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BASIC PRINCIPLES IN THE ASSESSMENT OF MALARIA ERADICATION PROGRAMMES ✓
IN RELATION TO OTHER MASS CAMPAIGNS

by

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INTRODUCTION

The concept of world-wide malaria eradication was first accepted by the World Health Assembly in 1955, and subsequently programmes were launched in all parts of the world. No other public health effort of comparable magnitude had ever been attempted against a single disease. Thus it was inevitable that much of the experience essential for the successful accomplishment of such a task had to be gained during the course of the execution of malaria eradication programmes.

In the early years of malaria eradication, practically the entire effort was concentrated on attack measures and it was only gradually that the need for a continuous and extensive assessment came to light and was fully appreciated. Although much of the knowledge gained on the assessment aspects was specific to malaria eradication, there emerged some factors of a general nature which are relevant to the assessment of mass campaigns against other diseases.

It is the intention of this paper to extract from experience gained in the epidemiological assessment of malaria eradication those basic principles which might have a wider application. In this context it is interesting to note that the experience gained in the assessment of malaria eradication compares closely with that of another major campaign - the elimination of yaws - and a surprising number of similarities can be recognized. Wherever appropriate, examples of one or both programmes are hereafter given to illustrate the need for a sound planning of assessment and the elements involved therein.

A mass campaign, either in the form of control or eradication, requires more than an average effort and financial outlay. Naturally, the discharge of such a responsibility demands a very detailed plan of action. This plan must comprise not only the strategy and tactics of the attack but also clear information on the methods by which the progress and results of a programme can be closely observed and assessed. Great importance must be attached to critical epidemiological assessment during and at the end of a mass campaign. On the results of such continuous evaluation can depend not only the duration of a programme but also the choice or change of attack methods to be used.

Although each infectious disease calls for specific planning based upon its epidemiology, certain basic principles can be defined which are applicable to all mass campaigns against communicable diseases. Generally four different problems demand thorough consideration before the epidemiological assessment system of a mass campaign can be instituted. These are:

- (1) epidemiological situations to be expected at the various stages of the campaign;
- (2) choice of diagnostic methods;
- (3) application of evaluation methods;
- (4) organization of the assessment service.

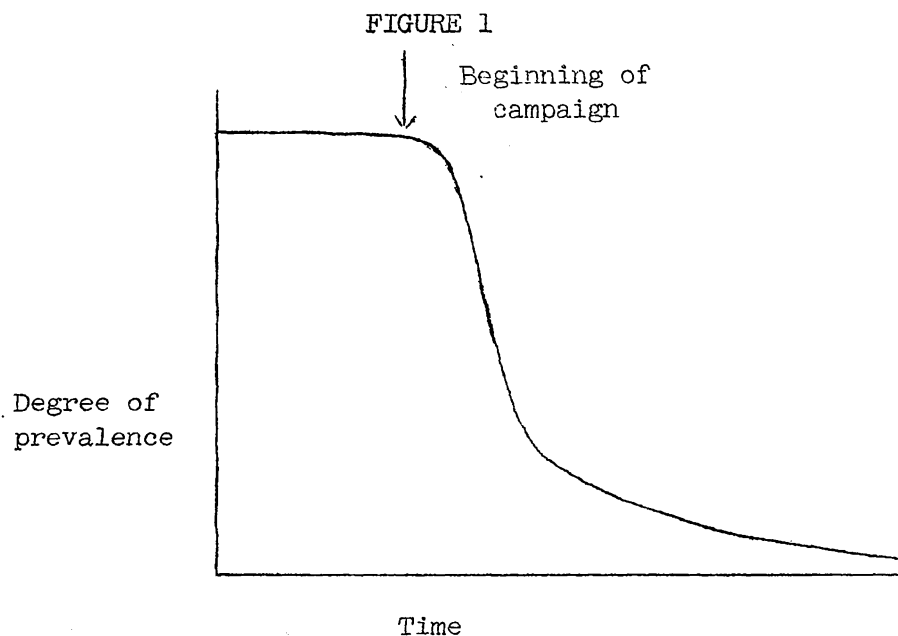
The following discussion stresses the eradication concept rather than that of control, the reason being that the assessment problems of a soundly planned control programme are closely related to those of eradication. In both the intention is to replace, eventually, the more costly measures of the campaign by cheaper assessment methods. Hence, from an evaluation point of view, good control and eradication do not present a difference of principle but only a difference in the degree of urgency.

EPIDEMIOLOGICAL SITUATION

For the assessment of progress or results, it is essential at the very beginning of a mass campaign to define clearly its final aim, its expected pattern of progress and the time required for its completion. The precise definition of the final objective of a programme is usually easy and must, in the case of an eradication

programme, be the complete elimination of the infection. It is considerably more difficult to establish the epidemiological trend of a campaign. For this it is essential to know precisely not only all the epidemiological factors which may have an influence but also the anticipated response of the infection to the measures used.

The establishment of baseline data at the beginning of the campaign is important for the assessment of the results, especially during the first years of the attack. Experience has shown that the initial impact of suitable attack measures will rapidly reduce the prevalence of the disease. It is, however, much more difficult and time-consuming to lower this still further in order to reach the ideal zero level of an eradication programme and to forecast times for these achievements. Figure 1 shows the curve of the common trend.



According to the type of transmission of an infection, a campaign can be divided into epidemiological stages, each limited by specific situations. As examples, yaws and malaria may be cited; their eradication programmes pass through the following stages:

<u>Stage</u>	<u>Yaws eradication</u>	<u>Malaria eradication</u>
1	Reduction of active yaws to 2% and infectious cases to 0.5% of population approximately at the end of two to four years of mass campaign	Interruption of transmission at the end of the first year
2	Complete disappearance of infectious cases and further reduction of active cases; requiring an additional one to three years	Reduction of the parasite reservoir in the population to an incidence of less than 0.5 per thousand per year; this should be reached at the end of the fourth year
3	The absence of infectious cases over a period of three years after which "epidemiological eradication" is reached	Elimination of the few remaining or renewed malaria foci and absence of indigenous malaria cases for at least three years, at the end of which eradication will have been achieved.
4	Disappearance of active yaws which brings eventually "complete eradication".	

In most campaigns there are at least two clearly distinguishable phases: the first comprises wide application of the essential attack measures and the second the detection of residual foci of transmission and their elimination. It is essential that epidemiological criteria be established, based upon theoretical conclusions or experimental findings, which have to be met within certain time limits. Only when sufficient evidence exists that these standards have been attained should a programme advance to the next phase. Hence it is essential to determine epidemiologically precisely when certain measures can be terminated and other operations can or have to be introduced.

The more clearly such intermediate standards can be established and the more numerous they are, the easier will be the continuous assessment, which alone will facilitate the early recognition of eventual difficulties or failures.

CHOICE OF DIAGNOSTIC METHODS

One of the necessities for precise and continuous assessment of any activity is the existence of a unit of measurement; this applies particularly to mass campaigns. It is naturally preferable to use units directly related to the infectious or infected person. Whether this is feasible depends upon the availability of the diagnostic facilities. Occasionally this direct assessment will be impossible because there are no suitable examination methods. In certain infections indirect measurements may be substituted and used in assessment; thus the epidemiological situation may be measured by the changes occurring in the transmission cycle outside man, such as in an animal transmitter or vector. Although preference is usually given to direct measurements, it is often advantageous to supplement this with indirect ones. This sometimes provides a good indication of where activities of the attack have to be strengthened or where they can be safely reduced.

It is not sufficiently precise simply to take the "case" as the unit of measurement. In the assessment of mass campaigns data from different areas or countries, or collected at different times, frequently need to be compared. Thus an agreed and precise definition of the unit is indispensable. For example, in the control era malaria was measured by the spleen enlargement in children or the number of clinical (not microscopically confirmed) malaria cases, in themselves already two widely differing measurements both too inaccurate for the evaluation of an eradication programme. It became essential to make it clearly understood that "malaria cases" are defined as only those persons in whose blood the malaria parasite can be demonstrated, regardless of the presence or absence of other symptoms of the infection at the same time. In the same way, in yaws campaigns a "case" is a person with active yaws lesions and no account is taken of a history of yaws. Any chosen definition must, of course, have regard to the availability of applicable examination techniques.

In the search for suitable diagnostic methods for mass campaigns it is important to realize that the choice of examinations or tests has many limitations. Some diagnostic procedures which are useful to the clinician may prove unsuitable in mass programmes. Several main aspects must be considered in choosing a method. One of the essential requisites is the feasibility of the diagnostic examination under prevailing field conditions. This excludes tests which are complicated, too costly or time-consuming and which demand more highly qualified personnel. Of paramount importance are the specificity and sensitivity of these tests.

By specificity is meant that a positive result can only be given in the presence of the specific infection, while sensitivity depends on the frequency with which a positive result will be given by a specific infection. In other words, the less the false positive results, the more specific is the method; and the less the false negative results, the more sensitive. For example, a parasitological/microscopical examination is very specific because the individual parasites can easily be distinguished one from the other. However, this examination is not very sensitive as parasites may be overlooked or, due to their scarcity, they may not be seen. On the other hand, a serological examination, such as for syphilis, is highly sensitive because, except for very early infections, all will give positive results. Nevertheless, a serological test may not be very specific because other diseases (yaws, certain acute infectious diseases, etc.) may also yield positive results. False positive results can also be expected when the examination is based upon immunological reactions or pathological changes in parenchymatic organs; here the return to normal after treatment may be delayed beyond the cure of the infection or may never be complete. The method of choice should be strongly specific and highly sensitive. For the use of these results in the assessment of an epidemiological situation it is essential, therefore, to know the value and limitations of each method.

Ideally, direct methods such as visual and palpatory examinations which require no additional resources would seem to be preferable. Not all communicable diseases, however, have external characteristics which can be easily recognized in this way. The visual examination is, for example, important in yaws campaigns where it is possible to train simple auxiliaries to diagnose typical skin and bone lesions.

Opposed to the time-saving and economic advantages of this method, there are unavoidable individual variations in the accuracy of diagnoses. With few exceptions, it can be said that in mass campaigns which employ quickly trained auxiliary personnel, visual or palpatory methods are usually too unspecific and insensitive and thus of limited use.

In the assessment of mass campaigns, simple laboratory tests, microscopical, serological or biochemical, play a considerable role. They can be easily standardized so that their results are as a rule less subjective. Often, especially in the parasitological/microscopical examinations a further advantage, in addition to their high specificity, is that the material can be preserved for later re-examination by others in different places. But, on the other hand, such methods need laboratories, better qualified personnel and, as a further disadvantage, there is nearly always a certain time and space lapse between the taking of the specimen and its examination. This often necessitates another time-consuming visit to the place where the infection was found in order to carry out further investigation or to give specific treatment.

A further defect in microscopical examination is the human element of fatigue which becomes increasingly important as when, towards the end of a successful malaria eradication campaign, the number of positive results will diminish so that many thousands of consecutive blood smears may be examined without perhaps finding a single parasite. Efforts are being made to find a substitute for this unpredictable human factor in electronic examination apparatus.

APPLICATION OF EVALUATION METHODS

After having chosen one or more methods by which the progress of a mass campaign can be assessed, the next step to consider is the means of application. There are three possibilities:

- random sampling;
- examination of the entire population of an area;
- institution of a specific screening device (preselection) before the actual examination.

Random sampling is used most commonly at the beginning of a campaign, when only an estimate of the prevalence is required, and during the first stage of the attack period when the impact of the remedial actions has to be measured. A random sample is obtained by the unbiased selection of a certain proportion of the population, families, houses or villages, in an area considered to be epidemiologically homogeneous, so that each has an equal chance of being chosen for examination. The selection within each of these homogeneous territories has to comply with precise statistical rules in order to ensure that the best representation of the total population is measured and that the results of the examination can be used as an index for the entire area. The required size of the sample can be statistically estimated and depends both on the expected prevalence and on the acceptable probability level.

In the continuous assessment of the epidemiological progress on random samples, it is often an advantage to repeat the examination on the same originally chosen groups, which can then be called indicator villages (or whatever the unit might be). The size of such samples depends more on the prevalence expected during the campaign than on its original level. If indicators are chosen, the correct statistical/epidemiological selection becomes even more important than where, for each repeated examination, a new group is used because any bias introduced at the original selection will run through the entire series of examinations.

The very evident advantages of the random sampling method are that considerably less personnel and materials are required. On the other hand, it must be recognized that absolute information will only be yielded for part of the entire area which then - after adjustment - has to be used for the whole. As long as the prevalence is sufficiently high and a certain level of probability is acceptable, the sampling method will be satisfactory. If, however, the absolute number of infections rapidly falls, a stage will be reached when the size of the necessary sample nearly equals or equals the total population, which means the sample method has lost its purpose.

The application of the assessment methods to the whole population naturally yields epidemiological information which approaches the true prevalence. This great advantage, however, raises problems of applicability and practicability. It is questionable whether the general application of such a method is possible and, if so, worth while.

This can only be decided for each programme separately and depends not only on the type of examination to be applied and its cost but also on the degree of precision required which may vary from one disease to another and at different stages within a programme. In a programme in which the elimination of the last focus of transmission is essential (as in malaria eradication), the use of costly assessment procedures can more readily be accepted in order not to jeopardize the final results through false economy. In other campaigns, if a few infected cases remain, this might be of lesser importance (as for instance in the yaws campaign) because, based on epidemiological and other considerations, it may be known that this will not give rise to a new endemic condition.

Apart from these two possibilities, that is, of examining a random sample or the total population, there is a third method in which the examination is preceded by a screening process so that testing applies only to those persons who have been thus selected. Unlike the random sample which is merely a reflection of the whole, the preselection (screening) covers a group which no longer represents the total population but in which one assumes that all or most of the infectious persons can be found, while the rest of the population can, for practical purposes, be regarded as free from infection. Preselection can be linked with the two others and often presents the only feasible solution in evaluation. Which selection factor should be used depends entirely upon the characteristics of the particular infectious disease. A selection process must be capable of being applied simply and quickly, otherwise it would lose any real advantage over the examination of the whole population. Such selection factor may be a special predestined age-group, a typical scar, or an unspecific but easily identifiable symptom which frequently accompanies the infection, i.e. fever, or anaemic signs, etc. Thus, in trypanosomiasis campaigns swollen cervical glands are used as a selection factor, and in malaria eradication several such factors are used, the main one of which is the simple recollection of an attack of fever (fever history). Not every fever case in the tropics is due to malaria, and not every person harbouring malaria parasites in his blood suffers from fever. However, experience has shown that parasite carriers will generally have attacks of fever from time to time, even though only slight. It is therefore, in general, sufficient for the detection of malaria cases to extend the parasitological examination

to persons with a fever history (with the possible exception of Africans). The value of this factor is based on clinical experience. There is another, based on epidemiological considerations, that in the neighbourhood of an infected person there may be a higher probability of finding further cases than in places where, for a long time, no infections have occurred. In the latter - the examination of contacts or collateral persons - the spatial coverage of this epidemiologically directed examination depends upon the extent of such a focus. Again, in malaria this must include all inhabitants of an area within the flight range of the vector from its local breeding places. In other infections the focus may be limited to a house or a village. Thus, it is important to conduct a well defined and purposeful assessment which increases the accuracy of measuring the infectious conditions of a population as compared with the blind application of a testing method.

When it has been decided who should be examined, it must next be considered when and how often this should be done. To ascertain this, it is vital to have a sound concept of the transmission cycle, the time element involved, and the factors favouring transmission, such as climate, social habits, etc. Where seasonal transmission occurs, examinations are made most frequently in those months when the highest number of infected persons will be expected.

In timing the examination, not only the seasonal cycle but also perhaps, under certain conditions, the daily cycle has to be considered. An extreme example of this, based on biological phenomena, is that of bancroftian filariasis where in some countries microfilariae appear primarily in the peripheral blood stream only at night. More often social factors may be of importance, such as choosing whenever possible those hours of the day when most of the population to be examined can be reached - the school hours for schoolchildren, and for adults times when they are at home and not engaged in outside activities.

The frequency of examination depends in general on two factors: one is the urgency of the assessment required by the programme, and the other is the speed with which an infection can be transmitted. At a stage where there is still high prevalence and when time must be allowed for the attack measures to take effect, little advantage is to be gained from too frequent re-examinations, but intervals

must be shorter when crucial decisions and the choice of remedial action depend on the assessment. This situation is more likely to arise at the end of a mass campaign. The time needed for an infection to develop consists of two components: one, the time needed for an infected person to become infectious (infection interval); the other, the reproduction rate - that is the number of possibilities for one infected person to infect others in a given community during a specific time interval. This latter is greatly influenced by the immunological conditions and/or the presence of a suitable vector, but climate and other factors may also play some part. In some infectious diseases this reproduction rate can, with a certain degree of accuracy, be estimated.

The estimation of the extent of the application of examination methods, as well as their timing and frequency, demands equally a thorough knowledge of the clinical and epidemiological characteristics of the infection as well as of the habits of the population. Only when these are known and when one has a clear concept of what is most important during the various stages, is it possible to formulate a definite plan for the exact assessment of the results of a campaign. It is, however, necessary to provide for a certain flexibility in order to adapt the assessment to changing situations or new ideas.

ORGANIZATION OF THE ASSESSMENT SERVICE

When the technical aspects in the assessment of a mass campaign have been clarified there remains the planning of the organization that will be responsible for the execution of this task. It is evident that the epidemiological assessment as an integral part of a mass campaign is a function of the public health service. Depending on the amount and the specific nature of the assessment work required, as well as the extent of the public health service, it has to be seen whether or not the existing public health staff will be able to take on these additional duties. As extensive programmes often demand an unusually high number of employees, for a certain length of time, it might be necessary to reinforce the service through newly recruited personnel. In the latter case it might be advantageous both for the new staff member and the public health service to consider the possibility of permanent employment of those who render satisfactory service. Generally, such an evaluation service consists of: the peripheral level, those performing the field operations; the intermediate or supervisory level, and the higher or directing and assessment level.

The staff of the peripheral level will always be numerically the largest. If the assessment duties permit, the personnel at this level might also be charged with other functions within the programme or within the wider framework of the public health service. In spite of variations between the different mass campaigns, it must be expected that generally personnel of a lower educational standard will have to be used at this level, although of course they must be literate. Occasionally it might be possible to strengthen the peripheral level by supplementing it with laymen working on a voluntary basis. In selecting such staff it must always be recognized that the value of the assessment will depend largely upon the accuracy of work performed by them. It is equally important to ensure that no undue demands are made on these people, to provide if possible a bonus system, and to use at this level local people as far as practicable, in order to avoid dialectic and ethnological difficulties.

Personnel at the intermediate or supervisory level must be chosen with extreme care. It is preferable that they already have some preliminary knowledge of the specific type of work expected from them. It is most important that persons having some organizational initiative be selected. Whether or not these groups should at the same time be given responsibilities in other fields of the public health service or the programme cannot be answered generally but will depend on local circumstances. If a combination of various duties is necessary, priorities of these functions must be established.

The highest level, "the brain of the service", which directs the work and assesses the results, ordinarily requires much fewer staff; the more so must the highest qualifications be demanded. This group should not be hampered with problems outside its own sphere, but their entire energy should be concentrated on the continuous assessment of the changing epidemiological situation. Considerable epidemiological experience must be one of the prerequisites of the chief of such a service.

In addition to staffing, setting-up of a simple and adequate reporting system is most important. This should comprise all the necessary though not superfluous questions, and duplication must be avoided. The tables and questions must correspond to the intelligence of the field personnel and should require the minimum of time and effort for completion. If material has to be forwarded for examination to laboratories at some distance from the place of collection, arrangements must be made for the avoidance of any undue delays and for its proper identification.

Often it is necessary to test or to compare, under field conditions, the examination methods, their application and organization, before they can be incorporated in a programme. The possibility of field experiments should be considered well in advance in order to have a fully functioning assessment system ready when it is required.

SUMMARY

In the above paper, an attempt has been made to set out some principles in the assessment of mass campaigns against diseases. Four basic problems have been discussed which should be solved before a campaign commences: the expected epidemiological trend, the choice of examination methods and their application, as well as the necessary organization of an assessment service.

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