FAMINE, INFECTIONS AND EPIDEMICS

by William H. Foege[1]

Introduction

History has wedded famine and pestilence in a special and devastating manner. From writings as early as 700 B.C., the association of infectious disease outbreaks in times of famine has been noted (McCance, 1951). Experience suggests the frequent simultaneous occurrence of famine and epidemics is not coincidental. Rather, famine with a high degree of predictability leads to a triad, including not only epidemics but also deaths due to starvation and social disruption (Fig. 1). This triad is perpaps best immortalized on a monument located near Quebec and dedicated to victims of the Irish Potato famine. The inscription reads ... "In this secluded spot lie the mortal remains of 5 294 persons, who, flying from pestilence and famine in Ireland in the year 1847, found in America but a grave" (Woodham-Smith, 1962).

The problem of infectious diseases in times of famine involves two definable mechanisms. One, there are indications that malnutrition often results in a more severe clinical infection. Second, the social disruption, crowding, and decrease in sanitation often fostered by famine enhance the transmissibility of many infectious diseases (Fig. 2).

The present discussion will consider the evidence for increased severity of infections in malnutrition, some historical evidence of increased transmission of infectious disease in famine, the possibility of aborting or preventing famine epidemics and the implications of these factors on a relief program.

Increased severity of infectious diseases in situations of malnutrition

First, it must be understood that famine is itself an epidemic; an epidemic of malnutrition. Therefore, the lessons learned from areas of endemic malnutrition or seasonal malnutrition have certain applicability to situations of epidemic malnutrition, which we call famine.

Measles, because of its recent role as a famine disease in Nigeria, deserves special attention. Extremely high death rates from measles have repeatedly been reported from West Africa (Morley, 1962; Morley, Woodland and Martin, 1963; McGregor, Billewicz and Thomson, 1962; Morley and Mc Gregor, 1964). Although early reporters suspected the difference in mortality between Africa and Europe was due to a different virus or climatic conditions, many writers now recognize and emphasize the striking relationship between malnutrition and the degree of severity of measles (Rey, 1967; Ogbeide, 1967; Morley, Martin and Allen, 1967). In Nigeria, it has been shown that children from elite Nigerian families do not incur the same risks of measles mortality as do children from lower socioeconomic families and that there is a strong relationship between measles deaths and low weights prior to the onset of measles (Hendrickse, 1967). Mortality rates have been found to increase in situations of poor nutritional status with mortality rates

[1] Director, Smallpox Eradication Program, US Department of Health, Education, and Welfare, Public Health Service, Health Services and Mental Health Administration, Center for Diseases Control, Atlanta, Georgia 30333.

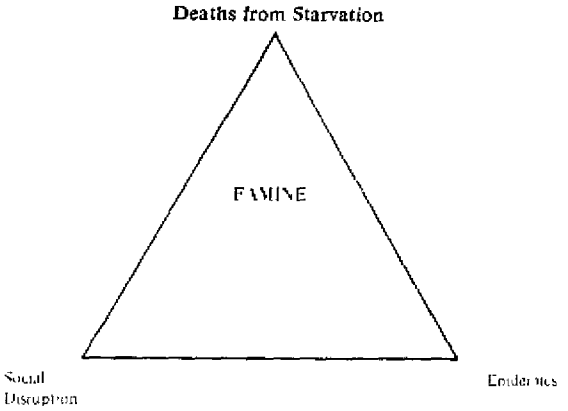

Fig 1. The famine triad.

as high as 50% in a measles epidemic involving children undergoing therapy in malnutrition treatment centers (Conrad, 1969). Hendrickse (1967) has summarized the opinion of many when he writes "it must be concluded that interaction between malnutrition and measles is strongly synergistic, and that malnutrition is probably the major determinant of the serious prognosis of measles in West Africa".

Tuberculosis increases in frequency in times of famine but also tends to progress more rapidly in malnourished patients (Keys, 1950). Diarrheal diseases occur more frequently and last longer among the malnourished. Studies have shown that a low weight for age renders young children highly susceptible to gastrointestinal infection (Whitman, Moodie, Hansen and Brock, 1967; Gordon, Guzman, Ascoli and Scrimshaw, 1964). An increased severity of other infections, including hepatitis, Herpes simplex, and typhus fever, has been recorded (Scrimshaw, Taylor and Gordon, 1968).

Although a decrease in severity of malaria in the malnourished has been reported (Hendrickse, 1967; Ramakrishnan, 1954), the converse has also been noted with malaria epidemics occurring during severe famine conditions, such as the 1935 famine in Ceylon (Frederiksen, 1970).

Numerous studies on man and animals showing the relationship between specific nutritional deficiencies and the disease producing capacity of specific organisms have recently been summarized (Scrimshaw, Taylor and Gordon, 1968). While specific nutritional deficiencies may inhibit the disease producing capacity of certain organisms, particularly viruses and protozoa, the authors feel the majority of evidence supports the conclusion that multiple nutritional deficiencies and protein deficiencies enhance the ability of infectious agents to produce disease. The mechanisms involved in synergism between nutritional deficiencies and infection are discussed by the same authors (Table 1).

The practical implications of these studies for relief workers are:

1. The nutritional state of an individual is often the deciding factor in the severity and the outcome of a particular infection. Severe clinical infections and higher case fatality ratios may, therefore, be seen in times of famine.

2. It is possible that increased severity in clinical illness may in some circumstances and in some diseases lead to increased transmission rates.

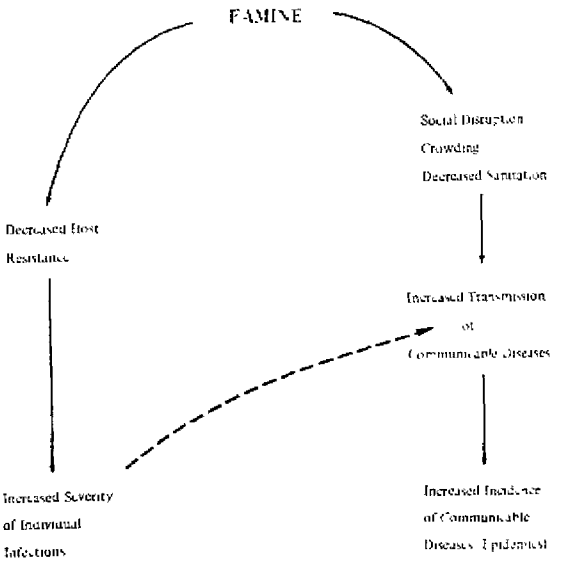

Fig. 2. Some effects of famine on communicable disease epidemiology.

TABLE 1. *Mechanisms decreasing resistance of malnourished individuals to infection.*[a]

Reduced capacity for antibody formation
Reduced phagocytic activity
Reduced epithelial tissue integrity
Reduced capacity for wound healing and collagen formation
Altered intestinal flora
Endocrine imbalance

[a] Scrimshaw, Taylor and Gordon (1968).

Increased transmission of infectious diseases during famine

"In most famines, deaths from epidemic diseases have far outnumbered deaths from starvation" (FAO No 21, 1967). In addition to higher case fatality ratios, more people as a rule acquire infections diseases during famine. As noted before this increase in transmissability is due to social disruption and its resultant crowding and decreased attention to sanitation.

Epidemics of any infectious disease may be associated with famine. Louse-borne typhus has been the great famine disease in Europe, while cholera and smallpox have been the traditional famine scourges in Asia (Davidson and Passmore, 1966). Other prominent famine epidemics have involved scarlet fever, plague, pertussis, diphtheria, dysentery, measles, typhoid, and tuberculosis (Keys, 1950; McCance, 1951).

The ancient association of famine and pestilence has been mentioned. No attempt will be made here to summarize the enormous literature on the topic. Several highlights will serve as examples. The first great plague epidemic of the 6th century was preceded and accompanied by a succesion of earthquakes, volcanic eruptions, and famines (Zinsser, 1935).

The crusades were often molded by famine and epidemics. Pestilence and famine reduced an army of 300 000 to 60 000 during the siege of Antioch in 1 098 (Zinsser, 1935).

The story becomes repetitious as thousands die of plague and typhus during the Russian famine of 1 602 and in Italy after the Thirty Years' War famine gave typhus "a free hand in some of the most severe epidemics of its history" (Zinsser, 1935).

Military sieges have repeatedly provided the laboratory for testing the combined effects of famine and superimposed diseases. The siege of Danzig (1813) resulted in 20% mortality among 36 000 defenders within a 60-day period. Lack of food and the spread of epidemics resulted in 30 000 French military deaths in less than 5 months during the Torgau siege (1830). During the siege of Paris in 1870–1871, a decreasing food supply led to periodic reductions in daily food rations from the initiation of the siege on September 19, 1870, until armistice on February 4, 1871. The week prior to the armistice was associated with a death rate five times the expected, as compared to previous years, with smallpox, typhoid fever, dysentery and diarrhea, pneumonia, and bronchitis accounting for over 40% of the 4 671 deaths in that week (Prinzing, 1916).

The Irish famine of the 1840's provides a well-documented account of epidemics in a debilitated population. The association between epidemics and famine was well-known and, therefore, the British Government made provisions for extra hospitals, dispensaries, and medical officers following the first failure of the potato in 1845. The Central Board of Health did not consider an epidemic to be imminent and, disregarding government directives, they made no preparations for this possibility. The second and total potato failure was followed in early 1847 by a "fever epidemic", the most important ingredients being typhus

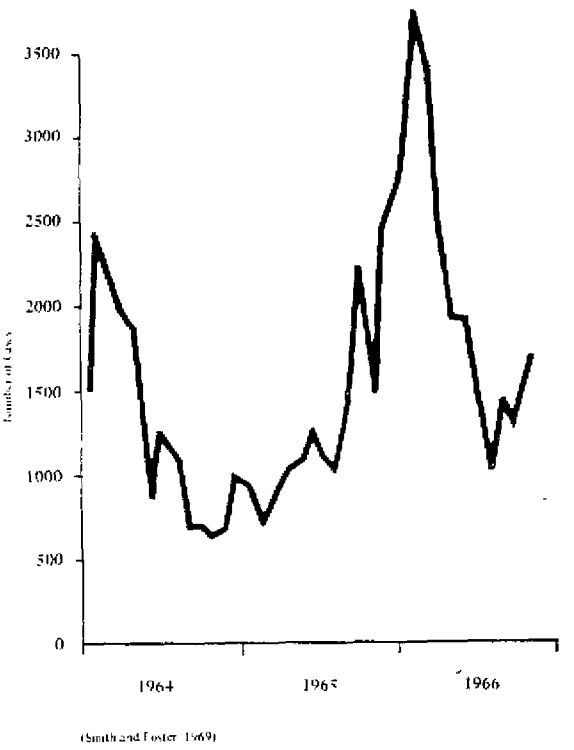

Fig. 3. Measles in Eastern Nigeria, 1964–1966.

and relapsing fever. Throughout 1847, deaths from "famine fever" continued at such a rate that clergymen reported the number of dead could not be ascertained and mass funerals were the rule. It is estimated that about "ten times more died of disease than of starvation" (Woodham-Smith, 1962). The literature is rich with similar accounts. In general, if a famine involves large numbers of people over a protracted period, the question is not "will there be an epidemic?" but rather "what will be the agent?"

Are epidemics inevitable in times of famine?

Although epidemics are historically inevitable, there have been noteworthy recent exceptions. Despite widespread starvation in Greece in 1942 and in Holland in 1945, no real epidemics developed. Even in the Warsaw Ghetto, with extreme malnutrition and almost 300 000 deaths, epidemics were very rare (Keys, 1950).

It is clear that early attention to sanitation and disinfection can reduce the risk of an epidemic and it is also clear that prompt and appropriate reaction to the first indications of an epidemic can reduce its impact.

In Eastern Nigeria, prior to the war, measles was an endemic disease with superimposed epidemic periods every 2 to 3 years. During epidemic years, such as in 1964 and 1966 (Fig. 3), the epidemics would generally last 4 to 6 months. In late 1968, surveillance of measles was reinstated in federally occupied areas of the three eastern states, using medical and nutritional relief teams as the reporting units No major epidemic had occurred in these particular areas for several years, therefore, a marked accumulation of susceptible children had developed. During the first week of January 1969, an increase in measles reports was noted. Federal and state health officials were prepared for the possibility of a measles epidemic and immediately launched a mobile vaccination program to immunize children in high risk areas. Instead of the expected epidemic of several month's duration, it can be seen (Fig. 4) that the epidemic was aborted within 1 month. Within a given village (Fig. 5), the measles epidemic was halted within one incubation period of the vaccination campaign.

Implications for relief operations in times of famine

Given a decreased resistance to infections in the malnourished, an increased risk of transmission because of the many factors commonly associated with famine, considerable historical evidence that infectious disease epidemics are commonly coexistent with famine, and the observation that in

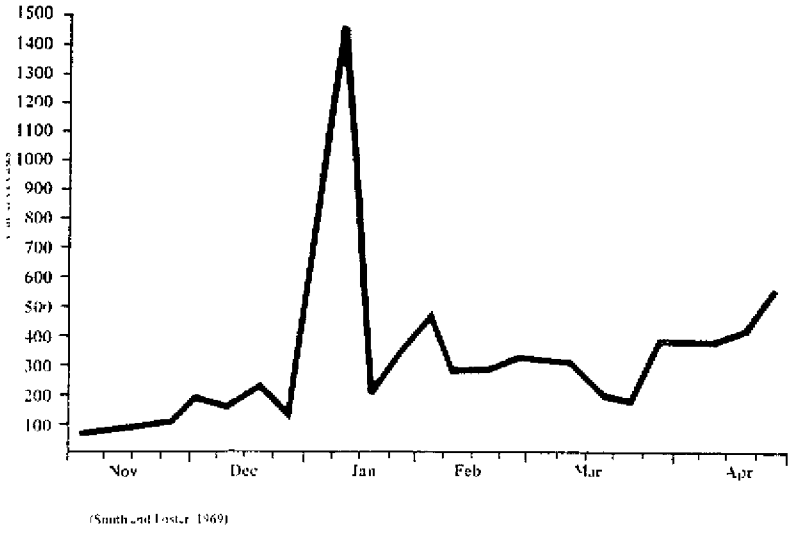

Fig. 4. Number of cases of measles in eastern states by weeks—November 1968 to April 1969.

many famines the terminal event is more likely to be an infectious disease than simple starvation, the implications are clear. Preventive and remedial action for infectious disease epidemics must receive the same priority attention given to food distribution. This requires application of the same principles which would be used in disease control in non-famine situations, namely, surveillance, analysis of surveillance reports, action, and assessment (Table 2).

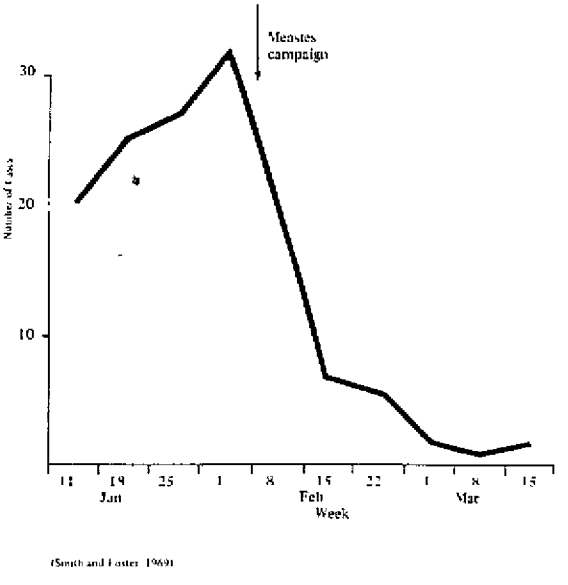

Fig. 5. Effect of measles vaccination campaign on epidemic in Ugbowo village.

Surveillance is the key to famine relief. Many aspects of famine relief including caloric diets and responses to various epidemics can be planned in advance, but only

TABLE 2. *Guidelines for disease control in times of famine.*

Surveillance of selected diseases
Limit to serious diseases likely to occur in area involved
Give priority to diseases amenable to control procedures
Provide for frequent positive and negative reporting from field units
Analysis of surveillance reports
Collate reports at central facility
Interpret significance of reports and decide on required action
Immediately investigate threatening disease situations
Action
Prepare plans for epidemic possibilities
Stockpile vaccine and therapeutic agents
Allocate transport, equipment, and personnel for epidemiologic investigation and control activities
Initiate control activities at earliest possible time
Assessment
Evaluate efficiency of surveillance system
Evaluate effectiveness of control procedures

surveillance can tell what is the situation to which we must react. Many of the historical mistakes in famine relief have resulted from inadequate and inaccurate information. Just as the nutritional aspects of famine relief require accurate information on deaths and malnutrition by geographic area and age, together with information on local food availability and required food imports, so do the infectious disease aspects or famine relief require accurate information on the geographic occurrence of infectious diseases over time. The selection of reporting units will vary from one relief situation to another, but will usually include combinations of relief teams and existing health facilities or special health facilities such as malnutrition treatment centers. Requests for information on a large variety of diseases are likely to reduce the quality and quantity of information on the most important infectious diseases. Therefore, it is useful to limit reporting to serious diseases likely to occur in the area. Also, if choices must be made between certain diseases, priority should be given to diseases amenable to control procedures.

Positive reporting systems, that is, systems which report only if cases of a particular disease are seen, often misinterpret "no report" for "no disease". Many errors are possible from forgetting on the part of the reporting agent, to loss of the report en route, or incorrect recording of the report after receipt. Therefore, it is important to institute a system which clearly reports the absence of disease as well as its presence and allows for three interpretations. First, the disease is present; second, the disease is absent for the stated time period; or third, no reports were received from the given area for the time period in question.

Surveillance reports must be interpreted in order to be useful. This includes collating reports for the entire relief area and interpreting the significance of the reports, whether action is required, and the type of action required. The central epidemiologic unit must contain personnel with competence and experience in investigating and controlling infectious disease outbreaks. In the case of certain reports, such as smallpox and cholera, immediate investigation must be made to determine whether the report is accurate, and if accurate, to institute immediate control procedures.

A responsibility included under surveillance and analysis is to not only collate reports for the use of a central office but also to return information on the entire relief action to the participating relief teams. This is not only useful for improving the knowledge, coordination, and effectiveness of relief teams, but it is also necessary if teams are to be motivated to continue reporting. Table 3 is a randomly selected surveillance report, issued each week by the Nigerian Red Cross, which summarizes for the week the number of people receiving food by geographic location and type of feeding, the tonnage distributed by geographic area, the number of patients treated each week by geographic area, and the geographic breakdown for selected communicable diseases which were being reported at that time. This type of feedback system is a vital link in famine surveillance systems.

The next segment of the surveillance arc, action, ideally requires a plan of operations prior to an actual epidemic. Such a plan would detail the responsibilities of various people and the course of intended action. Effective action would require either stockpiling certain vaccines and therapeutic agents at the central facility or making previous arrangements to secure selected vaccines and therapeutic agents within a short period of time. Transportation, equipment,

TABLE 3. *Relief action surveillance report for week ending April 12, 1969.*

	Geographic area				
	Enugu	Uyo/Calabar	Rivers	Mid-West	Total
Malnutrition and food distribution					
People receiving food					
People receiving several meals daily	2 375	991	472	0	3 838
People receiving daily rations	33 937	38 018	10 937	600	83 492
People receiving weekly rations	330 872	149 939	41 447	20 429	542 687
Total	367 184	188 948	52 856	21 029	630 017
Food distributed (in tons)					
Carbohydrate food	120 0	85.5	88.0	62.0	355.5
Protein food	244.3	67.0	34.6	81.0	426.9
Other food	5.5	2.9	7.8	0.0	16.2
Total	369.8	155 4	130.4	143 0	798.6
Treatment programmes					
Malnutrition					
Inpatients	744	840	131	—	1 715
Outpatients	852	3 136	1 533	—	5 521
Subtotal	1 596	3 976	1 664	—	7 236
Other medical patients	17 721	5 089	1 687	—	24 497
Total	19 317	9 065	3 351	—	31 733
Communicable diseases					
Smallpox	0	0	0	—	0
Measles	56	318	1	—	375
Whooping cough	11	77	2	—	90
Meningitis	0	0	0	—	0

Source· Nigerian Red Cross, April, 1969.

and personnel, both for epidemiologic investigation and control activities, must be allocated in advance. The significance of an epidemic may not be appreciated by all people when it threatens or early in its course, and clear contingency plans must be developed in advance to ensure that the proper input of resources is available at the earliest possible time. If early in an epidemic time must be lost convincing a relief administration of the importance of action, the opportunity for effective action may be irretrievably lost.

A final step frequently missing from relief plans is assessment. To know that the surveillance system is indeed sensitive to infectious disease occurrence, personnel must be available to conduct independent surveys on both the nutritional status of the population and the presence or absence of infectious disease. Whether talking about the nutritional status or disease status of an

area the important point is to avoid roadside surveys. Both situations will be found quietly in the huts. The successful surveillance agent will be the one who knows where to look.

Assessment must also be built into every control action. If the control action involves an immunization campaign, and if smallpox vaccination is an indicated part of the campaign, assessment can very easily be done one week later by randomly assessing for the presence or absence of a developing vaccination reaction. If smallpox vaccination is not indicated, an artificial marker can be used by dipping the fingers of recipients in a dye solution, allowing for assessment some hours or days later. In either case, campaign effectiveness must be objectively measured and remedial measures taken to correct deficiencies.

Summary

A close association between famines and epidemics has been noted historically. Two different mechanisms have been described to explain, in part, why infectious diseases become of great significance during times of famine. First, numerous studies have supported the conclusion that multiple nutritional deficiencies and protein deficiencies enhance the ability of infectious agents to produce disease. Second, social disruption, crowding, and a decrease in sanitary standards have frequently resulted in an increase in transmission of infectious diseases during famine.

Experiences during the second World War have shown that epidemics can be avoided with increased attention to sanitation, and experiences during the Nigerian war have shown that epidemics can be limited by rapidly applying control procedures.

Relief operations must regard disease control as a high priority. The key to effective disease control in times of famine is surveillance of selected diseases, using a positive and negative reporting procedure. Surveillance reports must be interpreted and immediate investigation made of unusual disease occurrence. Surveillance reports should periodically be summarized for distribution to reporting units. Operational plans for disease control should be prepared early with advance allocation of transportation, equipment, and personnel for epidemiologic investigation and control. Finally, assessment procedures must be instituted to measure the efficiency of the surveillance system and the efficacy of control actions.

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SUMMARY OF DISCUSSION

Rapporteurs: K. E. Knutsson and Y. Hofvander

The discussion was opened by *Passmore* who congratulated Foege on an excellent presentation

Ramalingaswami referred to the diagram showing the mechanisms of reaction to injury in protein depleted organisms. There is evidence now that the reaction to injury as it involves multiplication of cells in the fibrovascular system and fabrication of protein are both quite significantly affected in a protein-depleted organism. The doubling time of the immunologically competent cell in the spleen is markedly prolonged in the protein depleted state. Immunity is quite markedly disturbed in protein depletion. However, there is still much to learn about these mechanisms.

Ifekwunigwe emphasized the severity of measles in West Africa. There is an overall mortality of about 5% (up to 25% of those admitted to hospital for complications). If a measles epidemic had been superimposed on the malnutrition situation on top of the crisis in Nigeria this would have caused a catastrophic situation.

Viteri reported that measles seems to be one of the most severe forms of infection in terms of nutrition in Guatemala. It had been possible to quantitate the nitrogen losses in children admitted to a metabolic ward before being infected with measles. 7 children were followed during the whole measles period and were found to loose up to 10–12% of their body protein during hospitalization for measles. One can imagine that the loss may be even greater in the general population than in hospitalized individuals. The Guatemalan experiences from vaccinating smallpox in severely malnourished children had not been good at all. There had been two local disseminations of smallpox vaccine in severely malnourished children. One would hesitate to vaccinate under such circumstances. The granulomatous reaction to a skin blister had been studied at INCAP and it had been found a defective organization of fibrovascular tissue as also had been mentioned by Ramalingaswami. The severely malnourished child has very large amounts of IgA which may be a secretory immunological entrance from the intestines or the respiratory tract. In spite of a high gammaglobulin in infected children the production of immunoglobulins may be impaired.

Vahlquist stated that communicable diseases represent one of the most serious mechanisms precipitating malnutrition. Much more intense work should be made already in peace time through mass vaccination campaigns. He expressed the opinion that people interested in communicable diseases and those interested in malnutrition were not sufficiently close to each other. Mass campaigns against communicable diseases should definitely also be considered as a weapon against severe malnutrition. This seems to be the view of WHO.

Bengoa agreed with this. In programs in West Africa over the past three years 122 mill people have been vaccinated against

smallpox and 21 mill. children against measles. This is in line with WHO policy that also aims at such preventive campaigns.

Foege ended the discussion by stating that the administration of smallpox vaccine to 110 million persons in West and Central Africa in the past four years had not given reason to believe that malnutrition is a contraindication to vaccination or that complications are more frequent in malnourished patients.