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Short-Term Strategies to Contain Diarrhoeal Disease:
An Economic Approach
by
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SHORT-TERM STRATEGIES TO CONTAIN DIARRHOEAL DISEASE: AN ECONOMIC APPROACH

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Diarrhoeal diseases are a major cause of sickness and death in many developing countries. One recent study ranked diarrhoeal disease as the world's top priority in primary health care — higher than malaria, malnutrition, respiratory infections and poliomyelitis in view of its comparative prevalence, severity, and feasibility of control (Walsh & Warren, 1980). There are an estimated 3,000 to 5,000 million cases of diarrhoea in the world each year; 5 to 10 million deaths result from it (compared with perhaps 2 million from malnutrition, 1.2 million from malaria, and 10 to 20,000 from poliomyelitis). Furthermore, there are several inexpensive interventions (preventive and curative) against diarrhoea which are potentially highly effective.

Diarrhoea, like malnutrition, is a disease of poverty. Improved standards of housing, water supply, diet and sanitation would in the long-run probably do much to diminish the scale and severity of diarrhoea, most particularly in children. In the short run, the question of what is the most appropriate action for health programmes to take in tackling diarrhoea remains open to debate. Oral rehydration therapy — the use of a salts and glucose mixture — has been shown to be a potentially cheap, effective treatment for most infectious diarrhoeas, but how does this compare with such preventive interventions as improved personal hygiene, improved infant feeding, or immunization against diarrhoea? The question of what is the best mixture of these (and other) policies against diarrhoea is an important one when the very limited resources per head of population (less than £1 per head in some countries) for all primary health activities is considered. Clearly, both the probable costs and the likely effectiveness (or outcome) of each possible intervention should be taken into account. The options available are numerous: Feachem *et al* (1983) classify the potential means for reducing diarrhoeal morbidity and/or mortality among children into 4 main groups:

1. **Case management** (curative measures):
   i) oral rehydration (home- or health facility-based);
   ii) intravenous rehydration;
   iii) appropriate feeding;
   iv) chemotherapy.
2. **Increasing host resistance:**
   i) improving prenatal and postnatal maternal nutrition;
   ii) improving child nutrition — especially through prolonged breast feeding, improved weaning, supplementary feeding, use of growth charts to test infants' progress;
   iii) immunization against: measles, cholera, and rotavirus;
   iv) chemoprophylaxis of children at special risk.
3. **Reducing transmission:**
   i) improving water supply and excreta disposal;
   ii) improving personal and domestic hygiene (e.g. hand washing);
   iii) improving food hygiene (better preparation and storage, especially of weaning foods);
   iv) control of reservoirs of infection in pets, household pests and farm animals;
   v) fly control.
4. **Controlling/preventing epidemics:**
   i) Epidemic surveillance, investigation and control.

Assessment of the priority of these interventions, separately and in combination, requires a knowledge of the likely costs of the interventions, together with an epidemiological index of their probable impact, or effectiveness. The Diarrhoeal Disease Control Programme of the World Health Organization has undertaken a review of the above interventions (and other possibilities), the first findings of which have now been published. The measures studied include measles immunization (Feachem & Koblinsky, 1983), promotion of breast-feeding

(Feachem & Koblinsky, 1984) promotion of personal and domestic hygiene (Feachem, 1984) and supplementary feeding programmes (Feachem *et al*, 1983). In this paper, the likely cost effectiveness of measles immunization (to combat measles-related diarrhoea), together with the potential cost-effectiveness of two new vaccines against rotavirus and cholera, are considered.

Vaccine development is one of the most rapid areas of technological progress in medicine. Recent advances in biotechnology have opened the way to the isolation of viral agents which have not previously been culturable; and have created the possibility of safe, stable attenuated forms of viruses, or the production of synthetic antibodies, on a scale not previously possible. Particularly for virally-caused diseases (rotavirus diarrhoea, German measles, poliomyelitis) these create new, preventive opportunities for low-cost and effective public health measures. But this does not mean that all immunization programmes should be regarded as equally important priorities – the above list shows that there are many routes to the prevention of disease, as well as the possibility of low-cost curative measures

To compare the cost-effectiveness of potential interventions requires that cost-per-unit of health improvement be comparable for each possible programme. The most convenient way to do this for a single category of diseases is in terms of cost-per-case-prevented; though diarrhoeal disease includes some cases which differ rather widely from each other; so a second unit of comparison: cost-per-diarrhoea-death-prevented is also employed in the following discussion.

Not all diarrhoea can be prevented by immunization, though some of the most dangerous types may be avoided in this way. Measles and diarrhoea are associated, and together are often fatal. Measles is a very common infection in poor communities, with almost all children contracting it, and up to ten percent dying from it. A study in Bangladesh showed that 34 percent of diarrhoeal deaths were measles-associated, and on a global basis it is estimated that between six percent and twenty five percent of diarrhoea deaths might be prevented by measles immunization. Rotavirus (for which a vaccine is now undergoing field trials) has a relatively low incidence (about six percent of all diarrhoea episodes), but a disproportionately high effect on mortality, acconting for up to twenty percent of all diarrhoea deaths. Cholera varies widely in its incidence; in Bangladesh, where it is endemic, it accounts for over eight percent of diarrhoea deaths, but well below one percent of all diarrhoea cases. Immunization (with effective vaccines, given to infants in the most at-risk age groups) against these three conditions might reduce the total number of deaths from diarrhoea by between one-third and over one-half (or some 2 to 5 million deaths per annum worldwide).

But not all children vaccinated will develop full immunity: vaccine 'efficacy' varies considerably according to the dosage and potency of the vaccine, and the age and health status of the recipient. Measles vaccine is one of the most efficacious when the vaccine has been properly stored and handled: in these circumstances it is estimated to have a 95 percent efficacy level and to give long-lasting immunity. Cholera vaccines, on the other hand, have as yet proved to be short-lived in terms of the duration of immunity they impart (a maximum of a few months), and of relatively low-efficacy, often less than 60 percent. For widespread adoption of large-scale anti-diarrhoea programmes new cholera vaccines currently under development are expected to achieve efficacy levels of 60-70 percent. Lower success rates than these in raising immunity may damage the credibility of health care services and thus be counter-productive in improving health standards. Rotavirus vaccine is still in the pilot testing stage; again, a target efficacy level of 60-80 percent is likely to be a precondition for its widespread adoption.

From the above-mentioned parameters (the frequency of diarrhoea, the fraction of all diarrhoea mortality and morbidity that are attributable to each specific cause, and the known or likely efficacy of the vaccines), rough indices of the effectiveness of immunization interventions can be made.

Thus, effectiveness in terms of *case prevention* by measles vaccination can be estimated as:

efficacy of measles vaccine	×	**frequency of diarrhoea cases (all types)**	×	**measles-related cases as % of total**

So 1 a 95 percent efficacious vaccine; with a tota diarrhoea incidence of 3 cases-per-child-per-year, and an estimated 2.9 percent of these being measles-related, the number of cases prevented by immunizing an at-risk population of 1 million is:

1 million children	×	3 cases/yr ea. of diarrhoea	×	2.9% measles-related cases	×	95% efficacious measles vaccine

= **82,650** cases.

Similarly, effectiveness in terms of *avoided deaths* can be estimated as:

efficacy of measles vaccine	×	frequency of diarrhoea mortality	×	measles-related diarrhoea deaths as % of total

So, immunizing 1 million children with a 95 percent efficacious vaccine, where measles-related diarrhoea deaths account for 20 percent of an overall diarrhoea mortality rate of 15 per 1,000 would achieve:

1 million children	×	1.5% total diarrhoea mortality	×	20% reduction in mortality	×	95% vaccine efficacy

= 2,850 avoided deaths

Previously cited reviews have established likely ranges of values for each of these parameters for measles, rotavirus and cholera-specific diarrhoeas, so the prospective effectiveness of interventions in these areas can be simply modelled on the above lines.

How much will immunizations against diarrhoea cost?

Cost-per-avoided-death, or costs-per-diarrhoea-case-prevented may, in principle, be simply calculated, given the afore-mentioned information. If it costs $2 (throughout this paper $ denotes US$ at 1982 equivalent) for each immunized child, then the cost of a measles-related diarrhoea case prevented is:

$2 million/82650 = £24.2

and the cost-per-death-avoided is:

$2 million/2850 = **$701.7**

What would introducing these new vaccinations cost? The answer (of course) is . . . . it depends. In the first place, it depends on what type and scale of immunization programme already exists.

Almost all developing countries now have an on-going Expanded Programme on Immunization (EPI), aiming to give tetanus toxoid vaccinations to pregnant women; infant immunizations against tuberculosis (BCG), and combined diptheria, pertussis and tetanus (DPT). In an increasing number of countries, vaccinations against polio and measles are also being added to this schedule. Everywhere in the developing world, immunization priority for *infants* — i.e. those under 1 year — is stressed, since the mortality rates from these diseases are highest between the ages of 18-24 months.

The following Table shows variations in immunization costs for 8 countries.

Immunization against diarrhoeal disease would, in most cases, therefore, involve increments in the costs of existing programmes, rather than a complete new building, equipping, training and staffing operation.

Several recent pieces of analysis have documented immunization programme costs (the W.H.O. Expanded Programme on Immunization uses a standard costing approach — developed in C.D.S.) in 10 countries of Africa, Asia and Latin America. Accurate international cost comparisons are difficult, but it is clear that the costs-per-immunization and costs-per-fully-immunized-child differ widely, reflecting differences in input prices, in immunization programme content and organization, and in programme scale. Average cost for a (single dose) measles immunization in northern Brazil was as low as $1.7; in Cameroon the same immunization

COSTS PER IMMUNIZATION CONTACT, (US$ 1982 equivalent)

Costs/Contact Country	Cost/Fully Immunized Child	Minimum No. of Contacts for Full Immunization	Costs/Contact for Fully Immunized Children
Ivory Coast	4.8-13.9	1	4.8-13.9
Brazil	1.7-4.6 (Measles)	1	1.7-4.6
	2.04-4.8 (Polio)	3	0.68-1.6
Philippines	6.2	2	3.1
Indonesia	2.6	2	1.3
Thailand	13.4	2	6.7
Cameroon	9.5	4	2.4
Gambia	12.0	4	3.0
Kenya	16.6	4	4.15

Source: From Creese, A.L., "Cost-Effectiveness of Potential Immunization Interventions Against Diarrhoeal Disease" (forthcoming, 1985).

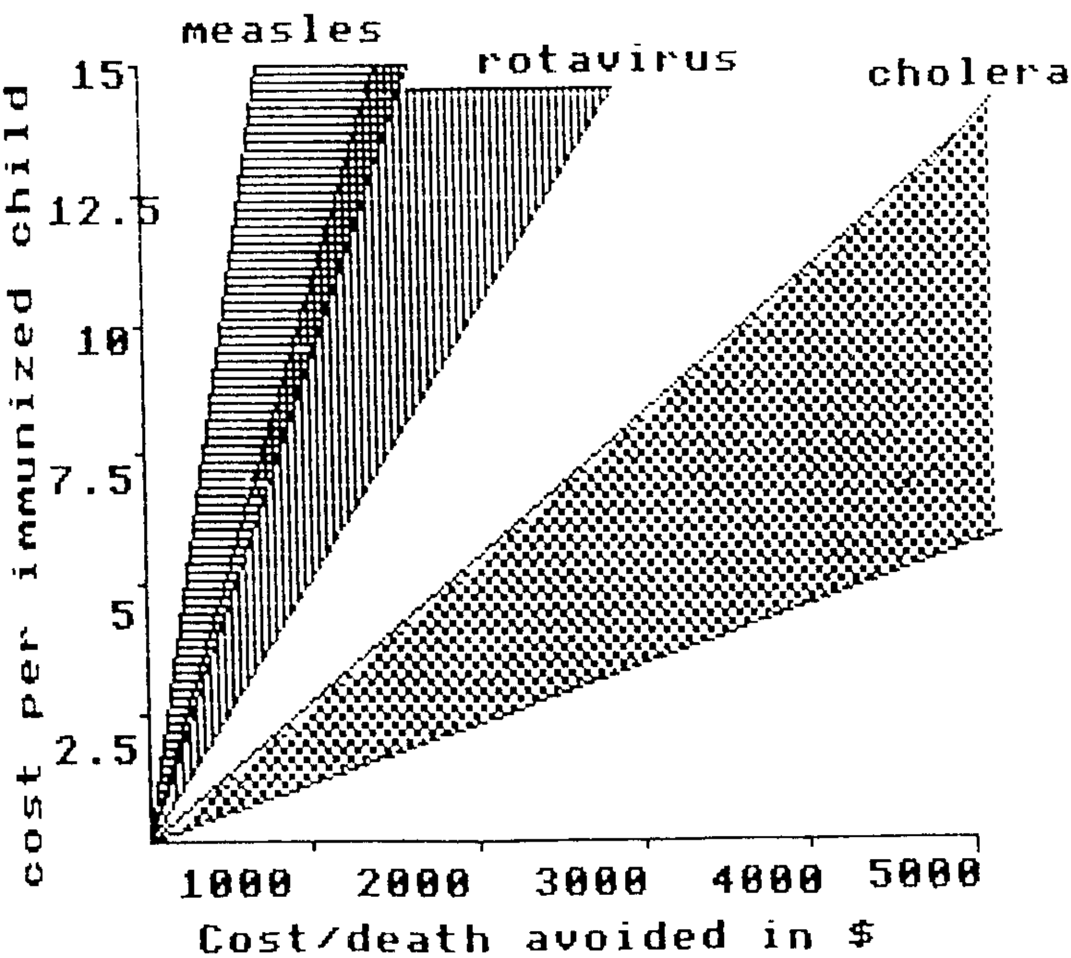
cost as much as £17.00 (1982 prices).

But from a knowledge of the determinants of immunization costs, and with some informed guesswork about the most likely form in which new vaccines will be administered (e.g. 1-dose or 3? Along or in combination with other vaccines? At under 1-year age or above?), it is possible to estimate the plausible upper and lower limits to the range of the incremental costs of adding new vaccines.

Vaccine costs, for example, constitutes an average of about one tenth of the total cost of an immunization, and will vary directly with the number of vaccines includes in the programme (and the number of children immunized). The capital costs of vaccination programmes — a share of the buildings, vehicles, refrigerators and other equipment — account for about 15 percent of the average cost-per-vaccination, when spread on an annual basis, and (in most cases) will not vary with the number of different vaccines managed by a programme. If existing prices are a good guide to the costs of new vaccines, it seems likely that new vaccines will increase total costs-per-vaccination contact by between 10-25 percent, depending on the individual programme's cost characteristics. Multi-dose new vaccines (rotavirus will probably be a 3-dose course) will mean that cost-per-fully-immunized child goes up by a factor reflecting the number of doses, *and* there is also an increased dropout rate after the first dose with multi-dose immunization.

In 'best practice' immunization programmes — those where costs appear low by international comparison — new vaccines, especially a single-dose ones like measles — may well cost under $1 more per immunized child. For 3-dose vaccines, which can be given simultaneously with others in the programme such as polio, the incremental costs-per-fully-immunized-child may still be under the $2 level, even allowing for dropouts (non-completers). But in 'expensive' programmes, and particularly if new vaccines mean additional visits to clinics, the incremental costs may be substantial. Extra clinic sessions, transport, and so on, may be needed by those receiving these vaccines. A separate sub-programme may also be needed if the target

COST PER DIARRHOEA DEATH AVOIDED IN $



group is of a different age from the under 1-year olds (on which EPI usually concentrates). In these cases, the marginal costs of new vaccines may well be comparable to the average costs of the existing programme.

For measles (a single-dose immunization of known high efficacy, optimally given to infants of about 8-9 months), it would seem possible to incorporate this (where not already provided) at relatively low additional cost with third doses of DPT and oral polio vaccine. Though these latter should be given at an earlier age, they are commonly administered to children at around 8-12 months and could, therefore, be given simultaneously with measles. Incremental costs of around $1 per measles vaccination would therefore seem a realistic possibility.

Rotavirus vaccine's administrative requirements are still uncertain. A 3-dose oral vaccine, possibly simultaneous with polio, appears a possibility. If this is so, costs-per-fully-immunized-child might be expected to rise by perhaps $1 to $2. But if separate visits are necessary (for example if a significantly better immune response is found by spacing polio and rotavirus vaccinations), then additional staff time will be required, and costs will be higher — perhaps around $5.

The costs of likely new cholera vaccine programmes may be even greater. For 5-year immunity repeat vaccinations are likely to be required, and the optimal age group will be between 1 and 2 years of age. Experience in many health programmes shows that parents (usually mothers) find it much more difficult to bring a child to a health clinic at this age — often because a younger sibling has just been born — so special arrangements would have to be made to launch immunizations for this group, with attendant cost increases.

The previous diagram sketches the likely cost-effectivefness of these three immunization interventions in terms of life-saving. Current cost estimates of vaccine efficacy, and specific diarrhoea mortality rates are used; and the incremental costs of a full course of vaccination are treated as a variable: it is unlikely that each vaccine will cost the same amount extra to introduce and any single vaccine may cost more in one country context than in another.

Even if all three vaccines (measles, rotavirus and cholera) could be introduced at a common cost increment, the relative attractiveness of measles and rotavirus over cholera would be clear. But the likely differences in incremental cost actually increase the differences in overall cost-effectiveness. Measles is likely to be the least expensive additional vaccine to take on; rotavirus the next; cholera the most. Thus, at $1 extra cost for measles, a child death may be avoided for $50-$100. At $2 extra cost for rotavirus, a prevented death will cost $150-$350. At an optimistic $5 extra per cholera immunization, each life saved will cost some $1,800-$2,000. Because diarrhoea reduction is essentially a spillover benefit from measles vaccinations, its priority becomes even more pronounced.

Many other possible routes to the efficient reduction of diarrhoea remain to be explored, and many other factors, influencing overall effectiveness, such as the perceived importance of the disease and the consequent acceptability of interventions, must be taken into account. The type of framework used in this analysis has the advantage of allowing a common index for comparing all of them, and thus making the choice of priorities a little clearer.

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