Chapter 19

IMMUNIZATION PROGRAMMES IN THE CONTEXT OF PREVENTION OF MALNUTRITION

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Introduction

The relationship between immunization and prevention of malnutrition is twofold. First, certain diseases are well known to be common precipitating factors of severe protein–energy malnutrition (*1*). Some, gastroenteritis and ascariasis, for example, are not preventable by immunization, others, such as measles, pertussis, and tuberculosis, can be prevented in this way. Second, a major obstacle to better child health services in developing countries is the heavy demands made on the available resources of both manpower and finance by large numbers of cases of preventable disease. Immunization is, in general, a fairly simple and inexpensive procedure, and the greater the scale on which it is practised the greater the relief given to the overextended medical services. This relief could result in a better service being provided in other health fields, including the treatment and prevention of malnutrition. At least one disease that is preventable by immunization—

namely, poliomyelitis—has little direct effect on nutritional status but produces cripples who have to be largely supported by poor families and poor communities.

In the area of immunization and nutrition we should therefore consider not only those diseases that have adverse effects on nutrition, but also all the important diseases of childhood that can be prevented by immunization. There is a further practical reason for this. It is now clear that a number of antigens can be given simultaneously to a child without affecting adversely either the immunogenic success of any of the antigens or the incidence of side-effects. For example, it is well known that triple vaccine (diphtheria, pertussis, and tetanus) produces the required levels of immunity in respect of all the components; when three more antigens are added in the form of trivalent poliomyelitis vaccine there is no diminution in response to either the triple or the poliomyelitis vaccines. The compressed schedule described later (p. 273) was used for administering vaccines to a large number of children in Uganda. Antibody studies in respect of the measles, poliomyelitis, and BCG vaccines revealed that the effect produced by each of them when combined was very similar to that found in trials where they were administered separately or in simpler combinations, and there were no ill-effects.

In general, the main cost of immunization lies not in the cost of the vaccine, but in taking the vaccine to the child and administering it, i.e., costs of transport, equipment, wages, refrigeration, etc. It is therefore a waste of opportunity to administer, for example, triple vaccine without at the same time administering oral poliomyelitis vaccine. Moreover, in a country where the incidence of new cases of tuberculosis is 1 per 200 or 300 of the population no opportunity should be neglected to administer BCG to children, and in countries where smallpox is still endemic or has only recently been eradicated any suitable opportunity should be taken to perform primary vaccination. In short, "sequential inoculations of one agent after the other—the 'disease-a-month' approach—are hardly practicable, are unnecessarily costly, and are not well accepted by the public" (*2*).

To exert the maximum effect on the health and nutrition of a community, therefore, immunization campaigns should be as comprehensive as possible in the range of immunization offered. Comprehensiveness should also be aimed at in coverage for the child population. In most of the diseases under discussion when the proportion of the child population that is immune passes beyond a certain level a bonus is obtained in the form of "herd immunity", i.e., the proportion of immunes is high enough to hinder transmission of the disease. The result is that even non-immune children are protected, or the chance of their being infected is reduced, and infections are therefore likely to occur at an older age when the children are not under such a severe nutritional stress. The level at which herd immunity occurs depends on various factors such as population size and distribution, the mode of transmission of the disease, and its infectivity. It can be safely stated, however, that if 100% coverage is aimed at and between 70% and 90% coverage is achieved the desired effect of herd immunity will usually be obtained.

The Effect of Immunization on Nutritional Status

If it is agreed that measles, pertussis, and tuberculosis are important precipitating factors of malnutrition in early childhood, it should in theory be possible to demonstrate that the effect of comprehensive immunization will be to raise the nutritional status of the child population aged 1–4 years. However, comprehensive immunization has, in the past, rarely been practised in developing countries outside a relatively small number of young-child clinics of high quality, where many other services have also been offered simultaneously. One instance in which a comprehensive immunization campaign was conducted outside such clinics is that of the mobile campaign carried out in a district of Uganda from 1965 to 1969. The campaign achieved 63% completed 3-visit coverage using schedule 2 (see p. 273). Nutritional status was measured before and after the campaign in a sample of children selected as near randomly as circumstances permitted; the second sample included both children who had attended for immunization and those who had not. The nutritional status of the children examined after the campaign was better than that of those examined before, and the difference in respect of weight for age was significant at the 1% level. However, from 1968 onwards other services were added, especially general "under-5s" clinics, and it is not possible to say that the improvement was due to immunization alone.

Evaluation in measured terms of the indirect effects of specific programmes conducted on a wide scale in rural areas of developing countries is a difficult task, and the results must be interpreted with caution. All that should be said at this stage is that such limited experience as is available tends to confirm in practice what could be expected on theoretical grounds—namely, that comprehensive immunization is likely to exert a modest but definite beneficial long-term effect on the nutritional status of the child population under 5 years of age. On present evidence, comprehensive immunization merits a place in the health component of nutrition programmes for the preschool child population.

Immunization and the Malnourished Child

Only a small minority of young children in any country suffer at any particular time from severe protein–energy malnutrition, i.e., Gomez class 3 (*3*) or kwashiorkor, and a much larger minority from moderate protein–energy malnutrition (Gomez class 2 or pre-kwashiorkor). In these cases we must consider (1) whether immunization could harm these children, and (2) whether its effectiveness will be diminished.

(1) Even in a healthy child certain immunizations, e.g., pertussis and measles, are often accompanied by minor uncomfortable side-effects, although extremely mild compared with the disease they prevent. We may expect the side-effects to be less mild in the sick child, and there is moreover some evidence for the contention that live virus antigens at least may cause a temporary drop in nitrogen retention in the severely malnourished child. Furthermore, it would seem less than kind to add immunization side-effects to the burdens of a severely malnourished or otherwise sick child unless it is absolutely necessary, as in a smallpox epidemic. It is therefore advisable to postpone immunization of severely malnourished children until they have partially recovered, towards the end of a period of hospitalization, for example. On the other hand, there is no reason to withhold immunization from those with moderate malnutrition. These children require immunization most urgently since they are less able than the normally nourished to withstand an infection such as measles or pertussis. Nevertheless, reactions to measles and pertussis vaccinations are sometimes noticeable, and weight loss, or at least failure to gain weight, has been reported to occur during the 2 weeks following these vaccinations. Where supplementary feeding programmes exist it is reasonable to include as beneficiaries, at least temporarily, children who are being immunized (*4*).

(2) On the question of malnutrition interfering with antibody production, a number of studies with both live and killed antigens have indicated that interference does occur, at least to a moderate degree, in severe cases of malnutrition. It seems usually to take the form of a slower reaction and the final production of lower than normal levels of antibody.

Kumate stated in a recent review (*5*) that the situation as regards serum levels of immunoglobulins is not yet clear, and there are paradoxical elements in the present state of knowledge that can only be elucidated by further research. From Kumate's studies it appears that serum levels of immunoglobulins G, A, and M are actually higher in malnourished than in normal children, and the response of malnourished children to the "O" antigen of TAB vaccine is only slightly below that of normal children. However, the responses to "H" antigen and to parotitis vaccine are rather more diminished in the malnourished. Kumate also showed that the inflammatory response is diminished in severe malnutrition.

For a comprehensive review of the subject, the reader is referred to a recent WHO memorandum (*6*). At the present time it is only possible to say that in severe malnutrition it seems likely that antibody response will be diminished but by no means absent. It would be wrong at present to believe that severe malnutrition renders immunization quite useless. However, for the reasons outlined above, it is not considered advisable in ordinary circumstances to immunize children who are suffering from *severe* protein–energy malnutrition. Postponement of immunization only applies to the small minority (usually between 1% and 5%) of the child population who are most severely malnourished and not to the much larger group of moderately malnourished.

In summary, in moderate protein–energy malnutrition immunization should be regarded not only as advisable, but also as a rather urgent requirement. In severe protein–energy malnutrition improvement in nutritional status should precede immunization.

Immunization Schedules Suitable for Developing Countries

It was pointed out at a recent conference on immunization (*2*) that an almost infinite number of immunization schedules could be prepared, each having both merits and defects. In deciding which vaccines to administer, both expert opinion in the particular area and the current medical literature should be consulted. The conference referred to above offered several broad alternatives to suit different circumstances in developing countries. The review by Stanfield (*7*) published in 1967 agrees closely with these views and remains an excellent guide to immunization.

It may be said that triple, BCG, poliomyelitis, smallpox, and measles vaccines should be administered in all developing countries in early childhood. Booster doses of smallpox and tetanus and poliomyelitis vaccines should be given when the child first starts school and again at the age of 10–14 years, possibly with the addition of a repeat BCG vaccination. Yellow fever vaccine is administered, where appropriate, at some time after the child's first birthday. The place of typhoid vaccine in this scheme is not easy to determine. Many physicians might consider it rather unwise to administer typhoid and triple vaccines at the same time since the side-effects produced by these two vaccines together could deter mothers from bringing their children for second and subsequent doses. On the other hand, there seems to be some support for the use of a combined DPT–typhoid vaccine, even in infancy (*2*). The decision should be based on the local epidemiological situation with respect to typhoid fever and the policy of the public health authorities.

The precise vaccination schedule depends also, to some extent, on the accessibility of the child population. Since the immunizations should preferably the given at optimal ages, the schedule offered to children living within easy reach of health centre facilities would extend over a longer period than that adopted for mobile campaigns in areas distant from a health centre. Two vaccination schedules are therefore proposed; the first is suitable for static health units (hospitals, health centres, etc.), the second for mobile campaigns.

Schedule 1. Comprehensive immunization schedule for children with easy access to static health units [a]

Time	Immunizations
During pregnancy	Tetanus toxoid: 3 doses for nonimmunized mothers 1 dose for previously immunized mothers
At birth	BCG (only practicable in large maternity units)
Age 3–4 months	1st triple vaccine dose 1st oral poliomyelitis vaccine dose Smallpox vaccination
Age 5–6 months	2nd triple vaccine dose 2nd oral poliomyelitis vaccine dose BCG (if not given at birth)
Age 9–12 months [b]	3rd triple vaccine dose 3rd oral poliomyelitis vaccine dose measles vaccination
Age 18–24 months	Triple vaccine booster dose Oral poliomyelitis vaccine booster dose
School entry	BCG and smallpox revaccinations (?) Typhoid vaccination Oral poliomyelitis vaccine booster dose Tetanus or diphtheria/tetanus vaccine booster dose
Age 10–14 years	Smallpox revaccination Oral poliomyelitis vaccine booster dose

[a] Source: Cruickshank, R. *WHO immunization programmes—principles and practices* (unpublished WHO working document EA/CD/25 Rev.1, 30 January 1970).

[b] If the triple vaccine is alum-absorbed and the interval between the first and second doses is not less than 2 months, and if measles vaccine is not available, this visit could be omitted.

Schedule 2. Compressed 3-visit immunization schedule [a] for mobile campaigns in rural areas for children aged 0–5 years [b] not previously immunized

Time	Immunizations
First visit	BCG, smallpox, 1st triple vaccine (or triple + typhoid vaccine) dose, 1st poliomyelitis vaccine dose
Second visit	2nd triple vaccine dose, 2nd poliomyelitis vaccine dose, and measles vaccine for those aged 9 months to 3 years unless they have previously had measles
Third visit	3rd triple vaccine dose, 3rd poliomyelitis vaccine dose

[a] Intervals of 4–8 weeks.

[b] Modify for the newborn infant aged 0–2 months by giving a half dose of triple vaccine, and possibly postpone smallpox vaccination until the third visit.

Some Practical Points Relative to the Conduct of Immunization Campaigns

The place of static health units and mobile campaigns

Every static health unit should provide a comprehensive immunization service for preschool children. Where this service has been provided for a number of years and most children over 1 year of age are already immunized, the immunizations can be given at young-child or child welfare clinics;

where immunization has not previously been provided on a significant scale the amount of work will be so great that special sessions and the application of a 3-visit compressed schedule will be necessary at first; otherwise, the clinics will be overwhelmed by the additional work load and the other activities will suffer.

A mother with 1 or more small children cannot be expected to attend regularly for immunization or to use the child welfare services if she has to walk more than 2–3 km. Unfortunately, those who live within a 3-km radius of a health centre or hospital or have access to regular transport are not in the majority in many developing countries. Therefore, if comprehensive coverage is desired, some form of mobility is required. This can take the form of periodic visits by a team from the static unit to various places in the district, possibly to provide other preventive services as well as immunization. Often, however, the health centre's resources of personnel and transport do not permit this approach. The alternative is to create special mobile teams for an immunization campaign; this is often the only feasible method of placing immunization services within walking distance of all the population of a rural area. After the first immunization work load has been dealt with the functions of these mobile teams can be broadened successively by adding other health promotional activities; in this way a "sequential" campaign is, in effect, developed (*8*).

In all immunization campaigns it is advisable to give careful consideration to the possibility of using jet-injection apparatus of the hand- or foot-operated type, or both. The larger the numbers to be immunized, the more likely it is that these injections will prove economical in the sense that the value of the time saved in monetary terms will outweigh the cost of the apparatus.

Records

It is desirable that the parent be given a record of the child's immunizations, either in the form of a special small card or included on the young-child clinic record card kept by the parent. Except for special research purposes, the mobile team does not need any other record except an accurate total of the different kinds of immunization performed each day, each month, and each year in all districts. First, second, third, and booster doses of triple and poliomyelitis vaccines must be recorded as such and not classified simply as triple or poliomyelitis vaccinations. This is necessary for calculating what proportion of those children who begin a course of immunizations finally complete the course.

Refrigeration

Static health units will find it difficult to offer a regular immunization service unless they have refrigeration facilities. The smallest refrigerators powered by kerosene, gas, or electricity have a capacity of about 0.6 m^3 and cost approximately US$120–150. Mobile teams require insulated boxes of about the same capacity and sealed bags or cans of a special type of gel that can be frozen solid each night at the team's base. These "cold-packs" retain the cold much longer than ice does. Provided that the insulated box is firmly closed when vaccine is not actually being taken from it, unused vials of vaccine can still be used the next day.

Equipment and sterilization

Teams that are not using jet-injection apparatus will find it worthwhile to have enough syringes and needles for a whole session without the need for re-sterilization. Savings are thereby obtained in staff time and productivity; moreover, the same amount of equipment will be used in the long term, even if it is supplied a little at a time. Both static health units having no autoclave and mobile teams will find the ordinary domestic pressure cooker of great value for sterilizing equipment. These cookers can meet the optimal requirements of 1 kgf of steam pressure per cm^2 [a] for 15 minutes and are economical to use. They hold a considerable amount of equipment, and for mobile teams injection equipment sterilized at the team's base in the evening can be transported to the site of operations in the same airtight container that has not been opened since sterilization was carried out. There is a danger that serum jaundice will be transmitted if a single 2, 5, or 10-ml syringe is used to give 4, 10, or 20 injections, even if a fresh sterile needle is used for each injection. If large numbers of people are to be immunized at one session, therefore, many syringes will have to be sterilized. Jet-injection apparatus or even disposable syringes and needles must be considered as possible alternatives.

Cost of comprehensive immunization

The cost will differ greatly from country to country according to variations in salaries, wages, and transport costs. Where measles vaccine is included, the cost will usually be between US$1.00 and US$2.00 per child immunized. This means that even in countries where *per caput* health expenditure is low comprehensive immunization of every child born would only amount to between 2% and 5% of the annual health budget. In general, immunization is an outstanding example of cost effectiveness in health services because the outlay is trivial in comparison with the cost of treating any of the diseases that it prevents.

[a] Approximately 105 kPa.

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