APPROACHES TO PLANNING AND DESIGN OF HEALTH CARE FACILITIES IN DEVELOPING AREAS

Volume 4

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TENTATIVE SYNOPTIC TABLE OF TOPICS TO BE COVERED IN THE SERIES

(The numbers in parentheses indicate the volume in which the topic is dealt with)¹

Prerequisites for planning

Legislation (1)
Standards (2)
Machinery for planning (2)
Training for planning (4)
Training for management (4)
Mechanisms for community involvement (4)

Area-wide planning (1,2)

Regionalization (2)
Types and functions of facilities with regard to resources and coverage
Coordination and cooperation between facilities: the referral system (2)
Political, social and economic aspects of allocation of resources
Health manpower, functions and facilities
Emergency service strategies

Tools for planning

The planning team (2)
Information requirements and sources (concerning population served, health services, and techniques involved)
Functional programming (interrelationships between policies, functions, equipment, and architecture (1)
Standardization and rationalization of both the process and the product (1)
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Planning of individual facilities

Steps in planning and provision for expansion and remodelling (2)
Time scheduling for design and construction (4)
Economic aspects of planning and operation
Relationships (client/architect/engineer/contractor) (4)
Site selection (4)
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Teaching hospitals
Specialized hospitals and departments

Planning of parts of facilities

Inpatient areas (3)
Intensive care unit
Outpatient services (3)
Emergency
Operating departments (3)
Burns department
Laboratory (4)
Pharmacy department
Radiology (3)
Rehabilitation
Central sterile supply

¹ Different aspects of a particular topic may be covered in different volumes.
Dietary department
Administration department
Laundry (4)
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Case studies
INTRODUCTION

PLANNING, BUILDING, AND OPERATION OF HEALTH CARE FACILITIES IN THE PERSPECTIVE OF THE DEVELOPMENT OF PRIMARY HEALTH CARE: SOME VIEWS BASED ON CASE STUDIES

B. M. Kleczkowski

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1. BACKGROUND

Through the World Health Assembly in 1977, nations made a commitment to "the attainment by all citizens of the world by the year 2000 of a level of health that will permit them to lead a socially useful and economically productive life" (1). At the Joint WHO/UNICEF Conference at Alma-Ata in 1978, it was declared that primary health care was the most promising vehicle for "attaining the target of health for all by the year 2000 as part of overall development and in the spirit of social justice" (2).

This new approach will certainly have its impact on the planning, building, and operation of health care facilities. It is therefore imperative, in order to avoid costly mistakes, to consider carefully what should be the place of these activities in a health system based on primary health care and what are the constraints to be overcome.

The implementation of primary health care usually starts from a situation characterized by considerable inequities in the distribution of health resources, especially health care facilities; by a medical establishment living mainly in cities with every professional and financial incentive to preserve the status quo; by legislation that sometimes stands in the way of a change in the distribution of responsibility for health tasks; and by a strong bias in favour of technology developed in affluent countries but inappropriate in the context of developing countries. What steps should be taken to remedy this situation? How can the functions of health care facilities be redesigned to provide efficient support to primary health care without usurping tasks that logically are not theirs and without absorbing money that would be more effectively used on tasks performed in other settings? How can scarce resources be rationally allocated and used at all stages in the development of health care facilities (planning, construction, and functioning) so as to meet at least the absolute priority needs and to avoid waste? How can equipment be standardized and simplified so that it can be easily maintained and repaired? How can the simplest possible logistics system to provide essential supplies be developed? Lastly, how can the teaching process and curricula be modified so that they correspond to new health development policies and cease to produce medical manpower that can only function with the aid of expensive facilities?

There are no single answers to these questions and as yet only partial solutions to the problems involved. But it is urgent to determine, as soon as possible, in what direction the answers should be sought.

For some time WHO has been endeavouring to dispel some erroneous views that have proved costly to developing countries.

For a long time, it was generally assumed that health care facilities in developing countries should follow the patterns prevalent in more developed countries and that only a few modifications, mainly to take climatic conditions into account, need be contemplated.

This view is still held by some architects inexperienced in, or insensitive to, the problems of developing countries but desirous of entering a promising market and, in developing countries themselves, by some doctors who would like to have at their disposal the sophisticated means they have become accustomed to during their studies or travels abroad, and by some decision-makers - sometimes outside the health field - lured by the prestige of having a hospital with sophisticated technology, even though the desirability of this is beginning to be questioned in the more affluent countries themselves.

However, on the one hand there have always been people, whether decision-makers, planners, architects, or doctors, who are keenly aware of the importance of taking into account the implications of a situation characterized by limited resources in staff and money, harsh climates, insufficient or unreliable utilities, and specific social and cultural traits. Consequently, many hospitals and health centres in developing countries could be cited as examples of reasonable and appropriate planning. On the other hand, facilities merely copied from affluent countries began to be the subject of serious criticism when they proved unduly costly to construct and run, difficult to manage, and sometimes so inappropriate that they were never commissioned.
Unfortunately such costly mistakes, though often a lesson for those who had to suffer from them, did not receive the publicity they deserved, so that the same errors were repeated over and over again. In addition, the almost total lack of publications proposing reasonable approaches adapted to conditions in developing countries made it impossible for planners and architects in those countries to rely on tried, well-documented guidelines.

It is in this context that WHO decided, in 1972, to undertake a study on the planning, programming, design, and architecture of hospitals and other medical facilities in developing countries and to disseminate its results through a series of publications.

While it was believed that this study would eventually lead to the publication of manuals, or monographs, on the subject, it was considered urgent to provide, at first, a means, however imperfect, of permitting users to make sure that the relevant problems had been identified, proper methods chosen, local constraints envisaged, and the various alternatives considered before a decision to build a facility was taken. An effort was therefore made to deal with a series of specific subjects of particular concern to health administrators, planners, and architects and to do it in such a way as to sensitize them to each other's problems and constraints. This is why, in each of the volumes of the present series, Approaches to Planning and Design of Health Care Facilities in Developing Areas, subjects of relevance to these three kinds of readers have been treated without attempting an exhaustive coverage of the topics under consideration.

So that the study could take into account, as fully as possible, the concerns of other interested bodies, the WHO Regional Offices, the International Hospital Federation (IHF), and the Public Health Group of the International Union of Architects (IUA) were consulted and involved from the outset.

An example of this common approach was the convening in Nairobi, in November 1974, of a Joint IHF/IUA/WHO Seminar on Planning and Building of Health Care Facilities under Conditions of Limited Resources. While this meeting demonstrated that some of the participants had not yet grasped the specificities of planning health care facilities in developing countries, it greatly helped, through some outstanding presentations and lively discussions, to dispel certain misunderstandings of long duration, and its findings were widely disseminated by publication in two special issues of World Hospitals (3).

After the publication of the first and second volumes of WHO's Approaches to Planning and Design of Health Care Facilities in Developing Areas, it was decided to carry out a series of country-based case studies, which would show how, under what constraints, and with what results, the planning and achievement of the health care infrastructure was taking place in practice. It was thought that the mistakes identified might be of great value, provided their causes were elucidated and their consequences analysed. Original solutions to recurrent problems could be followed up so as to determine whether they could be adapted to different contexts. Thanks to financing from the Swedish International Development Authority (SIDA), case studies were conducted in six countries: Algeria, Cuba, Senegal, Sudan, Venezuela, and Zambia. The results are now being analysed and volume five of the present series will be entirely devoted to these studies.

In each instance, the study was so devised as to be of immediate utility to the country involved: for example, in the Sudan, it served as a pilot study and was concluded by a meeting at the highest national level where the findings were discussed and important recommendations formulated concerning follow-up measures.

At the same time, WHO Regional Offices were conducting studies and developing projects of great potential value. Among these can be cited the project in the Region of the Americas to promote national systems for the maintenance and engineering of health care facilities, which was carried out in Venezuela and later extended to other Latin American countries; and the Subregional Congress on Health Care Facilities Programming, Development, and Maintenance, convened in Venezuela in 1980, which was the preparatory phase of a project involving the countries of the whole Andean Region (Bolivia, Chile, Colombia, Ecuador, and Peru). In the
Western Pacific Region an intercountry project on hospital management, design, and maintenance has been developed and supported by the UNDP (United Nations Development Programme). In the South-East Asia Region, there have been various activities concerned specifically with facilities in relation to basic health services. In this region, too, the problems of equipment maintenance have received much attention.

2. REVIEW OF CURRENT PROBLEMS AND APPROACHES

Current problem areas and relevant approaches can best be described according to the phases of the facility planning, building, and operation process in which they appear.

Planning of services and facilities

(1) The need to define tasks

Health care facilities are essentially only shelters in which health care functions are performed. Until those functions are defined, the real building needs cannot be identified. It is thus necessary to have a planning process capable of assessing priorities among health problems and of defining the health care tasks required to deal with these problems at various levels (for example, a process like that attempted by Country Health Programming). Through such a process, some countries are trying to identify feasible and affordable groupings of tasks, thus ascertaining the types of manpower required by defining their roles and responsibilities. Only then can it be determined what buildings, equipment, and drugs are needed for health care purposes. In short, health facilities are the result of an overall process of health service planning - they do not lead to it.

In the present attempts at planning health services oriented to community problems, the key issue is: what cost-effective package of services is likely to achieve the most relevant and equitable distribution of health care? This package includes health care facilities, but is not based on them. Practical experience, including that gained through the case studies, has shown that many primary health care tasks can be performed without special buildings - in houses, schools, workplaces, or even out of doors. Nevertheless, some tasks are much more adequately performed in a building designed and built with those particular tasks in mind. Such a building could be needed at the primary health care level, or, when a certain degree of technology becomes involved, could constitute the secondary health care level. The tasks in question do not necessarily involve high-technology medicine but may consist of simple surgery (4), the management of difficult births, the treatment of accidents, or diagnostic examinations requiring certain equipment (5). They do not need complex buildings but may greatly benefit from the availability of facilities of a reasonable standard (6). However, the planning, design, and operation of buildings to house them do present many opportunities for expensive mistakes.

In such a framework, hospitals could, and in fact would, support and complement primary health care. Care should be taken, however, in allocating resources, to ensure that they do not profit at the expense of community-based health efforts and supporting facilities.

The role of the hospital in the primary health care context will inevitably change, and it is difficult to predict the full extent of that change until primary health care programmes have become more firmly established. For example, the "by-pass phenomenon" will diminish as the quality and relevance of care at the community level improve. In any event, the rigid polarization between advocates of hospital development and partisans of primary health care development is quite irrelevant, since hospitals, albeit in modified form, and primary health care should both be integrated into a convenient local health system, with clearly defined essential requirements in terms of manpower, facilities, and supplies relevant to the health tasks to be performed. While special importance must be attached to rural health care, the increasing problems of primary health care in underserved urban and periurban areas should not be overlooked.

Constraints on effective task definition and allocation include an insufficiency of epidemiological and other data on community needs, leaving decisions on the type of services required to be determined on the basis of inadequately informed demands. Also, the attitude
prevailing among medical groups with a vested interest in the status quo, to the effect that the bulk of cases dealt with at primary level are trivial, leads them to go on to push for a "facility-oriented" plan. For example, in one of the countries taking part in the case studies, physicians had recently gone on strike to back the demand for more resources for hospitals.

At the facility planning level, the development of inappropriate buildings is often due to the lack of a task definition (or architect's briefing), or failure to communicate it, and also to an unrealistic view of the kind of medical and construction technology that would be locally appropriate. Even where facilities are built according to a sound brief they are often not used correctly, because of special local conditions such as lack of equipment or the particular interests of the staff. It is to be noted that, in two of the countries participating in case studies, all facilities from the primary health care unit to the district hospital formed a well-defined system. As each type of facility has a standard staffing pattern and, in principle, covers a defined range of population, the ratio of functions to facilities and population is apparently excellent. However, in one of these countries, because of lack of supervision and the existence of a "by-pass phenomenon", the reality is often far removed from the theory, while, in the other, where there is good supervision and little by-passing, reality and theory converge.

11) Intersectoral coordination

One of the problems in health facility planning in many countries, particularly those with market economies, lies in the multiplicity of decision centres. Sometimes this reflects positive developments, such as the participation of other sectors and the community itself in the financing and building of facilities. However, it often puts a strain on the coordinating function of ministries of health and other health authorities and requires them to have strong planning and administrative capabilities, as well as political and legal "clout".

For example, pledges by health authorities to staff and operate new facilities and extensions constructed through self-help have led to premises being built outside the supervision of the relevant technical unit and with serious structural defects; elsewhere, more disturbingly, wards are being added to hospitals without regard to the size limits set in the national plans, while preventive functions in the same areas are being neglected. In some countries, particularly in Latin America, social security funds build their own networks of facilities, many of which would seem, from a national viewpoint, to be redundant. In other countries, important economic complexes (mines, plantations, etc.) construct and operate facilities without regard to the balance and guidelines of the national health care system. There are also many cases in which ministries of education or defence have developed conventional teaching hospitals, or other specialized facilities, without considering their function in coordination with the national, regional, or local health systems.

Many epidemiological priorities demand more than just health services for effective intervention and control. They require efforts in such areas as water supply and sanitation, housing, employment, and food. This implies a more effective cooperation of health authorities with other sectors, at both national and local levels, in order to achieve a better coordination of all health-related tasks and activities.

There are sometimes problems of liaison between the ministries of health responsible for planning health care facilities and the public works departments dealing with their construction. This is often due to inadequate staffing resulting in a lack of architects in the Ministry of Health to brief and evaluate projects, or the absence of a proper "health unit", capable of physical planning for the health sector, in the Ministry of Works. One of the countries participating in the case studies had an efficient system consisting of an interministerial planning committee that met every week. Problems of cooperation between ministries affect not only the design and building process but also provisions for maintenance, an area in which responsibilities are not always defined. In a few countries, the health authorities have maintenance teams at their disposal for interventions at all levels; in others, such teams exist only in large hospitals; sometimes even this is not sufficient, and maintenance jobs are contracted out to the private sector. One of the countries participating in case studies is carrying out programmed preventive maintenance, which is more effective than just dealing with emergencies after they have occurred.
(iii) Planning capabilities

More effective planning is essential, if cost-effective health services are to be developed and if facilities are to play an appropriate and cost-effective part in those services. It is at the point at which an overall plan for health facilities is being derived from the plan for health services that some of the most costly mistakes are made. These of course are often due to lack of task definition, resulting in the poor briefing of architects and physical planners, or to insufficient coordination between various sectors. However, there can be other problems. One of these is the shortage of basic situational information.

There are several ways of collecting the necessary information. A national inventory of facilities and heavy equipment, periodically updated through surveys, visits, or reports, should provide, for the entire country, a minimum of information on the number and types of facilities, their age, present condition, and main problems (7).

Even where the basic information exists, ministries of health often lack the physical planning capacity to develop it into a comprehensive physical plan relating health service priorities to an action plan for the development, rehabilitation, and upgrading of facilities (8).

This aspect of national activities needs significant strengthening. Any national efforts should be supported, if need be, by international agencies. External technical and financial assistance would be much more effective if directed towards the support of planning activities rather than the construction of isolated facilities of a conspicuous kind.

A plan for health facilities does not of course stand in isolation, but is merely a component of the overall health strategy which would also include plans for manpower, supplies, transport, etc. It must also be developed in relation to the intersectoral aspects of national planning.

The advantages of integrating the plans for building health care facilities into more comprehensive plans covering the entire infrastructure of community services for an area are quite clear from some case studies. Health care facilities are limited in their effectiveness if all-weather roads, water supplies, and electricity are not available on the spot. Multi-service modules, providing facilities not only for health care but also for a series of community services such as education, shopping, etc., are another example of comprehensive physical planning.

Health planning authorities often have very weak links with the agencies responsible for the physical design, construction, and maintenance of facilities, which are often under the Ministry of Works. As a result, planners may lack sufficient structured information about existing facility inventories, prevailing capital, and recurrent costs, or maintenance budget requirements.

There are several ways of alleviating this problem. In one of the case-study countries, planning for development projects starts at the local level. Local proposals are comprehensively discussed at the provincial level, then a provincial proposal goes to the Ministry of Health. The Ministerial Advisory Committee, composed of all Directors and Assistant Commissioners of Health, the Ministry of Construction and Public Works being represented by the Chief of the Health Projects Unit, approves or amends this proposal within the framework of the indicative budget figures provided by the Ministry of Finance, before it is transmitted to the National Planning Commission.

In other countries, planning units have been set up in the Ministry of Health to prepare basic functional and architectural programmes for facilities and to control and approve designs prepared by the Ministry of Works. To take an example, the planning unit in one country consists of the Assistant Director of Medical Services, a doctor, a medical research officer, a statistician, a health planner, and an architect.
Facility design and implementation

(1) Shortage of designers

The shortage of trained and experienced designers of health buildings is one of the main obstacles to the implementation of an appropriate building programme within the health service framework. This shortage occurs at every level - central, provincial and district - and also at the different stages of implementation.

Architects are frequently not involved in formulating the building "brief" when decisions relating to the size and scope of facilities and to their general standard of construction and equipment are being made. At the design and production stage, excessive project loads lead to a general lowering of professional standards and the easy adoption of ad hoc designs (prepared initially for one location) as standard solutions. Construction is generally unsupervised since manpower resources are scarce and centralized, sometimes with disastrous effects on building quality and durability. The evaluation of completed projects is rarely assigned high enough priority to justify the manpower that would be needed.

All these problems are serious enough; however, a more fundamental problem is created by the shortage of building designers. In achieving the goal of "health for all" through the medium of health systems oriented towards primary health care, there needs to be a fundamental rearrangement of building and equipment priorities involving completely new building types, design approaches, methods of construction, uses of material, and modes of implementation. As long as the available manpower remains barely adequate to keep pace with the demands of on-going programmes, it is highly unlikely that this rearrangement of priorities will take place.

The shortage of building designers is aggravated by their frequent lack of experience or of special education in the field of health buildings in general and the requirements of primary health care facilities in particular. Architects in ministries of works are frequently expected to cope with a wide range of other building categories and are often not able to build up sufficient experience in the design and construction of multidisciplinary health units. Those who do develop the necessary expertise are often attracted into the more lucrative private sector in their own country or, worse still, abroad. Specialized training is rarely available locally, and training overseas is generally not relevant to the needs of developing countries, leading to inappropriate designs and professional dissatisfaction.

Attempts to mitigate the problems arising from the shortage and inexperience of health building professionals have met with varying degrees of success. A search for appropriate technical literature and the use of foreign or local architectural and engineering consultants are probably the most common tactics.

(11) Lack of appropriate technical literature

A major problem facing the designer of health care facilities in developing countries is a lack of relevant technical literature. The vast bulk of written material in the health field has been produced in developed countries and, although it is no doubt possible to extract some useful information from it, the hard-pressed architect in a developing country is not likely to find the time or opportunity to do so. Indeed the record shows that in too many cases this material is misapplied, the resulting buildings being inappropriate and generally extravagant.

In recent years, a number of technical papers (e.g., the present series) have been prepared for use in the developing world. However, the problem of how to make the intended users in developing countries aware of the existence of this material remains to be solved. In addition, much of it was not designed with the actual implementing architect in mind. However, there is no doubt that the production of more relevant literature has had a beneficial effect on ways of thinking and that there is now a sounder basis for further advanced guidelines.

Evidence of the lack of good design and technical guidelines is found throughout the case studies. Simple planning mistakes such as mixing outpatient and inpatient movement, or positioning the "scrub-up" between the sterilizing facilities and operating theatre, could be
mentioned. Frequently, designs were found demanding the use of mechanical ventilation, although the electricity supply was unreliable. Similarly, a water supply dependent on electric pumps meant that from time to time hospital buildings were unusable. Simple errors in foundation design rendered some of the hospital rooms dangerous to use.

Many of these mistakes are due to a lack of systematic exchange of information and to insufficient cooperation between developing countries. Sharing of bad as well as good experiences, communication of standards and plans, and exchanges of personnel would permit the regional pooling of scarce technical knowledge and resources and also facilitate research on problems common to a number of countries.

(iii) Use of consultants

Foreign consultants, often despite long experience of working abroad, are frequently inexperienced in, and lack motivation for, development work. Nevertheless, they are usually welcomed since their fees are often covered by bilateral aid agreements. Since they are used to working on large-scale projects with sophisticated manpower, materials, methods, and equipment at their disposal, they often produce inappropriate and out-of-scale solutions which are expensive to build, frequently imply an organization and staffing pattern ill-adapted to local manpower resources and skills, and are inordinately expensive to run. As the costs have to be borne by the country year after year, they very rapidly offset any gain that may accrue from a free consultant or even a free building.

The use of local consultants is to be preferred because they are more likely to be familiar with local conditions and also because the experience they gain should be retained within the country. There is, nevertheless, the question of fees (usually based on construction costs) which may make them look on simple buildings as unattractive propositions.

An alternative or supplement to the use of consultants is to secure technical assistance personnel. These sometimes have specialized knowledge of health facilities, although this has often been gained in developed countries and may lead to problems similar to those experienced with consultants. Even if their experience has been gained in other developing countries, they constitute a stopgap solution and will take their experience with them when they go.

(iv) Use of standard designs

The development by countries of standard or "type" designs can have several advantages. In particular, it economizes on architectural manpower in the implementation stage, theoretically allowing architects to concentrate on the briefing and design stages so that a better design can be produced. Unfortunately the additional design input required to produce good standard designs is not always forthcoming or is badly organized, and, as a result, expensive buildings proliferate. Type designs are usually not adaptable enough to meet regional variations in geography, climate, local customs, building materials, and health service requirements. To cope fully with such variations, a range of subtypes is required, and particularly a range of different sizes of facility, if overbuilding is to be avoided in sparsely populated areas.

Observations in the countries where case studies were carried out were generally favourable to the use of standard designs, especially in contrast to more ad hoc solutions. In one country, standard designs were being modified at the regional level to meet local requirements. This brings out the need for functional programmes to accompany the building plans so that the implications of design changes can be fully understood.

However, certain important problems are associated with the use of standard designs in nonindustrialized countries. Sometimes they are not appropriately followed, particularly by executants not belonging to the Ministry of Health. Elsewhere they may be followed too rigidly. A range of designs is necessary, even for the same type of facility, to allow for regional variations in climate, building materials, and possibly customs. Besides, the use of standard designs tends to promote "resource-oriented" programmes, perhaps at the expense of more relevant programmes not based on facilities.
A large number of buildings of a particular design should not be constructed until the first ones have been evaluated, otherwise mistakes are likely to proliferate. However, very few countries, if any, appear to be carrying out any functional evaluation of their health care facilities. Here one may cite the example of an outpatient department that was constructed in a way permitting various rearrangements of the space, so that it was possible to experiment with alternatives and choose the more adequate ones for wider application (9).

The possibility that type designs might reduce construction costs would depend upon the degree of industrialization in building techniques. One of the countries taking part in the case studies has opted for completely standardized designs because it has decided to base its entire construction effort, notably in health, education, and housing, on prefabrication. However, there is as yet no broad evidence that prefabrication will produce economies in production, and indeed it seems that it is distinctly unsuitable for many developing countries. On the other hand, type designs could lead to a more rational use of traditional materials and subsequent reductions in cost.

(v) Use of local materials and skills

From virtually every point of view, the fullest possible use of locally available building skills and materials is a valuable means of providing appropriate facilities. Conversely, the extensive use of imported skills, materials, and technology has tended to result in an architecture out of sympathy with local functional requirements, geographical conditions, climate, and cultural values. Imported materials and equipment are expensive to buy, use up foreign exchange, and are difficult and costly to maintain or replace.

The use of local materials and skills obviates most of the above problems, with the added developmental benefit of encouraging local employment and industry. In this context, community involvement through self-help projects was noted time and again in the case studies to be extremely valuable. In one country, 50% of rural building expenditure was provided locally. In another, the cost of facilities constructed by the community was only 3% of that of government-built facilities of the same type.

The involvement of the community in the development of its own health care facilities is generally valued very positively (though there is no doubt that further research would be needed for it to realize its full potential). In most cases, it means that the community builds, or helps to build, a facility by its money, work, or both. The health authorities then run the facility and pay either all running costs or staff expenses only. It is important that the health authorities should have their say at the outset, so that they should not have to run badly conceived or badly placed facilities, or facilities contributing to imbalances in the distribution of services.

Some operational considerations

(i) Costs and maintenance

In general, a more comprehensive view of costs, embracing planning, construction, and recurrent expenses, should be taken, especially since the recurrent expenses over a three-year period often equal the initial building costs.

There are many ways in which long-term costs and efficiency can be influenced by design and construction. Overextended facilities or units, in which "zoning" of activities and circulation flows have not been properly thought out, automatically imply that staff requirements will be 5%, 10%, or 15% higher than they should have been. There were several examples of this in the case studies. If the operational budget is not sufficient, as happened in one country, then the facilities are understaffed, undersupplied, and underutilized, which is equivalent to having wasted a part of the investment effort. As a result of faulty building techniques in some areas, heavy repairs were needed shortly after the inauguration of the facilities. On the other hand, a narrow concern for costs may result in inefficiency in the long run. In one country participating in case studies, for instance, the National Controller's Office set the single criterion of "lowest price" for the selection of suppliers of equipment; this greatly hindered the rationalization of equipment, with serious consequences for maintenance, acquisition of spare parts, and training.
The maintenance of buildings and equipment cannot, however, be considered solely as an economic problem. Often building design has failed to take into account the shortage of trained maintenance staff and the advantages of using local and more readily available materials and equipment. There are also many examples of inadequate control and supervision of maintenance staff, often because maintenance was outside the control of the Ministry of Health.

The case studies revealed several examples of poor motivation and organization of general maintenance staff. Cleaning often consisted of washing floors only at lengthy intervals between official inspections. The occurrence of broken pipes and fused electrical systems was often ascribed to lack of staff with basic training in utility maintenance.

Especially in the case of equipment and vehicles, lack of standardization and control of purchasing leads to such a proliferation of types and manufacturers that the stocking of adequate spare parts is impossible. For more sophisticated medical equipment, maintenance personnel are often trained by the supplier and, as a result, are unable to repair the equipment of other manufacturers. The problem of standardization is sometimes further exacerbated by gifts of equipment from donor agencies, by trade agreements between countries, and by the obvious need to find the best value for money. In the last respect, the tendering system of purchasing leads to overdiversification, if tender lists are not restricted.

(11) Shortage of managers

There are shortages of trained and experienced managers at all levels of health care services. At the local level in particular, managerial-type functions are left to medical practitioners (usually hospital doctors) who are invariably so fully occupied with clinical duties that they neglect their management functions.

How facilities are operated is a question of routine administration, and inadequacies at this level are reflected in such things as lack of cleanliness, nonobservance of aseptic or antiseptic procedures, faulty scheduling of staff time, maldistribution of patient arrivals, and defective provision and use of supplies. Most of these shortcomings must be imputed to a lack of proper supportive supervision.

Some positive aspects of organization and management were identified through the case studies: staff meetings in hospitals, control of personnel tasks, programme maintenance, financial accountability, well-defined catchment areas, and well-kept facilities. On the other hand, it was noted that, in some units that were perfectly adequate from the design point of view, some rooms were overcrowded, while others were underused, and that this was chiefly a problem of management.

The shortage of effective managers in health services can be ascribed partly to a lack of candidates due to the unattractiveness of the job compared with jobs in the private sector, partly to the lack, in some countries, of training facilities and career prospects specifically geared to health administration, and partly to the excessive burden of responsibility, combined with relative lack of authority, usually imposed on health administrators. The shortage of managers leads to the badly organized use of facilities and equipment but, conversely, buildings should be so designed as to simplify the task of the manager, who should be closely involved in the preparation of the architect's brief. As in other personnel areas, shortfalls could be mitigated by the availability of management tools such as job descriptions, and by procedural guidelines and building manuals.

The diversion of medical officers' time into management was noted, though no alternative solution was seen to this as long as they cannot be relieved by qualified nonmedical administrators. However, in countries where hospital directors were qualified laymen, the system showed distinct advantages.
(iii) **Housing for health personnel**

A contributory factor to the lack of management and other personnel is the common shortage of staff housing, which makes it difficult to recruit and assign staff, especially to rural areas. Though the need for more staff housing is clear, it is as important to maintain appropriate standards in the housing available as it is in the medical facilities themselves.

Most of the countries participating in case studies provided houses in the rural areas, but these were usually insufficient in number. One developing country with a socialist economy emphasized that all the staff, in all locations, were provided with housing of the same standard as that available to all other workers. In another country (of the market economy type), legislation had been passed obliging the government to build houses for doctors posted to small towns or settlements.

3. **CONCLUDING REMARKS**

Since many developing countries are staking large investments in vast national networks of health care facilities, the success or failure of their planning, building, and operation is a priority issue. Health administrators need, therefore, to be fully aware of all the many phases of the facility-planning process, from the formulation of national health and investment policies to the construction, maintenance, operation, and eventual replacement of each individual facility. In particular, they should be aware of the extent of their direct responsibility, since most of the problems detected in the case studies are attributable to omissions or deficiencies in the very first stages of the process: the formulation of an overall national health policy and plan, and the design of the health system infrastructure. Emphasis must be placed on the fundamental importance of a balance between the different types of organizational unit and the different levels of care. This balance should centre on the guiding principles of universal accessibility to essential services, economic affordability and efficiency, and manageability of the organizational units. It cannot be asserted categorically that one type of facility or another should be promoted or discouraged; each country should identify its own imbalances and strive to correct them. Usually, it is the primary level of a health system that has to be built up, and then the more central supporting elements. The technical and managerial cohesion of a balanced health system is easy to achieve by applying the principles of regionalization (10). This is, for example, the only means of reducing the anomaly of the bypassing of peripheral units by users of services, leading to the underutilization of these units and the overutilization of the larger and more costly facilities. The harmonization of the health system infrastructure with other components of the environment, such as roads, communications, energy sources, the way the community is organized, and the local culture and economy, is also essential to proper health system design and hence to appropriate decisions on the number and types of facilities required and their location. Integrated physical planning of all essential services for certain communities was observed in some countries included in the case studies, and this appears to be a solution that should be carefully taken into account by national policy-makers.

It was this type of finding that led to the progressive description and analysis of the entire health system in each of the countries included in the case studies, side-by-side with the architectural design and construction aspects. The lessons learnt in this way are being distilled and communicated to the appropriate decision-makers in different countries. The national process in this area should be interdisciplinary and multisectoral, as the planning of health care facilities requires. It may be started or revived in the countries where case studies have been, or are likely to be, undertaken, by means of workshops in which evaluation results can be discussed and used as a basis for recommendations for action.1

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National initiatives of this kind would be the best basis for international cooperation in the planning, building, and operation of health care facilities. They would indicate where support was needed; they would develop the capacity of countries to absorb and adjust the transfer of appropriate technology; they would make useful experience available to other developing countries, thus fostering the application of the TCDC (Technical Cooperation among Developing Countries) approach advocated by the United Nations. Experience shows that national experience can be pooled and exchanged among countries on a bilateral, regional (e.g., WHO's Western Pacific Region\(^1\)), or subregional (e.g., the Andean group of countries) basis.

4. REFERENCES

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3. Planning and building health care facilities under conditions of limited resources, World hospitals, 11(2-3, 4), 54-253 (1975)


\(^1\) See Annex 1 and Annex 2.
ANNEX 1

SUBJECT OUTLINE: PLANNING OF HEALTH CARE FACILITIES IN DEVELOPING AREAS

A. Areawide planning

Health care organizations have to be coordinated into an organizational and functional system; their integration into a structure would also allow joint administration.

1. The system should contain:

1.1 Horizontally considered services (including providers of primary, secondary and tertiary care to a whole area).

1.2 Vertically considered services (organizations coordinated from the upper level and providing problem-oriented functions).

2. Such a system:

2.1 Entails spreading of front-line activities and concentration of specialized activities.

2.2 Requires determination of the scope and range of activities for each facility.

3. In order to achieve the aforementioned, it is necessary to formulate plans for a whole area. Areawide planning is that part of health care facilities planning which aims at the most effective distribution of facilities to provide complex health care. It should be in accordance with the health services system adopted, and this contains three levels (in both urban and rural areas):

3.1 Peripheral - for delivery of primary care (health posts, health centres, primary hospitals).

3.2 Intermediate - for delivery of secondary care.

3.3 Central - for delivery of tertiary care.

B. Planning of facilities

This involves planning of the general features of the facilities in the area, region, or country, and planning of each facility individually.

The location, type, and characteristics of the facilities should be adapted to the levels of care within the area/regional system, considering that each facility does not constitute an independent or isolated service but an integral part of the system.

1. Peripheral facilities/primary care

The great demand for facilities at this level and their simplicity permit the design of standardized model types, which can with slight modifications be adapted to specific conditions. The facilities are:

1.1 Health post:

Entrusted to nonprofessional worker. Usually an existing room or premises made available by the community. Units needed: waiting, work, store.

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1 This subject is part of the section dealing with hospital planning, design, and maintenance in the course "Hospital Administration 204" given at the Institute of Public Health, University of the Philippines, and prepared by Dr R. Eldar, Medical Officer, WHO Regional Office for the Western Pacific, Manila, in collaboration with members of the Institute. This course is designed for participants not only from the Philippines, but also from other developing countries.
Annex 1

1.2 Main Health Centre:

Staffed by professionals. Units needed: administrative, curative, and preventive services, sometimes also beds, laboratory, X-ray, and supportive services. Plans should be flexible, adapted to proportion of working hours devoted to various activities, type of staff needed, and functional relationship. Suggestions:

1.2.1 site and location: accessible
material: local, durable and easy to clean
design: local characteristics
areas: waiting
working area
supporting services
office
beds?
equipment: simple, robust, unsophisticated.

2. Intermediate facilities/secondary care

From this level upwards, studies are necessary of the characteristics of community and specific function of the facility. In the Philippines, these facilities include mainly rural hospitals (emergency, district) but some urban hospitals are also classified as secondary.

2.1 Functions:

2.1.1 Take care of patients:

2.1.1.1 Who can only be properly treated in hospitals

2.1.1.2 Who cannot adequately be treated as outpatients (these could preferably be housed in hostels).

2.2 Basic requirements:

2.2.1 Surgery:

2.2.1.1 Room
2.2.1.2 Instruments
2.2.1.3 Basic services
2.2.1.4 Aseptic technique
2.2.1.5 Blood replacement
2.2.1.6 Anaesthesia.

2.2.2 Radiology:

Allows efficiency of treatment and prevents spread of diseases

2.2.2.1 Conditions for installation: M.D. and easy access to patients
2.2.2.2 Requirements: suite and equipment.
2.2.3 Laboratory:

Complete laboratory not contemplated, but essentials:

2.2.3.1 Room

2.2.3.2 Equipment.

3. Central facilities/tertiary care

General hospitals of various sizes and types, located in medium-sized towns or provincial capitals. They constitute the apex of the region's health services and contain services in at least four specialties and some subspecialties for inpatients and outpatients. They have to be planned, programmed, and designed individually. However, standardization can and must be maintained, so that they can be made to comply with standards at the national level. Medical centres are outside the scope of the regional system.

Suggested reading


ANNEX 2

SUBJECT OUTLINE: HEALTH CARE FACILITIES IN DEVELOPING AREAS

1. Definitions:

1.1 Facility: Something (building, premises, machinery, equipment) built, constructed, or installed to facilitate the performance of some particular functions.

1.2 Health care facility: That constituent of the infrastructure of the health care system which facilitates an environment in which a person can seek and receive health care.

2. Functions of health care facilities:

2.1 To provide shelter for actual activity to be performed (to allow provision of health care at different degrees of technical level and sophistication).

2.2 To serve as a basis for the generation of supportive services necessary for the main activities.

2.3 To enable education, training, and research.

Health care facilities are related to the pattern of health care, represent a sizeable part of the health care system, and have a multiplicity of functions to perform.

3. Health care facilities in developing areas:

In these areas the task at present is to increase the coverage of population groups that do not yet have access to health services, and this is closely linked with the development of a network of health care facilities to shelter and support health activities. Hence the concern for the planning, design, construction, and maintenance of these facilities.

4. Past mistakes:

These have been many and can be found on three levels:

4.1 The conceptual level at which health services development is institution-oriented instead of being problem-oriented, i.e.:

4.1.1 Development thought of in terms of ratios (and without exploring the relationships between facilities and staff).

4.1.2 Development based on the principle that the hospital is the focal point of health services (rather than their apex).

4.2 The level of areawide planning whose lack or deficiency leads to misuse or misdistribution of resources.

4.3 The level of planning of individual facilities that has disregarded health needs and problems, capability to maintain and manage, as well as costs.

5. Suggested, appropriate way:

Should consist first of all in changing the line of reasoning and then, once it has been decided to establish a specific facility, to consider the factors that affect its planning and design.

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1 See footnote to Annex 1.
5.1 The necessary line of reasoning:

5.1.1 Explore the health problems of the population that lacks coverage by health services.

5.1.2 Classify these problems according to their order of priority.

5.1.3 Determine the staff needed to deal with these problems and make it available.

5.1.4 Provide the facilities that will enable the staff to perform their activities.

5.2 The factors that affect planning and design:

5.2.1 Size of health care facility - depends on function and standards (according to dimensions of human bodies, expectations and practice of staff, and space occupied by electromechanical services).

5.2.2 Building material and methods - rely on local material and available level of skills.

5.2.3 Content (air-conditioning, mechanical, and electrical installations) - consider therapeutic and functional factors, costs, and reliability of operational and maintenance capability.

5.2.4 Climatic conditions require typical approach.

5.2.5 Socioeconomic factors - local customs and habits, distances and communications, needs and usages.

5.2.6 Staffing principles and procedures - to allow proper utilization and supervision.

5.2.7 Flexibility - internal (to allow change of function) and external (to allow growth).

6. General guidelines:

To be useful, these must suit local conditions and each country and region must evolve the types of health care facilities it needs. In general, in developing areas of the Philippines, these should probably be simple, low-rise buildings connected by circulation routes, buildings as uniform as possible, oriented to reduce solar gain and promote air movement, with ends free to expand and with electrical and mechanical plant and sophisticated equipment kept to a minimum.

7. Difficulties:

This approach may meet with disagreement from:

7.1 Medical staff
7.2 Architects
7.3 Politicians
7.4 Manufacturers and suppliers.

Suggested reading

# TYPE PLANS FOR SMALL HEALTH CARE FACILITIES:
THE SUDANESE APPROACH

**M.E.B.A. Aziz**

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FOREWORD

The perfect type plan for a health care facility would be a pure abstraction, as it is impossible to sketch any plan without making a series of assumptions concerning such factors as number and type of staff, number of patients, equipment, climate, and so on, of which some, but never all, will be relevant to a given situation.

An item as simple as a waiting-room will depend to such an extent on local conditions (number of patients per day, number of staff to deal with them, average time taken to see a patient, distribution of patients' arrival within the day, days when there are special clinics, days when there is a greater workload, such as market days, etc.) that a waiting-room sized according to a world mean would be ridiculously large for some areas and no less ridiculously small for others.

It should therefore be evident that it is not possible to recommend any set type plan. It will always be the task of each country to evolve its own type plans according to its own circumstances, and even to develop several such plans for the same kind of facility whenever this is required by significant differences within the country.

However, a discussion of type plans in the abstract would have presented more drawbacks than advantages. This is why the present paper describes type plans as they are formulated and used in the Sudan. They are not models to be followed, but examples to be critically studied. The outcome of such study should in no case be a mere adoption of the plans prepared; rather the reader should consider how far they might or might not apply to the circumstances and practices of his own country and note any potentially useful additions to his own ideas about type plans.

1. INTRODUCTION

The intention of this paper is to describe the main principles and concepts upon which type plans for small health care facilities in the Sudan have been based. It discusses and illustrates type plans for the following facilities:

- primary health care unit
- dispensary
- rural health centre
- urban health centre
- ward unit
- operating theatre.

These plans are intended to help health authorities to offer health services to the population in accordance with the new health policy as set out in the National Policy laid down in the country's Phased Programme of Action for Social and Economic Development. The following priorities are those laid down for the health sector:

- Services of preventive and social medicine are considered as having top priority, especially those dealing with the control or eradication of endemic and epidemic diseases and the improvement of environmental health conditions. Special attention is to be given to maternal and child health and school health services.

- Strengthening of rural health care facilities to ensure fair and complete distribution of basic health care to the entire population.

- Provision of training facilities for all levels of professional, technical, and auxiliary health manpower.
- Consolidation of existing curative health care facilities to provide better services for the population and allow for some expansion in curative health care facilities in the less developed areas.

- Direction of medical research towards health problems in order of priority.

All type plans for the above-mentioned facilities have been prepared by the Health Projects Unit, within the Architectural Section of the Ministry of Construction and Public Works, in collaboration with the Department for Planning and Development at the Ministry of Health.

2. TYPE PLANS

What is a type plan?

A type plan consists of an arrangement of spaces satisfying certain functional needs identified by the user and so designed that it can be used over and over again. An imaginative grouping of the spaces, taking into consideration such factors as location, materials, manpower, and above all cost and construction time, is a desirable objective.

Advantages and limitations

The use of type plans has the following advantages:

(1) It reduces the cost of producing designs and drawings started each time from scratch. Only such modifications as prove necessary in the light of local circumstances need to be made to the standard design. However, it must be kept in mind that the type plan should never be blindly reproduced and that a complete functional programme should always be drawn up in advance. It will then be easy to see in what respect the facility being planned will differ in functions or emphasis from the type functional programme and to alter the type plan accordingly. It is evident that constraints imposed by the site must also be taken into consideration at this stage.

(2) It allows for quality in design. Much more time can be devoted to a type plan than to an ordinary plan. A prerequisite for the drafting of a type plan should be a careful study and critical analysis of the existing facilities. The advantages and drawbacks of the various designs used in the country, as well as their cost implications for both construction and operation, should be studied in depth. It is especially important to seek the advice of the users, both staff and patients.

(3) It makes it possible to order materials and equipment in bulk for several facilities at once, thereby reducing costs, avoiding delays, and reducing problems of maintenance and replacement of equipment.

(4) It permits more rapid orientation of staff if they move from one facility to another.

However, it would be unwise to overlook or underestimate some limitations and constraints associated with the use of type plans:

(1) As already indicated, a type plan should not be merely copied but should be adapted to local circumstances. In countries where there are wide variations in geographical, climatic, or sociocultural conditions, or in the types of construction material available, it is advisable to prepare separate type plans for different regions.

(2) A type plan may have the unfortunate effect of spreading costly, inefficient, or otherwise faulty designs throughout a country. It is therefore necessary, before putting a type plan into general use, to construct a single facility based on it, to put this facility into operation for at least a year (longer would be preferable), and to assess it in depth so as to detect and remedy possible flaws. Only then can the type plan be used on a larger scale.
(3) The advantages of type plans diminish as the size of facilities grows. While a type plan for a health post or a health centre can be followed with only minor changes (if any), when it comes to large hospitals it is preferable to prepare type plans for separate components only (operation suite, radiology, laboratory, wards), leaving the user and the architect free to combine them in the light of the various significant local factors.

3. ORGANIZATION AND DELIVERY OF HEALTH CARE IN THE SUDAN

Administration

Health administration in the Sudan is the responsibility of both the central Ministry of Health and the local governments in the different provinces. At the central level, the Ministry is responsible for the key functions in the national health service such as health planning, training and research, provision of fellowships and technical advice, and control of epidemics.

At the provincial level, each assistant commissioner for health is responsible for all health work in his province.

Health care delivery system

All health services in the Sudan are carried out through the following facilities.

Primary health care units (see Fig. 1 and Fig. 2). These are the smallest health facilities. Each of them is staffed by one community health worker.

Dispensaries (see Fig. 1 and Fig. 2). These units come at the next level of care above the primary health care units. Each of them is staffed by one medical assistant, one or two nurses, and a cleaner.

Health centres (see also Fig. 2). These come above the dispensaries and are of two types: the rural type, staffed by a medical assistant and supporting staff, and the urban type, staffed by a doctor and supporting staff.

Rural hospitals/district hospitals (see also Fig. 2). These are at the next highest level of care. They are larger than the health centres and act as referral centres for the surrounding communities.

Provincial hospitals (see also Fig. 2). These come at the highest level of care and act as major referral units, receiving patients from the whole province as well as from other provinces.

4. THE PRIMARY HEALTH CARE UNIT

In the past, the functions of this, the smallest health care unit, were considered as essentially curative. Thus the unit was staffed by one hospital-trained nurse. It usually consisted of one room and a verandah.

It was in the second half of 1975, after the preparation of the National Health Programme, that it became necessary to revise the old type plans. Under the new approach, the primary health care unit undertook both curative and preventive care, as well as promotional work, the emphasis being on preventive care. Each unit is now staffed by a community health worker, who divides his time between the unit and the community in his catchment area.

Each primary health care unit is to serve a maximum population of 4000 within a radius of 10 miles (16 km). Where necessary, adjustment will be made to take population density differentials into account. For every five units a dispensary will be provided for purposes of referral, supervision, and supply of drugs. Each such group will constitute a "primary health care complex" (Fig. 2).
FIG. 1. HEALTH CARE UNITS, SUDAN

1 PHCU = primary health care unit.

FIG. 2. PRIMARY HEALTH CARE COMPLEX AND REFERRAL SYSTEM, SUDAN

PHCU = primary health care unit.

→ Normal referral.

-----→ Emergency referral.
As work on the new type plans for the primary health care units proceeded, it was felt necessary also to update the plans for the existing dressing stations in order to allow them to carry out their functions in accordance with the new approach.

**General planning and design features**

The unit consists of four basic areas (Fig. 3):

- storeroom subdivided for drugs and equipment
- reception and waiting area
- examination room
- room subdivided for dressings and injections.

Each of these areas is 300 x 480 cm (internal clear dimensions). The plan is based on a multiple grid of 30 cm internally between wall widths.

Room heights are a standard 3 m between the finished floor and the top of the string-course beam. The partitions, each 1.5 m high, are designed to allow for cross-ventilation and movement of air between room spaces.

The reception and waiting area, situated between the subdivided storeroom for drugs and equipment and the examination room, is well protected from morning and afternoon sun. It is roofed, but left open on both sides to facilitate adequate cross-ventilation.

The examination room and the room subdivided for dressings and injections are grouped together for easy use, with minimum movement, by the community health worker.

**FIG. 3. TYPE PLAN, PRIMARY HEALTH CARE UNIT**
A simple shed for protection against the sun is provided for both the unit guard, whose duties will include gardening and cleaning, and the relatives accompanying sick patients.

Two toilets are provided, one for males and one for females. Flush system, aqua-privy, or pit latrines may be used according to locality.

The suggested size of the plot for the unit (Fig. 4) allows for its future expansion when it develops into a dispensary. It is expected that, in the future, the dispensary will become the lowest-level facility. To create a pleasant environment for both staff and patients and to protect them from climatic extremes, special allowance was made for the development of green spaces.

Trees are to be planted to fence off the unit.

FIG. 4. SITE PLAN, PRIMARY HEALTH CARE UNIT
The roof of the unit is made up of simple timber or steel trusses, securely fixed to the top string-course beam, with large overhangs for protection against sun and rain. The roof cover consists of either zinc or asbestos sheeting fixed to purlins running across the trusses. The external underside of the roof overhang is of closely fitted timber boarding or bamboo to stop birds entering the roof space.

Celotex, masonite, or chipboard ceiling panels are used, interspersed with wire-mesh panels to allow for light penetration, thus discouraging bats, which can be a nuisance.

The details of the foundations differ from one area to another depending on ground conditions. The example shown in Fig. 5 is intended for cotton-clay soil. Short concrete columns are used with ground beam, which is left void underneath in order to absorb any upward lift in the wet season.

Glass panels for light are fixed only to the top parts of windows. This is to give them all-day shade from the roof overhang and protect them against possible damage due to rough use by visitors.

FIG. 5. TYPICAL CROSS-SECTION, PRIMARY HEALTH CARE AND OTHER\(^1\) UNITS

\(^1\) Dispensary, rural health centre, ward units for rural and district hospitals.
5. THE DISPENSARY

The dispensary comes at the next level above the primary health care unit. Each dispensary is to serve as a centre for every five primary health care units, for the purposes of referral, supervision, and supply of drugs. In addition, it operates as a primary health care unit for its own catchment area, serving a maximum population of 4000 within an attendance radius of 10 miles (16 km) (see Fig. 2).

It is staffed by one medical assistant (who is in charge), one or two nurses, and a cleaner. Other staff coming under the supervision of the medical assistant include sanitary overseers, and village midwives within the catchment area of the primary health care complex.

General planning and design features

The facility consists of the following basic areas which are contained in two units, each equal in size to a primary health care unit, linked by a covered walkway (Fig. 6):

- antenatal clinic
- reception and waiting area
- examination room
- room subdivided into small laboratory and drug storeroom for use by the medical assistant
- room subdivided into laboratory and storeroom
- general waiting area
- room subdivided into dispensary and waiting areas) grouped together for easy use by
- room subdivided for injections and dressings ) the nurse.

Each of these areas is 300 cm x 480 cm (internal clear dimensions). The plan is based on a multiple grid of 30 cm internally between wall widths.

Room heights are a standard 3 m between the finished floor and the top of the string-course beam. The partitions, each 1.5 m high, are designed to allow for cross-ventilation and movement of air between room spaces.

The reception and waiting area, being situated between the antenatal clinic and the medical assistant's examination room, is well protected against morning and afternoon sun. It is roofed, but left open on both sides to facilitate adequate cross-ventilation.

The main examination room and the room subdivided into a small laboratory and a small drug store are grouped together for easy use by the medical assistant.

The antenatal clinic is situated within easy reach of the main examination room, for consultation purposes. The reception and waiting area is shared by both the antenatal clinic and the main examination section.

As it is not expected that the dispensary will be developed into a health centre the size of the plot (30 x 30 m) is not to be increased (Fig. 7). Nevertheless, extra buildings may be added if necessary.

All construction details as well as general design features are similar to those of the primary health care unit (see Fig. 5).
FIG. 6. TYPE PLAN, DISPENSARY
6. THE RURAL HEALTH CENTRE (RAHAD TYPE)

The type plan for the rural health centre (Fig. 8) was introduced in the year 1974. The idea was to develop a rural health centre that could easily be developed into a rural hospital, phase by phase, when and where necessary.

Particular attention has been given to these rural health centres in areas which potentially require hospitals, namely those in which vast irrigation schemes to promote development are taking place.

A health centre is the facility at the next level above the dispensary (see Fig. 2). It is either rural or urban in type. The rural type is staffed by one medical assistant and supporting staff. The town type is staffed by one doctor and supporting staff. Each health centre is expected to serve a population of 50,000.

In the design, two considerations predominated:

1. that the centre could be developed by stages and would offer a full range of outpatient care when fully developed;

2. that the centre could easily function as an outpatient department, when developed to a rural hospital.
FIG. 8. TYPE PLAN, RURAL HEALTH CARE CENTRE
General planning and design features

The fully developed health centre consists of four blocks of buildings:

Block A. This block contains the following:

- the main reception, registration, and general waiting area
- examination rooms
- the health visitor section, which is near the examination rooms for easy consultation in respect of antenatal care, immunization, and health education
- demonstration rooms for mothers
- records section
- public health section: to be changed to a blood bank when the centre develops into an outpatient department for a rural hospital.

Block B

This block contains the dressings room with its waiting area and a small theatre for minor surgery.

Block C

This block contains two rooms with a waiting area between them. These rooms are multipurpose and will be used for different clinics, e.g., for dentistry or eye treatment, as may be decided.

Block D

This block contains the laboratory, the X-ray department, the main pharmacy, the injections room, changing facilities for both male and female staff, and conveniences for the public. The block is to serve outpatients as well as inpatients when the centre develops into a rural hospital, thus making maximum use of the X-ray department, the laboratory, and the pharmacy (see Fig. 8 and Fig. 9).

All the blocks are single-storey buildings with pitched roofs and load-bearing walls. The plans are based on a multiple grid of 1 m internally between wall widths. Room depths have been fixed at 5 m clear, which has been found sufficient to accommodate various functions.

All other architectural and structural details, as well as the building materials, are similar to those of the dispensary and the primary health care unit (see Fig. 5).
7. THE URBAN HEALTH CENTRE

The type plan for an urban health centre was introduced in the year 1976. The main idea was to develop a new type of urban health centre that could offer a comprehensive service, including specialized services as well as extra diagnostic facilities, in order to reduce the huge number of patients going directly to hospitals on a self-referral basis, particularly in towns and large cities. In principle each urban health centre will cover a population of 50 000.

In the design, two considerations predominated:

(1) that the centre could be developed by phases (Fig. 10);

(2) that the centre would offer outpatient care only.

General planning and design features

The design is based on a series of single-storey blocks, with semi-internal courts and open corridors to allow for movement of air, linked by covered walkways. All external walls are load-bearing, fair-faced externally, and plastered internally. Roofs are reinforced concrete slabs with overhangs 2 m wide. Verandahs are 2 m wide to allow for both circulation and waiting alongside the external walls.
The centre consists of five blocks of buildings, as follows:

**Block A** (Fig. 11)

This block contains the following:

- changing facilities for staff
- the main waiting area, which is subdivided for males and females, reception, and registration
- examination rooms for medical assistants and doctors
- a minor surgical theatre.

**Block B** (Fig. 12)

This block contains the health visitor section. It is well linked by an open corridor with the medical assistants' and doctors' offices for consultation purposes, as well as with the treatment facilities, pharmacy, and laboratory.

**Block C** (Fig. 11)

This block contains the pharmacy, the dressings rooms for both males and females, the injection rooms for both males and females, and the general store for the centre.

It is centrally positioned for ease of access.

**Block D** (Fig. 12)

This block contains the public health section, the main laboratory, and the public conveniences. It is linked to the health visitor section by a covered walkway and to other blocks by verandahs and open corridors.

**Block E** (Fig. 11)

This block contains the dental and eye clinics, and the X-ray department.
FIG. 11. TYPE PLAN, URBAN HEALTH CENTRE: BLOCKS A, C, AND E
FIG. 12. TYPE PLAN, URBAN HEALTH CENTRE: BLOCKS B AND D
Fig. 13 shows the main elevation and a section of the centre.

**FIG. 13. URBAN HEALTH CENTRE: MAIN ELEVATION AND SECTION**

8. TYPE PLANS FOR PARTS OF FACILITIES

New type plans developed for wards in rural and district general hospitals, and for operating theatres and ward units in provincial hospitals, are briefly described below.

**General planning and design features**

**Type plans for wards A, B, and C (Fig. 14, Fig. 15, and Fig. 16)**

These type plans are for wards in rural and district general hospitals.

Each ward is a single-storey building with a pitched roof and open verandahs on both sides for protection against sun and rain; it is linked to other parts of the hospital by covered walkways (see Fig. 9 for type lay-out plan for rural and district general hospitals).

The duty room is centrally positioned to permit easy supervision of patients through glass panels in its side walls, as well as a check on the number of visitors coming through the reception area on entry to the hospital.

On either side of the duty room is a 10-bed ward unit. This is to encourage a progressive patient care system, especially during night shifts when the number of staff is minimum, i.e., the nurse can have the critically ill patients close to the duty room with the others next to them.

The day-space provided in each 10-bed ward unit is intended as a social area for patients within the ward and can also be used for demonstration purposes in training medical staff.

In all types of wards, every patient is provided with a small built-in bedside cupboard. This has proved quite a useful way of solving the problem of the crowding together of beds in a ward which is liable to occur when the wall space is left empty.
FIG. 14. TYPE PLAN, WARD A, RURAL AND DISTRICT HOSPITALS

FIG. 15. FRONT ELEVATION AND TYPE PLAN, WARD B, RURAL AND DISTRICT HOSPITALS
The verandah opposite the visitors' way-in is intended to be used for catering and medical supply services.

The subdivided room for single beds in ward A is intended either for isolated cases or for private patients (paying patients, or senior government officials). Toilet facilities for these single bedrooms are provided in the adjacent room and accessible through the verandah.

In ward A, WCs, showers, medical baths, a utility room, and washing facilities for the two 10-bed ward units are grouped together in one block at the end of the ward and linked to the bed areas by a covered corridor and a verandah.

**Pattern of use.** Various arrangements of patients and medical specialities can be worked out for every type of ward according to the particular situation. For example, ward type B (see Fig. 15) can be used either by male or by female and child patients, or by both groups together. The two 10-bed ward units can be for one speciality, say, medical or surgical, or each can be used for a different speciality, allowing for the use of beds in the neighbouring unit (when the whole 20-bed ward is used for patients of one group), if, say, the medical speciality requires more beds than the surgical speciality or vice versa.

**General architectural and structural features.** The architectural and structural features as well as the choice of building materials are similar to those of the primary health care unit, the dispensary, and the rural health centre (Rahad type) (see Fig. 5).

**Type plan for ward D** (Fig. 17, Fig. 18, and Fig. 19)

This type of ward is designed for provincial hospitals. It is a two-storey building with allowance for a third storey to be built under the long-term plan (in 20-25 years' time). A framed structure with open verandahs on both sides for service and visitors, as well as for protection against sun and rain, it is linked to other parts of hospitals by covered walkways (see Fig. 22 for lay-out type plan for provincial hospitals).

The two duty rooms, each intended to serve a 10-bed ward unit, are centrally positioned to permit easy supervision of patients through the glass panels in their sidewalls, as well as a check on the number of visitors coming through the central reception hall.

On each floor a pantry and a treatment room are provided. They are to serve the patients on the same floor, thus reducing the amount of vertical and horizontal movement for both staff and patients.
FIG. 17. TYPE PLAN, WARD D, PROVINCIAL HOSPITAL

FIG. 18. MAIN ELEVATION, WARD D, PROVINCIAL HOSPITAL

FIG. 19. WARD D, PROVINCIAL HOSPITAL: ROOM ARRANGEMENT OPTIONS
Conveniences for each 10-bed ward unit are grouped together and linked to the bed areas by open corridors (see Fig. 17).

The staircase is centrally positioned for ease of access. A lift well (dotted area) is provided for future development. A patients' room is opposite the staircase on each floor; it provides television, journals, magazines, etc. for patients, and the medical staff can use it for consultation purposes when necessary.

**Pattern of use.** Various arrangements of patients and medical specialities can be worked out according to the particular situation. The two 10-bed ward units can either be for one speciality, say, medical or surgical, or each can be used for a different speciality, allowing for the use of beds in the neighbouring unit (when the whole 20-bed ward is used for patients of one group), if, say, the medical speciality requires more beds than the surgical speciality or vice versa.

**Type plan for operating theatres** (see Fig. 20, Fig. 21, and Fig. 22)

This type plan is used for provincial hospitals (see Fig. 22 for hospital lay-out).

The operating theatre is a single-storey framed structure, linked to other parts of the hospital by covered walkways.

Washing, sterilization, preparation, and recovery rooms are centrally positioned for ease of use by both theatre rooms (1 and 2).

The buffers shown are to allow for the installation of air coolers and air conditioning units and protect the glazed windows and panels against sun, rain, and breakage.

For the roof slab, reinforced concrete beams are used to give a clear ceiling which will be helpful for washing and cleaning.

The framed structure used for both ward D and the theatre is designed to allow for maximum flexibility in space arrangement.
FIG. 20. TYPE PLAN, OPERATING THEATRE BLOCK, PROVINCIAL HOSPITAL

FIG. 21. OPERATING THEATRE BLOCK, PROVINCIAL HOSPITAL:
MAIN ELEVATION AND SECTION

MAIN ELEVATION

SECTION A – A
FIG. 22. LAY-OUT TYPE PLAN, PROVINCIAL HOSPITAL

# PLANNING AND DESIGN OF LABORATORY FACILITIES

J. H. Barker* & L. Houang"  

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1. THE FUNCTIONS OF HEALTH LABORATORY SERVICES

Pathology as a diagnostic tool plays as vital a part in the care of patients as any other major branch of medicine. It is just as important to health centres and small rural hospitals as it is to large urban institutions and university hospitals. Therefore no health care facility should be without the appropriate laboratory services. Some of the functions of such services are outlined below.

Advisory functions

The first function of health laboratories (in both their clinical and their public health roles) is to advise clinicians, epidemiologists, or others about the laboratory tests most likely to be useful in elucidating the cause and nature of a particular problem, and to help in the interpretation of the results.

Analytical and technical functions

For clinical purposes, the laboratory will have to perform tests on different types of specimen, as requested by clinicians, for the diagnosis of disease and the selection and monitoring of treatment. The efficacy and usefulness of the laboratory services will depend not only on the accuracy of the results but also on the speed with which they reach the clinician. As any delays may have an adverse effect on the patient and, in addition, may prolong his stay in hospital, with obvious economic implications, it is essential to provide the laboratory with the right environment and conditions so that it may function as efficiently as possible.

The analytical services commence with receipt of a request to carry out a specified test on a specified patient and terminate with the dispatch by the laboratory of the result and its receipt by the user of the laboratory. Facilities must be available for the collection of specimens and their receipt in the laboratory from outlying health units and health workers in the field.

In the field of public health, the laboratory may be asked to take part in epidemiological surveys and carry out the microbiological, immunological, or other tests needed to confirm a clinical suspicion. Its epidemiological work will include ecological studies of infectious agents covering hosts, reservoirs, vectors, and environment. These studies will be based on samples of diverse human and environmental origin.

The health laboratory may also be called upon to assist environmental health officers in monitoring environmental factors, or groups of factors, with a suspected or established harmful effect. It may test foodstuffs, water, and air by screening procedures, going on to more detailed analyses where this seems necessary. It may also carry out studies on defined populations with a high prevalence of certain signs or symptoms that are suspected to be related to exposure to various simultaneously measurable environmental factors in the area where they live. This kind of monitoring needs rather elaborate laboratory facilities; apart from environmental samples, various samples of human origin, as well as the physiological functions of the persons involved, have to be examined.

Research and development

Here development means the orientation of research and the application of its results to a country's priority problems and to the improvement of the services provided. In effect, unless a laboratory can inaugurate new procedures and discontinue obsolete ones, it soon ceases, in a rapidly changing discipline, to be able to provide the standard of service that the community is entitled to expect from it.
A programme of improvement must include internal and external quality control. In an organized cooperative laboratory system, the central laboratory should be responsible for the external quality control of the regional or provincial laboratories, which in turn would organize quality control programmes within their own region or province. Central laboratories should also be concerned with standardizing the techniques and improving the methodology of laboratory examinations. This can be done by the continuing evaluation of new equipment and testing procedures that are relevant to the country's priority needs and resources. A central purchasing agency for laboratory equipment and reagents should take part in this work.

**Education and training**

The laboratory is the source of teaching material for staff training, for meetings between service providers and utilizers, and for sanitary education, clinical-pathology conferences, and training in critical evaluation of diagnosis and assessment of therapy. Experience has shown that an efficient health laboratory stimulates consultations among staff and contributes to the upgrading of medical care.

**Provision of information of public health interest**

The large number of specimens received in health laboratories makes it possible to carry out simple descriptive epidemiological studies on the basis of laboratory-confirmed cases, e.g., analyses of seasonal trends, geographical distribution, sex and age differences, etc. It may also provide other information of public interest such as drug resistance patterns. Information of this kind may be useful not only in planning the control and prevention of infectious diseases but also in deciding on the usefulness of certain laboratory procedures.

2. **THE LABORATORY IN THE CONTEXT OF THE HEALTH SERVICES**

In many developing countries, a system based on four echelons might be considered for the delivery of primary health care. In some countries, certain of the echelons (particularly 2 and 3) might be combined or simply may not exist.

1. At village level, health care aimed at the total well-being of the community is carried out by a village health worker, often supervised by a village health committee and technically supported by the next-highest echelons of the health care system. It includes the recognition, control, and treatment, where possible, of important communicable diseases, maternal and child welfare, nutrition, and hygiene.

2. A dispensary or subcentre, health post, or clinic, staffed by a small team of two or three health workers, may serve several villages.

3. Support and referral services for the village and dispensary health workers may be provided by a health centre serving a population of 5000-10 000, or more, and staffed by at least four people working closely together as a team to promote health development in the area served.⁴

4. The primary level hospital acts as the next point of referral. It receives patients requiring medical attention, including minor surgery, and at-risk obstetrical cases and provides the health centre team with technical and logistic support. The primary level hospital may also provide training facilities for health centre teams and village workers. In certain countries this type of hospital is more developed and therefore considered as being at intermediate rather than primary care level.

In some countries mobile teams have been organized to support and supplement the primary level facilities or to control certain highly endemic diseases.

⁴ To avoid the confusion that may arise from the variety of terms employed in different countries, it may be useful to indicate that by "health centre" is meant a facility devoted primarily to ambulatory patients with maybe a few beds for emergency or observation purposes.
At the intermediate level of health care, two or three echelons may be identified.

The district hospital provides general and essential specialized care for the majority of patients in geographical areas with 50 000-300 000 inhabitants. It acts as a referral centre for the health care facilities in the surrounding communities, including frontline hospitals. Above the district hospital are the provincial and regional hospitals.

The provincial hospital provides a more sophisticated form of care, together with specialized services, such as paediatrics, urology, cardiovascular diseases, ear, nose, and throat, and orthopaedics. A hospital at this level is likely to have 250-300 beds.

The regional hospital. In some countries, certain provincial hospitals may act as referral hospitals for a group of provinces. This is particularly common in large countries where the hospital in the capital cannot be reached or attended by the whole of the country's population. These hospitals generally have teaching facilities and slightly larger numbers of beds than the provincial hospitals. They also offer additional specialized services.

At the central level there is a hospital similar in type to the regional hospital but providing the most sophisticated form of care available in the country. In most cases, the departments are headed by professors from the local medical school.

3. ORGANIZATION OF A HEALTH LABORATORY SERVICE

The organization of a health laboratory service depends very much on the structure of the local health services. However, in general, three levels can be identified: peripheral, intermediate, and central.

At the peripheral level, there are two categories of laboratory: the frontline hospital laboratory and the health centre laboratory.

One of the main functions of laboratories at this level is analytical work. However, when they are located in places with disease patterns that are representative of a geographical region, they may serve as sentinel centres and play an important role in providing information of public health interest.

Mobile teams often have at their disposal a small laboratory for the performance of simple tests on the spot and the collection of specimens to be forwarded to a higher level.

The intermediate level. At this level two to three categories of laboratory may be found. As their activities will be closely linked with the function of the hospital in which they are located - regional, provincial or district - they will have to be adapted accordingly. Obviously there should be provision for research and development at the central and regional laboratories attached to teaching hospitals. This may not, however, be so important at the provincial level when a regional laboratory exists, and it is surely inapplicable at the district hospital level. However, all laboratories will provide clinical and public health services.

The central laboratory is located in the capital city. It has two main branches of activity, namely: (a) public health, and (b) clinical pathology. At the first stage in the development of the laboratory services, because of the need to economize and lack of technical staff, these two activities may conveniently be carried on in a single laboratory in the compound of the main hospital of the capital city. As laboratory activities develop further, and especially when a public health programme including environmental sanitation is evolved, it becomes necessary to have a separate public health laboratory in order to avoid clinical activities taking undue precedence in a situation of ever-increasing demand.
The health laboratory service must thus be considered as a network of activities requiring different concentrations of resources at different levels. There must be continuous communication between the different levels, referral services from the peripheral to the central level, and technical and managerial support from the central level - national or regional - to the peripheral units.

For the rational development and efficient operation of the network, a director of the health laboratory service with a mandatory voice in the decision-making process is required. The director will be responsible for the overall management (planning, organization, direction) of the service. He will advise the national health directorate on present and future needs and all matters relating to health laboratories. For this purpose, all relevant information and data required for the efficient planning and organization of the service should be available at his office.

When resources in professional manpower are limited, the office of the national health laboratory service may be located at the central laboratory and the director of this laboratory may act as director of the national service, carrying out his duties with the help of a health administrator.

The following aspects of the organization of health laboratory services require particular attention:

1. The need to consider the national health laboratory service as an integral part of the national health service.

2. The provision of health laboratories varying from simple to highly complex on the basis of priority health needs.

3. The desirability of having combined, rather than separate, public health and hospital laboratories at appropriate levels in order to minimize cost and make better use of trained personnel.

4. The desirability of integrating a country's health laboratories under a single administrative and technical system for proper management, and of establishing a division or department of health laboratories within the ministry of health, with a mandatory voice in the decision-making process.

5. The need to establish a national advisory body on health laboratories to advise the director of the service on matters of policy, standards, and legislation, and promote horizontal coordination.

6. The problems involved in providing sufficient numbers of trained laboratory workers of all categories to meet local priority needs and in obtaining more comprehensive legislation on the qualifications and standards required of laboratory personnel.

7. The promotion of more rational utilization and better appreciation of health laboratory services by medical and public health workers.

8. The need to improve cooperation between the different levels of the service, (rural, district, provincial, and national) and between the service as a whole and other divisions within the ministry of health, and other government services such as those dealing with water supply, veterinary medicine, agriculture, etc.

9. The establishment of specialized laboratories and reference laboratories in the country, as required.

10. The establishment of adequate international and bilateral collaboration in the field of laboratory services.
4. PLANNING HEALTH LABORATORY FACILITIES

Laboratory departments are very often hampered in their operation because of limited space or inefficient use of the space available. This is because insufficient attention has been paid to the design and planning of the laboratory.

The first and most essential stage in planning a laboratory department is for those involved, i.e., the pathologist, architect, health officials, and administrators, to have a clear idea of laboratory requirements.

The clinical pathologist, the health administrator, and the architect are the principal members of the planning team. When necessary, chiefs of personnel, central stores, central sterile supply, and others can be consulted as required. It is important that there should be mutual professional respect and confidence among all members of the planning team.

Role of the clinical pathologist

The clinical pathologist has a leading part to play in all phases of the planning and design of laboratory facilities. He must therefore have full knowledge of the needs of a clinical laboratory and what might be achieved with the resources available (provision for capital and running expenses, staff) in the geographical area it will serve. He must also be acquainted with current local trends in pathology practice and with projected changes in the area. All this information is essential to permit the pathologist to determine the function and duties of the laboratory and the space and equipment required. He will use it to prepare, in collaboration with the health administrator, a functional programme giving details on the size and the general characteristics of the laboratory to be designed, taking budgetary considerations into account.

This functional programme will consist of a detailed description (qualitative and quantitative) of the activities of each unit and thus determine the space and equipment required. It should also give full information about the operation of the laboratory so that the architect may design the layout more efficiently. The architect must take part in the finalization of the functional programme.

Role of the health administrator

From the clinical pathologist, the health administrator should receive all the technical justifications for the proposed plans, with indications of their clinical advantages and financial implications. He should be aware of how speed and accuracy in determining diagnosis can save money by economizing on bed-days, and of the need for well-planned and ample laboratory facilities if performance is to be acceptable.

Role of the architect

After having studied the functional programme and collected all the necessary information, the architect will draw the schematic design.

The schematic design is an outline plan of the proposed laboratory, showing various divisions and their specific relationship to one another. Corridors, stairways, etc., will be delineated as well. The surface of each item will be indicated. After the schematic design has been approved, the architect will prepare design development drawings showing the location of fixed and movable equipment inside the laboratories, ancillary support facilities etc.
The architect should have experience and expertise in the planning of laboratory facilities. This may be ascertained by obtaining a list of his completed projects in this area and the name of the person who may be contacted regarding each project. However, the architects employed are sometimes inexperienced in designing laboratories and know little of what is required. In this case, the functional programme prepared by the pathologist should cover as fully as possible the services to be provided, the functions and procedures involved, the personnel required, working relationships with other units in the health centre or hospital, and the equipment to be installed, as well as giving some idea of the space needed.

5. STEP-BY-STEP PROCEDURES FOR ESTABLISHING BASIC REQUIREMENTS FOR A LABORATORY FACILITY

1. Determine what activities are to be performed (include a projection for the next 15 years).

2. Determine the technical units and subunits (e.g., haematology, clinical chemistry, enzymology, etc.) and the procedures that will be used.

3. Identify procedures with special requirements (e.g., tests that pose a biological or chemical risk).

4. On the basis of step 3, determine: procedures to be implemented in the same unit or subunit, and those to be performed in completely separate work areas.

5. Estimate the volume of work in each area, unit and subunit.

6. Indicate the style of work in each unit (manual, mechanized, automated).

7. Indicate the number of personnel that will be working in each unit and subunit.

8. Describe the principal equipment and furniture (including specifications such as volume, floor or bench space required, power required, etc.) in each unit:

   (a) List equipment such as refrigerators, centrifuges, etc. with the floor space or bench space needed.

   (b) List the equipment that may usefully be shared by technical personnel belonging to different units. This applies particularly to precision balances and all costly and sophisticated material.

   (c) List the utilities to be provided, and any special requirements for instruments, e.g., for high precision balances, or for electronic measuring equipment, which may need separate electrical lines in order to avoid inaccuracy due to fluctuating voltage. An instrument room with a well-controlled environment may need to be set up for some equipment.

9. On the basis of step 8, indicate in linear metres the bench space required and how it should be arranged.

10. Determine the auxiliary areas and the personnel and equipment needed for each:

    (a) administration section for reception of specimens and dispatch of results, meeting-room, and classroom;

    (b) technical washing and sterilization section, area for preparation of reagents and culture media, storage and locker facilities.
11. Indicate the preferable locations for different units. For example, the bacteriology unit should preferably be located at the farthest end of the laboratory, next to the washing and sterilizing unit, to diminish the contamination hazard.

12. List environmental requirements such as positioning of ventilation in microbiology laboratories and safety measures required.

For estimating space requirements, a rule of thumb can be used, according to which $6 \text{ m}^2$ of floor space is needed per member of laboratory staff, whether technical or administrative. It is to be noted that this does not include corridors, stairs, toilets, rooms for building equipment, wall space etc. However, in small laboratories with only one or two workers (e.g., at health centres or rural hospitals), more space per laboratory worker may be required. The size of other areas may be governed by the size of the equipment or the amount of storage space needed. Net space requirements for administrative and supportive units will represent approximately 15% - at the most, 30% - of the basic laboratory area.

6. **THE LAYOUT OF A HEALTH LABORATORY FACILITY**

**Functional relationships**

All that may be needed in the way of layout for a small laboratory may be the arrangement of work stations, space for equipment, storage, etc., in a single room - and this is always the case in health centres and frontline hospitals. However, a large laboratory is more complex. For instance, some laboratory activities will involve rooms and instruments belonging to different sections of the laboratory. It is therefore essential to obtain a grouping of rooms and instruments that will allow for the most convenient relationship between sections using some common equipment. Areas involving high risk, such as the tuberculosis laboratory, should be located away from the high traffic areas. Laboratory activities that are likely to grow should not be adjacent to areas having structural or other features that would be unduly expensive to convert. Administrative areas should be grouped and located near, or at, the main entrance to the laboratory.

A laboratory serving a hospital should have good, short lines of communication with such areas of the hospital as the outpatient and emergency departments, the operating room, and the autopsy department. If, however, the laboratory's activities involve a high biological or chemical risk, a separate building may be needed to provide more isolation. This has the additional advantage of facilitating the extension of the laboratory as needed.

**Laboratory modules**

The basic building unit for a laboratory is the laboratory module having a particular width, depth, and height. This contains all of the standard features needed to support laboratory activities, including wet and dry services, lighting and electrical services, ventilation, etc. It is self-supporting and, during the design phase, is repeated as many times as necessary to make up a laboratory of the required size (see Fig. 1, Fig. 2 and Fig. 3).

Most floor-mounted laboratory equipment will fit in the depth required for standard benches; therefore the word "benches", as used in preliminary planning discussions, will often apply either to benches or to equipment space, these, in a general sense, being the two most important elements in a laboratory. The ideal shape for a module is the shape with the least area that will support the maximum length of benches - meaning benches and equipment.
FIG. 1. SAVING MODULAR SPACE

EXCESSIVE MODULAR WIDTH

IDEAL MODULAR WIDTH

FIG. 2. TWO-MODULE SUITE
Fig. 1 compares two differently shaped modules, each having 12 linear metres of benches or equipment space. The module on the left is 4.5 x 5.25 m, i.e., 23.625 m². The module on the right is 3 x 6 m, i.e., 18 m². A total of 5.625 m² can be saved by using the 3 x 6 m module since the space in the centre of the larger module cannot be effectively utilized. The module width is based on such factors as the standard depth for benches (approximately 75 cm) and the required clearance in front of them (approximately 75 cm).

The structural system can affect module width if the column spacings are not in multiples of the module dimensions. As established in the previous paragraph, a 3 x 6 m module permits a more efficient use of floor space. Some laboratories have been designed with modules 3.6 m wide; however, many of them have been redesigned so that the width is reduced to approximately 3 m.

Module depth may vary since it is not as critical as the width, though it must take natural lighting requirements into account. Doors in the side walls of a laboratory module will reduce the usable laboratory depth and should be avoided, though they may be necessary where an interconnecting suite of laboratory rooms is required for a single laboratory operation. The 3 x 6 m module also permits a subdivision into two 3 x 3 m spaces, which are ideally suited for areas such as isolation rooms, supervisors' offices, and dark-rooms.

Laboratory suites

The total space in a laboratory suite is made up of multiples of laboratory modules. A two-module suite, as shown in Fig. 2, contains a peninsular benchwork section with further benchwork along the side walls extending for about the same distance as the peninsular to within approximately 2 m of the corridor wall. The remainder of the side walls, and all the walls adjacent to the corridor, are left free of built-in benches to allow space for movable furniture or floor-mounted equipment. One of the most common errors in laboratory design is to provide for too much benchwork. If the corridor and a portion of the side walls are left free of built-in items, there will always be room to add a piece of equipment or furniture that had not been anticipated during the planning phase.

To illustrate further the flexibility of the modular approach, Fig. 3 shows a three-and-a-half module suite containing three special procedure rooms of half a module each and a two-module general laboratory. Any of the special procedure rooms may be used as an isolation room, a dark-room, or a supervisor's office.

FIG. 3. THREE-AND-A-HALF-MODULE SUITE
Usually the number of workers a laboratory suite can support is governed by the size of the general laboratory, since workers would not be expected to spend all their time in special procedure rooms, such as isolation rooms, dark-rooms, etc. For this reason, the primary work stations are provided in the general laboratory areas, with the special procedure areas requiring additional floor space. One module in a general laboratory could take 2-3 laboratory workers. Since the general laboratory in Fig. 3 contains three interconnecting doors that reduce the usable space, it is estimated that it could support at most 4 workers (2 per module). Where benchwork in a standard module is not reduced by interconnecting doors or for other reasons, work stations for 3 workers may be provided.

Walls

External and corridor walls are permanent, and a wide variety of materials may therefore be used, depending on local availability, cost, and personal preference. Because interlaboratory partitions are to be considered as temporary, relatively inexpensive wall materials should be used so that they can be taken out or replaced easily at minimal cost.

Ceilings

Ceilings in laboratories must be in a material that can be easily cleaned and disinfected. The entire ceiling area must provide a continuous seal to prevent contaminants from seeping through to otherwise inaccessible areas. This is extremely important where there is a risk of airborne contamination. Ceiling materials such as plaster or gypsum board are adequate; if properly sealed, wood or concrete are also adequate. Plaster ceilings are advisable in high-humidity areas. Ceiling height should be 2.55-2.80 m; the latter height would allow for wall-mounted distillation racks and tall equipment.

Floors

Floors should preferably be of materials that are resistant to acid, alkali, and salts and can be cleaned and disinfected, e.g., tiling, vinyl asbestos, and sheet vinyl. An installation with as few joints as possible is to be preferred. In areas exposed to excessive moisture, such as those used for glassware preparation, treated exposed concrete, seamless floorings, or epoxy-type floor coatings are desirable.

Doors

Doors should provide an easy exit and be located in places where they will not interfere with equipment and laboratory benches, in such a way that a straight egress is possible. Laboratory doors should be not less than 1 m wide so that equipment can pass through with ease. In some cases double doors of a total width of 1.20 m will be needed, e.g., for letting deep freezes pass through. In this case, one of the doors may have a width of 0.90 m and provide the normal means of entrance, while the other would have a width of 0.30 m and be opened only when equipment had to be moved through. The use of glazed doors may be helpful in lighting the corridor. The doors in laboratories should always open towards the corridor. Special attention should be given to the paintwork and a finger-plate should be fixed if the door is likely to be marked by hands stained with chemicals.

Windows

Natural light of a high standard is essential in a laboratory, besides providing a working environment with some form of visual contact with the world outside. The window should be as tall as possible in order to provide the maximum possible lighting against the inner wall, and it should be at least 90 cm above floor level so that benches can be put below it. The angle of incidence of light from the window to the inner working-post should not be less than 27°. The window area should be proportional to the floor area in the ratio of at least 1:5. Windows may be designed to open by pivoting, swinging, or sliding. In all cases it must be possible to open them without having to move apparatus from the window bench. In some cases this can be achieved by fixing a sash in the lower part of the window.
7. AIR HANDLING

Complete control of air circulation can best be achieved by taking advantage of natural ventilation, shading, and thermal barriers.

The use of natural ventilation includes the following measures:
- providing windows with screens for maximum flow of air and protection from insects;
- providing vents in the upper portion of the roof to allow hotter air to escape from the building through ceiling vents;
- providing an open "crawl" space under the floor to allow air to circulate and to decrease humidity;
- providing pressure walls, hedges, etc., on the outside of the building to direct air into windows or doors;
- separating various elements of a building operation into several connecting buildings to take full advantage of the natural airflow;
- orienting the building to take full advantage of prevailing winds.

The use of shading includes the following:
- providing wide roof overhangs to protect windows from direct sunlight;
- planting trees or building screens to provide shade to buildings during the hottest period of the day;
- orienting or designing the building to decrease the amount of afternoon exposure.

The use of thermal barriers includes the following:
- providing insulation in the roof and exterior walls to decrease the transmission of heat into the building;
- providing reflective material on windows that cannot be shaded, in order to redirect the rays of the sun;
- providing a body of earth adjacent to a building: this earth can serve to insulate a masonry wall;
- using lighter colours on the building exterior, especially on the roof, which is the most exposed area of the building.

Fig. 4 is a building section showing how some of the above features can be incorporated into the design of a laboratory. Cooler air can be circulated through the area by taking advantage of the fact that hot air moves in an upward direction. In the example illustrated, air moves from the laboratory up through the openings in the ceiling and out through the ridge vent.

Fig. 5 shows the separation of buildings to take advantage of prevailing winds. Since the laboratory is potentially contaminated, it is best to locate it downwind from the other elements of a hospital complex.
FIG. 4. USE OF THERMAL BARRIERS

SECTION

Continuous ridge vent with louvres and insect screens
Possible solar collector for hot water needs
Summer sun
Winter sun
Ø = latitude ± 10° - 15°
Horizontal sliding windows with insect screen
Overhang shades window from summer sun
Grass absorbs radiation and does not reflect heat to building

Movable equipment. Heat from refrigerators, etc., rises into attic
Building elevated above ground to allow cool breezes to cool the floor and keep moisture out

FIG. 5. TYPICAL HOSPITAL COMPOUND: HOT HUMID CLIMATE

Prevailing winds
Admission and administration, Outpatient services
Breezeways
Patient wards
Laboratory

NARROW BUILDINGS ELONGATED IN E-W DIRECTION WITH OCCUPIED AREAS TO THE SOUTH
BUILDINGS SEPARATED TO ALLOW CIRCULATION OF PREVAILING BREEZES
LABORATORY LOCATED DOWNWIND FROM THE REST OF THE BUILDINGS
TREES SHADING SOUTHERN WALLS BUT NOT INTERFERING WITH CIRCULATION OF BREEZES OR LOW SUN
Air-conditioning

Climatic conditions in developing countries may vary and require different degrees of control. In general, most laboratories in developing countries will not be air-conditioned to provide comfort for laboratory personnel; however, air-conditioning may be needed in some areas, since high humidity will affect the performance of certain instruments. If the humidity is extremely high (70% or higher), lowering the ambient temperature is the most practical means of lowering the humidity.

In developing countries, where power failures or failures in air-conditioning system are apt to occur, it is important that it should always be possible for the laboratory to function, whenever necessary, under natural ventilation, i.e., windows should always be provided.

If it is necessary to cool the air in a laboratory, care must be taken to select the proper system. If the laboratory procedure involves working with an infectious agent tending to aerosolize, a system that does not recirculate air must be used. If this hazard does not exist and the laboratory needs to be air-conditioned to reduce humidity for instrumentation, any system may be used, including window air-conditioning units.

Air pressure relationships

Relative air pressures within a laboratory building are extremely important. Air in the outside environment moves from high pressure to low pressure. This is precisely what should be accomplished in a laboratory building by varying air supply and exhaustion if the building is air-conditioned, and by means of exhaust fans if it is not. The intention is to create low pressure not only in areas of high biological risk but also in areas where extreme heat, odours, or chemical fumes are produced. Consequently, air movement in a laboratory should always be from areas of low risk to areas of high risk, or from clean to less clean areas.

Fig. 6 shows the desirable pressurization relationships for a laboratory suite containing all the rooms necessary to illustrate this concept. The corridor is under positive pressure, not because it is always the cleanest area, but to prevent any potential contamination from seeping out of the laboratory through the corridor and into another area. The aim is to contain airborne contaminants within the laboratory suite. Within the suite, the concept of air-flow from clean to less clean areas should apply. The clean room is under positive pressure in relation to the two other rooms, and the dirty room is under negative pressure. These pressure relationships may be achieved by providing an exhaust to the outside, with an exhaust fan, in the dirty room, and/or a biological safety cabinet with its own exhaust.

These pressure relationships may be created in several different ways depending on how the general air-flows are handled. If the building is ventilated by means of a central air-conditioning system, the pressure relationships are relatively easy to achieve. If a negative pressure is desired, the amount of air exhausted from the room must exceed the amount of air supplied to the room. If a positive pressure is desired, the amount of air supplied to the room must exceed the amount of air exhausted from the room. These differences in airflow quantities are attained by duct-sizing and damper controls.

The desirable pressure relationships in a non airconditioned laboratory may be accomplished by locating an exhaust fan in the area that requires the most negative pressure. A biological safety cabinet or fume hood in the area will normally provide sufficient exhaust capacity to create a negative pressure. In the absence of an exhaust fan, biological safety cabinet, or fume hood, the hazardous procedures could be carried out near an open window located downwind. This open-window method should be practiced only as a last resort. Good laboratory safety techniques should always be emphasized.
Hoods and cabinets

Because hazardous substances and agents are handled in the laboratory, airborne particles may be hazardous to laboratory workers. On the other hand, some procedures must be performed in a clean environment. It is, therefore, necessary to utilize certain auxiliary air-handling devices.

A fume hood is an air-handling device which removes fumes or odours created by chemical procedures. Air is directed from the laboratory room across the work surface and carried to the outside. There are several types of fume hoods; however, the conventional fume hood is adequate in most cases. Normally, 25-35 m/min air velocity at the front of the hood is adequate. If the hood is used to handle perchloric acid, the air velocity should be 40-45 m/min. The exhaust of a perchloric acid hood should not slant more than 45° from the vertical and should be equipped with wash-down features and chemical-resistant exhaust-duct material.

A biological safety cabinet is an auxiliary air-handling device whose aim is to protect the operator and the environment against the contaminants it contains. It provides a ventilated work area for the performance of hazardous microbiological procedures. Air is directed away from the laboratory worker, across the work surface, through high efficiency filters, and is carried out through an exhaust system. The exhaust blower should produce approximately 22 m/min air velocity at the front of the cabinet. Air exhausted from a biological safety cabinet is theoretically clean since it passes through a high efficiency filter; however, a leak could occur in or around the filter. For this reason, the exhaust air from the cabinet should not be recirculated back into the laboratory, but instead should be directed to the outside environment to a point above the roof.

A laminar-flow cabinet, sometimes referred to as a clean cabinet, is used to protect clean or noninfectious materials against contamination from outside. It is in most respects the opposite of the biological safety cabinet. Air is supplied to the cabinet, forced through high efficiency filters, passed over the work surface, and then emptied into the room. The high
efficiency or absolute filters are the same type as in a biological safety cabinet. The air is supplied to the cabinet from the room; therefore, the air in the room becomes cleaner as the cabinet blower continues to run. The desirable velocity for air leaving the cabinet is 24-36 m/min. This cabinet must never be used for handling pathogenic agents.

A laminar-flow/biological safety cabinet combines the features of a laminar-flow cabinet with those of a biological safety cabinet. This cabinet protects work and worker and should have an air velocity of approximately 22 m/min at the front of the cabinet. The exhaust air from this cabinet should be handled in the same way as that from a biological safety cabinet.

8. UTILITY SERVICES AND DISTRIBUTION

The basic utility services, such as water supply, sanitary drains, and drain vents, should always be provided in a laboratory. Electricity is also essential, except at the health centre laboratory where, as the work consists mainly of microscopic examination, it is not essential although it is highly desirable. Other special services such as gas, compressed air, distilled water, carbon dioxide, steam, etc. should only be provided if there is a definite need. In large laboratories, rooms may occasionally need one of these services. For example:

- Gas is needed mainly in the microbiology laboratory. However, in all other laboratories it may be used as a source of energy for heating. Special care should be taken to ensure that the required pressure is available at all working stations and that the gas lines are not running in confined spaces where leaking gas can collect and explode.

- Compressed air, provided by cylinder, a central system, or portable compressor, is useful for filtration.

- Distilled water is essential in the reagent and/or culture media preparation room and also in clinical chemistry.

- Carbon dioxide is used in microbiology for the isolation of many fastidious pathogenic bacteria.

- Steam is very useful in both washing and sterilizing rooms.

This underlines the need to group together certain laboratory units with similar requirements, and, for this purpose, to have a detailed functional programme prepared by the pathologists at the initial planning stage. In this case, the main distribution lines may be located along the rear of the laboratory rooms, and, if the service is needed, branch lines may be routed to the benches. Fig. 7 shows an example of how service lines are routed in a utility chase within the laboratory room. The utility lines should be accessible for maintenance. Removable panels at the backs of the knee spaces and at the ends of the utility chase help to achieve this.

Some method of identification should be used for pipes in chases or in other locations where several distribution systems exist and where it would be difficult to distinguish between them when maintenance is required. Tagging or colour-coding may be used; if tags are used, they should be at or near the valves. A colour code like the following could be used:

- hot water - orange
- cold water - blue
- drain - brown
- steam - gray
- compressed air - white
vacuum - black  
gas - yellow  
sprinkler water - red

This is of course merely an example, and whenever national norms have been established they must be followed.

FIG. 7. LOCATION OF UTILITY CHASE IN LABORATORY

Some of the special services will not need a distribution system. For example, if distilled water is needed, it is recommended that a water still of adequate capacity be installed on a wall in the laboratory or perhaps at a central location within a group of laboratory rooms. It may be advisable to provide a water still in the one laboratory room that uses the most distilled water. Distilled water should not be distributed in pipes from a central source, because of the high expense of the special piping needed to retain the quality of the water. Also, a central vacuum system is not recommended unless high efficiency filters are installed in the lines to protect them from dust or contamination in the laboratory. A simpler solution is to provide vacuum pumps where needed within the laboratory.
Many of the gases available in compressed cylinders can be delivered directly to the laboratory that requires them. If storage space is needed for extra cylinders and inflammable and explosive chemicals, it should be provided outside the building - preferably at least 15 m from the main structure and in a well-ventilated storeroom.

Electricity services

The trend is toward the use of more and more power, yet electricity is usually the most underestimated service. Electrical outlets should be provided every 1-1/2-2 m along benches and walls where no benches are located. The outlets on walls should be high enough to clear the highest laboratory bench. If this is done, benches and/or movable tables may be added later without having to relocate the outlets to a higher position. All outlets should be of the grounding type.

The general lighting level in a laboratory should be approximately 750 lm/m². A good arrangement is to locate fluorescent light fixtures at the ceiling along a line directly over the front edge of the bench-top surface. This position eliminates any shadow or reflection that could interfere with the performance of a laboratory procedure. A light fixture containing two 40-W tubes will provide approximately 750 lm/m² on a bench of standard height. This is sufficient for most laboratory procedures. Auxiliary lamps may be utilized if a specific work area requires a level of illumination higher than 750 lm/m².

To the total estimates of power requirements at the main electrical panel or panels, 25-30% should be added for future expansion of circuitry. All circuits should be grounded. The amperage loads for different types of laboratory equipment are as follows:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Wattage(W)</th>
<th>Voltage(V)</th>
<th>Approximate amperage load(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater and hotplate</td>
<td>2250</td>
<td>220</td>
<td>10</td>
</tr>
<tr>
<td>Incubator (large)</td>
<td>625</td>
<td>220</td>
<td>3</td>
</tr>
<tr>
<td>Incubator (small bench size)</td>
<td>350</td>
<td>220</td>
<td>1.5</td>
</tr>
<tr>
<td>Water bath</td>
<td>1500-2000</td>
<td>240</td>
<td>7-10</td>
</tr>
<tr>
<td>Autoclave</td>
<td>8250</td>
<td>240</td>
<td>35</td>
</tr>
<tr>
<td>Water still</td>
<td>2500</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

It is important to know the type of electrical equipment that will be used in each unit and particularly its rating in watts so that the total power requirement at peak utilization periods may be estimated. This information should be obtained for each unit so that adequate electrical power may be brought into the laboratory department and sufficient amounts distributed to individual panel-boards for use in the different units. The following table indicates the relationship between amperage load and wire gauge.

<table>
<thead>
<tr>
<th>Amperage load(A)</th>
<th>Wire gauge (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>2.25</td>
</tr>
<tr>
<td>20</td>
<td>3.5</td>
</tr>
<tr>
<td>30</td>
<td>5.5</td>
</tr>
<tr>
<td>40</td>
<td>8.5</td>
</tr>
<tr>
<td>55</td>
<td>13.5</td>
</tr>
<tr>
<td>70</td>
<td>25.0</td>
</tr>
<tr>
<td>95</td>
<td>35.0</td>
</tr>
<tr>
<td>110</td>
<td>45.0</td>
</tr>
</tbody>
</table>
The following estimation of the electrical power (kW) needs for a glass washing and sterilizing room is given as an example. It is assumed that the equipment used in the unit includes:

- 1 autoclave (8250 W)
- 1 hot-air oven (2000 W)
- 1 water-still, 11 l/h (2500 W)
- Lighting, 325 lux x 11 m² (240 W)

The total power required would then be 13 kW, which corresponds to 60 A. Therefore the power should be supplied by two lines of at least 5.5 mm² each, or one line having a section of more than 13.5 mm².

In many areas power failures are common. It is, therefore, necessary to determine which equipment must be on emergency power in the event of a power failure. Consideration should be given to such items as refrigerators, incubators, minimum lighting, biological safety cabinets, and fume hoods. A decision must also be made as to the desired degree of continued operation in the event of a power failure. The prime objectives of an emergency power system are:

- To ensure continued operation of safety equipment, minimum lighting, ventilation, etc., at least long enough to terminate any procedures that may have been in progress at the time of the power failure.

- To prevent any loss of specimens due to insufficient refrigeration or incubation.

- To assure proper ventilation to areas where animals are kept.

In some small laboratories in remote areas, a gasoline generator may be the only source of electricity, in which case no emergency power would be needed.

When ordering equipment requiring electricity, local voltages and cycles should be specified.

9. FURNITURE AND FINISHES

Furniture

Depending on the location of the laboratory, a particular choice of material for cabinets may or may not be available. The cabinets may be of wood, steel, or some form of plastic material. Wood or plastic units are more suited to regions of high humidity. Whenever possible, cabinets should be built from locally available materials that are economical. The standard manufactured base cabinets are approximately 75 cm deep, which includes a space approximately 20 cm deep for utility lines. Once the utility lines are run to this space, the service outlets may be located at any point along the back of the bench top. Base cabinets arranged back-to-back require only one space for utility lines.

Normally, two heights of base cabinet are used in laboratories. The "stand-up" height of 90 cm is used at work stations where the laboratory workers stand (or sit on high stools). The "sit-down" height of 75 cm is used at work stations where the workers sit on chairs.

The types of space provided in the line of base cabinets, whether drawers, open storage space, or just knee space, should be closely coordinated with the needs of the laboratory personnel. Fig. 8 shows the various types of standard cabinet.

Shelving or wall cabinets may be installed on the walls above the base cabinets; however, the planner must make sure that the walls are structurally sound enough to support the extra weight.
FIG. 8. LABORATORY FURNITURE

Bench tops

Many bench-top materials are available, and it is often very difficult to select the right ones. The selection of a bench top should be based on the expected exposure and usage, together with the cost and the desired flexibility of use. If economics did not need to be considered, the selection would be easier. Unfortunately, it is usually a very important consideration. When selecting a bench top, the two most important questions to ask are:

- Will the bench surface be exposed to acids?
- Will the bench top be exposed to extremely wet conditions?

If acids are a problem, bench tops of stone, resin, or asbestos are satisfactory. If extremely wet conditions are anticipated, a bench top of stainless steel may be required. There are some bench-top materials that will withstand a very moderate degree of moisture. There are tops that are chemically resistant to varying extents; it is therefore wise to test samples of several bench-top materials with acids commonly used in the laboratory before a final selection is made. If exposure to chemicals and moisture is not a major consideration, laminated plastic makes a very economical and serviceable bench top.

10. ORGANIZATION OF A LABORATORY IN A HEALTH CENTRE

There are large variations in the number of people served by a health centre and in its staffing. However, for the purpose of this paper and to facilitate the determination of the range of tests and analyses to be performed, an attempt will be made to give an indication of the functions and staffing of an integrated health centre. A centre of this type will provide ambulatory, curative, and preventive services and may have a few beds for the observation of patients pending their possible referral to hospital. Its main function will be to serve as a
facility for patients referred from the lower levels (dispensaries, village health worker),
for screening, for preventive care, for ante- and postnatal care (including family planning,
nutritional advice, and health education), and for other public health purposes.
Administratively and functionally it is linked to the primary level hospital; it is staffed by
a medical assistant, a fully qualified nurse, a midwife, and a minimum of two or three
auxiliary staff; and it covers a population of around 25,000 (this figure is purely arbitrary
as the real range of coverage could be far higher or lower).

The existence of a laboratory will improve the quality of the primary health care offered
by the centre in the following ways:

- It will provide the health worker with laboratory support when a disease is difficult
to diagnose clinically. A correct and early diagnosis will ensure the most suitable
treatment for the patient, and in many cases, the need for future hospitalization may
be avoided, thus significantly reducing the cost of health care and increasing the
efficiency of the centre.

- It will help workers in deciding whether to refer a patient to the hospital.

- It will assist in the control of prevalent communicable diseases and the follow-up
care of patients.

- It will lead to better population coverage through the use of simple, low-cost
techniques.

The laboratory will be of the integrated type, performing both clinical and public
health activities, although at a very simple level.

This type of laboratory might play a crucial role in the control of the following
diseases, which are among the most common in developing countries:

1. Parasitic diseases diagnosed by direct microscopic examination or after staining:
   - malaria
   - onchocerciasis
   - trypanosomiasis
   - filariasis
   - schistosomiasis
   - vaginal trichomoniasis
   - amoebiasis, Trichomoniasis, and other parasite infestations diagnosed in stools.

2. Bacterial diseases diagnosed by microscopic examination after staining:
   - tuberculosis
   - leprosy
   - gonococcal infections
   - meningococcal and pneumococcal meningitis.

3. Other conditions, particularly noncommunicable ones, such as anaemia, diabetes,
   and eclampsia.

The health centre laboratory should be staffed by a trained laboratory assistant who
should be part of the health centre team and able to assist in other health activities when
there is insufficient laboratory work. He or she should receive technical and logistic
support and supervision from the nearest higher-level laboratory.

The main functions of this laboratory assistant would be:

- to perform all simple routine analyses, as well as direct microscopy, in the areas
  of parasitology, bacteriology, haematology, and chemistry (urine and spinal fluid)
  according to written instructions;
- to collect and dispatch biological samples;
- to keep a record of expended material, chemical reagents, etc. and to order new stocks;
- to prepare a monthly report of activities.

**Essential laboratory tests for use in the health centre**

Besides the availability of resources and manpower, the following factors are important in deciding which tests should be undertaken at the health centre level:

- the priority health needs of the people according to prevailing local conditions;
- the location of the health centre, including its distance from the referral hospital and the availability of transport facilities;
- the possibility of collecting and sending specimens for testing to the hospital laboratory and the time taken for the return of the results;
- the need for immediate action in emergencies;
- the type and degree of training of the laboratory personnel.

In the light of these factors, a list of essential tests to be carried out at the health centre level has been prepared, including classical and simple methods. However, in some countries, reagent test strips and kits are being used, e.g., for urinalysis. Because of their cost and the problems associated with their use in tropical conditions (high temperature and humidity), a careful study should be carried out before their introduction in the laboratory.

This list comprises the strict minimum that a laboratory can perform with very simple equipment and reagents; it consists of microscopic examinations, basic urine tests, and determination of erythrocyte sedimentation rate.

<table>
<thead>
<tr>
<th>Tests</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood</td>
<td></td>
</tr>
<tr>
<td>haemoglobin</td>
<td>comparator¹</td>
</tr>
<tr>
<td>white cell count</td>
<td>counting chamber</td>
</tr>
<tr>
<td>examination of a film</td>
<td>stained film</td>
</tr>
<tr>
<td>for cell morphology</td>
<td>Westergren</td>
</tr>
<tr>
<td>erythrocyte sedimentation rate</td>
<td>direct and Romanowsky-stained preparations</td>
</tr>
<tr>
<td>parasites</td>
<td></td>
</tr>
<tr>
<td>Urine</td>
<td></td>
</tr>
<tr>
<td>protein</td>
<td>sulfosalicylic acid</td>
</tr>
<tr>
<td>glucose</td>
<td>Benedict's</td>
</tr>
<tr>
<td>sediment for cells,</td>
<td>direct microscopy</td>
</tr>
<tr>
<td>casts, parasites</td>
<td></td>
</tr>
<tr>
<td>Sputum</td>
<td></td>
</tr>
<tr>
<td>M. tuberculosis</td>
<td>Ziehl-Neelsen-stained smear</td>
</tr>
<tr>
<td>Stools</td>
<td></td>
</tr>
<tr>
<td>protozoa and ova</td>
<td>direct saline and iodine preparation</td>
</tr>
<tr>
<td>Skin</td>
<td></td>
</tr>
<tr>
<td>M. leprae</td>
<td>modified Ziehl-Neelsen-stained smears</td>
</tr>
<tr>
<td>O. volvulus microfilariae</td>
<td>direct wet preparation</td>
</tr>
<tr>
<td>Pus and exudates</td>
<td></td>
</tr>
<tr>
<td>bacteria</td>
<td>gram-stained smear, especially for gonococci</td>
</tr>
</tbody>
</table>

¹ When possible, a colorimetric method is recommended.
According to the priority health needs of the community and the resources available, other tests may also need to be carried out at health centre level as supplementary laboratory tests.

Planning a health centre laboratory

The probable workload of the health centre laboratory must be estimated locally on the basis of the population covered by the centre, the expected number of new contacts per year, and the probable number of tests per new contact. It must be remembered that a laboratory worker is able to perform 700-950 tests per month, and that 400 tests per month is considered a minimum if he or she is to continue working with an acceptable expectation of reliability.

This local estimate will therefore indicate whether the health centre should be provided with a laboratory, and, if so, how many laboratory workers will be needed to run it.

The laboratory described below will be staffed by a single laboratory assistant and will be convenient for a workload of 5000-10 000 tests per year. Should the expected workload be near the upper limit, it would be advisable to plan either for a laboratory with two workers or for premises that can be easily expanded when needed.

A room of 12 m² (3x4 m) with a total of about 6 m of laboratory bench is considered adequate. As this type of laboratory will be mainly concerned with microscopy, it is advisable to have, against the window wall, a work bench 3 m long with 2 knee spaces so that 2 microscopy workposts can be set up. The second workpost would make it possible to have an extra laboratory worker in case of a special campaign (e.g., malaria eradication). The remainder of the work bench is for chemical and other tests such as haemoglobin measurement, sedimentation rate, etc. At one end of the bench is a sink, where stained slides and pipettes are washed. A glove box or fume hood is also provided to prevent possible spread of infection to personnel when they are processing specimens. It should be located where the air disturbance caused at the front of the hood by persons walking is at a minimum.

According to the UNICEF Price List (UNIPAC) for 1978, investment in equipment for this category of laboratory costs between US$ 650 and US$ 750. The annual operational cost, with provision for reagents and glassware, is approximately US$ 100-150 on the basis of 500-800 tests per month. As a laboratory assistant’s skill will be sufficient at this level, the salary cost will be comparatively low.

From the above, it can be seen that the cost of establishing a laboratory in a health centre is modest in relation to the large benefits to be derived from it. A prerequisite to the setting up of a laboratory at this level is the existence of facilities for the supply of safe water, a stable source of electricity, and means of sterilization. There are two possibilities as regards arrangements for the planning and organization of a laboratory in a health centre:

(a) available facilities in an existing health centre have to be adapted for the purpose;
(b) plans are made for a laboratory in a new health centre.

In the first case, flexibility and adaptation to existing allocated space are essential. However, there are minimum requirements to be met, e.g., a bench of 2.5 m length with a sink against a wall with window, a cupboard for the storage of laboratory materials, and a desk for the registration of specimens and recording of results. A separate room should be provided for the laboratory, so that the laboratory worker can work without interruptions from people attending the health centre (see Fig. 9). The layout of a health centre laboratory is shown in Fig. 10.
FIG. 9. HEALTH CENTRE LABORATORY: LOCATION IN RELATION TO OTHER SERVICES

FIG. 10. LAYOUT OF A HEALTH CENTRE LABORATORY
11. ORGANIZATION OF A LABORATORY IN A PRIMARY LEVEL HOSPITAL

The primary level hospital should be recognized as the first point of referral beyond the health centre that might provide at least some beds for medical and obstetrical care and surgical emergencies. It could be identified with a general hospital having basic facilities; in many countries, it corresponds to a district hospital. In spite of the difficulty of defining all the functions of this type of hospital, which depend on several variables, such as population density, environment, accessibility, manpower, equipment, and supplies, it is generally agreed that it has between 30 and 150 beds and covers a population of some 30 000-100 000 inhabitants. These figures are subject to modification to take geographical conditions and concentrations of population into account.

The primary level hospital is intended to deal with major health problems and serve as a referral centre for peripheral health services. It should, in turn, refer to higher levels, cases that are considered too complicated or for which a more precise diagnosis or more specialized treatment is required.

The primary level hospital comprises an outpatient and an inpatient department. The outpatient department has functions similar to those of the health centre, although on a larger scale.

The inpatient department carries on the following activities:

- general medicine;
- general surgery, including surgical emergencies;
- obstetrics, including surgery for the prevention and treatment of complications.

Provided the necessary staff and equipment are available, certain specialized services could be added, as the need arises, to deal with a wider range of prevalent diseases and conditions. Depending on the pattern of morbidity in the area, the extent to which qualified manpower and equipment are available, and the size of the hospital, there could be a rehabilitation service. The hospital could also be used as a base for mobile health services. An elementary X-ray unit and a laboratory will be required, in support of all these services.

All laboratory tests performed in a primary level hospital should be based on the activities and functions of the hospital and the actual priority needs for laboratory support.

The laboratory described below is designed to serve a rural hospital of 90 beds with an active outpatient department. The workload for the inpatient service may be calculated as follows. First the number of bed days per year must be estimated. This may vary from 3500 for an occupation rate of 30% to 10 500 for an occupation rate of 90%, and statistical returns to the central laboratory could show a utilization index for laboratory services ranging from 0.35 to 1 laboratory test per inpatient day. The workload may thus vary considerably, and for planning purposes it is often necessary to take into consideration the average laboratory utilization in hospitals operating in similar conditions. Suppose that this is 12 000 laboratory tests annually for the inpatient department. To this has to be added the workload of the outpatient department, which is servicing a population of 25 000 and also provides a referral service to the health centres operating at the peripheral level. Let us estimate this workload at 6000, which, added to the workload from the inpatient department, will bring the total workload to 18 000 laboratory tests annually. For the type of laboratory tests implemented at this level, this workload calls for 3 technicians, and a three-module laboratory is accordingly proposed (see Fig. 11). The technical area has an open-plan arrangement which offers many advantages; the common use of laboratory equipment such as refrigerators, centrifuges, etc., and also the flexible use of polyvalent technical staff. The size of the workload permits both haematology and microbiology to be carried on in one module, and urinalysis and biochemistry in a second module. In the technical area, there is a desk for all administrative work. The third module is divided into two subunits; the glassware washing unit and the toilets (one for the staff, the other for patients).
12. ORGANIZATION OF A LABORATORY IN AN INTERMEDIATE LEVEL HOSPITAL

The suggested plan (see Fig. 12) is for a laboratory to serve a 600-bed general hospital providing some 170,000 bed-days annually and comprising the following departments: general medicine, surgery, pediatrics, gynecology, obstetrics, cardiovascular diseases, chest diseases, ear-nose-and-throat, and dermatovenerology. It will also have an intensive care unit.

The technical area for laboratory services in this type of hospital would require the following units: hematology, urinalysis, biochemistry, and serology/bacteriology. If the needs of the outpatient department for laboratory services are also taken into account, the total workload may be estimated at 85,000-120,000 tests annually. These figures are based on estimates of the workload of each technical unit, a knowledge of which is essential for the subsequent determination of the staff and space required for each unit. Most often this kind of estimate will be based on statistical returns from hospitals with similar functions and operating in comparable conditions. The number of technical staff required would be 7-10 laboratory technicians, while the auxiliary staff would include 3 glass-washers and one secretary. All the figures given above are purely arbitrary. They will vary from place to place and should not be taken as norms. The methodology of workload measurement and manpower estimation is dealt with in a related document which is available on request from Health Laboratory Technology, WHO Headquarters, Geneva, Switzerland.
To achieve an optimal relationship between all the units, the haematology unit is situated near the waiting-room. This could be particularly useful if this unit should be involved in blood collection for transfusion purposes. The bacteriology unit is near the decontamination and washing unit so as to avoid contamination of the laboratory. In the bacteriology unit there is an isolation room that can be used for microbial isolation and the preparation of tuberculosis smears. The office of the chief of the unit is in the centre of the laboratory to facilitate supervision.
# CHOICE OF HEALTH SERVICE TRANSPORT

Oscar Gish

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*WHO Consultant.*
1. INTRODUCTION

To be successful, national health service systems require assurances of adequate support for the work of peripheral units and the appropriate referral of patients from these units to facilities having more technical sophistication. In most developing countries, the technical difficulties involved are compounded by the often scattered location of populations, poor roads, limited public and private means of transport, and the overall constraint of very limited resources. A further complicating factor in the context of health service planning is that the particular assets of different forms of transport are frequently not closely related to the medical needs of Third World populations or the resources available to their governments.

It is the purpose of this paper to draw attention to the need to consider the potential users of various types of transport when decisions on health plans are being made. It is based on experience in a number of countries, as borne out by case studies.

2. ASPECTS OF HEALTH SERVICE MOBILITY

Mobile activities are an integral part of health services, the most significant of these activities being the travel of patients from their homes to places where health care is dispensed. In this form, patients often indirectly bear a substantial part of the total costs of health services (1). The reverse activity, in which health workers leave their base and visit people for whom access to fixed health units is particularly difficult, takes place within the framework of the health care services in most countries.

It has been suggested (2) that different aspects of health care should be taken into account when mobile services are being considered. These include the requirements of accessibility to, and periodicity of, care, the greater or lesser importance of speed, and the availability of simpler and/or more complex facilities and more highly and/or basically trained personnel. Fixed facilities are better at providing some features, and mobile facilities others. It is through an optimum mix of fixed and mobile services that scarce resources will be used most efficiently.

The need for mobility in health services will vary, depending to a significant degree upon population distribution. In urban areas, the movement of health workers will play a more limited role. In areas with low population densities, mobility in health services is essential for increasing the outreach of the fixed facilities, particularly in view of the fact that a journey of 2-3 hours seems to be the accepted upper limit of travel to a fixed health unit (3). Ideally, appropriate maps should be drawn around staffed facilities to indicate realistic catchment populations (4). In poor countries, such sophisticated data are rarely available, and in any event transport systems are usually rudimentary, the main form of movement being by foot. Consequently, the effective catchment areas of most rural facilities fall within a radius of 8-16 km (5-10 miles). Coverage can thus be at least roughly calculated, if population distribution maps are available (as they usually are, even if outdated).

Planning decisions must be taken concerning the provision of increased access to health care for people living in areas more than 3 hours' travelling time, or 16 km, from a fixed staffed facility. These decisions will depend primarily upon the manpower and financial resources available to the health services and the physical location of the populations living in these areas. Decisions must be taken about how best to reach these people, either by means of additional fixed facilities or by the use of a mobile unit operating from an existing staffed base. Of course this choice does not preclude the development of village health services from within the villages themselves, which may be, in fact, a necessary supporting feature of whatever system is adopted. Theoretically, in terms of the comparative cost-effectiveness of static and mobile facilities, there is a switchover from static to mobile services as population density decreases. In practice, the point at which this occurs is seldom clear because of the many other constraints affecting the provision of health services and the influence of changing population density on the provision of any particular form of health (or other) service. Thus health care is provided from hospitals mainly in areas of high population density, since it is there that they are generally found, whereas in sparsely populated areas health services are mostly provided by personnel with relatively elementary training and dispensed from simpler facilities.
3. FUNCTIONAL USES OF TRANSPORT

The main health service functions in which mechanical transport has been used are:

- supportive visits to peripheral basic care units,
- ambulance work,
- vertical health programmes,
- delivery of basic patient care,
- scheduled visits not necessarily including direct patient care,
- specialist clinical rounds on a scheduled basis.

In most low-income countries, supportive visiting to rural primary care units is the health service activity with the highest cost-benefit ratio in which mechanical transport can be used.

Supportive visits to peripheral units

Visits by relatively highly trained, but scarce, health personnel will probably greatly increase the effectiveness of the care dispensed from units staffed by workers with more elementary training. A particularly important aspect is the establishment of continuing and regular contact between health personnel, leading to the development of the rapport and confidence so essential to the effective functioning of a dispersed health care network. The optimal frequency of these supportive and educational visits would appear to be at intervals of about a fortnight, with each visit lasting approximately four hours. During these visits, several tasks can usually be performed:

- referral clinics can be held, at which patients already screened by permanent staff are seen;
- on-going (especially preventive) health programmes can be discussed and problems clarified;
- supplies, both medical and general, can be delivered;
- where indicated, pathological specimens, e.g., sputum in suspected cases of tuberculosis, and blood for haemoglobin determination and Wassermann and Kahn testing, can be collected - the results being brought back at the next visit;
- where required, more general areas of community concern can be discussed with local representatives, e.g., development officers, teachers, tribal authorities, or elected bodies; and
- those patients requiring the more sophisticated facilities of a hospital can be transported to one on the return journey.

Ambulance work

Transport solely for the conveyance of patients is difficult to justify in developing countries. While this use of transport is often the most immediately appealing, it is expensive and dependent upon good communication systems. Examples of the successful use of light aircraft for ambulance services in general are only to be found in high-income countries. In most developing countries, such services have "had to cope with many financial and technical difficulties" (3). The cost per emergency flight is usually high. During 1973, for the service operated by the African Medical and Research Foundation in Nairobi, it was $ 220 and, for the Royal Australian Flying Doctor Service, it was about $ 525. However, the disparity in health expenditure between these two countries is very great: Kenya spent just over $ 2 per capita in 1973 while Australia spent almost $ 125 per capita in 1971.

Vertical health programmes

Vertical health programmes have been great users of transport. However, over the past decade it has been increasingly realized that such programmes are likely to be more effective and efficient in the use of scarce resources if they are integrated into comprehensive primary care systems.
Basic patient care

The delivery of basic patient care from land vehicles or aircraft is far less cost-effective than the provision of care from fixed clinics. A recent study in Botswana (6) has compared the cost-effectiveness of mobile land and air clinics with that of fixed clinics. The fixed clinics were found to be about 14 times more cost-effective than the air service and eight times more than the land-based transport. This was in great part due to the larger proportion of patients seen at fixed clinics whom it was considered could be treated effectively, and to the fact that the costs of transport were higher than equivalent annual capital costs for fixed facilities.

Scheduled visits not necessarily including direct patient care

Regular deliveries of supplies to peripheral health units are extremely important for their effective functioning. Usually these deliveries can be integrated into supportive visiting schedules, although occasionally, when particularly bulky or heavy objects have to be transported, special visits by large vehicles are necessary.

Specialist clinical rounds

Specialist clinical rounds from regional or national hospitals to relatively isolated hospitals are likely to be important, once again mainly for their educational and supportive value. However, their place among total health service transport requirements is likely to be a relatively minor one.

4. MATCHING TRANSPORT TO HEALTH CARE FUNCTIONS

Different modes of transport vary in such aspects as capital cost, running cost per mile, carrying capacity, speed, requirements for sophisticated maintenance, and the need for an associated physical infrastructure (7). The uses to which they are put within the health services vary greatly, as also does the level of personnel that will utilize them and the location and disease patterns of the populations to be served. The most important attributes of certain forms of transport are set out in Tables 1-3. It is necessary to match the mode of transport to its proposed use and the type of personnel that will utilize it, as outlined in Table 4. This is of critical importance if an optimum use of health transport is to be achieved within the financial constraint of the relevant provision in the health budget. Given the probability that fuel prices will increase in the future at a greater rate than the health budget, it becomes even more important that all forms of transport should be utilized to the best advantage.

Land transport

Greater use must be made of less expensive and simpler types of transport for most travel undertaken by health personnel. Disregarding the walks to and from work by health workers residing close to their base, which often constitute an important part of total health service mobility, greater use could be made of bicycles or motorcycles and, in certain instances, animals, e.g., horses and donkeys. Where larger vehicles are required or longer distances covered, light delivery vehicles are likely to be adequate in the majority of instances. Four-wheel drive vehicles should be used only in a limited number of situations in which it is essential for the vehicle to be able to cover exceptionally difficult terrain. Four-wheel drive vehicles are expensive to buy and operate; in fact, two or three two-wheel drive "pick-ups" cost the same as one four-wheel drive vehicle. The choice is often between supplying one-third of the clinics with vehicles that will be able to travel almost all year round and supplying all of them with vehicles that may not be able to travel over some roads during the worst of the rainy season (usually not more than 2 to 3 months in any year). It seems inappropriate that a large proportion of four-wheel drive vehicles appear to be used mainly within capital cities and other towns where roads are generally good. Particular attention should be given to light "pick-ups", cars or vans, and especially front-wheel drive vehicles, which are likely to be more maneuverable in sandy or rough country than more orthodox rear-wheel drive vehicles. It is also important that an adequate spares service should be available within the country. Several factors affect the running costs of individual vehicles, including speed, vehicle condition and age, and road and environmental conditions.
### Table 1. Characteristics of Certain Modes of Transport

<table>
<thead>
<tr>
<th>Mode of transport</th>
<th>Speed in km/h (approx.)</th>
<th>Capital cost in US$ (approx.)</th>
<th>Running cost per km in US$ (approx.)</th>
<th>Litres per 100 km (approx.)</th>
<th>Carrying capacity in kg (approx.)</th>
<th>Level of technical sophistication</th>
<th>Probable need for separate driver</th>
<th>Type of terrain needed for operation</th>
<th>Need for associated infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot</td>
<td>5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>a few</td>
<td>low</td>
<td>NA</td>
<td>NA</td>
<td>most</td>
</tr>
<tr>
<td>Animal: donkey</td>
<td>8</td>
<td>150</td>
<td>?</td>
<td>NA</td>
<td>18</td>
<td>low</td>
<td>no</td>
<td>most</td>
<td>no</td>
</tr>
<tr>
<td></td>
<td>horse</td>
<td>8</td>
<td>400</td>
<td>NA</td>
<td>18</td>
<td>low</td>
<td>no</td>
<td>most</td>
<td>no</td>
</tr>
<tr>
<td>Bicycle</td>
<td>16</td>
<td>95</td>
<td>very low</td>
<td>NA</td>
<td>9</td>
<td>low</td>
<td>no</td>
<td>level terrain easier, difficult in sand</td>
<td>require paths</td>
</tr>
<tr>
<td>Light motor-cycle</td>
<td>24</td>
<td>500</td>
<td>0.02</td>
<td>3.5</td>
<td>14</td>
<td>low/moderate</td>
<td>no</td>
<td>level terrain easier, difficult in sand</td>
<td>require paths</td>
</tr>
<tr>
<td>Small van or pickup</td>
<td>48</td>
<td>2500-3500</td>
<td>0.06</td>
<td>9.0</td>
<td>500-1000</td>
<td>moderate</td>
<td>yes</td>
<td>low road clearance, difficult in sand or mud</td>
<td>require roads or tracks</td>
</tr>
<tr>
<td>&quot;Go-anywhere&quot; four-wheel drive vehicle</td>
<td>48</td>
<td>6150-8000</td>
<td>0.10</td>
<td>18.0</td>
<td>1000</td>
<td>moderate</td>
<td>yes</td>
<td>most</td>
<td>not usually</td>
</tr>
<tr>
<td>Light single-engined aircraft</td>
<td>224</td>
<td>64 000</td>
<td>0.15</td>
<td>22.5</td>
<td>290</td>
<td>high</td>
<td>yes, pilot</td>
<td>most</td>
<td>require sophisticated base facilities</td>
</tr>
</tbody>
</table>

1 Sources: data obtained from several sources, including vehicle dealers, motoring organizations, and COMMERCIAL MOTOR Tables of operating costs for goods and passenger vehicles, Feltham, Hamlyn, 1972.
2 All costs 1975, Southern Africa, converted to US$.
3 Includes insurance, petrol, oil, and servicing.
4 Not applicable.
5 E.g., Honda, Puch, Suzuki, or similar 50-70 cc model.
6 E.g., Datsun, Ford, Leyland, Peugeot, Renault, Toyota, or similar 3/4-1 ton model.
7 E.g., Ford F250 4x4, Leyland Land-Rover, or Toyota Land Cruiser.
8 E.g., Cessna-206 or similar model.

### Table 2. Comparison of Capital Costs for Certain Vehicles

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Capital cost in US$ (approx.)</th>
<th>Ratios of capital costs for certain vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Bicycle=1 Small van or pickup=1 Four-wheel drive vehicle=1</td>
</tr>
<tr>
<td>Bicycle</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>Light motor-cycle</td>
<td>500</td>
<td>5</td>
</tr>
<tr>
<td>Small van or pickup</td>
<td>3 000</td>
<td>32</td>
</tr>
<tr>
<td>&quot;Go-anywhere&quot; four-wheel drive vehicle</td>
<td>7 000</td>
<td>74</td>
</tr>
<tr>
<td>Light single-engined aircraft</td>
<td>64 000</td>
<td>674</td>
</tr>
</tbody>
</table>

1 Sources: data obtained from respective vehicle dealers.
2 All costs 1975, Southern Africa.
3 E.g., Honda, Puch, Suzuki, or similar 50-70 cc model.
4 E.g., Datsun, Ford, Leyland, Peugeot, Renault, Toyota, or similar 3/4-1 ton model.
5 E.g., Ford F250 4x4, Leyland Land-Rover, or Toyota Land Cruiser.
6 E.g., Cessna-206 or similar model.
### TABLE 3. COMPARISON OF RUNNING COSTS FOR CERTAIN VEHICLES

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Ratios of running costs for certain vehicles</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Running cost per km in $ (approx.)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Light-motor-cycle=1</td>
<td>Small van or pick-up=1</td>
<td>Four-wheel drive vehicle=1</td>
</tr>
<tr>
<td>Light motor-cycle&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.02</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small van or pick-up&lt;sup&gt;4&lt;/sup&gt;</td>
<td>0.06</td>
<td>5</td>
<td>1.7</td>
<td>1.6</td>
</tr>
<tr>
<td>&quot;Go-anywhere&quot; four-wheel drive vehicle&lt;sup&gt;5&lt;/sup&gt;</td>
<td>0.10</td>
<td>10</td>
<td>2.7</td>
<td>1.6</td>
</tr>
<tr>
<td>Light single-engined aircraft&lt;sup&gt;6&lt;/sup&gt;</td>
<td>0.15</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> Sources: data obtained from respective vehicle dealers.

<sup>2</sup> All costs 1975, Southern Africa.

<sup>3</sup> E.g., Honda, Puch, Suzuki, or similar 50-70 cc model.

<sup>4</sup> E.g., Datsun, Ford, Leyland, Peugeot, Renault, Toyota, or similar 3/4-1 ton model

<sup>5</sup> E.g., Ford F 250 4x4, Leyland Land-Rover, or Toyota Land Cruiser.

<sup>6</sup> E.g., Cessna-206 or similar model.

### TABLE 4. MATCHING THE MODE OF TRANSPORT, ITS PROPOSED USE, AND THE PERSONNEL INVOLVED

<table>
<thead>
<tr>
<th>Mode of transport</th>
<th>Proposed use</th>
<th>Health personnel involved</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot, bicycle</td>
<td>Home visiting close to health base (health post, clinic, health centre or hospital)</td>
<td>Primarily basically trained personnel (village health worker), but also nurses and health assistants</td>
<td>Speed not important</td>
</tr>
<tr>
<td>Horse or donkey, motorcycle</td>
<td>Visiting subcentres (health posts) from clinic or health base in support of basically trained personnel and for carrying out planned procedures, e.g., immunizations, health education, delivery of supplies, etc.</td>
<td>Nurses and health assistants</td>
<td>Speed of no great importance</td>
</tr>
<tr>
<td>Small van or pick-up</td>
<td>Visiting subcentres as above, but located at a moderate distance from health base</td>
<td>Nurses and health assistants</td>
<td>Speed moderately important</td>
</tr>
<tr>
<td></td>
<td>Visiting permanently staffed facilities in a supportive capacity</td>
<td>Higher trained personnel, e.g., doctor, nurse, or health assistant</td>
<td>Speed moderately important</td>
</tr>
<tr>
<td>Light single-engined aircraft</td>
<td>Visiting permanently staffed facilities at a great distance from health base in a supportive capacity</td>
<td>Higher trained personnel (as above)</td>
<td>Speed important</td>
</tr>
</tbody>
</table>
The standardization of the vehicles in use in developing countries is an important goal. This will facilitate maintenance and repairs, as it will be easier to stock spare parts and mechanics will be able to work more efficiently if they have a smaller variety of vehicles with which to contend. It is also possible that chauffeurs would make fewer driving errors if they did not have to change types of vehicle so often. Very often, developing countries are placed in the awkward position of having to accept from donors vehicles for which they have little or no maintenance capacity.

It cannot be assumed that the mere provision of the right type of vehicle for various kinds of services and terrains will in itself be sufficient to ensure a smooth transport service. It is also necessary for transport to have the backing of a sound supportive structure. Attention must be given to the regulations governing this structure. Should these be too slack, vehicles may be used for private convenience, and petrol and parts may be pilfered; should they be too constraining, they may become an obstacle to the legitimate use of the vehicles. Responsibility for the use of the vehicles, as appropriate, at the various levels of the health services should remain with the ministry of health, and in general the vehicles should not be entrusted to other than health authorities. How far control over vehicle utilization should be decentralized will depend on the circumstances of each country, and decisions on this point must take into account both efficiency and cost. For instance, in countries with a high inflation rate, cash for direct payments must be available at various levels for the purchase of petrol, as distributors may not be in a position to wait six months to a year for payment; individual health facilities should not be dependent for their petrol on a distant provincial capital.

Another important component of a vehicle support system is that of servicing and repairs. Here again the choice must be dictated by the local context: government repair depots have the advantage of pooling spare parts and skills, but health service vehicles may be allotted a relatively low priority. In some circumstances, a health service depot might be a good solution, provided there are enough vehicles to ensure continuity of work.

**Purpose-built vehicles**

A wide range of purpose-built mobile units are available. These vary from ambulances, blood banks, field laboratories, and X-ray and dental clinics to multiphasic screening units. The cost of the conversion of a basic vehicle for specific purposes varies, depending upon its sophistication and the equipment installed. For even the most simple of these vehicles, the cost is usually twice as great as for the basic production model. In view of this high cost, e.g., in 1975, a two-stretcher Land-Rover ambulance already cost $12 500-15 000 and a mobile health clinic on a Bedford chassis about $23 000 (as against about $6250 for a Land-Rover long-wheelbase pickup and about $9250 for a five-ton Bedford lorry), extreme caution would be necessary before purchasing one.

In any case, it appears that in practice many such vehicles are not actually used for the purposes for which they were designed. This may be due to one of several reasons. In many instances, they have not been critically designed in consultation with the people who will be using them, or else the conditions under which they will have to function have not been sufficiently taken into account. Often the conversions are too sophisticated, and as a result problems of maintenance and spare parts develop. For the vast majority of situations in which vehicles are used in the health services, at least in developing countries, there is no need to have purpose-built conversions. In most cases, the necessary minor adaptations are possible locally at far less cost.

It is not unusual for purpose-built vehicles to be offered to countries by external donors. The life expectancy of these vehicles is generally quite short. They are too large for any but the best roads, which in any event are mainly located between the largest and best served urban areas, and their relatively specialized and unique equipment causes further problems. As with other transport and equipment, there is a need for a certain number to be in use before they become viable with regard to efficient operation, maintenance, and repair.
Aircraft

Light aircraft fall into the two basic categories of one- and two-engine machines. Helicopters are generally agreed to be too difficult and expensive to maintain to be useful for flying health services. Compared with fixed-wing machines, helicopters incur appreciably higher costs (both fixed and running), their carrying capacity per unit cost is lower, and their servicing requirements are higher. The capital cost of a twin-engine plane is two to three times that of a single-engine one, and the operating cost is about 50% greater. The major advantage of a twin-engine plane is a marginally greater safety factor, although experience has shown one-engine aircraft to be perfectly satisfactory in this respect.

The major consideration with regard to the use of airplanes for the delivery of health care is to ensure that this use is restricted only to planned, cost-effective activities. In the context of virtually any Third World country, this will rule out the use of aircraft for emergency services. And yet, in terms of health services, the airplane is most commonly thought of as being particularly useful for emergency care and, in fact, is commonly used in this way. The difficult factor is that if an aircraft is available to a Ministry of Health or any other health/medical service, it then becomes virtually inevitable for it to be called upon when emergencies do arise. In such situations, it is generally impossible to refuse the use of the aircraft for the emergency.

It is quite clear that, unless flying doctor services are planned against the need for emergency care, the very availability of the aircraft is almost certain to draw it into such work. If its use for emergency work were to be accepted, it would then become necessary to include an element of spare capacity in the amount of potential air hours available to the flying medical service. This spare capacity would almost certainly be turned to administrative or "neo-emergency" medical purposes, thus substantially reducing the cost-effectiveness of the airplane. The costs of operating aircraft are so high that it is overwhelmingly important to limit their use to pre-planned activities. If this cannot be guaranteed, an economic argument cannot be made in favour of the use of aircraft within the health services of low-income countries.

It is part of the usual work of a Ministry of Health to provide back-up services to those of its units providing primary care. These services include the regular visiting of primary care units by more highly trained staff than are normally available within the units. Vehicles are generally required to transport the visiting staff. The choice of vehicle will depend upon such major factors as the degree of dispersion of the units to be visited, the availability of skilled health workers, and the cost of the transport. The questions of speed and convenience of travel are usually implicitly taken into account with the factors just mentioned. Primary health care delivered by aircraft is costly and relatively ineffective when compared with that dispensed from permanently staffed clinics. It is also likely to have less of a lasting impact on the health of the communities visited. In fact, it may even delay the implementation of a more appropriate delivery system (e.g., a village health worker and, perhaps, a low-cost facility).

The reason for using an airplane in the health services is to take advantage of the long distances that a plane can cover in a relatively short period of time. This can be done by utilizing the airplane only in relationship to fixed units which could not be as cost-effectively reached by land-based vehicles. The criteria developed for the selection of those units to be visited by aircraft in a recent feasibility study carried out in Botswana (9) were as follows: those clinics that are located by virtue of distance or difficult terrain at such travelling time from the health team's base by road that (a) more than one day is required for the visit to one clinic, or (b) a total stay of more than four nights away from the base is required for any one trip. Although these criteria were developed specifically within the manpower and financial restraints of Botswana, they are likely to have wider applicability.
When aircraft are used in this supportive visiting role, there is an absolute need to integrate the airplane functionally into the on-going health delivery system based on fixed units. For all but some relatively wealthy countries, this would rule out any proposals for administratively independent mobile flying doctor services having their own pilots and aircraft as well as medical staff. Such proposals usually turn out to be so expensive as to be impossible of acceptance by the countries concerned, and the possibilities of a more limited use of airplanes, within the context of an integrated health delivery system, are unfortunately not given sufficient attention. The very substantial publicity given to the finding that it is only slightly more expensive to travel by light aircraft than by a four-wheel drive land vehicle has stimulated interest in the potential use of the airplane for health services. However, the calculations on which this finding is based take into account only the cost of the aircraft and pilot, comparing it with the corresponding figure for the land vehicle on a per mile (or per kilometre) basis. This is quite a different thing from the cost of an administratively independent and complete mobile flying unit with its own medical and other personnel, or the cost per effective patient contact. Conclusions based only upon mileage costs for a plane and pilot cannot be carried across to the development of separate (non-integrated), completely staffed, flying doctor/health units. Such flying units are usually more costly than anything in the way of teams travelling by land that might be provided in practice by governments, and, in any case, governments would rarely provide a land vehicle for the transport of an emergency case for several hundred miles, which is the kind of distance usually postulated in comparing the cost of air and land transport.

It must be stressed that the use of aircraft that are not integrated into the overall health delivery system of a country is, in almost all cases, to be avoided. There are few arguments in its favour, except that it might be convenient for individual health workers or important to the odd emergency patient (see later discussion for some possible exceptions). In fact, it appears that the development of flying doctor services has been to a large extent due to their especial convenience for medical doctors, as though almost no other considerations needed to be taken into account except the saving of doctors' time. Of course, there may be some situations in which this should be the major, or even the only, consideration.

It is sometimes argued that the existence of a flying medical service is a prerequisite for the employment of expatriates, especially in remote areas. However, there is little if any evidence to support this argument and, anyway, it is unlikely that an airplane would not be available on a special basis to cater for the emergency medical needs of expatriates. The airplane, in many cases, is also seen as a device for quick visits to "open up" the countryside. This kind of visit is often based on hurried and uncoordinated roadside stops, in which the flying team must keep one eye on their watches to make sure they can get back to home base before dark. One significant point about this type of flying "safari" is that the people gathered to await the coming of the plane cannot be certain it will actually arrive, because of its tight schedule dictated in particular by the need to return to home base before dark.

Flying health services would appear to be justified to the extent to which they operate in conjunction with the on-going fixed health facilities and pay regular visits to far-flung stations that it would otherwise be particularly difficult to reach so frequently. Essentially, this would be the same sort of visiting as that carried out by land vehicles, i.e., for the purpose of providing support and supervision for lower-level institutions and attending to selected screened patients. It is right for the visiting doctor (or other health worker) to see selected patients, not only because particular skills might be needed in individual cases, but also as part of the training and supervisory work that should always be carried out in conjunction with patient care. The visiting doctor should normally be the regional/district medical officer.

Several passages in the literature note the importance of the monthly or fortnightly visits of the doctor to the nurse or other paramedical or auxiliary health worker functioning in an isolated health post. It must be stressed that the airplane is to be used for such visits only when it is absolutely clear that a land vehicle is not to be preferred. This is not only because of cost considerations, but because the team arriving by road is likely to spend a longer time at an outlying post (in fact, at a very far-flung station, it will probably remain overnight), as well as to have seen a greater number of people en route. The airplane becomes particularly
useful in cases when the very furthest health facility to be visited is a considerable distance from the next nearer facility. In any event, the remoter outposts must be visited from time to time by a land vehicle, if only because it can carry more supplies than the airplane and the greater number of people that may occasionally be required.

Another possible use of the airplane would be for the extension and improvement of the surgical care available at district and regional hospitals. This is an especially important consideration because the referral system does not work well in most countries. The aircraft could ferry a surgeon (or surgical team) about on a scheduled basis. The same principle might apply to several other medical specialties, but its usefulness is most apparent in the case of surgery. The weakness in using an airplane to transport a surgical team is that the team's visit is primarily for clinical work and it is unlikely to stay on to do any teaching, except that performed in the course of the surgical sessions. In some rather special situations, the airplane might also be used for the transport of staff for such activities as immunization, health education, or disease surveys, and the transport of medical supplies.

It is difficult to obtain accurate and comparable data on costs and levels of utilization for the various flying doctor services. Table 5 shows the costs for certain items of service for some flying doctor systems. The cost per patient contact varies widely among the different services. Although many factors, including distance travelled per contact, could account for part of this variation, it might be worth noting that the cost is least for a service (Lesotho) that over the years has had to review its operations critically and restrict them to those areas that cannot be served more cheaply by alternative forms of transport.

**TABLE 5. UNIT OUTPUT COSTS FOR CERTAIN FLYING DOCTOR SERVICES, 1973 (US$)**

<table>
<thead>
<tr>
<th>Service</th>
<th>Cost per flight</th>
<th>Cost per patient contact</th>
<th>Cost per emergency call</th>
<th>Transport cost per operation performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Royal Australian Flying Doctor Service</td>
<td>525</td>
<td>21</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>African Medical and Research Foundation (AMRF)</td>
<td>NA</td>
<td>8.0</td>
<td>220</td>
<td>40</td>
</tr>
<tr>
<td>Zambia Flying Doctor Service</td>
<td>NA</td>
<td>9.25</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Lesotho Flying Doctor Service</td>
<td>NA</td>
<td>4.56</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

1 Sources, developed from data obtained from The flying doctor, Canberra, Australian Information Service, 1974; Annual report for 1973, Nairobi, AMRF, 1974; Annual report for 1973, Ndola, Zambia Flying Doctor Service, 1974; Administrator, Lesotho Flying Doctor Service, personal communication, 1975.

2 Not available or not applicable.

3 The figures for the AMRF were calculated by allocating the costs for all aviation administrative hours flown proportionately to the three main categories of air transport, i.e., emergency, routine surgical, and routine medical. Perhaps 10% of aviation administrative hours flown fall into other categories. This would indicate a reduction of about 3% in each of the figures shown for the AMRF.

4 1972.

5 A proportion of these patients were referred.

6 Patients seen at referral clinics by medical officer.
5. CONCLUSION

The use of mechanical transport within health services must be viewed critically; this has become all the more important with the recent massive increases in fuel prices. The attributes of various forms of transport must be matched more closely to their proposed use and the level of personnel that will utilize them. More attention should be given to using appropriate low-technology systems for the greater part of the transport required in health services. Where mechanical vehicles are used, particular attention should be given to the organization of adequate servicing. Cheaper light delivery vehicles as compared with more sophisticated and expensive four-wheel drive ones should be used more often.

In working toward an optimal mix of transport within the constraints of any health system, it will be necessary to accept that "ideal" matching to cover all eventualities will not be possible. However, if a critical appraisal is not carried out, some parts of the system will suffer more than need be the case. These are likely to be those serving populations at a substantial distance from the main centres of influence.

Mobility in health services is particularly important in attempting to equalize access to modern health care, although it has only a very limited role to play in the direct delivery of primary care. The more sophisticated and costly the transport, the more limited is its place in the health services of Third World countries. In view of the limited resources of developing countries in both money and manpower, and the demographic and disease patterns of their populations, the most cost-effective use of transport within health services is likely to be for regular supportive (not policing) visits to fixed, permanently staffed, basic care facilities by more highly skilled personnel. Those clinics located relatively close to the regional base can almost always be reached more cheaply by land transport; in the case of those at a greater distance, the use of a light airplane might be justified. Where aircraft are used in this supportive role, it is important they should be integrated into the ongoing health services and tightly scheduled to lessen the risk of their diversion to less cost-effective activities.

6. REFERENCES


7. ACKNOWLEDGEMENTS

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