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THEORETICAL AND PRACTICAL PROBLEMS IN MEASLES CONTROL

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INTRODUCTION

Since 1967, the demands of smallpox eradication have properly pre-empted those of measles control. However, with the rapid elimination of smallpox from all but a few of the 19 countries, the challenge of measles control is attracting increasing interest. This paper describes theoretical studies of, and practical attempts to achieve, measles control.

Measles control is difficult to define in quantitative terms. The common definitions such as "elimination of epidemics," reduction to an "irreducible minimum" or to levels of "public health significance," etc. are imprecise. For our purposes, measles control means the interruption of endemic measles transmission, the prompt notification of imported cases, and rapid control of outbreaks resulting from them. This differs little from usual concepts of measles eradication but it does not imply permanent freedom from measles.

INITIAL DESIGN OF THE REGIONAL MEASLES CONTROL PROGRAMME

While it was known that measles was transmitted far more readily than smallpox and that the disease occurred predominantly among very young children, in 1966 these considerations did not greatly influence plans for the regional immunization drive. Campaigns were designed primarily to achieve smallpox eradication and schedules were constructed to mesh with existing prospection or medical field unit schedules in those countries with such systems. Budgetary considerations also played a role. The basic plan conceived of a three-year vaccination campaign with one-third of each country to be vaccinated each year, all persons were to be vaccinated against smallpox and children six months to six years old against measles.

This design was soon challenged by Drake, NCDC/USAID Medical Officer Advisor, Senegal, as being inefficient and unlikely to reduce measles incidence significantly. He and Gelfand, using life-table techniques, assumed optimal vaccination coverage and vaccine efficacy in each area of a hypothetical country during each year of a three-year campaign. They showed that even after three years of optimal operation, only 40 percent of incoming susceptibles would have been vaccinated before exposure to the disease. Citing the young age distribution of measles in Africa, they felt major measles epidemics would continue to occur. Although the life-table model was useful in appraisal of the problem, it could not effectively analyse the dynamics of measles transmission during and after the vaccination campaign.

THE COMPUTER MODEL

The late Professor George Macdonald of London created a computer model to simulate the West African situation and studied transmission of measles in a model community. The model assumes a steady influx of susceptibles and a high effective contact rate, such that one case gives rise to ten cases among susceptibles and that this high contact rate is constant through the year. As shown in Figure 1, measles transmission proceeds in a pattern not unlike that naturally observed, i.e. epidemics recur every 2 to 3 years as susceptibles accumulate resulting in sharp reductions in susceptibles leading to inter-epidemic troughs of incidence. Macdonald then assumed periodic immunization at intervals of three years and two years and one year (figures 2,3 and 4 respectively). Mass vaccination cycles in which 85% of the target population was vaccinated and which were conducted at a three year and at a two-year interval did little but temporarily suppress impending epidemics. Only an annual cycle of mass vaccina-

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tion (Figure 4) consistently succeeded in interrupting transmission.

As shown in Figure 5, however, immunization of a child as he becomes susceptible is the most efficient and rapid way to interrupt transmission. Unfortunately, the lack of local health services in Africa precludes a system based on this approach.

The Macdonald model suggests three conclusions: (1) a single mass immunization campagin, no matter how successful, will have no lasting effect on measles transmission, (2) mass immunization campaigns conducted at three year or even at two-year intervals serve only to postpone temporarily measles epidemics (3) mass immunization campaigns at one-year intervals or less are required to assure interruption of transmission.

PRACTICAL ATTEMPTS AT MEASLES CONTROL

The theoretical findings help in interpreting the pattern of measles occurrence in Africa. In two areas, urban Ibadan in Western Nigeria and rural Gambia, provide case studies in which to contrast theoretical considerations with reality.

IBADAN, WESTERN NIGERIA

Ibadan, Western Nigeria, is a major metropolitan area with a population of some 900,000 people. Measles occurred annually until July 1967. In a beautifully executed 10-day campaign, 750,000 persons were vaccinated against smallpox and 72,000 children received measles vaccine. A post-campaign survey revealed a coverage rate of 92% among children 0-3 years of age. Measles transmission sharply declined in Ibadan (figure 6); only 43 cases were seen at the University College Hospital Outpatient Department from August through December in contrast to 764 cases seen there from January through July.

Reported measles cases increased in January 1968; in February 6,400 vaccinations were done in a maintenance campaign aimed at children six to 18 months of age. Reported measles cases continued at relatively low levels and in August 1968, in another maintenance campaign, 4,800 children were vaccinated. Neither maintenance vaccination campaign was followed by an assessment of coverage. In November 1968, reported cases sharply increased and by December, a full-blown epidemic swept the city. Forty-two thousand vaccinations were given in January, February and early March; case figures for March are not yet available.

The cause for the resurgence of measles in Ibadan can be reconstructed. Six months were required to accumulate sufficient susceptibles to permit an increase in incidence in January 1968. The limited campaign of February reduced the number of susceptibles enough to prevent a resurgence of measles in February and March despite the presence of about 20,000 susceptibles in a seasonal environment most favorable for spread. Not until November, after the rains, when over 30,000 susceptibles were present, did measles incidence rise sharply. By the time the epidemic control campaign started, probably 40,000 susceptibles were present in Ibadan.

The Ibadan experience emphasizes the extreme importance of responding vigorously to any evidence of an increase in incidence. It also dramatizes the need for continual awareness of the increasing pool of susceptibles. However, the experience suggests that even in densely populated urban areas, well executed semi-annual maintenance measles vaccination campaigns with high coverage (in contrast to the 30% and 15% in the maintenance programme described above) can prevent the occurrence of epidemics. There appears to be a threshold level of susceptibles, probably approximately 20,000 necessary to permit a recognizable epidemic in Ibadan. Well executed semi-annual campaigns should maintain susceptibles below this level essentially indefinitely.

THE GAMBIA

The Gambia provides a contrast to Ibadan. A small country astride the Gambia River, it has a population of 340,000 people with one major city. Bathurst, (population 32,000). The population density of the country is 90 persons per square mile. From May 1967 to April 1968, the Ministry of Health conducted a systematic country-wide smallpox/measles immunization programme. Overall coverage rates approximated 90% in every division. Maintenance campaigns of immunizations were planned to be conducted annually supplemented by focal outbreak control immunizations where necessary.

As shown in Figures 7 and 8 each divisional campaign was followed by cessation of measles transmission. Since April 1968, only 43 measles cases have been reported throughout Gambia in contrast to 2,700 for the same period the previous year. Nine of the 43 cases since April were imported; three failed to give rise to secondary cases.

The estimated number of susceptibles by month by division is shown in Figure 8. In Western Division and in Lower River Division, measles appeared briefly and then disappeared. In the Western Division, six imported cases gave rise to eight indigenous cases. The maintenance immunizations apparently prevented re-establishment in Gambia despite a year's lapse since conclusion of the mass campaign. Measles control in Gambia is not only possible but has been achieved during the last year. From the available evidence, the annual maintenance vaccination campaigns planned will prove adequate to prevent the accumulation of susceptibles necessary for resurgence of measles.

DISCUSSION

Measles in Africa presents a formidable challenge because of its age distribution. Mass immunization, dependent on mobile units, demands exceptional logistical skill to get to the susceptible child with vaccine before the disease attacks.

Nonetheless, the behaviour of measles in Africa, as elsewhere, appears quite predictable. Several conclusions seem justified from our experience to date:

1. Principles deduced from mathematical models can be of help in planning programmes to interrupt measles transmission.

2. Population size, density and cultural attributes affect the rate of accumulation of susceptibles, the frequency and intimacy of contact, and, the age distribution of disease. From these factors, one can predict the course of measles occurrence and plan maintenance immunization programmes to minimize the chance of re-establishing transmission.

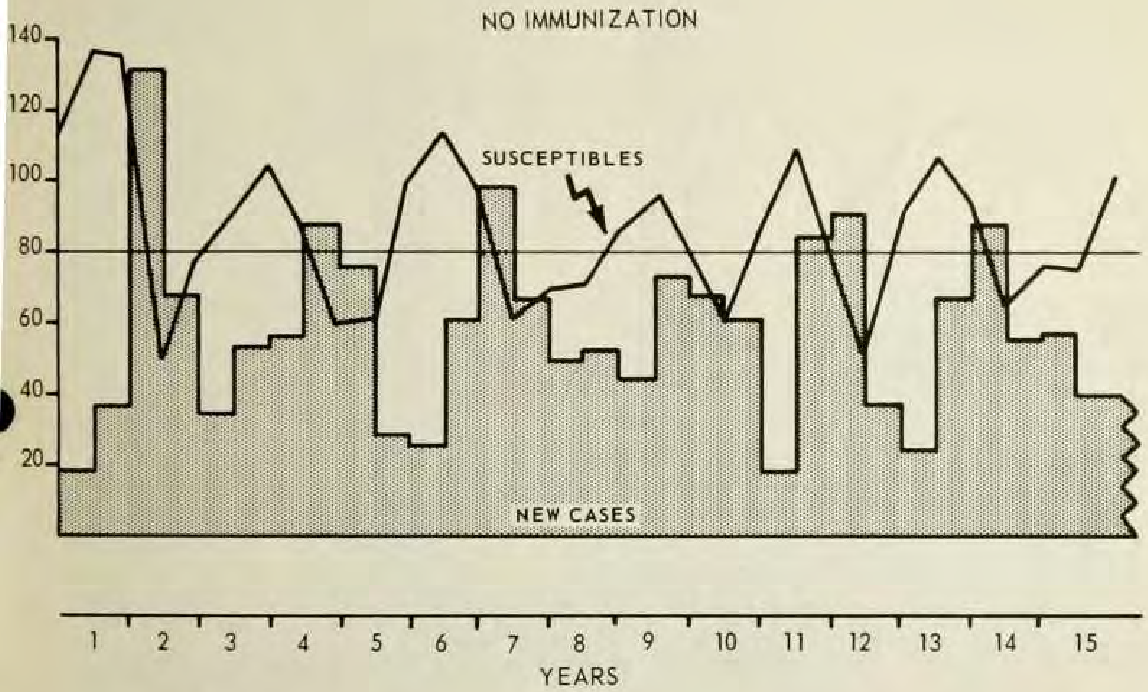
3. Adequate surveillance to detect measles outbreaks quickly and vigorous epidemic control are critically important to prevent re-establishment of transmission.

4. Experience in both urban and rural Africa suggests that measles transmission can be eliminated for long periods of time despite limitations in resources and the absence of a well developed medical care system.

More specifically, semi-annual immunization campaigns, if well executed can control measles in densely populated urban areas; in less populous rural areas, annual campaigns, again well executed, should suffice. From the available data, it appears that even longer lapses between vaccination campaigns may be tolerable in more remote and sparsely populated rural areas depending on local population characteristics. Success in these ventures, however, presupposes the will to continue operating at a high level of efficiency, and more particularly to maintain a sensitive and very responsive surveillance system.

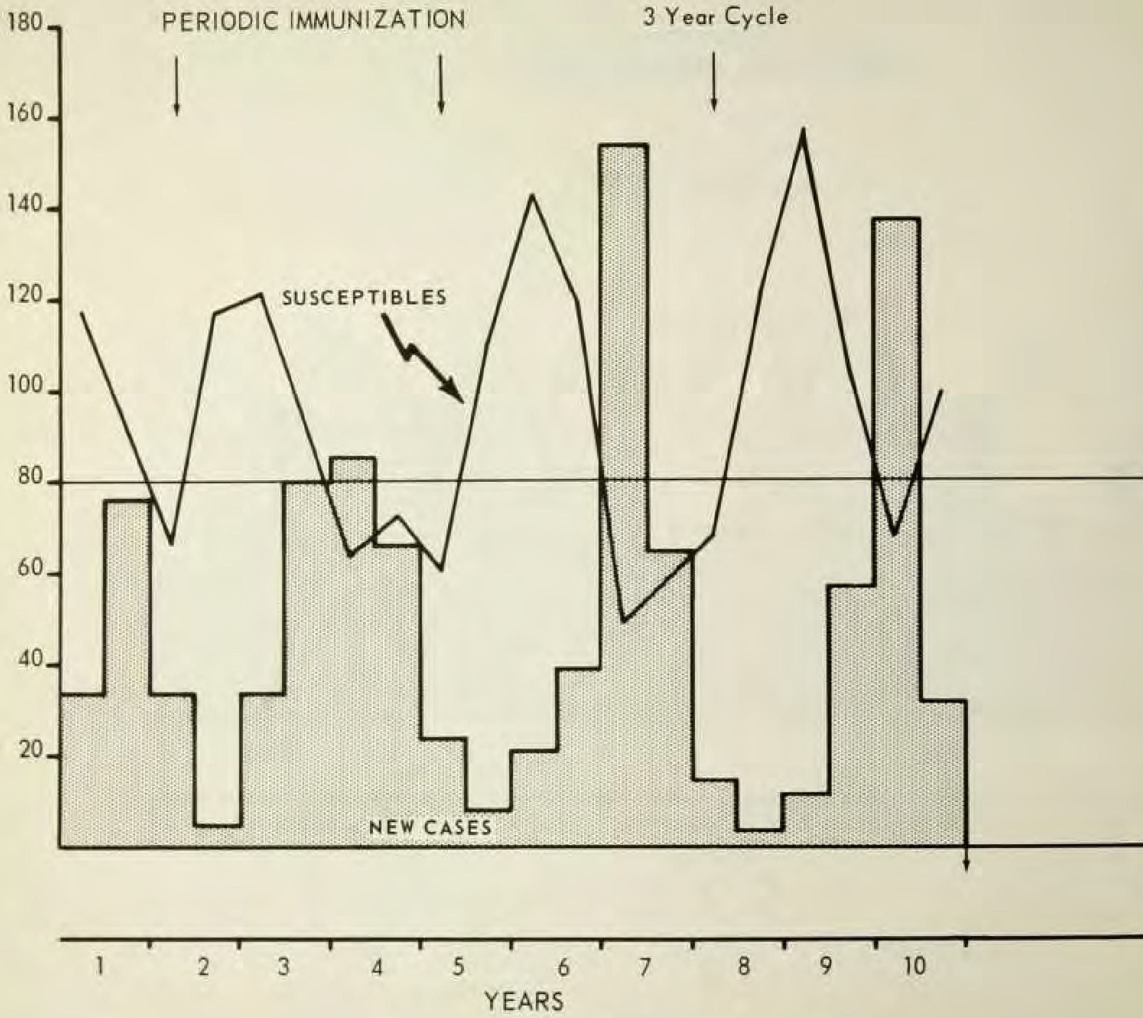
I believe that measles is potentially eradicable in West Africa provided the resources and the will are present. Evidence for any epidemiologic barrier to measles eradication appears to be vanishing rapidly.

FIGURE 1
THEORETICAL MEASLES MODEL*



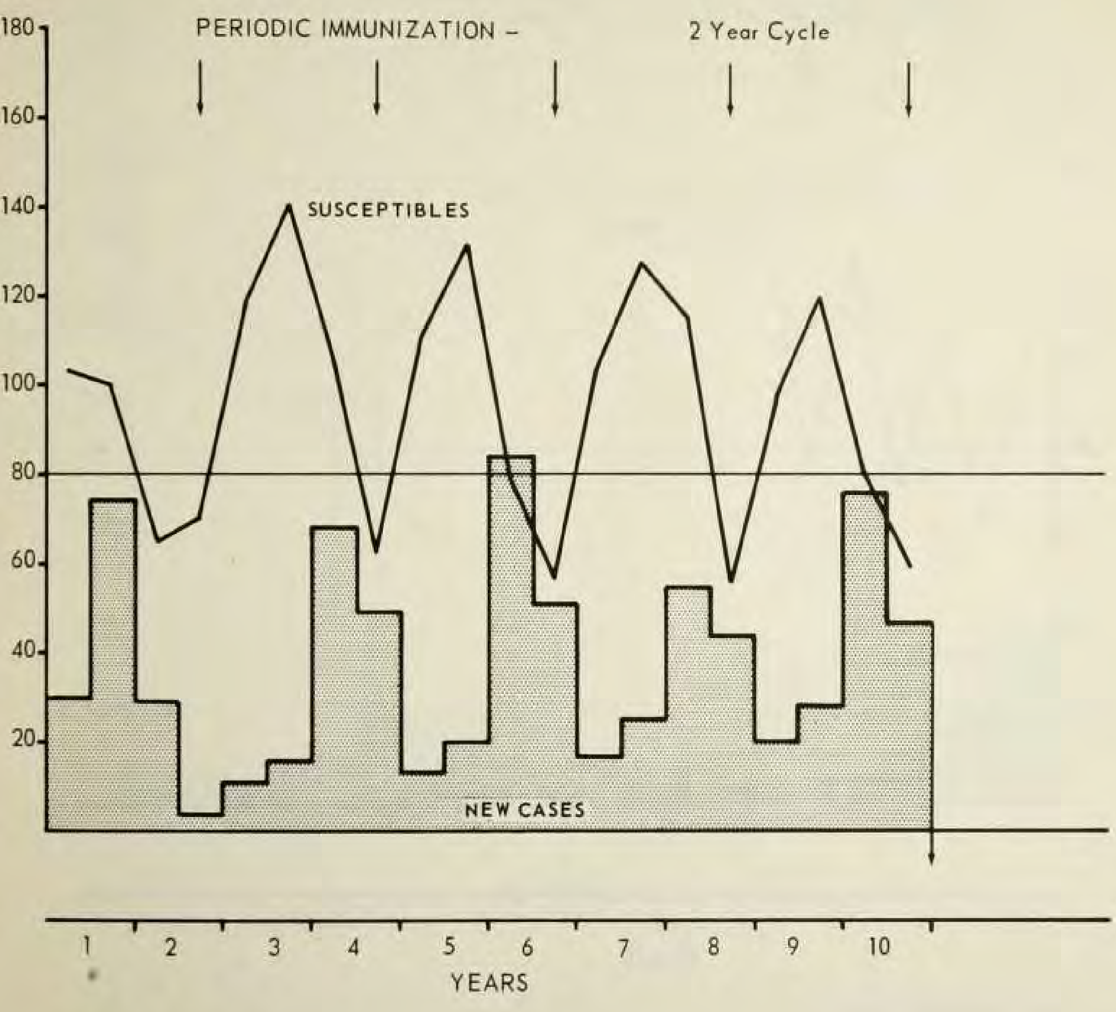
*Macdonald, G., 1967.

FIGURE 2
THEORETICAL MEASLES MODEL*



*Macdonald, G., 1967.

FIGURE 3
THEORETICAL MEASLES MODEL*



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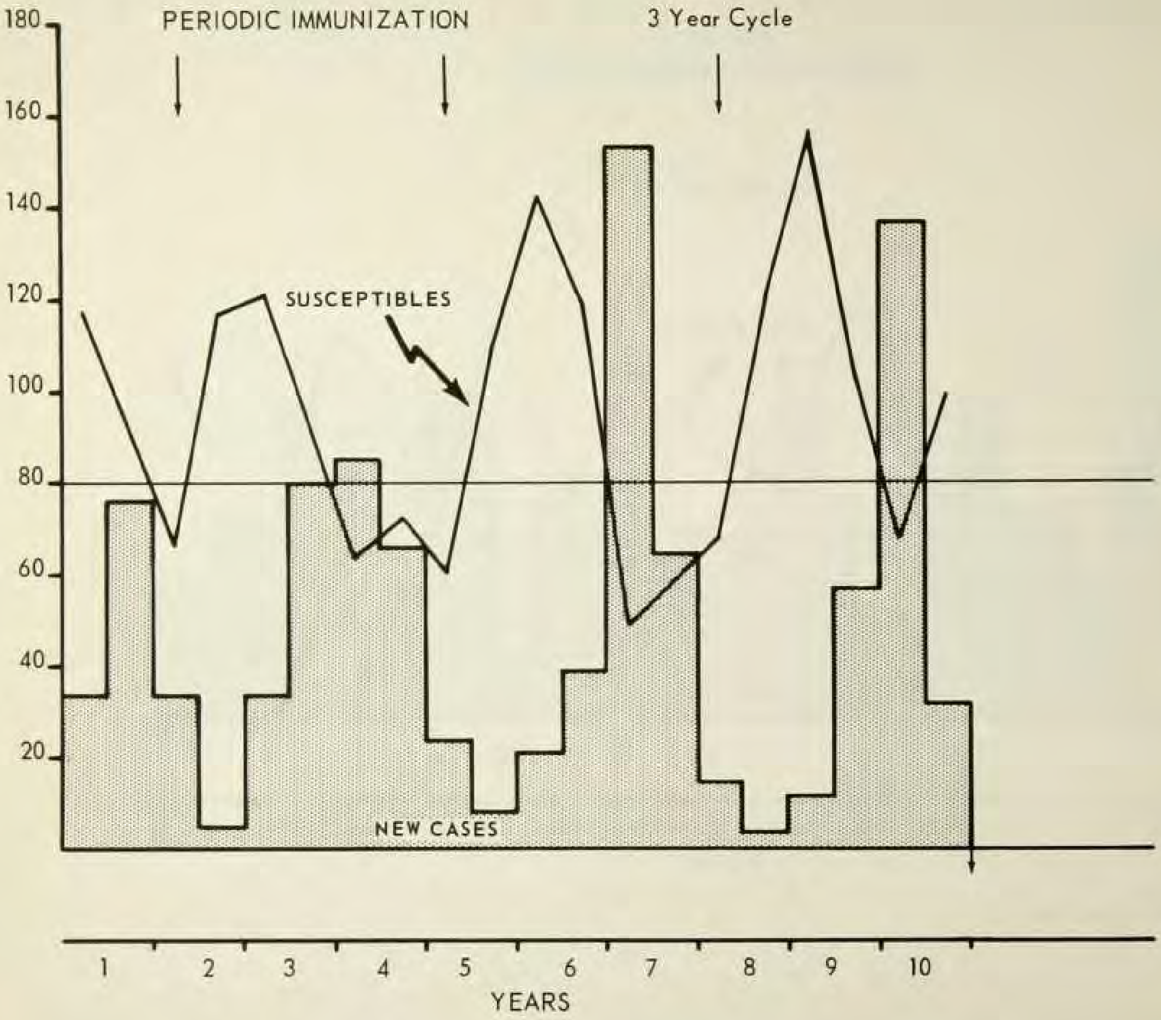

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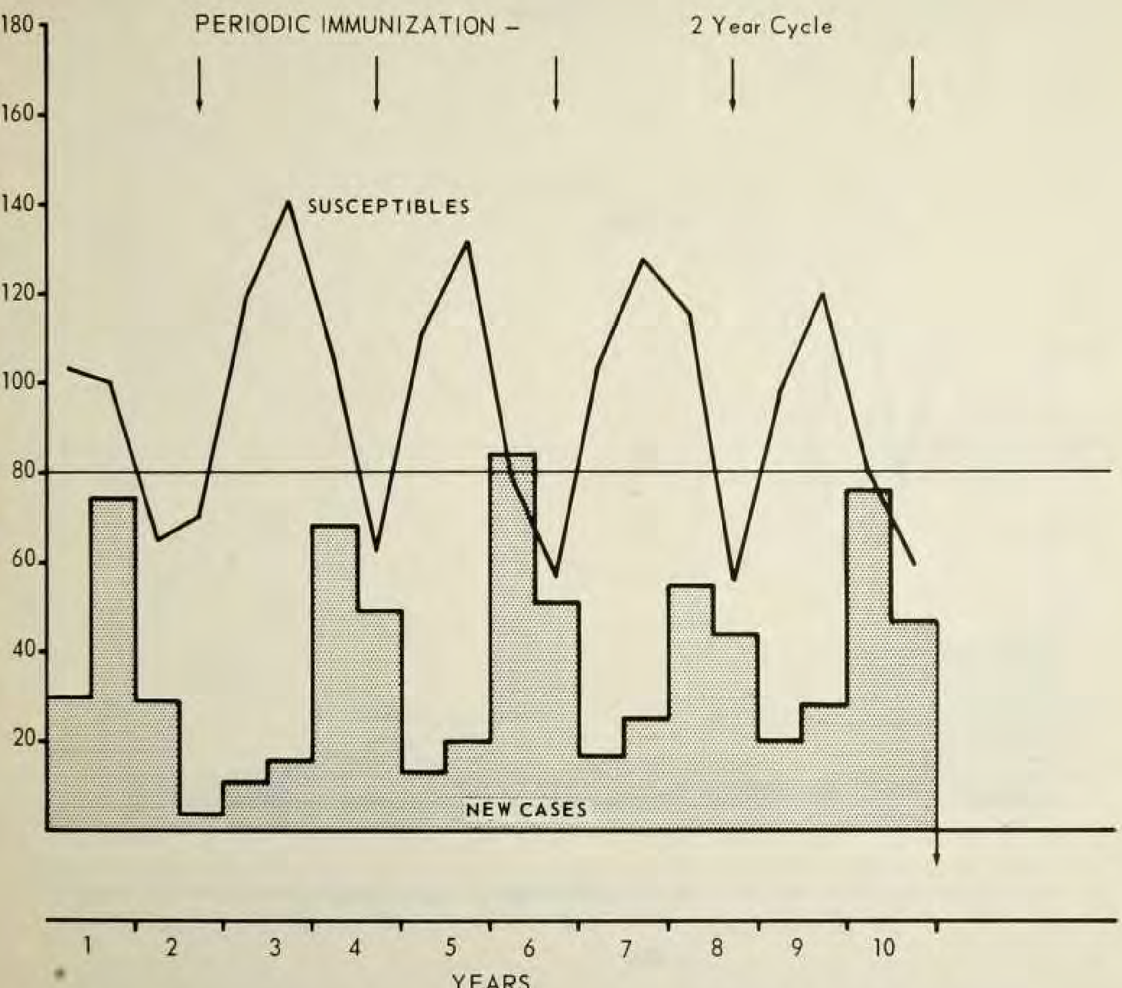
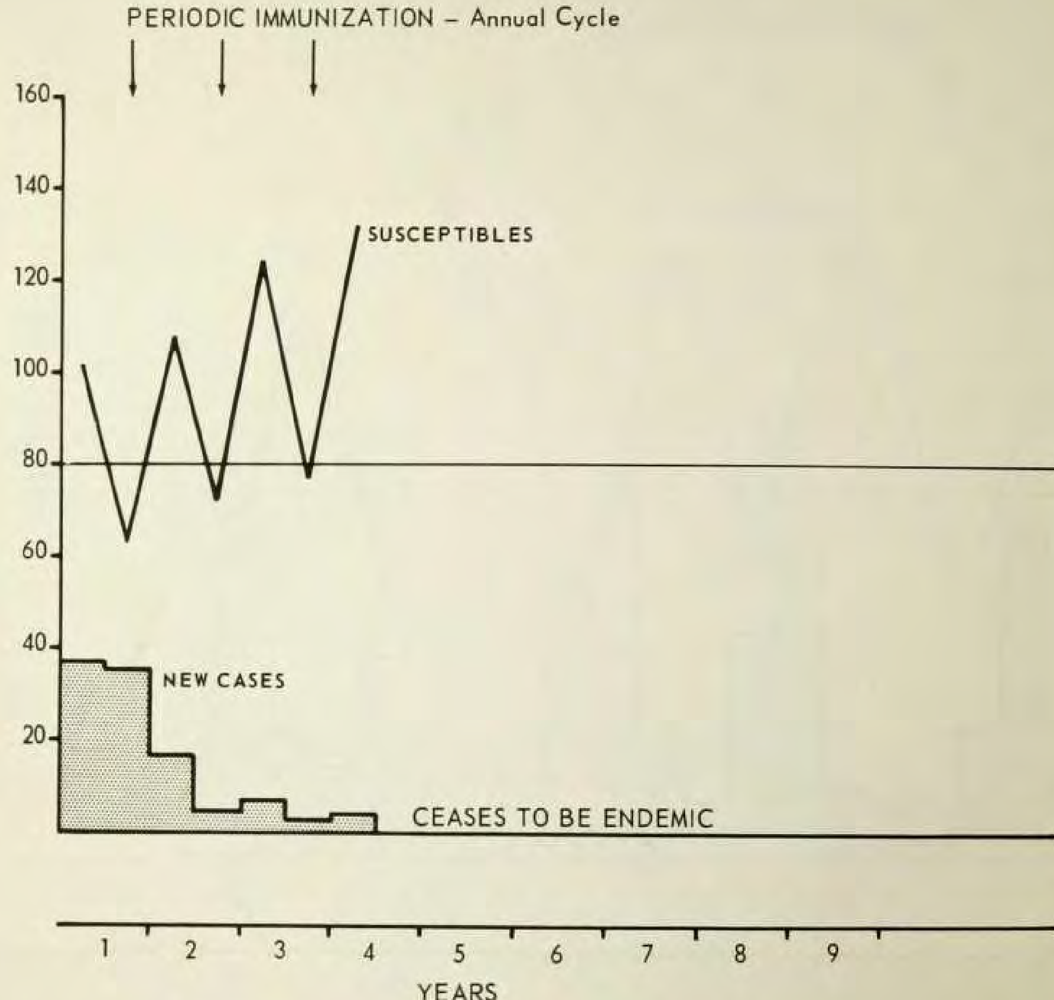
THEORETICAL MEASLES MODEL*



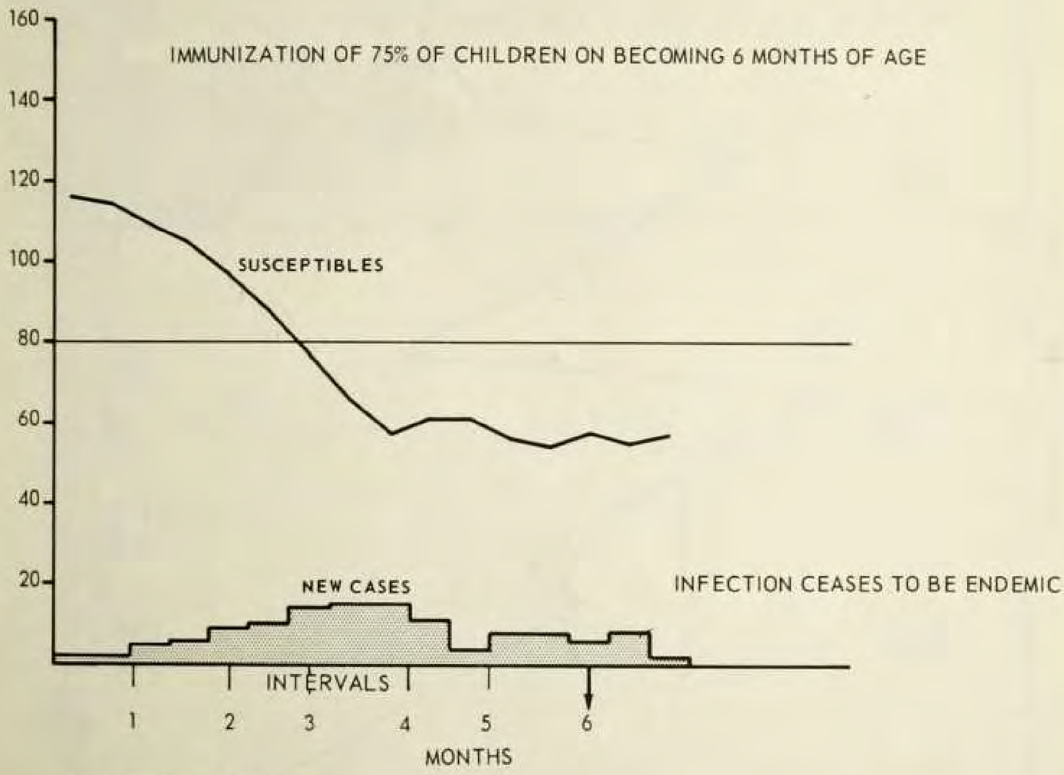
*Macdonald, G., 1967.

FIGURE 4
THEORETICAL MEASLES MODEL*



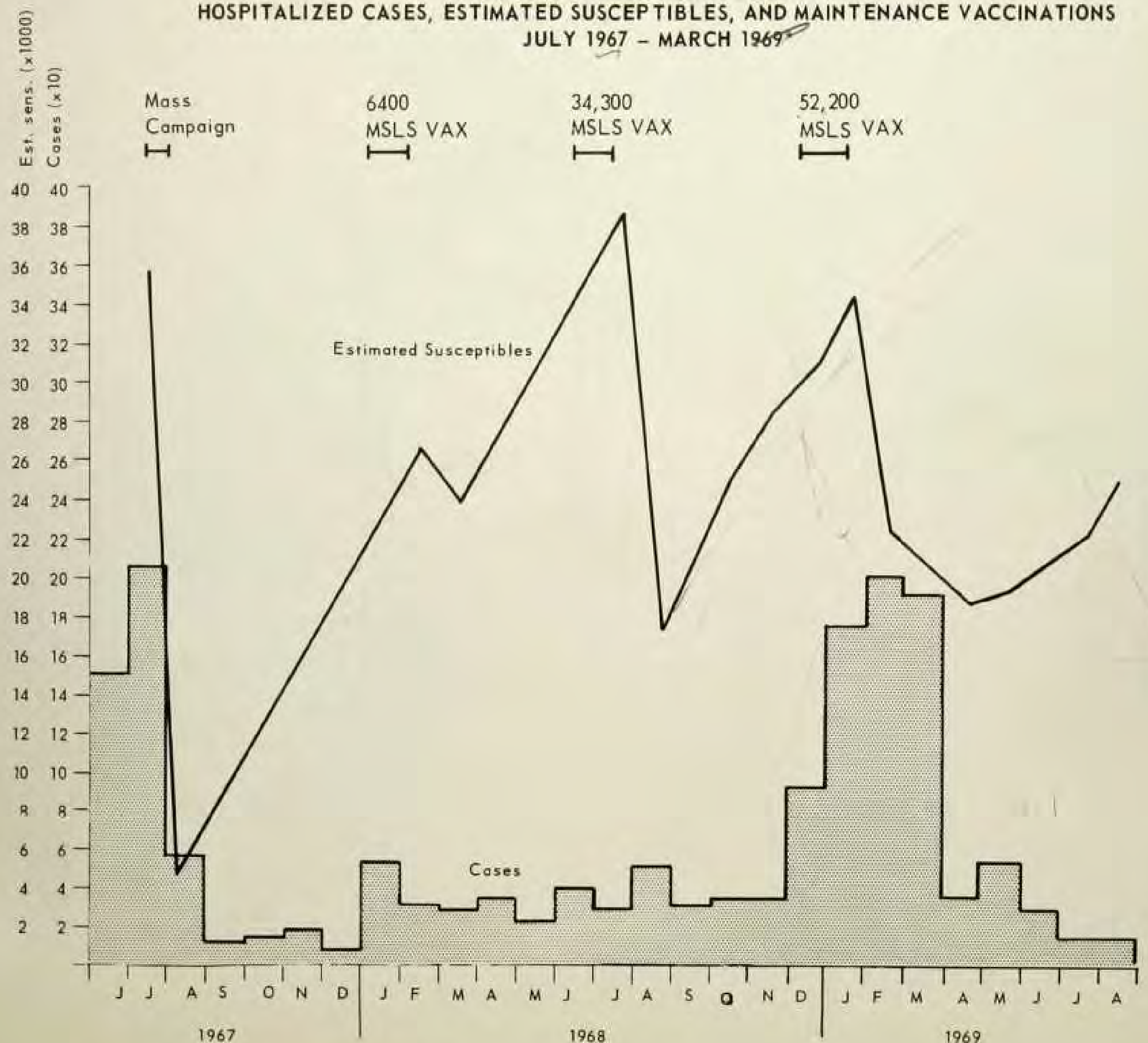
*Macdonald, G., 1967.

FIGURE 5
THEORETICAL MEASLES MODEL*



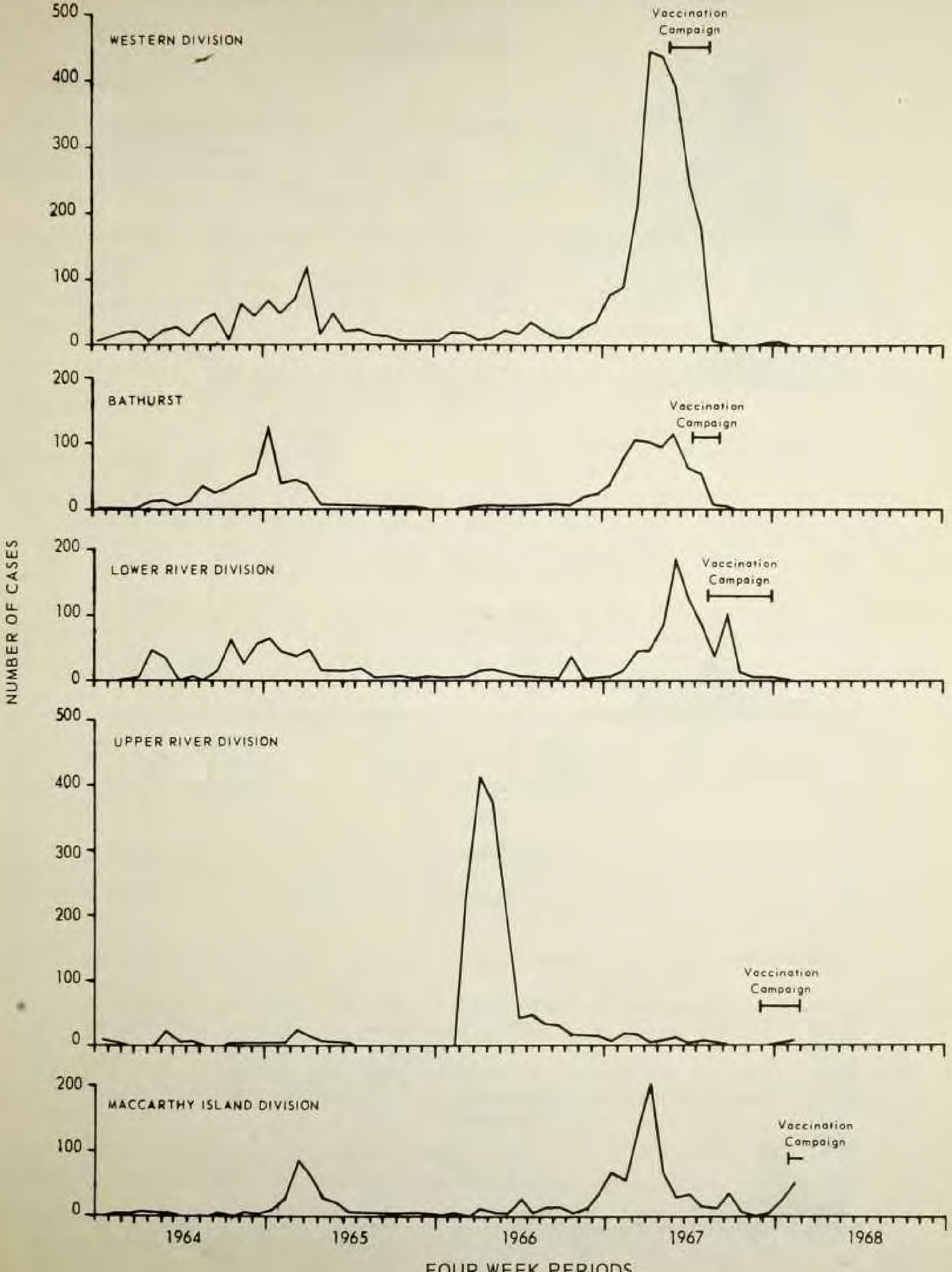
*Macdonald, G., 1967.

FIGURE 6
MEASLES – IBADAN, W. NIGERIA
HOSPITALIZED CASES, ESTIMATED SUSCEPTIBLES, AND MAINTENANCE VACCINATIONS
JULY 1967 – MARCH 1969



PERSONAL COMMUNICATION

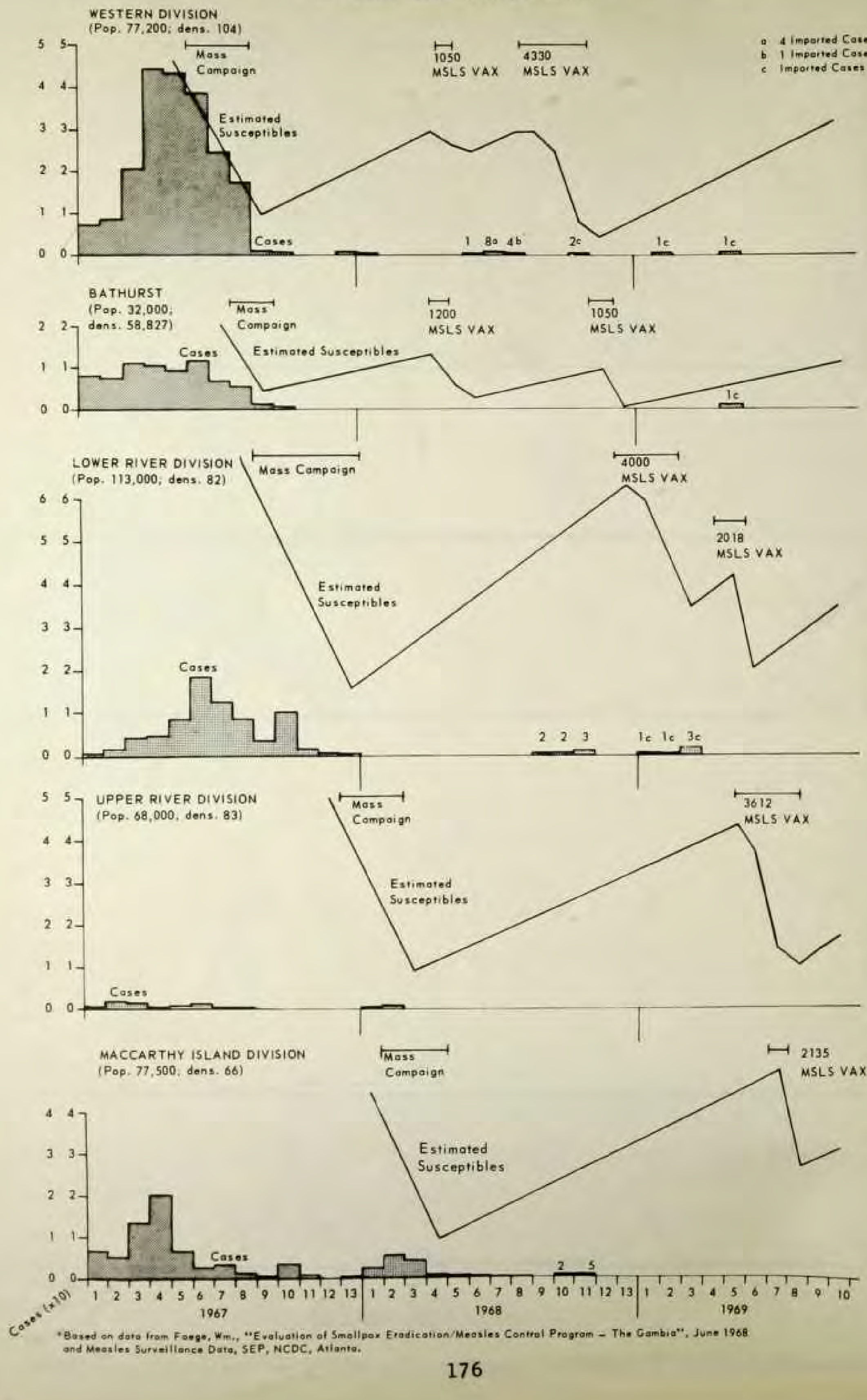
FIGURE 7
SEQUENCE OF VACCINATION CAMPAIGN - THE GAMBIA*



*Foege, William, "Evaluation of Smallpox Eradication/Measles Control Program - The Gambia," June 1968.

FIGURE 8

MEASLES, THE GAMBIA (JANUARY 1967 – MARCH 1969)
REPORTED CASES, ESTIMATED SUSCEPTIBLES, AND MAINTENANCE VACCINATIONS
BY FOUR-WEEK PERIODS BY DIVISION*



*Based on data from Foege, Wm., "Evaluation of Smallpox Eradication/Measles Control Program – The Gambia", June 1968 and Measles Surveillance Data, SEP, NCDC, Atlanta.