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Appropriate Technology

Nicolas Jéquier

Appropriate technology needs political "push"

The appropriate technology concept has won the support of leading figures in finance and industry. The main obstacles now are not technical but political.

The widespread acceptance of appropriate technology in recent years has led to what may be viewed as a cultural revolution. The support it enjoys, however, should not blind us to a number of basic operational problems that will have to be solved if appropriate technology is to offer more than just promises.

In the industrial countries, the term *appropriate technology* has come to refer to technologies that are ecologically well adapted to the local environment, small in scale, and sparing of such natural resources as energy; but the term generally means a wide range of low-cost technologies aimed specifically at meeting the most basic needs of the world's poorest people. In the latter sense appropriate technology focuses particularly on the problems of developing countries—health, food production, nutrition, housing, and employment.

Appropriate technology has become a "growth industry". In 1970 there were about 15 groups throughout the world working on the development and diffusion of appropriate technologies; by 1977 there were roughly 500; and in 1980 the figure was about 1000.

This quantitative growth has been accompanied by deep structural changes within the appropriate technology movement. What started as an innovative effort on the part of a few small groups working against the "system" has developed into a major effort supported by the big international development agencies, government ministries, industrial firms, universities, and a number of leading development thinkers. Appropriate technology has been integrated into the mainstream of development policies, and the principal innovators today are no longer the marginalists and misfits, but the decision-makers in ministries, banks, private firms, and international organizations. Nevertheless, though its success is encouraging, it must be realized that the problems appropriate technology poses are at least as numerous as the problems it was intended to solve.

Expectations and Achievements

The first of these new problems is the enormous gap between expectations and achievements.

A number of technical and organizational developments of the past 10 years have clearly shown that more appropriate types of technology can be economically competitive with large-scale modern technology, socially acceptable, and technically viable. In India,

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for example, it has been demonstrated that small-scale labour-intensive sugar mills can be quite as efficient as the much larger capital-intensive mills of the modern sector (*1*). Similarly, research carried out by the World Bank on labour-intensive road construction methods suggests that with the proper type of organization, good supervision, and well-designed hand-tools, it is technically feasible and economically possible to build roads and dig canals without using any heavy equipment (*2*).

Encouraging as they are, these examples are all too rare; and the range of appropriate technologies that have proved to be economically and technically operational is at present far too narrow to enable them to make more than a marginal contribution to economic and social development. In fact, the situation today is that the demand for more appropriate types of technology is far in excess of our ability to meet it.

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There are many reasons for this apparent weakness in innovation. The most conspicuous is the length of time needed to translate a good idea into a workable product or a reasonably efficient social service. For instance, it will have taken the Indians approximately 15 years to develop and perfect their highly competitive small sugar plants, and the World Bank's research on labour-intensive construction methods extended over a period of almost 10 years. Such lead times are quite normal, and cannot be expected to be substantially reduced.

A second reason is the organizational complexity of the delivery system in appropriate technology. Designing a good water pump, a cheap village-level water-purification system, or a new way to build low-cost houses is technically difficult enough; but the problems of diffusing such technologies to a very large number of beneficiaries are immensely more complex. Moreover, the managerial and organizational technology required for such a task is often not available.

A third reason for the apparent weakness in innovation is that we are dealing here with technologies that touch upon spheres of human activity and cultural domains that are inherently very stable and that tend to be greatly influenced by traditions, ethical norms, religion, and taboos. Providing a village with clean drinking-water or safe sanitation facilities or introducing innovations on food preparation, nutrition, or housing is generally an extremely complex entreprise from a social and cultural point of view (*3*).

The "Software" Dimension of Appropriate Technology

Although much of the expenditure and labour on appropriate technology is devoted to research and development related to new equipment and to the collection, production, and transmission of information, the major challenge facing proponents of appropriate technology today is, I suggest, the development of "software"—the managerial tools, organizational forms, financial incentives, legal structures, and cultural knowledge that determine the success or failure of innovation.

For example, experience has shown that one of the most important factors in the success of self-help housing and slum-upgrading schemes is a legal one, namely, security of tenure (*4*). If the very complex problems of land ownership, registration, and rental practices are not solved at the outset, efforts to introduce better hardware and more adequate services meet with enormous difficulties, and the potential benefits of self-help cannot be realized.

Another major constraint on the diffusion of more appropriate types of technology is lack of funds. For example, a biogas plant costs about US$ 300, which is the equivalent of the monetary income of a whole year for a poor Indian family; moreover, if that family does not own at least three cows to supply it

with enough dung to fuel the plant, the quantity of gas produced will be too small to meet all the cooking needs of the family, and a standby system (charcoal burner or wood stove) must be permanently available. Inexpensive small loans for purchasing appropriate devices should be made available—a type of loan that conventional financial institutions generally do not make and that would require payment of an exorbitant amount of interest if obtained from a traditional moneylender. What is needed is an intermediate-level lending system geared to making small disbursements to poor people who usually do not have any collateral to offer except their personal reputation in the community. Such systems have been established in a number of instances; and there is strong evidence that this is perhaps one of the most effective ways of facilitating the widespread adoption of more appropriate technologies by the individual or the family.

In the community, too, money may be an important factor in encouraging appropriate technology, but the real difficulties here are apt to be organizational and political. Community projects—in health services, public works, environmental improvement, or basic education, for example—require very detailed planning in the preparation stage and careful supervision in the execution stage; they are, in fact, very labour-intensive from a managerial point of view, which can create enormous problems. We do not yet have the managerial technology for carrying out large numbers of projects of this type. In terms of managerial methods, appropriate technology today is at the same level of sophistication as that of American industry in the late 1940s or as that of European industry in the late 1950s, when there were very few business schools, corporate strategy was in its infancy, financial control was very elementary, and there were very few managers who knew how to develop and run a multinational corporation. What is needed now is a new type of managerial technology that is now only just beginning to be developed. At the technical level, it involves the introduction of such notions as cost-effectiveness, quality control, marketing, and organizational planning—notions that are largely unfamiliar to the innovators in appropriate technology.

The Politics of Appropriate Technology

In the same way that the big "frontier" of appropriate technology in the 1970s was its public legitimation and the development of new hardware, the frontier of the 1980s will probably be the development of organizational and managerial tools designed to promote large-scale diffusion of appropriate technology. It would be a mistake, however, to imagine that the problems facing appropriate technology are only technical: technology is a political issue, and should be clearly recognized as such by all who, in one way or another, are trying to promote the development and wider use of more appropriate types of technology. When appropriate technology is recognized by policy-makers as one of the ways of meeting everyone's basic needs—as is the case today in a growing number of countries—it becomes an eminently political issue.

We are beginning to realize that the basic political options chosen by national governments are among the fundamental determinants in the orientations of the technological system. The emergence of appropriate technology as a political issue may be as distasteful to the early pioneers as the growing role of governments and international agencies, but this institutionalization of appropriate technology is one of the preconditions for its widespread diffusion. We must recognize that bringing health to all with the help of appropriate technology is not a technical issue, but a political one.

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David Banta

Technology assessment in health care

In parallel with the increasing role of technology in health care, more efforts are being made to assess its possible risks and to weigh them against its potential benefits. It has begun to be realized that many policy decisions should be based on evaluation of the technology involved. The major concerns with regard to medical technology are efficacy, safety, and cost.

Assessing Efficacy and Safety

Let us begin with some definitions that, though complex, contain elements each of which is essential for assessing health-care technologies.

1. Efficacy is the probability of benefit to individuals in a defined population from a medical technology applied for a given medical problem under ideal conditions of use (*1*).

2. Safety refers to judgement concerning the acceptability of relative risk in a specified situation.

3. Risk is a measure of the probability of an adverse outcome and the severity of the resultant harm to the health of individuals in a defined population from the use of medical technology applied for a given medical problem under specified conditions of use.

Questions about efficacy and safety have arisen for two reasons: first, it is difficult to determine a clear-cut relationship between much of the new technology and the health status of the population, and, second, many technologies have come into widespread use without being adequately assessed and in some cases have turned out to be of very limited value. A dramatic illustration is that of gastric freezing, which was widely used as a treatment for peptic ulcer in the 1960s and then was completely abandoned because of lack of benefit (*2*). A number of surgical procedures for coronary artery disease have been abandoned for similar reasons (*3*). But perhaps more important is the *lack* of information. Such technologies as computed tomography scanners (*4*, *5*), electronic fetal monitors (*6*), and radical mastectomy (*7*) have come into widespread use, but their ultimate place in medical practice is not known. The vital question for the physician is whether a particular patient will benefit from a specific technology. Without good information on efficacy—especially concerning appropriate conditions of use—the technology will not be used optimally. In many cases, technologies seem to be over-used.

Personal observations of individual patients have been, and will continue to be, fundamental to the progress of medicine (*8*). Such assessment has its limitations, however: the physician has a psychological need to show that an intervention works (*9*), and the natural history of disease is not understood well enough to allow precise prediction of what will happen to a patient without intervention. These problems have led to the development of controlled clinical trials, in conjunction with statistical techniques for their interpretation. The most powerful technique for testing efficacy is the randomized controlled clinical trial, in which potential patients are assigned randomly to an experimental or a control group (*10*).

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Controlled clinical trials are not very frequent, however. Administrative, statistical, and financial resources to support them are meager, even in the USA, with its annual expenditures on health care of more than $ 200 billion. The US Congress's Office of Technology Assessment (OTA) has estimated that the US government spends about $ 200 million a year on clinical trials.

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Because of the limitations that prevent a great expansion in clinical trials, alternatives are being examined. In some cases uncontrolled clinical testing may be perfectly sufficient; in others, epidemiological data can serve as a substitute. A growing alternative is the computer model. Using existing data and making assumptions where data are lacking, it may be possible to develop a reliable computer-based model that will allow prediction of the efficacy and safety of a particular technology.

Perhaps the most widely used method of assessing the efficacy and safety of medical technology is synthesis. Everyone does some sort of synthesis of knowledge, and most physicians do their own syntheses of what is known concerning certain important technologies. In many countries groups of expert physicians are brought together and asked to recommend health policies (*11*). Increasingly, a structured literature review and synthesis of good research and clinical observations are becoming a part of this process, though the reliability and validity of this procedure depend partly on the availability of results of good research.

This procedure is more appropriate for examining efficacy than for examining safety. Adverse reactions from technologies such as drugs often have to be searched out. They may occur infrequently, or can easily be considered part of an ongoing disease process. Although clinical trials reveal some risk, long-term follow-up studies are ultimately necessary to document the risks of specific technologies fully, and sometimes large epidemiological studies are required to settle this question.

Assessing Cost-Effectiveness

Physicians and health administrators have always had to consider costs in making their decisions. Before the days of health insurance in the industrialized world, the calculation was whether the patient could afford to pay. With the growth in insurance and medical care programs, this market function has been weakened or eliminated, which has led to the development of more formal techniques for comparing the negative and positive consequences of alternative procedures or decisions (*12*).

In cost-benefit analysis, all consequences, health outcomes as well as cost, are valued in monetary terms. In cost-effectiveness analysis, desirable program consequences are not valued in monetary terms but are measured by some other unit; for example, years of life saved and days of morbidity or disability avoided. Cost-benefit is the theoretical ideal; but problems in application are myriad, including the necessity of valuing life in monetary terms. Therefore, experience in the application of cost-effectiveness techniques is growing.

In an extensive study of cost-effectiveness techniques, the Office of Technology Assessment has recently concluded that performing an analysis of costs and benefits has the potential of being helpful to decision-makers because the process itself can structure the problem, allow open consideration of the relevant effects of a decision, and force the explicit treatment of key assumptions (*13*). It also concluded, however, that cost-effectiveness has too many methodological and other weaknesses to justify one's relying solely (or even primarily) on it in making a decision.

Technology Assessment in Policy Decisions

In any country where the government is involved in the delivery of medical care, it is

likely that there will be activities related to technology; but thus far technology assessment has been used very little in helping those concerned to make the relevant decisions. Currently, international organizations, such as the World Health Organization and the Organization for Economic Cooperation and Development, and the governments of a number of countries are actively discussing how the use of technology assessment can be expanded; several international conferences on the subject have been held.

To improve decision-making concerning medical technologies by doing assessments and making the information available to policy-makers, it is necessary to have a system for assessing medical technologies (*1*, *13*). In such a system the technologies needing study must be identified and tested, and the information from trials and other sources must be synthesized in order to arrive at recommendations for those who must make decisions on medical technology. Lack of such a system is perhaps the biggest problem in present-day medical technology assessment activities. An interesting and relevant experiment is under way in the USA. In 1978 the US Congress established a National Center for Health Care Technology that is the beginning of such a system. If it works, it may serve as a model for other countries; if it fails, its experience will none the less be valuable to others.

Implications of Technology Assessment for Developing Countries

The interest in technology assessment in industrial countries has grown out of a realization that resources are limited and that all technology is not necessarily good in all circumstances. This lesson is surely applicable, in general terms, to developing countries.

A broader consideration of the role of medical technology may be an appropriate starting place. Should a country invest in computed tomography or immunization? Is the technical knowledge and skill available in the country to operate and maintain intensive monitoring equipment? Does it make sense to develop sophisticated diagnostic capabilities to detect diseases that could be prevented? These are the kinds of questions that must be considered at the level of an entire country or region.

Another important consideration is whether a particular country can develop medical technology to meet its own needs. Generally speaking, this is unlikely. The developing countries are largely dependent on the industrial ones for technology, at least for technology whose production requires capital investment. In the area of health, much of this technology is made up of the drugs and devices of modern medical care, and the process of transfer is controlled by multinational firms. The Associated South-East Asian Nations have made a trenchant observation about this process (*14*): "... we are often abused by sellers who overprice their technologies, let us (or encourage us to) purchase inappropriate technologies, or do not actually transfer know-how." It seems evident that if the developing countries are to manage the transfer of technology, they must have some independent capability to do technology assessment. For example, strengthening existing laws concerning the importation of drugs or enforcing those that are on the books would go far in addressing the problems of inappropriate prescribing so prevalent on much of Latin America (*15*).

Technology assessment can be applied to any type of technology. This means that it can be applied to systems and programs attacking problems on a regional basis. The principles of assuring that benefits and risks are in balance and that the costs are as small as possible apply very well to the current effort to develop primary care services. Technology assessment can help assure that the population is provided with services to meet critical needs; health problems in a particular area can be specified and programs built on the basis of effective interventions. There is little point in developing a program to combat a particular disease if no effective preventive or treatment technology is available. Walsh & Warren (*16*) have followed this principle in proposing a basic set of effective and cost-effective services: (1) measles and DPT vaccination for children over six months old; (2) tetanus toxoid for pregnant women; (3) encouragement of long-term breast-feeding; (4) chloroquine for children under three years old in

malarious areas during febrile episodes; (5) making of oral rehydration packets and instructions widely available.

Technology assessment can also be used as a guide to technology development. Analyzing a problem may point up needs that can be met through existing technology or the application of technological capabilities. In the smallpox eradication program, for example, it was necessary to develop portable refrigeration units to prevent loss of viability of the vaccine, and these units are continuing to be used in other programs.

Paradoxically, because of limited resources, technology assessment has been used less in the developing countries than in industrial ones, yet the need for it is probably more critical in the former. Although it is not a panacea, technology assessment is an important part of a strategy to provide effective and appropriate health care for all.

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Ciro A. de Quadros

Appropriate technology in the extension of immunization

Vaccination schedules worked out in a developed country may be quite inappropriate in a less developed setting, in which people work longer and may have no transport. The number of contacts between subject and health service must be kept to the absolute minimum.

Six preventable diseases of childhood are now included in WHO's Expanded Programme on Immunization: diphtheria, tetanus, whooping cough, measles, poliomyelitis, and tuberculosis.

Although these diseases are now well under control in the industrial world, they continue to kill or cripple millions of children every year in the developing countries. Measles and whooping cough have case fatality rates ranging from 1% to 10%. Of the newborn infected with tetanus, 70–90% die. Virtually every nonimmunized child is infected with one or more of the polioviruses; this infection results in paralysis in about 1% of children under the age of 3 years, and death occurs in approximately 15% of paralytic cases. There are some 3.5 million new cases and half a million deaths from tuberculosis in the world each year. Morbidity and mortality from diphtheria are less well defined, but over 100 000 deaths are believed to occur annually in the world among children under 5 years of age.

The Ten-Year Health Plan for the Americas, which was approved in Santiago, Chile, in 1972, and several World Health Assembly resolutions have called on WHO Member States to intensify immunization activities within their primary health care systems. The objective is to ensure that by 1990 all children will be provided with immunization services.

My focus is on some aspects of management that are crucially important for large-scale application of more appropriate technologies aimed at reducing morbidity and mortality from the target diseases—specifically, on a low-cost, resource-saving, appropriate, minimum immunization schedule that can be used to increase protection in the high-priority groups.

The Target Groups

One of the basic principles of the Expanded Programme on Immunization is to concentrate immunization activities on two relatively small target groups: infants below one year of age and pregnant women.

There are a number of reasons why infants under one year of age have been given priority. They constitute a relatively small group (3–4% of the total population, compared with children under five, who make up 15–20% of the population) the vaccination of which will prevent a large proportion of the vaccine-preventable diseases and deaths in early childhood; and they are the group that will benefit most from vaccination. In countries with low vaccination coverage, the six chosen diseases are common and attack most children at an early age, with the result that many children have already had the diseases while still very young. Vaccinating those who have already had a disease and hence become immune to it

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is a waste of resources and personnel. It is better to concentrate the limited amount of resources on the under-one-year group.

It must be emphasized, however, that continuity and regularity are essential. Obviously, a new group requiring vaccination is born each year; and a programme that cannot vaccinate all, or nearly all, the children born each year will not be able to keep the diseases under control. Immunization services should be designed so that they can be maintained; their effectiveness will be much greater than that of mass campaigns, which do not achieve high coverage of the target groups on a regular basis.

Problems of Immunization in Developing Countries

Immunization programmes in developing countries face a number of specific problems. Limited resources are a major obstacle: health budgets commonly have only US$ 3–10 to spend per person per year for *all* services and are insufficient for purchasing the necessary equipment and vaccines and paying operational costs; the supply of health personnel is inadequate to meet the population's needs; and there is not enough transport for moving vaccines, personnel, or equipment. Much thought must be given to allocating scarce resources to activities that promise the best return for what is invested.

Another consideration is the demands immunization programmes make on family members who, in bringing their children for vaccination, have to spend time travelling to and from the health facility and then spend more time waiting until the vaccination is actually performed. Especially for poor families, whose children are at greatest risk, this expenditure of time and effort can represent a real hardship. When vaccinations are spread out and require many contacts with the health service, the difficulties mount. It is generally true that the greater the number of contacts required to complete a vaccination schedule, the lower the coverage of the total population. The vaccination schedule must be arranged so that the smallest possible number of contacts is required between the child or pregnant woman and the health service.

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A Minimum Vaccination Schedule

In light of the objectives of the Expanded Programme and the necessity for making as few contacts as possible with the health service for immunization purposes, the vaccination schedule given below, which is being used in some countries of the Americas, is considered appropriate.

If the third DPT/polio dose is scheduled for administration at the same time as the measles vaccine at nine months, the number of con-

Vaccination schedule

Vaccine	Target group	No. of doses	Age at first dose	Interval between doses
Measles*	Under 1 year	1	9–12 months	—
Polio*	Under 1 year	3	2–3 months	1–3 months
Diphtheria-pertussis-tetanus*	Under 1 year	3	2–3 months	1–3 months
BCG*	Under 1 year	1	At birth	—
Tetanus toxoid	Pregnant women	2	During pregnancy	1–2 months

* All these vaccines can be administered simultaneously.

tacts will be four; and if BCG is administered with the first, second, or third dose of DPT/polio, the number of contacts can be reduced to three. At each visit a child can be given as many vaccines as are indicated by his or her age. For instance, a three-month-old can be given DPT (injection in the thigh or buttocks), BCG (intradermal injection in the right upper arm), and polio (drops in the mouth). Studies have shown that vaccines given together are as effective (or nearly so) as when given separately; furthermore, simultaneous administration of vaccines does not increase the risk of reactions or complications.

The above schedule can be implemented with minimum resources, and facilitates the extension of protection to most of the target population.

Any country with sufficient resources to guarantee that all (or almost all) children under one year of age follow this minimum vaccination schedule can then embark on more ambitious programmes, such as giving booster doses, vaccinating all women of childbearing age with tetanus toxoid, or adding other vaccines (e.g., rubella, yellow fever) if particular diseases are public health problems.

Conclusions

Having potent vaccines available will serve no purpose unless they are used to immunize those who need them. The Expanded Programme on Immunization has therefore emphasized not only the equipment necessary to produce and ship vaccines but also the management skills necessary to ensure that children are actually vaccinated. Accordingly, the vaccination schedules and target populations that were established for the industrial countries have been re-evaluated in terms of their appropriateness to conditions in developing countries. Numerous visits to a doctor may be practicable in industrial societies, where transportation is not a problem, but they pose a serious obstacle to immunization efforts in developing countries, where a visit to a clinic can mean a two-hour walk.

An appropriate immunization technology is one that requires the least resources—for both the provider and the consumer—yet still ensures effective coverage of the population. In view of the evidence supporting simultaneous administration of vaccines and the feasibility of extending the length of time between doses, it is appropriate, in areas where coverage is now inadequate, to use a vaccination schedule that will require only three contacts to immunize a child fully. Countries should not be locked into the vaccination technologies developed by others to meet particular needs and problems; rather, they should devise and apply innovations that do not reduce safety and effectiveness yet are better suited to their own situation. □