treatment, the number of susceptibles would continue to be low for several years and their increase would largely depend upon births.

In communities where the prevalence was low the importance of reintroduction would again depend on the number of susceptibles present. If, however, the low clinical prevalence was a manifestation of a possible epidemiological cycle of high followed by low prevalence (Hackett, 1957a) reintroduction might be important since there might be many susceptibles, conditions favouring transmission would still be present, and the expected rise in prevalence might be hastened.

Continued surveillance of the community from adequate rural health centres is of great importance in the later stages of a yaws eradication campaign. Full co-operation of the people themselves should ensure that all cases of early yaws are brought to treatment early. Where adequate post-campaign activities have been established, the reintroduction of infectious yaws is not likely since new infections would be immediately recognized and brought to treatment. If established rural health facilities are inadequate to maintain the surveillance, then some form of periodical resurveys must be maintained. Thus in many instances the risk of reintroduction of yaws from across an international border is related to the adequacy of the rural health services.

Co-ordination between health administrations on each side of a frontier is needed since there are often difficulties and misunderstandings in such positions. Also, frontiers over which these difficulties arise are usually remote and the establishment of adequate rural health services near them is likely to be delayed. The eradication of yaws in adjacent countries is essential in the eradication of yaws from continents.

SIGNIFICANCE OF THE OCCURRENCE OF SPORADIC CASES OF INFECTIOUS YAWS IN THE LATER STAGES OF YAWS ERADICATION

In several campaigns where careful and repeated resurveys have been made at intervals of 6-12 months a few infectious cases—a prevalence of under 0.1% of the total population—continue to be found. The possible origin of these cases has caused considerable discussion. They have been reported after mass patient and total mass treatment campaigns (see Annex 1, page 759) (personal communications from Dr F. N. Guimarães, 1956, and the late Dr J. Fraisse, 1957; and unpublished Indonesian data). Probably many are delayed relapses of latent infections, especially where no other source can be discovered. Some of these cases have been traced to infectious visitors, and others to what are usually regarded as non-infectious late yaws lesions (see pages 741 and 755) (personal communication from Dr F. N. Guimarães, 1956). In others, despite meticulous inquiry no source has been found. Sometimes the importance of delayed relapses has been overlooked and the possibility of a prolonged incubation period or prolonged survival of the treponemes away from the body has been raised, for both of which there is at present no evidence. Some of these infectious cases may have initial lesions, indicating that they are new infections.

The occurrence of these few and scattered infectious cases in the later stages of mass campaigns stresses the importance of adequate surveillance or of periodical resurveys, combined with other health measures, in consolidating the achievements of the earlier mass-treatment stages of the campaign so that the eradication of the infection results.

EFFECTS ON THE PREVALENCE OF YAWS OF NEGLECTING RESURVEYS WITH TREATMENT AFTER INITIAL TREATMENT SURVEYS IN MASS TREATMENT CAMPAIGNS

Six to twelve months after the initial treatment survey of a high percentage (90% or more) of the population in a total mass treatment campaign the prevalence of yaws is greatly reduced (Zahra, 1956). But if no further action is undertaken it has been found that a few years after mass patient treatment (see Annex 1, page 759) the prevalence of active yaws may have risen—in previously high prevalence areas almost to its original level—

especially where the percentage of the population seen at the initial survey had been low. In total mass treatment the treatment given to infected persons (both active cases and latent cases) will almost completely cure or suppress clinical manifestations for several years, but will only protect from infection for one or two weeks susceptible (uninfected) persons who might be expected to comprise about 40% of the population. These, if exposed to the very occasional infectious relapse that may occur in treated persons or in those who were not seen at the initial treatment survey, are likely to become infected. Thus the infection would gradually re-develop at a rate and to an extent inversely related to the percentage coverage of the population and proportional to the prevalence at the initial treatment survey.

It should not be forgotten that the doses of arsenical and bismuth preparations that were usually given in the past were much less effective in suppressing relapses than is the single dose of PAM (1.2 mega units (4 ml), adult dose) recommended in present-day mass treatment campaigns against yaws (Hackett & Guthe, 1956). After PAM, as used in total mass treatment, one would not usually expect a serious rise in prevalence for several years if high coverage had been achieved at the initial treatment survey (Kranendonk, 1958).

Six to twelve months after mass patient treatment (see Annex 1, page 759) the clinical prevalence is usually reduced to about a third of what it was at the initial treatment survey. More relapses from the untreated latent cases and contacts have been found in some campaigns at this first resurvey than during the next few years. This suggests that first resurveys should not be delayed more than 12 months. The relation between duration of the incubation period of yaws and the optimal period between surveys has not been determined. About 24-30 months after resurveys at intervals of 6-12 months the prevalence of clinically active yaws is usually under about 2% and by that time most of the population has been seen at least once (Soetopo et al., 1956; and unpublished Indonesian data). Since latent cases and contacts are not "protected" in patient treatment, the relapses from the former and the infection of the latter will maintain the infection, if no resurveys or similar activity are carried out In several areas, in the absence of further activities after the initial treatment survey, the prevalence of active yaws, especially when arsenical and bismuth preparations have been used, has risen fairly rapidly and, if no other measures have been undertaken or changes occurred, after 5-10 years the prevalence may have reached its previous level (Kivits & Friedheim, 1951). More recently, however, in some countries improved rural water supplies appear to have adversely affected yaws transmission and after rather inadequate patient-treatment campaigns the clinical prevalence has not approached its previous level after over five years. A decrease in the numbers of sero-reactors in such communities would occur if the disease were really dying out and transmission were stopping and not merely inactive.

The unsatisfactory results of anti-yaws activities that, among other things, do not take into account the latency of the disease have been well shown in Trinidad (Fawkes, 1957).

RESULTS OF SUDDEN CESSATION OF YAWS TRANSMISSION

If the conditions favouring transmission suddenly ceased in a stabilized yaws-endemic community, it would be interesting to consider (*a*) how the disease would decline, and (*b*) how long the infection would take to disappear completely.

In a community where yaws is stable it may be assumed that the prevalence of sero-reactors would be about 60% and of clinically active cases about 20%. The latter would consist of (see page 741):

early cases	30%
cases with solitary hyperkeratosis	60%
late cases	10%

The prevalence of initial lesions would be about 0.4% of the population or 2% of active cases.

From the time when all transmission ceased, perhaps as the result of a change in the hygienic conditions of the people, initial lesions would continue to develop for the next month or so—until the incubation period in persons already infected had ended. These and other recent infections would run their course of an eruption of papillomata or other early lesions and one or more relapses of early lesions, but they would not give rise to further new infections.

After several years the prevalence of early lesions would fall, and after five years, perhaps, very few early lesions would occur. The lesions that would be seen in the community at that time would be solitary hyperkeratoses and late lesions in undiminished numbers.

Five to ten years from the cessation of transmission the prevalence of solitary hyperkeratosis would start to fall, followed, a few years later, by the diminution of late lesions. Perhaps 20-30 years after the cessation of transmission these two groups of lesions would be very infrequent or would have finally disappeared. At this stage, about 30 years from the cessation of transmission, the only evidence of the presence of yaws in the community would be serological reactions in older people. The younger half or more of the population by that time will have escaped infection with yaws. Taking into account the length of life in such areas and the unknown extent of spontaneous cure, only about 20% of the population might be sero-reactors. Sero-reversal of untreated serologically latent cases is slow. The ages of the sero-reactors in the community would rise at the same time as those of the few patients with active yaws lesions (Medina, 1959).

In many populations at present 20%-30% of the total and 50% of the adults, but very few children, are sero-reactors and at the same time clinically active yaws is scarce or absent. In such populations yaws may be said to be in recession (Hackett, 1959); in some chemotherapy may have played some part.

After a further 20 years, making 50 years from the cessation of transmission, death will probably have removed the remaining evidence of past yaws infection. Now none of the community will have been infected with yaws and all will be susceptible to infection with the treponemes which, fortunately, could not occur because conditions favouring yaws transmission would not be present.

Such a complete and sudden cessation of transmission of yaws spontaneously or by human agency has never been reported. Any important interruption of transmission due to chemotherapy has been much slower—at least several years after total mass treatment and usually much longer after casual patient treatment (see Annex 1, page 759), and still longer when due to improvement of environmental conditions.

In such circumstances the prevalence of active yaws falls but some transmission continues, together with the development of a few late cases. Some time later, in total mass and casual patient treatment and also in mass patient treatment (see Annex 1, page 759), all active yaws disappears, but for some years to come an occasional case of early yaws occurs (see page 752), arising from delayed relapses and in part, perhaps, from apparently non-infectious relapses such as solitary hyperkeratoses or late lesions. For some of these infectious lesions and even initial lesions no obvious source may be found.

CHANGES IN PREVALENCE OF YAWS LESIONS AFTER MASS TREATMENT

In a community in which yaws infection is stable, only minor changes in prevalence of active yaws and of lesion frequencies from one year to the next over short periods might be expected. However, the possibility of a cycle with a high, followed by a low, prevalence in about 40-60 years (Hackett, 1957a) should not be overlooked. Over short periods the pattern of yaws in a community might thus appear fairly constant. In such a community, if yaws infection were moderately active there would be a few initial lesions, resulting from recent transmission, and more numerous patients with early lesions resulting from longer-standing infections and relapses from infections of less than five years' duration. There would also be a group with hyperkeratoses arising from older infections, and a group with late lesions, mostly among persons infected more than 5-10 years previously (see pages 740-744).

If the results of the reagin serological tests for syphilis in the whole community are considered, two other groupings emerge, namely, the sero-reactors and the non-reactive persons (see page 744).

It is assumed for the present discussion that no other treponematoses are present in the community and that biologically false-positive tests are not important. In populations with endemic treponematoses it has been found that biologically false-positives are probably less than 5% of sero-reactors. Sero-reactors with no active yaws represent the latent infections which may relapse from time to time either with early or with late lesions but never both simultaneously. It is the neglect of these latent infections in the past which, when one single mass patient-treatment action alone has been undertaken, has so often resulted in the rapid return of the prevalence of active yaws to its original level. This risk is greatly reduced by total mass treatment (see Annex 1, page 759) where patients and also the rest of the population, to include the latent cases and contacts, are treated, but even then mass-treatment must be followed by resurveys to ensure permanent results unless the initial prevalence of active yaws was low.

Non-reactors comprise all persons who are not infected and thus are presumably susceptible (see pages 739 and 746). The importance of these susceptibles in maintaining the infection in the community is

only equalled by that of patients with infectious lesions. If it were possible, perhaps by immunization, to remove all susceptibles from a yaws-endemic community and also to prevent any susceptibles from entering the community, transmission would cease and yaws would die out from that community during the next 20-30 years.

The influence of mass treatment on such a balance has been observed many times but, unfortunately, there are uncontrolled variables and other important data that are usually not recorded. The failure to carry out treatment surveys of the whole population at the initial action, the use of inadequate doses of arsenical and bismuth preparations, and inadequate training and supervision of auxiliary field staff so that diagnoses and treatment are not consistent, all tend to reduce the effect of the mass treatment.

After total mass treatment with a long-acting penicillin preparation (provided that the whole population is adequately treated), the prevalence of clinically active yaws can be expected to fall rapidly—the early lesions at first more rapidly and markedly than the late lesions.

Infectious relapses in cases treated with PAM are very infrequent for a year or two (Hume & Facio, 1956). Unpublished Indonesian data show that there may be some non-infectious relapses, but they are more frequent after smaller doses of PAM (i.e., 0.6 mega units—2 ml) than after larger doses (1.2 mega units—4 ml). Relapses from treated latent cases probably follow a similar pattern. It is noteworthy that the later resurveys after total mass treatment often reveal, among the very few active cases found, a high proportion of initial lesions (see page 740). The normal tendency of yaws to relapse thus appears to be largely suppressed. As the protective action of the PAM after a single injection, in persons in the incubation period or in uninfected persons, lasts for only about a week or two, both these groups soon become again susceptible to infection on effective contact with any infectious patient. There might be a phase when late lesions were the only active ones present. If no resurveys and no surveillance were carried out, the prevalence of active disease might be expected slowly to return to its stable level or threshold.

Dr F. N. Guimarães, in a personal communication, has stated that infection is possible from so-called non-infectious late lesions (see page 752). He has found treponemes in late ulcers and has infected human volunteers with material from such lesions. This again stresses the need for resurveys. In Western Samoa after a fairly extensive mass patient-treatment (see Annex 1, page 759) campaign only late cases persisted, yet a few years later a high prevalence of a wide variety of active yaws was again present (Lambert, 1936). This resurgence was almost certainly due more to infection from relapses of untreated latent early cases than from late cases.

COMPARISON OF RESULTS OF TOTAL MASS TREATMENT AND MASS PATIENT TREATMENT

In total mass treatment the whole population is seen and all patients with active disease are treated while the remainder of the population is given half doses as latent cases and contacts (see Annex 1, page 759). The proportion of the remainder treated may be reduced if the prevalence of active cases is below 10% (Hackett & Guthe, 1956). The extent of the yaws infection in a yaws-endemic community is greater than that shown by the prevalence of active cases. There is the important group of latent cases which is at least as large as that of active cases, and if much treatment has been given in the past it may be 2-3 or more times greater. These latent cases can only be recognized by serological surveys. If treatment is to be based upon serological surveys, then the rapidity and ease of handling the individual patient when treatment consists of a single intramuscular injection are greatly reduced, and the difficulties of the campaign are greatly increased—unless, of course, a simplified and rapid serological technique is used.

There is a small but important group of persons who are in the incubation period and, since they would be non-reactive to the serological tests for syphilis, would thus not be identified in serological surveys. They would later develop papillomata, so maintaining the disease in the community by infecting susceptibles. This is one reason for grouping together these two groups into "latent cases and contacts" (Hackett & Guthe, 1956). The intention of total mass treatment is that all active cases will be clinically cured, a few will undergo serological reversal and, if PAM is used, relapses, especially infectious relapses, will be greatly reduced for one or two years at least. The half-doses given to latent cases will cause seroreversal in some and will suppress the infections in others for about two years or longer so that some of these will then have passed out of the early stage and thus will no longer have infectious relapses. The half-doses given to

susceptible persons who have been in effective contact with infectious patients will probably abort these incubating infections. The half-doses given to uninfected susceptibles will perhaps protect them from infection for about a week or two, at any rate for longer than treated infectious patients will remain infectious.

Total mass treatment is thus a comprehensive treatment policy, indications for the application of which are based upon clinical inspection. Its results support the principles upon which it is based. A year after an initial treatment survey in which total mass treatment has been carried out it can confidently be expected, if most of the population has been seen, that the prevalence of all active yaws will have fallen from 15%-20% to under 2%, and infectious lesions will have fallen from 3%-5% to under 0.5% (Zahra, 1956). Thus the first step towards the eradication of yaws from a population has been taken (Kranendonk, 1958).

In mass patient treatment (see Annex 1, page 759) the whole population is seen but only patients with active disease are treated. In some areas attempts to widen this treatment policy have been made by treating household contacts or persons who say they have had yaws. These extensions are probably of more value when the prevalence of active yaws is high, under which circumstances total mass treatment is indicated, than when it is low (below 5%). The effect of mass patient treatment using PAM is that there is a reduction in active yaws to about a third of its previous level. Subsequent periodical resurveys at intervals of about 6-12 months bring about further reductions so that within 2-3 years the prevalence of active yaws will usually have fallen from 15%-20% to about 2%, and of infectious yaws from 3%-5% to under 0.5% (Soetopo et al., 1956). Unpublished Indonesian data show that usually after 3-4 resurveys practically all the population will have been seen at least once even if the coverages at surveys were 60%-80%. Transmission is less because infectious lesions are greatly reduced. Most relapses of early lesions in patients whose infections were latent at the time of the initial treatment survey will be recognized and treated at the early resurveys. These relapses will also decrease with time, and because of treatment at resurvey they will ultimately cease.

When this state is reached, by either total mass treatment or mass patient treatment, the community is ready to pass from the mass treatment stage of the campaign to that of surveillance. The anti-yaws activities should then be integrated into the public health service if adequate facilities are available in the community. Thus there is no reason why either of these treatment policies, if thoroughly carried out and followed by adequate surveillance, should not lead to eradication.

Where auxiliary staff can be afforded and are available in adequate numbers, and where the population can be readily gathered together in largish groups for the initial treatment survey, total mass treatment is the more satisfactory treatment policy. If these conditions are not readily fulfilled, and especially if auxiliary staff is inexpensive and the population is more reserved and conservative and does not understand the need for treatment in the absence of active lesions, then mass patient treatment has been found effective. In Indonesia, where mass patient treatment is widely carried out by the Treponematosis Control Project Simplified method (Soetopo et al., 1956), periodical resurveys by simply trained auxiliaries are carried out at intervals of 6-12 months with a regularity found nowhere else. This regularity of resurveys, which is part of the thoroughness of the whole campaign, might well be an essential element in the Indonesian success. In Indonesia the anti-yaws activities are integrated into the rural health services from the start. It should also be recalled that in areas in Indonesia wherever the prevalence of clinically active yaws is over 30%, or where for practical purposes the whole of the population may be regarded as infected or, regardless of the prevalence, where the community is difficult of access either because it is remote or dispersed or it is nomadic, then total mass treatment is used (Soetopo et al. 1956).

COMPARISON OF THE RESULTS OF THE TREATMENT OF YAWS WITH INADEQUATE DOSES OF (A) ARSENICAL AND BISMUTH PREPARATIONS AND (B) PAM

Adequate individual treatment of a patient with yaws might ideally be regarded as that which produces serological reversal. In mass campaigns treatment might be regarded as adequate when few if any relapses follow it; the absence of infectious relapses is more important than the absence of relapse of late lesions. Inadequate treatment would be that which fails to produce this standard of cure. When arsenical and/or bismuth preparations were used it was usually the intention to give each patient with active yaws 4-6 pairs of injections at weekly intervals. Usually the patient did not

report after the first 2-3 weeks because his lesions would then probably have healed and aches and pains would have ceased.

Occasionally adults with early yaws have undergone seroreversal after a single dose of neoarsphenamine of 0.6 g. Apted et al. (1948) have reported 27%, 38% and 31% seroreversals 6, 18 and 30 months after 3-4 paired injections of arsenic and bismuth; 48 out of 86 patients gave doubtful or negative reactions after 2½ years. Apted (1951) found only 12% seroreversals and 9% doubtful reactions 2 years after 5 injections of bismuth salicylate, suspended in arachis oil, at intervals of 5-7 days. In both these studies it was assumed that all patients were sero-reactors at the time they were treated. Relapses following 1-2 injections were frequent. Rural people often believe that treatment with arsenical or bismuth preparations before the early lesions are well-developed is likely to be followed by more frequent serious late manifestations. This may be based upon the observations of sufferers themselves and their relatives and friends of the inadequacy of much of the arsenical and bismuth treatment in checking the normal course of the disease.

Since a single injection of PAM is usually more effective than the courses of arsenical and bismuth preparation that were usually given, all patients treated with PAM are more adequately treated. One or two years after a single injection of PAM 1.2 mega units (4 ml) seroreversal may be expected in about 20%-30% of sero-reactors. In one area it appeared that after PAM seroreversal was more frequent (40% of reactors) among serologically latent cases than among active cases. In contradistinction to the results of inadequate doses of arsenicals and bismuth, infectious relapses after these small doses of PAM are unusual but the frequency of non-infectious relapses, although low, appears to be inversely related to the dosage.

What is an inadequate dose of PAM in mass campaigns is difficult to define. Studies in Haiti (Hume & Facio, 1956) showed that 0.6 mega units (2 ml) and perhaps even 0.3 mega units (1 ml) may be regarded as adequate by some workers when assessed by the absence of treponeme-positive relapses that followed their use.

Apart from the ease of administration of a single intramuscular injection, modern yaws campaigns using PAM have several advantages over the older ones that used arsenic or bismuth preparations. Among these advantages are (1) greater effectiveness of a single injection than the several of arsenicals and bismuth usually given; (2) greatly reduced infectious relapse rate and reduced non-infectious relapses; (3) hastened healing of late lesions; and (4) the good effect of PAM, in the doses used, on conditions other than yaws, such as ulcers not due to yaws, and gonorrhoea. For these reasons attendance at initial treatment surveys is usually high when PAM is given.

POSSIBLE MEANS OF YAWS ERADICATION OTHER THAN MASS TREATMENT

There is no doubt that in yaws a single operation of mass treatment cannot be expected by itself to result in eradication. In the past, failure to realize this has taught the lesson that continued public health activities are essential. The most obvious of these are regular periodical resurveys followed by surveillance. However, from the earliest stages of the campaign, plans and actions to improve hygiene, the rural health services and the standard of living of the population should be undertaken.

This raises the question of what improvements of hygiene are likely to produce results. It is obvious that to bring about any changes in environmental sanitation in a community in which yaws is endemic will require great effort and much thought and skill. It is important, therefore, that any recommendations should, if possible, be simple, effective, inexpensive, and as much as possible within the scope of the community. They should be understood and desired by the population. Such measures, in addition to removing the conditions favouring yaws transmission, will certainly bring other benefits. If their application in the field is not already well stabilized, they should be carefully tried out in limited areas before any attempt is made to introduce them widely. Such trials may encounter difficulties in application that only experience could reveal.

Observations of field conditions and of changing prevalences of yaws, the study of epidemiological data, and the consideration of the mechanism of the transmission of yaws (Hackett, 1957a), suggest that an important factor in reducing the prevalence of yaws in a community, probably by reducing transmission, is the presence of a moderately readily available and adequate water supply. Thus it would appear that priority should be given to the introduction of satisfactory rural water supplies. It may be assumed that a supply of about five gallons per head per day should be striven for at first. The improvement and protection of existing

supplies, and the gravity-fed piping of such supplies where necessary, are obvious tasks. Simple measures applicable to the smallest population and involving relatively little cost are required. The first need is for more water conveniently located. Its quality should be improved when its quantity is satisfactory, but its source must be carefully selected and protected from human contamination to avoid the propagation of water-borne diseases. Large communities may need mechanical raising and storage of water as well as piped reticulation, but at once costs rise for construction and maintenance; maintenance may well prove the more difficult, if not the more expensive.

This recommendation would appear of value in the woodland savanna type of country where water supplies may not be adequate at all times of the year, but its value is not so apparent in those yaws areas where water is relatively abundant throughout the year. Such places include coastal areas and areas of perennial irrigation. In some areas, also, humidity and higher rainfall are thought to be associated with higher yaws prevalence. Yaws has been reported to be more prevalent on the side of a mountain range that is exposed to the prevailing moisture-laden winds than on the other protected side.

Where improved water supplies have been associated with reduced yaws prevalence other factors may doubtless have improved at the same time. The most important of these may be the use of soap, of which the value is limited if there is not enough water for washing, and the wearing of more clothing and shoes, especially by children (see page 749). Improving economic standards will increase the availability of soap, clothing and shoes.

Before any plans for the improvement of hygiene are finalized they should be discussed with the members of the community concerned, and approval and co-operation should be gained for their execution.

The wider necessities of community development should be recognized early, and as much should be done as the community is ready for. It has been repeatedly shown that a community which is itself helping to raise its own standards will make more effective use of suitable outside help than a stagnant conservative community in greater need. A list of priorities should be drawn up; good road communications will probably appear high on it. A good road not only enables help to come more readily to the community but also enables surplus produce to go to bigger markets.

Harding (1949) has suggested that yaws is a house disease and that it is transmitted in houses which are crowded and ill-ventilated. However, in some parts of the world where yaws is prevalent houses are airy and crowding is absent.

Further precise studies are needed on eradicating yaws by means other than mass treatment, and suitable trials to test any recommendations arising from such studies which are not based upon established practices should be carried out before they are widely applied.

CHANGES OF CONDITIONS IN COMMUNITIES WHERE PREVIOUSLY HIGH YAWS PREVALENCE HAS DECREASED

Yaws prevalence would be expected to be high in rural communities lacking many of the advantages of more developed communities (see page 749). The more important deficiencies likely to be present might be listed as follows:

good personal and domestic hygiene
education
economic resources
all-the-year adequate food supplies
all-the-year adequate water supplies
road communications
preventive and curative medical services
clothing.

A great reduction in the prevalence of yaws not attributable to a mass treatment campaign is usually accompanied by other changes that have contributed to the raising of the standard of living. The more obvious of these are better and more clothing; more bicycles on the roads; more village schools and more secondary school places; more dams, boreholes and wells available and in use; and more soap—all of which are signs that the community is wealthier. However, village houses may be in no better state of repair, and excreta disposal may still remain a matter of individual action. Perhaps the most striking factors are the more and cleaner clothing, cleaner bodies, more adequate water supplies, and good communications. There may be little evidence of improved village hygiene or effective sanitary supervision; in fact villages may still consist of dispersed huts which would make supervision difficult.

It is at least suggestive that one of the main factors reducing yaws prevalence may be more water to go with more soap.

Annex 1

DEFINITIONS OF TREATMENT POLICIES

In considering the extent of yaws in a community, the treatment which that community has received during the past 5-10 years must be taken into account. To clarify this attention might be drawn to certain definitions.

(*i*) Untreated (UT)—no treatment at all

(*ii*) Casual patient treatment (CPT)—at clinics, etc., *patients seeking treatment* are given it either for a fee or free of cost.

(*iii*) Mass patient treatment (MPT)—at surveys of the whole population, *all patients with clinically active disease are treated* free of cost.

(*iv*) Total mass treatment (TMT)—at surveys of the whole population, *all patients with clinically active disease are treated and the remainder of the population receives half doses as latent cases and contacts*. This is recommended when the prevalence of clinically active yaws is over 10% (Hackett & Guthe, 1956).

(*v*) Juvenile mass treatment (JMT)—at surveys of the whole population, *all clinically active cases are treated and the obvious contacts of infectious cases, together with all other children under the age of 15 years, receive half dose as latent cases and contacts*. This is recommended when the prevalence of clinically active disease is 5%-10% (Hackett & Guthe, 1956).

(*vi*) Selective mass treatment (SMT)—at surveys of the whole population, *all clinically active cases are treated and the obvious contacts of infectious cases receive half doses*. This is recommended when the prevalence of active disease is less than 5% (Hackett & Guthe, 1956).

Annex 2

SOME EPIDEMIOLOGICAL FACTORS IN YAWS

Many of the features that might influence the extent and pattern of yaws in a community and which would help in the analysis of its epidemiology (see page 751) may be listed more extensively under three main headings: (*a*) the infection and the disease; (*b*) the population; (*c*) the climate, terrain, and other factors.

The infection and the disease

Incubation period

Age at which yaws is usually contracted, and the interval after the infecting contact at which the patient becomes infectious

Duration of infectiousness immediately following the development of the disease

Frequency and duration of latency, of infectious and of " non-infectious " relapses

Relative infectiousness of late ulcers as compared with papillomata

Serial interval, i.e., the period from the observation of symptoms in one case until the observation of symptoms in a second directly infected from the first

Actual and potential numbers of infections arising from each infectious case of yaws in units of duration of the incubation period

Proportion of new infections arising from initial lesions, papillomata, all other lesions

Spontaneous cure rate, and the frequency of susceptibility in spontaneous cures

Duration of infection after which spontaneous cure is most likely to occur.

Onset of immunity in relation to the acquisition of the infection, the development of recognizable lesions, and the development of lesions that would bring the patient to seek treatment; and duration of the resulting immunity

Variability of infectiousness of the treponeme, and duration and severity of the outbreaks in the population

Variability of all items, e.g., incubation period, latent period, relapse rates, infection rates, prevalence rates, etc.

The population

Critical threshold of susceptibles below which there would be no outbreak, but above which, by

the addition of susceptibles, there would be an outbreak

Threshold of population density below which the infection would not be maintained or spread

Probability of adequate contact, that is, adequate for the transmission of the disease between any two individuals during the time of one incubation period (This depends, among other things, upon the activity of an infective person and the number of persons with whom he is in contact. An individual, in many communities where yaws is endemic, is probably in close contact with only a few persons in the usual day's activity. This may be less than 10-15; thus the unit of the household should be kept in mind. There is, of course, much overlapping of these groups, hence a larger outbreak is really a number of smaller outbreaks. Each household unit, as a group of persons in closer contact among themselves than with other persons, probably has a fairly definite pattern of behaviour or movements concerned with food, water and fuel for domestic fires, as well as play among children. The points of contact with other household groups would probably be most likely during such activities. These activities have sex and age attributes. Infection within the household in yaws is probably not the most important occurrence in communities of moderate or higher prevalence, since many of the family members will already have been infected and will thus no longer be susceptible. The household or family may be considered as a unit of infection. Relation of the number of households infected to the number of infectious cases should also be taken into account. Susceptibles are maintained by the newborn and immigrants, and perhaps to some extent by spontaneous seroreversals with loss of immunity.)

Differences in susceptibility of individuals not already infected, and their chances of becoming infected

Size and age grouping of population

The prevalence by age groups of initial lesions, infectious lesions (less initial lesions), other early lesions, hyperkeratoses, late lesions, sero-reactors with no active lesions of high and low titres, and non-reactors (susceptibles)

The climate, terrain and other factors

Prevalence of yaws in relation to rainfall, temperature, humidity, altitude, soil type and adequacy of drainage, vegetation, etc.

Seasonal variations of prevalence of active yaws, and the relation to variations in nutrition

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RÉSUMÉ

A mesure qu'arrivent à leur terme les campagnes contre le pian dans les régions de fréquence élevée, les lacunes de nos connaissances sur l'épidémiologie de la maladie, en particulier dans les régions où l'infection est moins répandue, apparaissent plus nettement. Une grande partie des observations faites au cours des campagnes n'ont pas été publiées. Nombre d'entre elles pourraient être utiles à ceux qui sont chargés de poursuivre ces campagnes dans les régions de faible endémicité. L'auteur engage donc ceux qui ont participé à la lutte antipianique et y ont recueilli observations et expériences, à les ordonner en vue de leur publication. A titre d'introduction, il discute dans cet article quatorze points, qui sont autant de sujets d'intérêt demandant des compléments d'information. En voici quelques-uns: les données nécessaires pour déterminer exactement dans une communauté l'état de développement du pian; l'introduction du pian dans une collectivité; les risques de réinfection dans une collectivité débarrassée du pian à la suite du traitement systématique; les conséquences du relâchement de la surveillance dans les zones traitées; les résultats de l'interruption brusque de la transmission du pian; les résultats et les conséquences du traitement par des doses inadéquates de bismuth, d'arsenic et de PAM; les possibilités d'éradication du pian par des méthodes autres que le traitement de masse; le changement des conditions de vie dans les collectivités, autrefois fortement infestées, où le pian est en voie de régression.

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