Appropriate Technology

Immunisation, rehydration, and transfusion

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To meet the target of Health for All by the Year 2000, set up at Alma-Ata at the joint World Health Organisation (WHO) and United Nations International Children's Emergency Fund (UNICEF) meeting in 1978, all people must have access to effective primary health care. The shape of this health care infrastructure will vary between different countries but is likely to be based on a network of minimally trained community health workers who provide care in the villages and neighbourhoods. These workers need support from the health centres and small hospitals in their area, and such support must include not only possibilities for supervision and referral but also a whole range of really appropriate health related technologies—the tools needed to carry out the tasks.

This back up for community health workers is essential, and these conventional health services must act as staging posts where essential materials may be prepared, or received and safely stored on arrival from central depots, ready for use or for further distribution to the periphery. In 1983 UNICEF, in response to its report on the state of the world's children, declared that it intended to concentrate on four major aspects of child health: breast feeding, growth monitoring, immunisation, and oral rehydration. This declaration implied even greater future collaboration between WHO and UNICEF to expand and extend oral rehydration and immunisation programmes to cover even the most remote areas. Both types of programmes have technological implications for the health centre and small district hospital.

Immunisation

Immunisation services should be provided as an integral part of a primary health care system, and immunisation coverage is both a simple and an important indicator of that system's success. The technologies concerned in providing such a service consist of the provision of effective vaccines when and where they are to be used, combined with the knowledge of how vaccines may be safely stored and transported. In addition, reliable immunisation programmes must be planned and then implemented locally. Those concerned with providing immunisation services must reckon with the realities of available vaccine as well as the local skills to implement the programme.

The success of the smallpox eradication programme was helped by the development of a heat stable, freeze dried vaccine, the use of the bifurcated needle which could be sterilised easily and used again in multiple pressure vaccination, and the surveillance by WHO reference laboratories of the quality of vaccine from different sources. Cleaning the skin before vaccination was found to be unnecessary, and so the vaccinator's

total equipment could be carried in one pocket—two small plastic tubes for needles plus vaccine and a diluent.

Work is being done to produce less fragile vaccines for use against other major communicable diseases—for example, a freeze dried diphtheria/pertussis/tetanus (DPT) vaccine. New immunisation schedules are being developed to reduce the number of visits necessary by combining inactivated and live vaccines for simultaneous administration, or by decreasing the need for additional inoculations by conferring more effective protection initially. Meanwhile, until advanced laboratory technology has managed to produce a one shot vaccine that will remain potent in any health worker's pocket, problems of transport and storage of vaccine remain a matter of concern. The vaccines that are currently used need to be kept at temperatures around freezing point at all stages in their journey from the point of manufacture right up to their point of entry into the person who is being immunised.

Refrigeration

In the health centre or small district hospital vaccine safety is likely to depend on domestic refrigerators powered by electricity, gas, or kerosene. Electricity in rural areas is often unreliable or non-existent. Supplies of bottled gas and kerosene depend on transport facilities and are affected by road conditions and pilferage. Kerosene refrigerators require careful maintenance to keep them functioning efficiently. There is also the temptation to use some of the limited refrigeration space for perishable foods and cold drinks (an understandable weakness in places where ambient temperatures are uncomfortably high and there is no other method of cooling things), but a refrigerator frequently opened is not a safe place for vaccines. These must be placed within their own special refrigerator because DPT, tetanus toxoid, and BCG vaccines need to be stored at 4–8°C and never frozen, whereas measles and polio vaccines should be kept below 0°C in the freezing compartment.

The refrigerator must also provide the ice required for the transport of vaccines to outlying clinics and health posts. Vaccines should be carried in cold boxes and in vacuum flask type carriers. In these containers vaccines must be kept cool by packing them with commercial ice packs or bags of ice cubes. Good supplies of ice are, therefore, essential for efficient immunisation. A properly made, well insulated cold box containing sufficient quantities of ice will keep vaccines safe for up to four days, provided that it is kept in the shade and not opened too often. Refrigeration plays a crucial part in immunisation and is not susceptible to improvisation.

Recent advances

Technology may contribute to success of immunisation in various ways: firstly, by improving refrigerator design—for example, top rather than front opening entails less cold loss,

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and simple improvements to the gas or kerosene burner unit may make maintenance easier—and, secondly, by developing alternative power sources for refrigeration such as solar power, which has the potential for higher performance, lower running costs, improved reliability, and a longer working life than conventionally powered refrigerators. A solar powered refrigerator/freezer for storing vaccines is being tested by the Lewis Research Centre of the National Aeronautics and Space Administration of the United States of America in collaboration with the WHO in six countries, starting in India.¹ Research is also being carried out at other centres on a whole range of different approaches to solar powered refrigeration (fig 1). Its success may make a major contribution to the refrigeration requirements of small hospitals and health centres, as it makes use of a free and freely available source of power.

The success of any immunisation programme depends on the integrity of the "cold chain" between central store, district hospital, health centre, and the community. Technology has made effective monitoring of the cold chain's integrity possible by producing a vaccine safety marker. This is a heat sensitive indicator to monitor the time and temperature history of individual phials of vaccine. The indicator consists of a small circular paper tab, with adhesive backing and protective coating, which is applied to individual vaccine phials on the flip off part of the cap, either at the central store or at the site of manufacture of the vaccine. Developed by PATH (Program for Appropriate Technology in Health),² the marker is based on a polymer that changes colour from red to black when exposed to a critical accumulation of time and temperature. The rate of colour change parallels, but on the conservative side, the rate of decline towards minimum potency of the vaccine, rapidly changing from an initial safe red to danger black when the vaccine should not be used. Darkening of the red suggests that the vaccine should be used without delay. At present the marker is adjusted for measles vaccine (which is notoriously fragile, see fig 2), and costs less than 10% of a 10 dose phial of measles vaccine. The marker is being tested in the field, and work is under way to adapt the basic principle for use with other vaccines, starting with polio. The London School of Hygiene and Tropical Medicine, the International Development Research Centre in Canada, the Edna McConnell Clark Foundation, and the WHO have all collaborated with PATH to develop the vaccine safety marker. It is an excellent example of the imaginative application of modern technology to solve a problem that usually arises in remote circumstances where the cold chain is most likely to be broken.

FIG 1—Schematic representation of how a solar powered refrigerator works.

FIG 2—Freeze dried measles vaccine may be stored safely for 1-2 years at 2-8°C, but when exposed to 37°C the potency falls below acceptable levels within 1-2 weeks. The degradation of the indicator parallels the rate of decline of the vaccine, and it changes colour after exposure to a critical accumulation of time and temperature.

Fluid replacement

Of the four major interventions that UNICEF is promoting, oral rehydration has the greatest immediate potential for saving life.^{3,4} Diarrhoea kills at least five million children every year in the Third World and contributes to the ill health and malnutrition of countless others who survive. In diarrhoea, dehydration is the lethal factor, and since the early 1970s it has been known that the fluids and electrolytes that are lost may usually be replaced satisfactorily by mouth instead of intravenously. This therapeutic advance is based on the discovery that glucose aids intestinal absorption of sodium, thus hastening the restoration of fluid balance. The formula recommended by WHO for oral rehydration salts solution is as follows: sodium chloride 3.5 g, sodium bicarbonate 2.5 g, potassium chloride 1.5 g, glucose 20 g. These quantities are mixed with one litre of (preferably) safe water.

Sachets or packets of oral rehydration salts may be kept at the district hospital and distributed to the smaller hospitals and health centres. The full formula, containing sodium bicarbonate, needs to be packaged in foil or freshly made up from the separate ingredients. Local packets have a limited shelf life, and in many areas it may be more practicable to teach the mothers how to make up simple sugar and salt mixtures.

In areas where oral rehydration programmes have been established successfully the need for parenteral fluids is reduced, but intravenous fluids are still needed for children with gross hypovolaemia. Such fluids must, therefore, be readily available. Apart from their use in cases of severe dehydration they are also needed to treat patients with trauma, obstetric haemorrhage, the need for emergency surgery, and so on. Saline based fluids are perhaps most efficiently produced at a central health facility, but they are heavy, bulky, and expensive to transport and have a limited shelf life of three to six months. They may be made at small hospitals provided that scrupulous care is taken to avoid contamination. Ingredients must be pure and measured out accurately. An abundant supply of distilled water is essential, and the design of efficient stills for this purpose is important.

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Stills are probably best made of glass and heated by any convenient source of energy—electricity, gas, or kerosene (the development of solar powered stills would be an advantage in many areas). The risk of contamination with pyrogens is reduced if the distilled water is filtered through an easily cleaned sintered glass filter. Plastic rather than rubber connections are recommended, but rubber bung seals for the bottles remain essential. These are still available from some manufacturers and

are almost infinitely reusable, as are the glass bottles. Disposable plastic giving sets should be used, not rubber tubing. Efficient autoclaves are another essential, and here again, as with stills, appropriate technological interests should be enlisted with regard to design, power sources, and easy maintenance. Any risk of contamination should be slight provided that sufficient care is taken at all stages, including the cleaning of all apparatus. Staff who take on this responsibility at the periphery must receive proper training, which may best be undertaken centrally.

Plasma and blood

Plasma cannot be prepared locally, but freeze dried plasma has a long life if kept in a refrigerator. It may be reconstituted as required using freshly prepared and filtered distilled water. Blood supplies frequently come from a central blood bank and can be stored safely in a refrigerator for up to 21 days at a temperature that does not exceed 4°C. Blood grouping and cross matching must also be available, and therefore blood may be collected locally at health centres or small hospitals, using containers as prepared for other intravenous fluids. Again, it is recommended that prepacked plastic disposable taking and giving sets should be used. As it is already recognised that plastic disposable syringes are often resterilised for multiple use, however, research ought to be done into all so called disposable equipment to establish how and how often it may safely be reused.

Sterilisation of some types of equipment may be improvised—for example, syringes and needles, some instruments, and ligatures may be simply boiled in any container over any source of heat—although autoclaving is essential for many purposes. PATH is developing a sterilisation safety marker, which is shortly to be tested in the field. It consists of a coloured plastic disc protected by a metal ring. The colour changes when the

disc has been kept at a temperature of 100°C for not less than 20 minutes. The disc is reusable and cheap and should be a useful way to check the adequacy of sterilisation by boiling, as for instance in home deliveries or in field conditions for immunisation.

Adequate storage facilities in hospitals and health centres are essential, and there are several simple ways in which they may be readily improved. A useful handbook has recently been published by AHRTAG called *How to Look After a Health Centre Store*.⁵ This makes a good companion volume to their earlier publication *How to Look After a Refrigerator*, which is soon to be reissued in an updated version. Undoubtedly efficient refrigeration is crucial for the proper functioning of any medical centre, not only for the storage and transport of vaccine but also for the safe storage of serum; antitoxin; reconstituted antibiotics for injection; drugs such as some forms of insulin; and, finally, plasma and blood.

To look at immunisation, rehydration, and transfusion as peripheral procedures, clearly there is great scope for modification of existing methods and the imaginative application of appropriate technologies.

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Hospital Topics

Contribution of general practitioner hospitals in Scotland

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Abstract

The results of a survey of 64 Scottish general practitioner hospitals showed that in 1980 these hospitals contained 3.3% of available staffed beds in Scotland; 13.6% of the resident population had access for initial hospital care, and 14.5% of Scottish general practitioners were on their staffs. During the year of the survey they discharged 1.8% of all non-surgical patients, treated almost 100 000 patients for accidents and emergencies and 140 000 out-patients, and 4.4% of all deliveries in Scotland were carried out in the hospitals surveyed.

Most communities which are served by general practitioner hospitals in Scotland are rural and on average are more than 30 miles from their nearest district general hospital. The contribution that these small hospitals make to the overall hospital workload has not previously been estimated. It has been shown nationally to be small but not inconsiderable. In terms of the contribution to the health care of the communities they serve it cannot and should not be underestimated.

Introduction

The contribution of the general practitioner hospital in providing health care in Scotland has not been well documented. In an extensive study Cavenagh showed that 3% of short term hospital beds in England and Wales were in general practitioner hospitals and they provided initial hospital care for up to 20% of the