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

Volume 3

Edited by
B. M. KLECKOWSKI & R. PIBOULEAU
Division of Strengthening of Health Services,
World Health Organization, Geneva

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# CONTENTS

Tentative synoptic table of topics to be covered in the series ........................................ 3
Introduction : Problems of health care facilities planning and design, and possible solutions 5
Inpatient areas – R. Llewelyn-Davies and J. Weeks .......................................................... 19
Outpatient department – L. C. Vogel ................................................................................. 37
The minimum requirement for surgery – J. Cook ............................................................... 73
Radiology in basic-care hospitals and clinics – P. E. S. Palmer ......................................... 83
Equipping hospitals and other health care facilities in developing countries – J. Cooper-Poole 125
Use of mobile and transportable health facilities in developing countries – M. Torfs ........ 141
TENTATIVE SYNAPTIC TABLE OF TOPICS TO BE COVERED IN THE SERIES

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

**Prerequisites for planning**
- Legislation (1)
- Standards (2)
- Machinery for planning (2)
- Training for planning
- Training for management
- Mechanisms for community involvement

**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
- 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)
- Type plans

**Planning of individual facilities**
- Steps in planning and provision for expansion and remodelling (2)
- Time scheduling for design and construction
- Economic aspects of planning and operation
- Relationships (client/architect/engineer/contractor)
- Site selection
- First-line facilities (health centres, health posts, mobile units) (2, 3)
- General hospitals (rural, district and regional)
- 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
- Pharmacy department
- Radiology (3)
- Rehabilitation
- Central sterile supply

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Different aspects of a particular topic may be covered in different volumes.
Dietary department
Administration department
Laundry
Medical records facilities
Stores
Communications and traffic
Power
Sanitary equipment
Piping installations
Floors and floor coverings
Use of centralized on- and off-site services
Staff accommodation

Construction

Methods (1)
Low cost building methods
Materials
Environmental aspects (1)
Internal finishes
Costs

Operation

Commissioning
Medical and surgical equipment (3)
Furniture
Behavioural and social aspects
Safety
Hygiene
Maintenance and engineering services
Optimal use of resources
Evaluation
Physical and functional evaluation of existing facilities

Case studies
INTRODUCTION

PROBLEMS OF HEALTH CARE FACILITIES PLANNING AND DESIGN AND POSSIBLE SOLUTIONS

In order to assess Volumes 1 and 2 of Approaches to planning and design of health care facilities in developing areas, and to prepare subsequent issues in the series, a meeting was convened in Geneva from 26 October to 1 November 1976. It seems useful, for the benefit of the readers and potential users of the series, to provide a synthesis of the participants' opinions concerning technical and administrative matters of general importance pertaining to the development of health care facilities in developing areas.

The present summary of the discussions follows the sequence of the agenda of the meeting. Special emphasis was given to the two main facets of the subject: the "whats", i.e., the problems and approaches; and the "hows", i.e., the guidelines and solutions as seen by the participants.¹

The problem of planning, programming, building, staffing and operating health care facilities is complex and cannot be solved without considering economics, manpower policy, town and country planning, means of communication and other factors pertaining to socioeconomic fields. Ideally, each sector should progress at the same speed and develop in parallel but, in practice, some sectors usually lag behind. It is, unfortunately, often the health sector which suffers most from the obstacles and constraints jeopardizing the development of the whole socioeconomic sector. Developing countries cannot master their destiny in isolation; complex ties bind them to developed countries. But experience has shown that the aid they receive from the developed countries, at least in the field of health care facilities, is often tinged with commercial vested interest of private enterprises, national or multinational, even if channelled through bilateral or multilateral arrangements between governments. Moreover, in many cases, planners and architects are prone to mistakes which "stem from a belief that the problems of planning and construction of such facilities are essentially the same in both developed and developing countries, differing only in detail".² It is, therefore, essential to identify and measure the obstacles and constraints which, on the one hand, hamper the use of existing facilities and, on the other, delay their development.

THE "WHATS"

Concerns about equity

Although it is not the place here to discuss equity either outside the health field or as an idealistic goal, it should be noted that there is a consensus about the beneficial influence that a more equitable distribution of resources would have on health. Malnutrition, poor housing, insanitary environments, insufficient social and educational services are as much conducive to poor health as are inadequate health services. This is why the present efforts to develop primary health care have to include such problems if they are to be understood and accepted by the community. Social inequities are paralleled

¹ The participants represented a wide spectrum of opinions, coming from Argentina, Brazil, Burma, France, Nigeria, Philippines and the United Kingdom. The International Hospital Federation, the Commission of European Communities, the Danish International Development Agency, the Swedish International Development Authority, the World Bank, the International Union of Architects, and the Battelle Memorial Institute were also represented. Finally, several WHO staff members from headquarters and five regional offices actively participated.

by inequities in the receipt of health services which are, above all, a question of barriers. Barriers can be geographical (distances, material obstacles), financial, educational, or psychological. While some barriers are very difficult to overcome, others have been shown to yield to innovative approaches. Unfortunately, resistance to innovation is felt most acutely in the very circles which should initiate it: medical doctors and health authorities. Resistance often takes the form of lip service to the development of peripheral services while the lion's share of capital investment and running expenses continues to go to hospitals. It would not be of much use to be content with denouncing such attitudes. It is only after the sometimes perfectly legitimate motivations of these resistances are well understood that an effort of persuasion in-depth can be undertaken.

**Concerns about proper distribution of health care facilities**

It would be naïve to think that a regular pattern of health care facilities based on norms leading to solutions unrelated to geography, climate, population differential density, and means of communication would answer the problem of accessibility. These factors are subject to precise measurements. Even in the most remote areas, it is possible to have an assessment of the size of the population clusters, of means of transport, and of time to travel from one point to another.

But other factors, albeit of the utmost importance, are not so easily measured. Among them, the salient ones are:

- Financial ability to cover the cost of medical care;
- Perception of disease and readiness to seek medical care, traditional attitudes concerning care to be given to children and the elderly;
- Popular opinion concerning the quality of medical care and confidence in the health staff.

Each of these factors requires a short explanation. Even when theoretically free-of-charge, any contact with health services has a cost for its consumer, especially in rural areas. It may be the cost of transport, or the loss of earnings, or the salary given to a hired worker for continuing agricultural work, or the cost of prescribed drugs, or other unavowable expenses.

Many rural population groups do not perceive morbidity in the same way as urbanized people. They are concerned with acute dramatic conditions but they accept disability and chronic disorders as a natural consequence of aging, especially when the trouble they are suffering from is commonly observed in the community. Also, in many societies, it is still considered shameful to get rid of or to leave alone in a hospital a sick child or an elderly person. Therefore, admission of the extreme age-groups is not readily accepted by the community.

Rural people are perfectly able to judge the quality of medical care from its outcome. They are aware of the fact that a medical worker without any valid equipment, lacking basic drugs, and dissatisfied with his job conditions is unable to deliver good medical care. Moreover, peripheral health facilities are often staffed with young medical workers from distant towns and it takes time for them to be trusted by the local population. Finally, if a few postoperative infections occur or if even one woman dies after the delivery of her child in a local hospital, the whole population may distrust the health facility for some years. It is, therefore, not surprising that so many rural medical posts are bypassed or underused.
Concerns about community participation

Two joint UNICEF/WHO studies\(^1\,^2\) underlined many examples of community participation in several countries. Social structures should be analysed in order to bring to light the factors enabling community development and those which threaten it. External advice is often considered with suspicion and even animosity by the villagers and their chiefs. The caste system is an obstacle not easily overcome. Where the best lands are owned by a few landowners and money lenders, the community is silenced and cannot express its basic wants. Even if sociologists try to interview people, they meet either the rulers only or individuals who do not dare to speak freely. The influence of local healers, herbalists, witch doctors or medicine men who fear to lose their privileges should not be minimized and an effort should be made to integrate them into the health care delivery system.

Many of these obstacles could be overcome by seeking the cooperation of those who have a real local power, whatever they be, but it takes time to demonstrate that the new approach is unbiased and the motive unselfish. Failures may occur when health facilities built by the villagers themselves become foreign bodies because the staff is not readily accepted by the community. A good project may be ruined if the health personnel do not belong to the community or when, being trained elsewhere, they have no strong reasons for coming back because decent living and career prospects are not satisfactory.

New social facilities which do not meet all the community needs are another cause for failure. In the health field the priority, as felt by the people, is nearly always for curative services. If these are satisfactory, preventive measures can be progressively implemented. But such action should not be strictly limited to health, even if interpreted in its widest sense. When community health care is not a part of a larger organization aiming at improving agriculture (and therefore nutrition), education (including health education), water supply (needed at first for irrigation), environmental sanitation (preventing intestinal disorders), progress in the health status of the population will be slow or even nil. Most population groups are aware that improvement in health depends not only on medical services but also on adequate feeding and better housing.

Concerns about more rationality

In many developing areas, rural medical posts and health centres are often bypassed or underused, large hospitals are crowded with minor or desperate cases, and new hospitals cannot be operated because of lack of personnel, financial constraints or breakdowns of mechanical and electrical equipment. These commonly observed failures generally have their cause in faulty planning, programming or operation, and call for some improvements in efficiency.

Efficiency can be considered under its allocative aspect and under its operational aspect.\(^3\)

Allocative efficiency refers to the appropriateness of resource allocation within the health care sector. It should be noted here that the "modern hospital" as we know it today, meaning a specialized, adequately equipped medical institution, staffed permanently by specialists, represents an admirable and often highly successful instrument for its specific purposes and catches the public attention. As a result, too much emphasis is placed on hospitals by politicians, the population and, sometimes, the doctors, to the detriment of other sectors.

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\(^1\) Djukanovic, V. & Mach, E. P. (1975) Alternative approaches to meeting basic health needs in developing countries, Geneva, World Health Organization.


In some developing countries, highly specialized, highly technical and sometimes, commercialized curative medical care for a very few selected patients obtains the lion's share of the available funds and personnel. But such "chrome and nickel" hospitals, where super-specialists cure previously hopeless cases with "wonder" drugs and methods, do not improve the health condition of such a country if this means that promotion of health, prevention of disease, and the broad mass application of medical knowledge to the needs of the population are neglected. In fact, such a situation hampers the development of the priority items of health services and thereby contributes to a deterioration of health conditions. By making the hospital an integrated part of a nationally planned and comprehensive health service, a better balance in allocative efficiency may be established from the beginning.

Operational efficiency refers to the appropriateness of operational activities. It is well known that the most expensive part of medical care services is inpatient hospital care. The more that this can be reduced, therefore, without lowering standards of care, the lower the total costs to the community. Ideally, inpatient care should be restricted to those patients whose medical condition can only be effectively diagnosed or treated by residence in hospital. Unfortunately, this is not the case. Some patients may be admitted to hospital for social rather than medical reasons. Others may be admitted for the convenience of their medical practitioner and, in some remote areas, this may be the only way to fit them into the health system. Yet others may be admitted to hospital simply because the community does not have the necessary alternatives such as outpatient, ambulatory or home care services, patient transport services, etc.

In deciding whether a patient should be treated in hospital and, if so, for how long he should remain there, a knowledge of appropriate marginal cost estimates (including non-financial opportunity costs) may encourage doctors to use facilities more efficiently and look for suitable but cheaper alternatives of care. Monitoring the behaviour of the medical care system, i.e., assessing the factors that affect the allocation of care among different types of conditions and different types of patients, may produce information that will bring about conscious improvement in decisions.

A different group of problems is associated with the efficient technical production of a given set of health services. What are the effects of hospital size on the cost of providing care? How do changes in the relative quantities of doctors, nurses, beds and other inputs affect hospital output? What determines the extent to which the capacity is utilized? What is the relative value, in terms of their effectiveness and efficiency, of some alternatives and substitutes to hospital care? Answers to questions such as these can provide health authorities with information for improving the operational efficiency of various health care facilities.

Efficiency of a health care delivery system is not easy to measure in monetary terms but some indices can be used to compare the efficiency of different systems. If we again take the notion of reasonable quality making health care delivery acceptable by the population, the proportion of postoperative infections, the mortality rate, the average length of stay of inpatients, the proportion of outpatient attendances per population, the rate of recurrent consultations are useful yardsticks, provided comparisons are made between institutions fulfilling similar functions. (For example, it is misleading to use the above indices for comparing specialized departments of teaching hospitals with general medicine wards of intermediate hospitals, or public with private-for-profit institutions, where the mixtures of different types of patient are not comparable.)

There are other ways of determining efficiency of health care services. Bridgman has proposed the concept of the threshold of efficiency. While there are no universal values for this threshold, it may be assumed that a health system which cannot ensure a minimum amount of curative and preventive contacts per population per annum is unable to meet the basic needs of the population. With some reservations, the importance of waiting lists is another method for evaluating the proper balance between supply and demand.

The administration of a health system may be centralized or decentralized but both extremes are conducive to low efficiency. Strict centralization entails rigidity and delays in decision-making and action. Tracing the paths followed by requests from bottom to top and by decisions from top to bottom too often shows unacceptable delays and faulty assessments. Excessive decentralization engenders competition, gaps or duplication.

The referral system sometimes works in one direction only, i.e., from peripheral units to central institutions. The danger is a progressive accumulation of long-term cases in the best hospitals at a considerable expense, precluding a rational utilization which would contribute to the nation's health. Peripheral units should be able to admit convalescent and long-term cases referred back from short-term acute hospitals.

Objectivity in planning and programming is not easy to achieve, and many plans fail because their implications, however, far-reaching, have not been considered. Many developing countries with large and populated rural territories see no other solution than to build a large number of health centres in order to cover the whole population. But it is often overlooked that these health centres must be staffed and equipped, their equipment maintained, repaired or replaced, the laboratory, the X-ray apparatus and the pharmacy supplied with reagents, films and medicines. It is, therefore, necessary to set-up a strong logistic section at regional or central level and to start by erecting a few functional and operational institutions rather than hastily building a large network unable to function properly.

Flexibility is seldom the main characteristic of any health system. Institutions are assigned a certain number of beds with specific functions. But conditions are rapidly changing and when a given institution meets the expectations of the population the demand may grow very rapidly. If this institution is not able to adapt, it will fail to meet the pressure, the quality of care will decrease as the staff becomes over-worked and the technical services overwhelmed, and the population will become dissatisfied. Institutions are very often entrusted with specific functions such as maternal and child health, tuberculosis campaigns, psychiatric care, infectious diseases control, etc. However well planned they may be at the beginning, any change in the balance between the different programmes will tend to empty some institutions and overburden others. Architecture and administration should make for a large degree of interchangeability and flexibility of functions.

Reliability of the building and the equipment is a condition which is not always fulfilled. Buildings in developing countries are often subject to abuse, and equipment quickly becomes dilapidated. This is partly due to climatic conditions but also to carelessness of personnel and patients. Sometimes the unconsidered use of new materials which do not stand humidity and heat is responsible for rapid deterioration. Too often laboratories and radiological machines are installed without giving thought to maintenance, spare parts, availability of skilled technicians, transport, in brief, to the complex machinery called logistics. In many countries, the whole network of health care facilities from rural posts to large hospitals depends on central supplies and pharmaceutical stores which, in turn, depend on goods sometimes produced in the country but more often imported from abroad. The danger of such a centralized system is an avoidable irregularity of supplies and long delays between orders and delivery. These drawbacks are responsible for indecipherable X-ray films, false results from laboratories due to use of outdated reagents, irresponsible reuse of disposables, and inefficient pharmacotherapy. These result in a low quality of medical care, high rates of complications and accidents, dissatisfaction of personnel and distrust by the population. Again no panacea is available and it is necessary to weigh carefully the advantages and drawbacks of various degrees of decentralization.

Management and administration abilities

It seems that some confusion has recently been introduced by the application to health care facilities of the modern theory of management for commercial firms and industrial plants. If car factories are very much the same all over the world because the technical and cost factors are predominant, health care facilities differ considerably. How is it possible to implement the same management methods in a large voluntary hospital in the United States of America, in a regionalized group of hospitals in the United Kingdom, and in a provincial hospital in a developing country?
It is certainly rewarding to give trainees a wide view of problems and to show them examples from foreign countries, but the bulk of training programmes should be oriented towards the job the recipients will have to perform during their professional life. In developing countries, top administrators are not always aware of planning and programming methods in use in developed countries; middle-level administrators are not well informed about national legislation and regulations; institutional managers have not been properly trained in accounting, bookkeeping, personnel careers and promotion rights, purchasing, ordering, and daily control of premises, equipment and stores.

Tasks and job descriptions at each level should be clearly defined. Weak administration and poor management lead to haphazard planning, irrational priorities, arbitrary financing, inadequate decisions, dissatisfaction of personnel, constant incidents and unsolved problems. It is too often observed that unskilled administrators and managers hide their embarrassment behind a screen of authoritarianism which creates vexation and frustration among the personnel, thus generating low efficiency and wasting scarce resources.

Health care facilities in their socioeconomic context

Development of any area requires balanced efforts in all socioeconomic sectors. For example, it is wrong to build a referral hospital in the absence of a weatherproof network of roads and bridges. There are instances of X-ray machines being installed in towns where electricity is cut off during the daytime, of air conditioners being provided in hot and dry climates without adequate water supply for the cooling system. Sometimes decisions are taken by central authorities without considering priorities as seen by the local population. The fact that rural people rank irrigation water higher than drinking water, that schools are felt more essential than health centres, and that, generally speaking, people are more interested in obtaining services which are of permanent and daily use rather than facilities which each individual uses seldom should not be disregarded.

The impact of development on health is not invariably beneficial. Some large industrial projects such as dams, mines or quarries have severely endangered the health of the local population because the technical advice of health experts has not been sought. Deep tillage of lateritic soil has destroyed the thin humus layer, created erosion, and led to the starvation of villagers. Large industrial plants have greatly disturbed agriculture and fisheries, especially when no precautions were taken against pollution by chemicals or overheating of rivers and lakes.

A proper balance between the social and economic sectors is certainly difficult to obtain but it is an aim which should never be disregarded or minimized.

Definitions of roles and functions

Any health system is made up of different institutions which are theoretically graded according to the tasks they have to fulfill and linked by a two-way referral system. It is usual to classify these institutions as follows: peripheral units staffed with auxiliary health workers, health centres with or without beds, local hospitals, intermediate or district hospitals, regional hospitals often linked with medical schools, to which may be added special institutions for rehabilitation and long-term care, for the mentally sick, etc. Each category may deliver both curative and preventive care to a variable extent. There is a consensus on the enumeration of functions each of these categories should fulfill but, in practice, large differences are found between what each part of the system should do and what it actually does.

Facilities will perform functions above their normal level when their staff wishes, and is able, to deal with cases that normally should be referred to higher-level facilities, but also when it proves impossible to refer the patient upwards. They will perform functions below their normal levels either when they do not have the adequate staff and equipment or when the patients bypass facilities at lower levels.

Moreover, a factor which minimizes the efficiency of the better-equipped hospitals in developing countries is the flow of terminal cases who have been inadequately treated in
peripheral units and are referred too late. Often coming from very far, they have to be admitted and it is difficult to discharge them before their death. All these difficulties stem from the fact that hospitals have been developed in the past as purely curative services. They are not prepared for change in the direction of prevention and community-based care. Even when the hospital staff wishes to give more weight to prevention, legislation, traditional regulations, financial rules and the expectations of the population are obstacles which are not easily overcome.

In theory, promotive, preventive, therapeutic, rehabilitative and terminal care should be dealt with in facilities which are built, staffed and equipped for these specific functions. This theory is not contrary to the integration concept and does not necessarily imply an atomization of independent institutions. But for each institution, either simple or complex, functions should be defined and the internal structure should correspond to functions. The possible evolution of functions should, however, be taken into consideration, hence the necessity of introducing the concept of flexibility in the structure of the health system and of its components.

Links between the health system and other social services

In many countries, and especially in developing countries, hospitals are built within the limits of municipal territories but they do not belong to local authorities. This is a rational trend because it is now nearly impossible for a community to erect and run by its own means all the medical and social institutions it needs. Technical and financial support from authorities at an upper level is necessary. In consequence, the community has little or no say in the establishment or running of a large hospital. On the one hand, every individual is glad to have access to the hospital when sick; on the other, he is quite indifferent to the hospital when in good health. In the daily life of the citizens, the hospital is something foreign and remote.

The most important links to be established and maintained are those not only between health facilities but also with other socioeconomic undertakings. For example, health centres should develop the proper links in order to have an influence on matters such as school health, occupational health, working conditions in factories and workshops and control of public places, such as markets, cinemas, slaughterhouses, food shops, etc.

Staffing

In developing countries, national statistics on health manpower often show an average ratio of all kinds of personnel much below what is considered as an acceptable minimum, and scarcity of health manpower is aggravated by maldistribution. Sometimes the total number of posts in facilities seems satisfactory but many vacant posts are not filled because of financial constraints or lack of candidates.

The training of medical staff is too often not tailored to the needs of the country. When staff are trained abroad, both the context and resources they have become accustomed to are irrelevant. Even if education is delivered in the medical schools of the country itself, the teachers are often from developed countries and they have a tendency to put the emphasis on diagnostic and therapeutic methods needing technical facilities which are generally unavailable outside the teaching hospitals.

After qualification, many doctors are inclined to practise privately in large towns or, worse, to emigrate to industrial countries, because the standards of living, salaries and technical facilities in their own areas seem unacceptable to them. The health authorities are generally unable to reverse this tendency because other governmental authorities approve of the multiplication of private practitioners from whom they can collect higher income taxes than from salaried officers and also because foreign currencies earned by the beneficiaries of the brain drain are welcome.

All these factors make it necessary to have recourse to auxiliary personnel and traditional healers who have received some training because both have the advantage of living in the villages and of having the confidence of the population. There would not
be much progress in the health level of the population if insufficiently trained auxiliaries and healers were left in isolation. They should therefore be submitted to frequent controls and follow training courses.

Costs

In many countries, the cost of health care is difficult to determine with accuracy. Some countries have a budget for health activities carried out by the government and this budget is shared between different institutions according to criteria which are largely conjectural and even arbitrary. Often, at the institutional level, the allotted budget is not sufficient to cover all expenditures, so that savings have to be made on food, linen and even drugs which the patient's relatives are requested to provide in kind. In other countries, there is no budget at all at the institutional level: salaries are paid from the central public service or from the national bank; supplies and drugs are provided in kind without being accounted; maintenance and repairs are carried out by the department of public works. It is, therefore, impossible to compare the running cost of different institutions and it would be unrealistic to put cost-analysis into practice.

The same uncertainty can be seen as regards capital investment. When money is available through external assistance or loans, it can happen that no consideration is given to subsequent running expenditure and to amortization. Several examples can be found of large hospitals built at great expense which take a lion's share of the health budget every year, thus jeopardizing extension of coverage and the financing of primary health care and preventive programmes. In the absence of an amortization fund, maintenance, repairs and replacement of heavy equipment are left to improvisation.

The question arises as to why the adoption of modern accounting and financing methods is so slow or simply ignored while the need for improvement is so urgent. It seems that the stumbling block is often to be found in the offices of the ministry of finance, because in the absence of realistic budgets corresponding to the real needs of health care facilities, this ministry is left free to decide arbitrarily the amount of money to be allotted to the ministry of health. This situation makes the dialogue between provider and spender impossible.

It cannot be denied that social security is a powerful means for improving and rationalizing health care financing methods. When social insurance covers a relatively large part of medical care expenditure, accounting methods must be introduced in order to determine with accuracy the actual cost of medical care for the insured patients. An annual budget must therefore be assessed, making possible comparison between departments and institutions and auditing on a rational basis. It should also be pointed out that the budget of social insurance comes from the gross mass of salaries and is therefore approximately proportional to the gross national product, so that a large part of the medical care budget can grow pari passu with the gross national product.

Maintenance

It is too often overlooked that buildings, machines, instruments, mechanical and electric equipment and textiles are subject to obsolescence and prone to failures. In developing countries, and especially in rural areas, it is difficult to have at hand a team of skilled technicians able to maintain and repair complex apparatus. The logical approach would be to avoid equipping provincial and local institutions with sophisticated machines and instruments, but medical technology has made such progress, especially in the field of laboratory, radiology, surgery and anaesthesiology, that it is difficult to refuse these aids inasmuch as such a policy would increase either the risks incurred by the patients or the number of referrals to central institutions. On the other hand, equipment is of no use when broken down and is potentially dangerous when improperly maintained or used.

The inefficiency of central workshops has often been stressed but the difficulties of regional decentralization are equally grave as maintenance continues to appear only as an isolated effort in major health facilities. As far as buildings are concerned, it is not easy to strike a proper balance between high-quality finishes which cost more and last longer and
low-cost finishes needing labour-intensive maintenance. The latter may be preferred when unskilled labour is available and needs work.

To these basic problems should be added the multiplicity of types of foreign equipment and materials. When there are only a few machines of the same type in a whole country, it is obvious that maintenance and spare parts cannot be provided at a reasonable cost and without undue delays. This aspect of the problem is the outcome not only of marketing pressure from foreign firms, often backed by diplomatic leverage, but also of specific demands from specialists who wish to have the equipment they were accustomed to use during their training abroad.

The problem of maintenance is so acute that several developing countries have tried to create training facilities either at national level or in intercountry centres. Although success has not always rewarded such efforts, there is no doubt that they should be continued.

THE "HOWS"

Although there is obviously no universal recipe to solve so many problems which are either technical or linked to historical, political, religious and cultural considerations, the above analysis of the main causes jeopardizing the development of health programmes and the functioning of health care facilities would not be complete if it did not consider various possible solutions. Clarifying a complex problem implies evoking the ways of solving it.

National level

At national level it appears that modern governments can no longer leave entirely to improvisation, to the goodwill of charitable people or to vested interests the organization of health services which now drain between 6% and 8% of the gross national product and continue to grow steadily. Whatever the balance between public and private institutions, a national policy and planning machinery is necessary, whether it be executive or advisory.

Methods for financing health care services are not just a question of choice between various systems. Methods of financing are conditioned by the political systems, the economic situation and their cultural acceptability. For instance, socialist countries will, in general, opt for financing from the government budget, in conformity with their general political policy; financing through social security needs a high proportion of salaried workers in order to function properly; financing through private or mutual insurance is possible only insofar as the population is keenly health conscious.

In their turn, the methods of financing largely determine the type, mixture and cost of health services provided. For instance, financing from the government budget gives more rationality of choice; in particular, more emphasis may be placed on preventive services and on services for underserved population groups. On the other hand, although government revenue will follow the evolution of the gross national product, the share of the health services in the overall budget will depend on a political decision. Financing through social security will entail, at least in a first phase, emphasis on curative services. The resources available to health services will depend on the evolution of wages and salaries. Financing through private or mutual insurance or direct payment mainly applies to personal health care; the state will have to be responsible for practically all preventive health care, making the integration of preventive and curative health care very difficult.

In practice, combinations of these methods of financing are observed but they often retain the main characteristics of the method which predominates. The emergence of non-traditional sources and methods of financing, such as locally-generated funds or contributions in kind or, at the other extreme, external aid, also sets specific problems. In the first case it is essential to ensure that the local population obtain a fair return from their efforts. For instance, should a community prepare to build a health centre, it would
be disastrous if they were later to discover, as has happened, that the health authorities are not in a position to find staff for it. In the second case, before requesting or accepting external aid, it is necessary to make sure that such aid fits into the general health plan and that it will not entail subsequent expenses that would impose a disproportionate burden on the health budget; too often health authorities, when considering the erection of a hospital financed through external aid, forget that the annual running cost will be about a third of the total capital cost.

Mechanisms for measuring the impact of health-related factors such as housing, nutrition, environmental control and wage levels as compared with the cost of living offer an open field for study. Research may lead to determining optimum levels to ensure happiness and quality of life. For example, it is well established that underfed populations suffer from specific diseases (including cerebral damage in children) while overfeeding entails other potential dangers. If the supposed good health of rural people living under primitive conditions is a deceitful myth, the accidents and the psychological disorders of workers living under stress in crowded cities are a serious concern to town planners.

It is, therefore, essential that socioeconomic planning be undertaken jointly by all the ministries concerned. The importance of considering health programmes in the broadest sense as part of overall socioeconomic planning cannot be overemphasized. Programming methods should be developed at two levels, one at macro-level, i.e., a functional description of the components of a health service system in a geographical or programme area, the other at micro-level, i.e., the functioning of individual health care facilities.

From that broad point of view, it appears that health planning and programming are not restricted to medicine only. Economists and sociologists should be involved in the process and planning bodies should include experts in various disciplines. Planning and programming should be supported by practical examples and case studies which should include a statement of the problems, the goals to be attained, methodology, activities, staffing, supervision, continuous training and an evaluation of the outcomes. Among these prerequisites a thorough study of utilization of health facilities by the population served would identify the areas, the age-groups and the social groups which are underserved in contrast to those whose utilization profiles approach the optimum level. The results of such up-to-date studies are invaluable in assessing the problems and determining the priorities for action.

In practice, socioeconomic planning at national level should be studied by ad hoc or standing committees acting as advisory bodies to special organizations, which may be ministries of planning, or special departments attached to prime minister's offices, or ministries of finance and economic affairs. Such committees or organizations should not only be horizontally integrated at national level but also vertically connected, so as to ensure local community participation. The members should not only include top professionals and experts but also a certain proportion of advisers with practical experience in the field. If community participation is sought, representatives of the community should be able to express their views freely.

Standards. In this context, standards are defined as being tools to guide planning, assess proposals and control quality. They are the guidelines to which planners, administrators, architects and evaluators refer to assess projects and evaluate completed work. Standards are in use in most developed countries in the form either of compulsory basic requirements or of outlines. Some standards have to be in the form of rigid norms, e.g., for electrical conductivity of floor coverings in operating theatres; others are, rather, optimum values often accompanied by minimum and maximum requirements, that is, a range between two extremes. These standards apply mainly to architecture, e.g., the average floor area per bed, and to staffing ratios. Some standards are universal, such as the maximum radiation dose permissible for human beings working in radiology or isotope departments. But most standards must be adapted to local conditions. They may be different for every kind of health care facility from primary to tertiary levels of care. They may also be different according to conditions prevailing in each country. When projects are
drafted by private organizations requesting governmental subsidies, the compliance with official standards is often a prerequisite for approval by the authorities.

Standards concerning the number of beds per population, or number of ambulatory patient attendances, or number of hospital admissions per year per capita are very useful reference data for coordination and planning, but their validity is confined to a given country or region.

Training. Planning health care facilities cannot be restricted to geographical distribution, architecture and equipment. Manpower development is essential and involves recruitment, training and continuous education. Staffing involves not only careful job descriptions but also a parallel between manpower planning and physical planning to ensure that a facility can become operational as soon as it is ready. Foreseeable constraints in manpower availability should induce planners to consider the opportunities presented by phased construction, but this can evidently not happen in the absence of effective communication between the authorities responsible for training and those responsible for the physical infrastructure.

Some points appear to be of special importance for health administrators and managers:

- Government commitment to the principle of developing management training programmes with a corresponding allocation of resources;
- Basic training programmes for first-line and middle management as well as for top management, adapted to the needs of each country and directed toward the functions the managers have to perform;
- Training packages, manuals and periodicals for teaching basic management techniques;
- Organization of seminars for exchange of information and experiences between senior and junior staff;
- Organization of associations of health care administrators and affiliation to international professional organizations.

Training should be the occasion to expose people to questions which, while strictly speaking outside their direct field, are still connected with it. For instance, professional medical staff are not sufficiently aware of financial matters in which they are very likely to become involved later as, say, director of a facility. Likewise, medical administrators must know something of the preoccupations of architects and engineers if they are to be able to have fruitful dialogues with them.

Too often developing countries must resort for the planning of their health facilities either to national architects with insufficient knowledge of the very specialized field of hospital planning or to foreign architects whose grasp of the various local factors having a bearing on the features of the facility is not sufficient to avoid mistakes.

This is why it would be opportune for developing countries to consider postgraduate training of some architects in health facility planning.

International level

Nowadays, some technologies are in use all over the world. In the medical field, the same techniques for surgical operations, sterilization, radiology and laboratory procedures are applied everywhere. Environmental sanitation, family planning, basic medical care and prevention campaigns may, however, differ greatly according to the means available and sociological factors. For example, the content and methods of health education cannot be the same in developed temperate regions as in developing tropical areas, in the face of different problems and cultural backgrounds. Countries with similar cultures and climate may, however, face comparable problems and adopt similar solutions.
It is within the specific responsibilities of intergovernmental organizations such as WHO, ILO, the World Bank, UNDP and the Inter-American Development Bank to offer assistance in solving problems, with the cooperation of voluntary international agencies or nongovernmental organizations.

Every large country should set up or improve its machinery for screening projects and evaluating programmes. Small countries which have only a few projects to study and implement each year might be well advised to set up, with the help of international institutions, intercountry centres staffed by personnel from each affiliated country. These institutions should, in addition to education and training, initiate research, prepare publications and working documents and organize regional and intercountry seminars and workshops to study problems and progress in health service provision in developing countries. Comparative studies of legislation, regulations and standards would be invaluable and publications on these subjects should be updated periodically.

Some countries have undertaken fascinating experiments in the construction of health centres and simple patient accommodation using local materials such as mud bricks, reeds, compressed earth, or in the control of vectors of parasitic diseases by the exclusive use of cheap or voluntary human labour and traditional tools. International cooperation is the only way to disseminate knowledge concerning the enabling conditions, the difficulties and the implementation techniques of such experiments.

**CONCLUSIONS**

Readers should not feel depressed by the long and detailed analysis of the "whats" and the multiplicity of the "hows". They should not retain the impression that planning and designing health care facilities in developing areas are formidable tasks requiring a huge compilation of data, a profound reform of the governmental structures, and a sophisticated mental exercise needing years of discussion and recourse to abstract mathematical techniques.

Firstly, it should be recalled that, among developed countries, there are various approaches, each with its advantages and disadvantages. No country has a perfect health system and health planning is always the outcome of compromises which take into account existing facilities, current legislation and regulations and sometimes conflicting interests, be they between local, regional and national levels or between public and private institutions. The health protection of the population is about the same in all developed countries, as proved by the narrow range of health indices, whatever methods and systems they use.

Secondly, in depressed areas where availability and efficiency of health services are far below an acceptable level, the risk of making a serious mistake in strengthening well-located health care facilities is very slight. More refined methods are necessary when the situation in a given area is not too far from the optimum level.

In developing countries there is, in most cases, both a problem of coordinating existing health care facilities and a need for improving their number, their capacity and their efficiency. A short review of the basic prerequisites may be useful to show that the goal is not out of reach of relatively simple planning organizations. The necessary steps to be taken might be enumerated as follows.

1. An inventory of existing health care facilities with their location, the number of beds, of personnel, of outpatient attendances, of inpatient discharges, and of bed-days per year.

2. A population census by relatively small administrative areas and by age-group and sex (the latter may be derived at first by sampling of selected villages and towns).

3. Improved methods of accounting to assess the real running cost of each facility.

4. Dissemination and retrieval of forms to be filled in at the institutional level for each discharged patient or each contact (this information may be obtained by sampling from books and ledgers provided they are properly kept).
5. Setting up an information unit at central level able to process and interpret the data; up to a certain volume of data, computerization is not necessary as traditional punched cards and sorting machines are adequate.

6. A logistic department to be organized at the appropriate level(s) with adequate staff, facilities for stockage, and proper means of delivery.

7. The creation of an office in the ministry of health to draft laws, regulations and standards.

8. The training of some administrators able to control, at regional level, the quality and reliability of basic statistical data and to interpret, explain and check the implementation of laws, regulations, decisions and standards at local institutional level.

9. The setting-up of a standing interministerial committee for health planning, programming and evaluation.

Most developing countries could put these nine points into practice without great difficulty or expense. If too much sophistication is avoided at the start, the implementation of basic surveys, population census and data collection from the existing institutions might require one year; another year would be required for their processing, interpretation and publication. Thus, in two years, planners could have enough data to start working, and at the end of the third year authorities would be in a position to promulgate laws and regulations and initiate the development phase. Further refinements would come later, taking into account evaluation of the first results.

This conclusion aims at encouraging health authorities of developing countries to overcome the reluctance of other authorities and administrators who may feel that the health care facilities planning and design methods in use in developed countries are too complicated to be adapted to their own problems.
# INPATIENT AREAS

Richard Llewelyn-Davies* and John Weeks*

## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Function</td>
<td>20</td>
</tr>
<tr>
<td>2. Variety of accommodation needed</td>
<td>21</td>
</tr>
<tr>
<td>Medical specialties</td>
<td>21</td>
</tr>
<tr>
<td>Nursing care</td>
<td>21</td>
</tr>
<tr>
<td>3. Size of nursing unit</td>
<td>27</td>
</tr>
<tr>
<td>4. Patient rooms</td>
<td>27</td>
</tr>
<tr>
<td>5. Data needed</td>
<td>27</td>
</tr>
<tr>
<td>Demographic context</td>
<td>28</td>
</tr>
<tr>
<td>Cultural and economic factors</td>
<td>28</td>
</tr>
<tr>
<td>Operational requirements</td>
<td>28</td>
</tr>
<tr>
<td>6. Physical provision</td>
<td>29</td>
</tr>
<tr>
<td>Siting</td>
<td>29</td>
</tr>
<tr>
<td>Capital and running costs</td>
<td>29</td>
</tr>
<tr>
<td>Ward design</td>
<td>30</td>
</tr>
<tr>
<td>7. General design considerations</td>
<td>34</td>
</tr>
<tr>
<td>8. Bibliography</td>
<td>35</td>
</tr>
</tbody>
</table>

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*4 Fitzroy Square, London W1, England.
Inpatient areas are the distinguishing characteristic of hospitals as distinct from other types of health buildings. With the exception of outpatient departments, each major hospital operational function relates to the inpatient areas. Inpatient areas are generally the largest single component of a hospital, although the proportion of space they occupy and the area allocated to each bed varies between countries, as shown in the following table.

**RANGE OF INPATIENT AREAS\(^a\) OBSERVED IN HOSPITALS IN DIFFERENT COUNTRIES**

<table>
<thead>
<tr>
<th>Country</th>
<th>Inpatient areas as percentage of total hospital area</th>
<th>Inpatient area m(^2) per bed(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United Kingdom</td>
<td>41-56</td>
<td>21-27</td>
</tr>
<tr>
<td>Brazil(^c)</td>
<td>44</td>
<td>20-24</td>
</tr>
<tr>
<td>Africa (Kenya and United Republic of Tanzania)(^d)</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>Africa (range)(^e)</td>
<td>-</td>
<td>3.1-8.9</td>
</tr>
</tbody>
</table>

\(^a\) Departmental area including support areas and circulation within department.

\(^b\) General acute beds.

\(^c\) Brazil, Ministry of Health (1974) *Normas de construção e instalação do hospital geral*.

\(^d\) Mein, P., & Jorgensen, T. (1975) *Design for medical buildings: A manual for the planning and building of health care facilities under conditions of limited resources*. Nairobi, Housing Research and Development Unit, University of Nairobi and African Medical and Research Foundation.

\(^e\) Llewelyn-Davies, R. & Weeks, J. Sample of 29 hospitals in Africa. (Unpublished data, 1974).

1. **FUNCTION**

The prime function of inpatient areas is to provide accommodation for patients at the point in an illness when dependence on others is at its highest. Because of this they are, with the emergency department, the only areas in continuous day and night operation for patient-related activities. Three broad functions are to be observed in all inpatient units:

- Normal body activities (eating, sleeping, toilet activities, diversational matters) for which the inpatient unit serves as a substitute for the home;

- Treatment, including examination, drug administration, ambulation as therapy;

- Preparing the patient to return to domestic life, including rehabilitation and retraining.
Each of these functions is focused through the activities of the nursing staff, who provide a link between the patient and all other activities directed towards the management of his illness. The nurses carry out the wishes of the medical staff in relation to diagnosis and treatment, observe and record the patient's response to diagnostic and treatment procedures, ensure that the most appropriate atmosphere exists in which the patient can best respond, and act as his communication channel while the patient is separated from his normal environment.

These three functions are required in all hospitals, from the most simple rural situation to a regional centre. The manner in which the functions are discharged, however, will vary widely; in many areas, the shortage of skilled staff and equipment will affect the intensity of care which can be achieved. The important point is, however, that the inpatient facility provided is appropriate to the resources available; there is no point, for example, in the provision of elaborate kitchens if it is the custom for patients' relatives to cook for them; in the construction of bathrooms where water is scarce and showers are more usual; in a complex treatment suite where only the simplest procedures will occur; in an air-conditioned building when no other air-conditioned building can be experienced by those who will use the hospital or where skilled maintenance is unavailable. The essential requirement of a forward unit is to provide facilities, appropriate and useful in every sense to the situation, for patients who need care and treatment of such a kind, or so frequently, that it cannot be provided in their own homes.

2. VARIETY OF ACCOMMODATION NEEDED

Medical specialties

There are certain specialties which are normally treated in special accommodation for medical or social reasons. These include: communicable diseases (tuberculosis, leprosy), units for recognized special categories (paediatrics, psychiatry, obstetrics), and units where specialist nursing, treatment and equipment may be called for (burns, transplants). But these specialist units are likely to be found only in national or regional centres, where the opportunity can be taken to concentrate particular service skills. In most hospitals, and certainly in small rural hospitals, the accommodation is likely to consist of general acute beds, with little or no differentiation of accommodation, for all medical and surgical specialties, including orthopaedics, and sometimes a maternity unit. In this kind of design, the requirements for isolation become a matter of ward management and staff discipline.

Whether wards are for men, women or children or whether they are for medical or surgical cases does not affect their design; similarity of design also improves their flexibility potential. ¹

Nursing care

In developed countries, inpatients are likely to fall into one of five broad care groupings in the proportions shown:

- Intensive medical care, where continuous medical and nursing observation and mechanical assistance is necessary to maintain life 1%
- Intensive nursing care, where patients are unable to leave their beds, and where they are in need of continuous nursing, observation and physical assistance 20-25%
- Medium nursing care, where patients are able to leave their beds for short periods (up to four hours) each day with assistance while ambulant 25-35%

¹ Although children may be given special accommodation in a large hospital, in a medium-size or rural hospital this is often not the case.
Low nursing care, where patients are able to leave their beds for more than four hours per day, requiring minimal assistance  
20-30%

Self-care patients leading apparently a normal life, who are in hospital for observation or recuperation  
5-10%

Using a similar classification, the proportions of patients in a developing country are likely to be considerably higher in the intensive and medium care categories, perhaps up to 75-80% of total patients being within these two areas. This may be due to patient transport difficulties, limited primary care referral facilities and limited bed availability. The pattern is, however, unlikely to remain static in most developing countries as transport and communication are improved and community health facilities are developed. The likelihood of such change is another important argument for flexibility in the design of inpatient accommodation.

Intensive medical care patients, both medical and surgical, in developing countries are best accommodated in large well-staffed hospitals, in special units of at least 6-8 beds, with permanent allocation of skilled staff and with a concentration of equipment and services. Where such accommodation is impossible, intensive medical care patients are better housed in part of a general ward unit, as their complete separation is potentially dangerous (Fig. 1). It is, however, essential that visitors to patients in a less serious condition do not have ready access to those in the intensive care section. This section at least must be partitioned off from the rest of the ward and should be very close to the nurses' station. For these patients, who may effectively need constant supervision in order to maintain life, each ward will need one partitioned bed space; experience may show that two will be required (Fig. 2 and 3).

Patients needing other levels of nursing are likely to be placed in common accommodation, with divisions in the larger hospitals by sex, specialty and, sometimes, class (Fig. 1). In smaller hospitals, the divisions may only be made by sex (Fig. 4). The need to retain the maximum degree of flexibility in use to respond to varying numbers in each of the categories cannot be overemphasized. Flexibility of nursing care may be achieved through management, by allocating beds to ensure the best use of all beds, but also through planning; so far as possible, wards should not be specialized but should be usable by all categories of patient. The exception to this general rule is the category of first-class patients. When provision for these patients is essential, these form a small group of single-bed rooms. Preferably, they are part of a general ward floor, and may then be allocated, in an emergency, to a seriously ill patient irrespective of class. This is the most flexible arrangement (Fig. 3).

In countries where the number of beds available is small in relation to need, many patients will be discharged very early in their convalescence. This can be done safely if local health aid is available near their homes. Where this is not the case, consideration should be given to the provision of a special self-care ward with minimal staff close to the main hospital. Such units are cheaper to build and to staff than a building providing full hospital ward facilities. Qualified nursing and medical help is available close by; patients may attend the hospital easily; and members of the patients' own family may be able to help the patient through his convalescence entirely adequately with very little assistance. Such units may consist entirely of four-bed rooms (the beds arranged as divans, in the corners, rather than free-standing as in a ward) together with a simple kitchen, in which relatives may prepare patients' meals and a toilet block. In a 1976 sampling (unpublished) of rural hospitals in Africa, it was found that 58% of the hospitals in the sample had a self-care unit attached. A further 10% had arrangements for accommodation in adjacent villages. These self-care beds accounted for between 8.8% and 13% of the bed total.
FIG. 1. THREE CLASSES OF BED ON ONE FLOOR OF A TEACHING HOSPITAL

On this floor there are 68 beds with varying accommodation. A-class beds are air-conditioned but B- and C-class beds are not. Each bedroom has its own shower and WC compartment and single rooms are available in each class. 12 beds are available in a high dependency unit with its own service back-up accommodation. Lift and stairs, ancillary workers' and doctors' rooms are in the short arm of the T. Service rooms at the centre of the wing are air-conditioned. The corridor in the high-dependency unit can be isolated from the main corridor and is not a through passage.
The building is surrounded by a verandah and the sanitary block is placed across the prevailing wind. The minimum distance between the centre of each bed is 1.6 m and built-in tables between each bed are designed to maintain this bed spacing.
In this building most rooms are naturally ventilated. Each floor has two 27-bed ward units with their own high-dependency-bed bay. Two beds are in single rooms, each with its own WC compartment. The nurses' station is opposite the single rooms, which may be used as part of the high-dependency unit. There is a day room in each 27-bed ward. Between the two are 8 beds in single rooms each with its own WC and shower compartment. These would be used for first-class patients and these rooms are air-conditioned. The main lifts and stairs are shared between adjacent buildings. This hospital includes a medical school and there are research laboratories in a similar building connected to the wards at each level. A ramp system (not shown) serves all floors.
Partitions are open above door head heights, allowing cross-ventilation in all rooms. Additional flexibility would be achieved if the toilets were in two separate blocks.
3. SIZE OF NURSING UNIT

The size of the nursing unit depends on the most effective deployment of available staff and helpers. In some developing countries, skilled nursing staff is scarce. In such cases it is probable that much reliance must be placed on semi-skilled labour and the patients' own families. The size and layout of inpatient areas should therefore take into account the need for supervision of helpers by scarce fully trained staff. Acknowledging this wide variety of nursing skills, nursing units normally consist of 20-30 beds each, the lower number being suitable for nursing where only one trained nurse is available. Below 20 beds, the unit is limited in the flexibility it can offer and inefficient in its use of skilled staff - the most expensive component of the nursing costs of any hospital. Above 30 beds, it is unlikely that a single nursing team could cope with the demands of all patients. Additional economy can be achieved by sharing the ward ancillary rooms (pantry, clean supply room, disposal room, sisters' room, storage) between two nursing units, providing a 60-bed unit (maximum) comprised of two 30-bed units, each with its own nursing team with overall responsibility to a qualified senior nurse.

4. PATIENT ROOMS

Patient rooms within nursing units vary from one large room containing all the beds in a unit to the opposite extreme, where each patient is allocated an individual room for his own use. A combination of single and multi-bed rooms, however, can afford privacy to individual patients who need it, combined with ease of observations of the largest number by nursing staff. The appropriate number of 1-bed rooms will vary with the local cultural, social and medical conditions.

The larger the number of single rooms, the more expensive the unit will be to construct since the more single rooms there are, the larger the ward building will be. A room for one patient cannot be planned adequately in less than 6.5 m² exclusive of all service rooms and corridors, whereas an open ward can reasonably be planned with as little as 6-8 m² per bed inclusive of circulation and ancillary rooms. A ward with large numbers of single rooms will also be more expensive to run because, since patients in single rooms are much more difficult to observe, they require a larger staff to look after them properly. The case for a proportion of single-bed rooms rests on the need of some patients for privacy and the need sometimes to protect other patients from disagreeable sounds and smells. While some may benefit from isolation for medical reasons, the majority do not. For some patients privacy may be provided for social reasons (for example, in a hospital which provides for different classes, as shown in Fig. 1 and 3) but for most patients isolation from a community of fellow sufferers may deprive them of support when they most need it. Where patients pay the real cost of private accommodation, single rooms may be economical; but this cost is high, since it is made up of increased building costs, increased staffing costs and increased cleaning and maintenance costs. A balance has to be struck between economics and flexibility, between medical requirements and status, between the need for privacy and the need for support. In each 30-patient ward, one or two separately partitioned bed spaces will be required for patients on medical grounds. In circumstances of adequate finance, skilled staff and reliable maintenance, as many as 15-20% of beds may be planned in single rooms, a figure which has emerged from several studies.1 This figure should, however, not be taken uncritically and it is certainly irrelevant in conditions of limited resources.

5. DATA NEEDED

The development of a particular design solution most appropriate to the inpatient needs of a particular hospital will depend on three types of data:

- The demographic context of the hospital;
- Cultural and economic factors;
- Operational requirements of the unit.

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1 See Nuffield Provincial Hospitals Trust (1955) and Thompson & Goldin (1975).
When using the data, it is always necessary to consider how they are changing. Buildings usually outlast their initial functions but if the possibility of future growth and altering patterns of care is recognized and potential for change built into the plans, the buildings will be able to survive into the future more efficiently and more economically. No prediction is accurate but future trends can usually be detected and, to an extent, they can influence present planning.

**Demographic context**

Data will need to be collected concerning the catchment population to be served. This topic is dealt with in detail in volume 2 of the present series.

**Cultural and economic factors**

A more detailed examination of local factors will now be required. Cultural factors, including the influence of religious trends, the definition of class or sex segregation conventions and any defined ethnic groupings, will play a considerable part in the detailing of facilities. It is critical that such considerations are given full weight. If a unit is not designed to make provision for them, it will either impose patterns which cause distress to patients and staff alike or, and this is more likely, the cultural factors will prevail and the unit will either be altered to conform to them or the wished-for-patterns will be imposed inefficiently on the unit. In either case the building will waste scarce resources. Not only will cultural patterns affect the way in which care is given to the patient at the bedside, but they will also affect the supporting areas associated with the inpatient units. As examples of these factors, the influence and assistance of relatives in the direct care of patients, the eating habits of the population and whether or not paying patients are to be nursed in the same ward unit as public patients will all have a direct effect on the type of unit to be provided.

Similarly, economic constraints will not only govern the scale of the overall programme, but also may determine aspects of planning. Whether patients will be expected to pay for treatment and, if so, in what proportion to income and to the overall numbers of patients treated will influence the numbers and sizes of individual rooms. Economic constraints may play a large part in the solutions adopted to deal with climatic considerations. The extent of air-conditioning, an expensive provision, will greatly influence the shape and capacity of each inpatient unit and its relationship to others on the same site. This and other technical considerations are discussed more fully under the heading of capital and running costs, in section 6 below.

**Operational requirements**

In establishing data prior to producing a solution for a particular situation, there are a number of assumptions which must be agreed upon in relation to the likely operation of the unit as a whole.

Based on the context data already established and refined by knowledge of cultural and economic considerations, data may be collected on the more specific requirements of the inpatient unit and the needs of the patients who will be nursed there. The likely medical specialties to be accommodated may be identified and calculations made as to the likely occupancy rates and lengths of stay within them. An assessment may also be made of the nursing care categories to be treated, which, when allied to knowledge of the future availability of health care staff in all categories, will develop into a definition of the likely staffing pattern and nursing regimes to be adopted. Staff must be considered in all groups, medical, nursing, technical, auxiliary, and include unpaid care groups, such as relatives and friends. This assessment of staff will link up with identification of training programmes, both community and institution based, and an assessment will thus be built up of both numbers and skill levels available for particular tasks.

Links with patterns of referral, including emergency services, will also be required at this stage to establish the likely condition of patients, both on arrival and at discharge. Selection procedures prior to admission should be considered as well as medical supervision
while in hospital, whether this is to continue on from the community care patterns or be wholly controlled by hospital staff doctors. The quality of housing and the public transport available in the area served by the hospital will affect the discharge policy and affect the decision on whether to provide a self-care unit for convalescence.

The objectives of the data collection as outlined above are: to build up a picture of the patient likely to be treated in the inpatient unit, his background and his needs; to prepare the most appropriate facilities in both staff and buildings to be ready to respond to his needs within the existing financial constraints; and to develop an operational framework within which he can be most effectively cared for.

The following discussion develops a response to these requirements in physical terms, emphasizing the need to respond to trends in socioeconomic patterns and to changes in medical technology.

6. PHYSICAL PROVISION

Siting

A major factor which constrains the design of any health building is the availability of money. Another is the extent of the building land available. In the selection of sites it is important that one should be chosen which will permit future expansion; a small city site which is hemmed in by well-established businesses or other facilities will not be satisfactory in the long run since it will not allow the hospital to expand.

Inpatients normally expect to be visited; and their well-being may depend as much on external accessibility to the hospital as it does on internal arrangements. All hospitals must therefore be accessible to the regional road network but a remote rural site, however accessible to the road network, is unsuitable for a regional centre because of the difficulty patients as well as staff may have in getting to it. Sites for small rural hospitals should be part of a village community in order to be identified with the population the hospital serves. Care should be taken, however, to keep away from sources of environmental pollution.

The site required for a hospital must be large enough to allow space for future expansion of the service. For example, a hospital of 100-150 beds will require, with necessary staff housing, a site of at least 4 hectares (10 acres). At the other extreme, a 500-bed national hospital with teaching facilities will require about 24 hectares (60 acres) to provide adequately for housing and car-parking and to allow room for expansion. In both these examples a low density development of naturally ventilated buildings is envisaged. Small sites require dense development which may in turn require air-conditioning.

Capital and running costs

The rate of flow of capital into large projects is not very predictable, and so it is usually essential that inpatient accommodation, no less than the remainder of the hospital, be designed so that it may be built in stages. Reducing the required first investment will enable a start to be made on the project. A staged building programme has the further advantage that later stages may easily incorporate modifications to the original design, making them suitable for developments in medical and nursing techniques no less than changes in national resources of finance and skilled medical and nursing staff. A staged building programme requires a design strategy which takes account of these factors. A loose assembly of low buildings, served by a central extendible communication route on a large site has more inherent potential for ordered growth than a tight plan, for example round an open courtyard, from which future expansion possibilities are severely constrained.

The question of air-conditioning in hospitals is becoming a major area for decision since air-conditioning has become more widely available. The use of air-conditioning imposes a severe discipline on the design of the buildings and carries a heavy maintenance requirement and consequent high recurring costs. It involves also a really reliable electricity supply. There have been instances where high-technology buildings, totally dependent on air-conditioning and incorporating very advanced equipment, have not been able to maintain full
working capacity owing to continuous maintenance problems. Air-conditioning may not be justifiable in countries where, for example, high temperatures are usually accompanied by light breezes; in such climates rather simple buildings, the walls well shaded by deep eaves, with natural ventilation sometimes supplemented with fans will provide a very satisfactory environment, and one which poses no cross-infection hazards (Fig. 5).

In a totally air-conditioned building the design of the inpatient accommodation should be different from that of a building which relies on natural ventilation. An air-conditioned building is compact and deep with as small an amount of external wall as possible to reduce the heat transfer between the outside and inside; a naturally ventilated building is long and thin for maximum exposure to breezes. Additional problems may arise where, for local reasons, several classes of patients are to be housed in one building. In many places, first-class patients expect air-conditioning, but money may not be available for its provision for other patients. Plans for wards in hot, humid climates are illustrated in Fig. 1 and 3 showing how air-conditioned and non-air-conditioned accommodation may share the same building. Provision may be made in the structure for the addition of air-conditioning after the building has been completed, but it should be recognized that a building designed for natural ventilation cannot be converted into a wholly air-conditioned building efficiently.

Ward design

Since the decision on the type of ward unit required is a crucial one, the main kinds of unit which have been developed may be considered here briefly.

The history of ward design in developed countries is, in summary, one of change from large open wards with the beds, head to the windows, ranged along both long walls, to a ward consisting of smaller groups of beds in rooms. For a long time, wards known as the "Nightingale" ward in many countries (although such wards were in use before the celebrated nurse gave this kind of plan her personal blessing), were universal. This type of ward was followed by a modification in which beds are placed parallel with the windows. At first these beds were in open bays on either side of a central corridor (as at the Riga Hospital in Copenhagen, which gave its name to this kind of plan) and in later hospitals the bays are often enclosed, so that they become rooms. For the last 20-30 years, most new hospitals in developed countries have followed this pattern - although there are many versions of the basic idea - and combine 4-, 5- and 6-bed rooms with single-bed rooms in varying proportions. In some countries, notably the United States of America, the supposed demand for privacy has led in some cases to the provision of all beds in single rooms. Such hospitals are, however, expensive to build and run, and no serious study has been able to substantiate either that all patients need or enjoy complete privacy or that the total flexibility offered by such plans offsets, by allowing 100% occupancy, the requirement for additional staff and the provision of elaborate communication systems. The matter is discussed at great length by Thompson & Goldin (1975) and in Nuffield Provincial Hospitals Trust (1955). Both these sources contain comprehensive bibliographies of relevant literature.

It is most important that the choice of ward for hospitals in developing countries is made after full consideration of the implications in terms of staffing, cost of construction, cost of maintenance, climate and patient expectations. The change ("change" is not to be regarded here as synonymous with progress) from open wards to small rooms in developed countries has incurred losses as well as gains, notably in the loss of direct supervision of patients by staff and, more importantly, in the inability of patients to see staff in the ward. This has led to the need for electronic devices to enable a patient to call a nurse, some of which are very complex, providing two-way communication, and all of which are expensive to install, need experience in the use of electronic systems to be effective, and require regular and skilled maintenance.
The tower contains service rooms, waiting spaces, main lifts and stairs. The ward block is naturally ventilated and each floor has deep shading balconies. These balconies are not normally accessible to patients.

Associated architects: Llewelyn-Davies Weeks Forestier-Walker & Bor and Kingston Reynolds Thom & Allardice Ltd.
The "Nightingale" ward is the cheapest to construct and easiest to supervise (Fig. 2). It is inflexible as to sex differentiation (though not as to medical or surgical cases) and while affording patients the greatest support by their fellows, is barrack-like in appearance and atmosphere. There is usually a high noise level. Since windows are both behind and opposite each patient, it is necessary to take precautions in the design to prevent glaring light from disturbing them. This may be done by extending the eaves in single-storey buildings, by the use of deep balconies in multi-storey buildings, and by keeping the tops of windows to no higher than 2 metres.

In "Nightingale" wards, patients and staff are in constant sight of each other and nurses have easy and direct access to each bed. However, as the ancillary rooms are at the entrance end of the ward to control the visitors' point of entry, the distances walked by nurses between the beds and the service rooms are longer than in some other plans.

In a "Rigs" layout, the ward is composed of many smaller groups of patients and is more flexible in use (Fig. 4, for example). Adjacent bays may be used by men and women (if the culture is tolerant of this arrangement). Ward service areas may be at any point in the plan and the patients needing closest observation may be arranged in the bay opposite the nurses' station. As the beds are parallel with the windows, the daylight conditions are pleasant and each patient has the option of facing a window or not.

"Rigs" ward layouts need deeper buildings than "Nightingale" layouts and the space per bed is higher, since each group of beds has its own circulation space in addition to the main corridor. A fundamental decision in the design of wards is the bed spacing. In conditions of high demand for beds, it is perfectly natural that hospital administrators and doctors will endeavour to put as many beds as possible into a ward building. Bedside patient-care, however, has certain basic requirements which define a minimum dimension. The minimum possible distance between the centres of adjacent beds is 1.6 m; 1.8 m is better. If cubicle curtains are provided around each bed for the privacy of patients during examinations, toilet, etc., the centres of beds should be at least 2.2 m and preferably 2.4 m apart. At this dimension patients have the option of a right-hand or left-hand locker, the full range of nursing procedures can be carried out without interference with the adjacent bedspace and there is room for visitors round each bed. The minimum dimension, where this is used, should be secured by the provision, between each bed, of a fixed locker or cupboard so that it is impossible to squeeze the beds close together (Fig. 2 and 6).

In ward planning there may be apparent conflict between the requirements for observation and control and patients' desire for privacy. The concept of privacy and its desirability are not easily definable. In some countries, privacy is rated very highly by many patients and they may be prepared to pay for it. In other countries, privacy does not rate at all or it is not customary to provide privacy and so it is not demanded. Where privacy is rated highly, proper provision must nevertheless be made for nursing supervision, either through glazed screens, windows in doors, or wide openings. Where staff is short or privacy is not the highest priority, the placing of beds in open bays provides a good solution and, as has been argued above, gives good flexibility in the allocation of beds according to patients' sex and condition. Cross-ventilation is easily obtained through open bays. Except in the case of grossly infectious conditions, it has not been established that the planning of beds in open bays has any measurable effect on cross-infection rates, provided that nursing regimes are carefully designed and supervised.

A "Rigs" layout is not the cheapest to build and the separate bed compartments are less easy to clean. Advantages are, in addition to flexibility, greater compactness, a better lighting environment, a measure of privacy for patients (i.e. smaller groups rather than a community of over 20), greater quiet and a less "busy" appearance. Provided that the beds are in open bays rather than enclosed rooms - in any event desirable to promote cross-ventilation - and the seriously ill or terminal patients are grouped close to the nurses' station, no additional staff will be needed. A simple patient-operated nurse-call light is an advantage but not essential.
A. 6 beds in a bay with a generous distance (2.4 m) between the centres of each bed. Each bed may be screened by hanging curtains. There is room for a bedside locker and visitor's chair by each bed. Toilet accommodation is assumed to be close by.

B. 5 beds in a bay with similar distances between the centres of each bed. In place of the sixth bed a small day space is provided in which ambulant patients may take their meals.

C. 4 beds in a bay. In addition to the day space, a bathroom including a WC, adjacent to the access corridor.

D. 10 beds with the minimum distance between the centres of each bed, with a central corridor. There is just room for a table in each bay. The unit could be symmetrical with two 6-bed bays on either side of the central corridor. A 26-bed ward could be built of two 12-bed units (male and female) with two single rooms opposite the adjacent nurses' station.

E. 10 beds, as in D, but with the centres of beds at a distance of 2 m apart.
In the larger, better staffed hospitals where it is practical to allocate beds in the wards so that some are set aside for intensive nursing care, the intensive-care areas very close to a nurses' station will include a clean preparation area and disposal room (Fig. 1 and 3).

Most patients in an inpatient unit will be able to get out of bed for short periods every day. This means that they have a need for toilet accommodation close by, access to a table and chairs for eating their meals, and, for some, an easy chair. Provision of these facilities lightens their dependence on nurses or ancillary workers but the facilities must be easily accessible. Whenever money will allow, toilet facilities should be close to patients' bedrooms and not all grouped at one point in the ward (Fig. 1 and 6C). While this is a very convenient, indeed therapeutic arrangement (since it encourages early walking by offering an easily available alternative to a bed-pan regime, much disliked by patients and staff), it may not be culturally acceptable or financially feasible. In such cases, toilets should be grouped in a position where they are well ventilated and have common plumbing. They may be provided in a separate building with covered access from the ward building, and two adjacent wards may share the use of the toilet block. A WC, shower and washbasin should be provided for each 8-12 patients, the smaller figure being very desirable (Fig. 2 and 4). Toilets should be easily accessible to cleaners.

After concern with their illness, most inpatients are next concerned with the food provided in the hospital. In some countries, patients' relatives customarily feed them, and several relatives may spend much of the day close to the patient. If this is to be encouraged, it must be recognized during the design of inpatient accommodation. It is difficult to make arrangements for such habits in a multi-storey building, but shaded verandahs for the use of relatives as an extension to the patients' room are easily provided in a single storey building (Fig. 2 and 4).

If the hospital is to be responsible for feeding patients, facilities must be provided which may range from a ward kitchen (where all food is cooked, after it has been prepared centrally) to a small pantry in each ward for light snacks only, all the food being cooked centrally in bulk, and distributed around the hospital in patient-sized portions or in bulk containers, each one supplying meals for all the patients in one ward. The latter is the most economic method, and suitable for all hospitals except the largest and most spread-out. Central cooking is an unnecessary expense and irrelevant where patients' food is usually prepared by their families. Central cooking and plating for the distribution of individual trays for each patient in the hospital is the most expensive and needs the highest discipline and most elaborate equipment, which is not normally available in developing countries.

7. GENERAL DESIGN CONSIDERATIONS

Hospitals have been and continue to be planned in a variety of forms. At one end of the spectrum is the open, low-density plan with all the buildings accessible from a covered way. At the other end is the monolithic, air-conditioned tower giving very high-density site cover, in between are various grades of mixed developments. Up to about 300 beds, and neglecting the cost of the site, the lowest density gives the lowest cost. Low-density developments are more easily ventilated naturally, need no lifts, are more easily extended and built in stages and can be built very cheaply using locally available material and building labour. There is no reliable evidence that a low-density hospital requires more staff to run it than a high-density hospital. Thus, small rural hospitals should always be of low density. It has already been noted that small urban sites with fixed boundaries should be avoided since they put a limit on growth. They should also be avoided since they impose a high-density solution to the building problem with consequent high capital and maintenance costs. Definitions of high density vary from country to country, but a plot ratio of 2:1 (that is, a building area which is twice the site area) must be considered high since at this density it will be impossible to avoid high buildings, requiring many lifts, and a great many internal rooms requiring air-conditioning. With more than 300 beds, a hospital development consisting entirely of single-storey buildings will cover a very large area, and travel times within the complex become so great that the whole may tend to appear to its users as a collection of disparate units rather than a single organization. The site cover is reduced by the use of
2- or 3-storey ward buildings, but they must be planned with care to allow breezes to circulate freely between them. In any event, adjacent ward buildings should be at least 9 m apart, even if they are planned on one floor, to prevent conversation in one building being overheard in the other when the windows are open. Higher buildings should be built so that the space between them is at least equal to their height.

In areas where skilled maintenance for lift installations cannot be relied on and the inpatient accommodation is on more than one floor, it is essential to plan a ramp system which will enable wheeled transport to reach every ward level.

In hot dry climates, buildings with small windows, highly insulated walls and deep shady internal courts may be the local architectural vernacular. Such buildings, allowing no sun penetration, are cool without recourse to air-conditioning. It is not impossible to construct a cheap hospital in this way; certainly, in every case, new buildings should follow the local traditions unless there is some real reason why they should not. For example, the use of mud and untreated wattle in an area subject to termite attack may be continued if improved local techniques are used, such as cement rendered on mud and wattle with 0.3% emulsion of a suitable insecticide in the mud to reduce termite attack. Even when new materials are used, as much as possible about climate control should be learned from the traditional building forms. They are very arbitrary and, whatever the climate, they represent the best and most appropriate use of local resources, both material and human.

In all inpatient accommodation it is essential to take fire-hazard seriously. While some patients may be able to walk unaided to escape, many others are not able to do so. Where accommodation is planned at ground level only, escape through doors to the verandahs or into the hospital grounds is readily available, but multi-storey ward buildings present a much more serious problem. In such cases, care should be taken to separate high life-risk departments from high fire-risk areas. Means of escape must be provided at the ends of the building as well as at the centre. There should be fire-resisting doors which may be closed across corridors at one or more points. In this way, it will usually be possible to clear the ward where the fire has started and retreat into a fire-resistant compartment at the other end of the building. Concrete construction does not imply total security from fire. Floor finishes, bedding, curtains and furniture are all combustible and though the structure will survive all but the most severe and prolonged fire, means of escape will always be required.

Hospital building designs may vary from the most simple to very high technology installations. There is, however, no call for more expensive facilities than can be afforded easily or maintained properly. High buildings and monumental designs convey no particular advantages to the users. Much of the best medicine occurs in relatively simple buildings. The most appropriate facility for all the circumstances will be the best; one which is at variance with its physical, financial or organizational environment will always result in wasted resources.

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OUTPATIENT DEPARTMENT

L. C. Vogel *

CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction</td>
<td>39</td>
</tr>
<tr>
<td>Definitions</td>
<td>39</td>
</tr>
<tr>
<td>The context of ambulatory care services</td>
<td>39</td>
</tr>
<tr>
<td>Axioms</td>
<td>40</td>
</tr>
<tr>
<td>The four levels of care and the referral system</td>
<td>41</td>
</tr>
<tr>
<td>Desirability, feasibility, acceptability</td>
<td>42</td>
</tr>
<tr>
<td>New and redesigned facilities</td>
<td>42</td>
</tr>
<tr>
<td>Planning for future demands and needs</td>
<td>42</td>
</tr>
<tr>
<td>2. Concepts, parameters and the data base required</td>
<td>43</td>
</tr>
<tr>
<td>The right to health care</td>
<td>43</td>
</tr>
<tr>
<td>Demand, utilization and coverage</td>
<td>43</td>
</tr>
<tr>
<td>The flow concept</td>
<td>44</td>
</tr>
<tr>
<td>Parameters of outpatient department operations</td>
<td>45</td>
</tr>
<tr>
<td>Operational parameters</td>
<td>45</td>
</tr>
<tr>
<td>Quality of care parameters</td>
<td>46</td>
</tr>
<tr>
<td>Cost and efficiency parameters</td>
<td>47</td>
</tr>
<tr>
<td>Expectation and satisfaction parameters</td>
<td>48</td>
</tr>
<tr>
<td>3. Common problems in ambulatory care services</td>
<td>48</td>
</tr>
<tr>
<td>Is anything wrong with the outpatient department?</td>
<td>48</td>
</tr>
<tr>
<td>What are the problems?</td>
<td>49</td>
</tr>
<tr>
<td>Who’s view?</td>
<td>49</td>
</tr>
<tr>
<td>Causes and effects of problems</td>
<td>49</td>
</tr>
<tr>
<td>Discrepancy between demand and resources</td>
<td>51</td>
</tr>
<tr>
<td>The referral system</td>
<td>52</td>
</tr>
<tr>
<td>Quantity or quality?</td>
<td>52</td>
</tr>
<tr>
<td>Equipment: the demand for sophistication and the need for simplicity</td>
<td>52</td>
</tr>
<tr>
<td>The physical structure</td>
<td>53</td>
</tr>
<tr>
<td>Who should and could rectify the situation?</td>
<td>53</td>
</tr>
<tr>
<td>4. Assumptions, predictions, alternatives and decisions</td>
<td>54</td>
</tr>
<tr>
<td>The unstable base in the planning process</td>
<td>54</td>
</tr>
<tr>
<td>Any need for research and experiments?</td>
<td>54</td>
</tr>
</tbody>
</table>

* Project leader, Kenya–Netherlands Project for Operations Research in Outpatient Services, Medical Research Centre, Nairobi; Department of the Royal Tropical Institute, Amsterdam, Netherlands.
1. INTRODUCTION

Definitions

"Ambulatory care" is the medical care provided to patients who are not confined to bed. It can be provided at a general practitioner's or specialist's practice premises or at a health post, health centre or hospital. When such care is rendered at premises which are part of a hospital or inpatient establishment (outpatient department) or in a facility distinct from the hospital (health centres, clinics, dispensaries) but directly depending on it, it is termed "outpatient care", and the services rendering or organizing it are named "outpatient services".

Patients confined to bed or homebound will be treated either at their own home (home care) or in hospital (inpatient care).

The context of ambulatory care services

Ambulatory care services are, in most countries, the most visible aspect to the community of the health care delivery system, the aspect also with which the great majority of citizens have at least some experience. As a consequence, ambulatory care services are more readily criticized by the public, community leaders, politicians and newspapers than other health care services. Ambulatory care services, particularly at the primary care level, are also the entry-point into the health care delivery system.

The outpatient department of a hospital is one aspect of ambulatory care services and one link in a hierarchical chain of health care facilities. It cannot be considered in isolation from either the chain or the hospital of which it is a part. The function of an outpatient department is to provide care to ambulatory patients who demand such care; this is not to say that they need it. There is reason for concern over whether those who need care will demand it and whether they will in fact utilize the services available to them. Ambulatory care may contribute to a reduction in morbidity and mortality and it may provide a stepping stone to health promotion and disease prevention. An adequately functioning outpatient department may reduce the number of admissions to a hospital and enable the hospital to raise the threshold of admissions. It may also ensure that only those are admitted who need inpatient care most or who are most likely to benefit from such care.

This paper outlines various aspects of the outpatient department and in particular those operational aspects which are relevant to: the manager of the outpatient department; the planner/administrator of the health service; and the architect who is called upon to design a new facility or redesign an existing one.

The following presentation in general relates to a context of limited available resources, high (often apparently excessive) demand for outpatient services, and the social, cultural, political and organizational constraints with which the providers of these services at the national as well as at the local level are faced.

The outlook described may appear somewhat conformist in that it does not include modern ideas such as the community-based village health worker; it is, however, not contrary to this approach. Morley (1975) and others have argued in favour of hospital involvement in community health care and there are some examples of successes in this field, particularly in mission-related medical services.

Before embarking upon the discussion of the outpatient department itself, outlines are given of:

- Some axioms which are needed as a basis for discussion;
- The concept of the levels of care and the referral system;
- Problems of desirability, feasibility and acceptability;
- The difference between designing a new facility and redesigning an existing one.
It should be recognized that this paper is written largely with the author's experience in East Africa in mind (Vogel et al., 1975). Though literature from elsewhere was reviewed, the emphasis is on situations with which the author is most familiar.

**Axioms**

The planning and design of an outpatient department discussed below refers to a system where the following axioms have been accepted:

(a) Services for outpatients are part of a regionalized health care delivery system (a "closed" system), which includes dispensaries, health centres and hospitals with their outpatient departments. The outpatient department of a hospital has administrative and functional links with dispensaries and health centres as well as with the hospital of which it is a part. Planning for a health care facility is meaningful only if it is part of overall planning for a health care system.

(b) Services for ambulatory patients are provided at several levels, linked into a chain by a referral system (both external and internal).

(c) The population to be served by ambulatory care services has to be defined as clearly as possible and the quantity of expected demand as well as the quality of care to be provided must be determined.

(d) The outpatient department building is an envelope around an organization; the structure must meet the requirements of the organization it houses and the layout should be designed only after operational policies and procedures have been outlined in considerable detail. Consequently, the organization comes first, the building second.

(e) The planner/administrator of the health service must be prepared and able to phrase explicitly several assumptions and predictions and to decide upon many operational aspects (policies and procedures) of the outpatient department before he can discuss a draft brief with the architect.

(f) The manager of the outpatient department must be familiar with and accept the operational guidelines which have been defined by the planner/administrator in consultation with himself, the staff and representatives of the community. Planner, health administrator and architect must present the manager of the outpatient department with a "user's manual".

(g) The organization has to be defined in terms of operational policies and procedures as well as in terms of capacity needed and of resources to provide the care.

(h) Medical care is often sought and demanded by persons who do not need this care from the medical point of view; the justification for providing this care is largely social and political.

(i) High, and possibly excessive, demand for medical care may put an intolerable strain on resources and may be an obstacle to providing an adequate quality of care to those who need it most.

(j) The principal challenges in primary medical care are the identification of potentially serious and high-risk cases and the operation of the referral system.

(k) Given limited resources, the product of "quantity of demand times quality of care" is constant (i.e., health worker and community must choose between quantity and quality) unless the manager of the service is able to increase the efficiency of the organization.

(1) If, as a matter of policy, curative care is to be combined with preventive and promotive care, the decision to provide integrated services has to be made at an early stage as it has far-reaching implications for the medical, administrative and technical procedures, for the flow of patients/clients, and for the layout of the building.
The four levels of care and the referral system

In many developing countries, ambulatory care is provided at four echelons (levels) of the health care delivery system. The level of care is mainly determined by the level of staff in the crucial role, i.e., decision-making regarding diagnosis, treatment and referral. The higher the level of care, the greater the complexity of the organization and the facility in which the services are provided.¹

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<tr>
<th>Level of care</th>
<th>Medical facility</th>
<th>Level of decision-maker</th>
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<tr>
<td>Primary</td>
<td>Dispensary, health centre</td>
<td>Medical assistant</td>
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<tr>
<td>Secondary</td>
<td>District hospital, or similar</td>
<td>General duty medical officer</td>
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<tr>
<td>(intermediate)</td>
<td></td>
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<tr>
<td>Tertiary</td>
<td>Provincial hospital, or similar</td>
<td>Clinical specialist</td>
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<tr>
<td>(regional)</td>
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<tr>
<td>Quaternary</td>
<td>National or teaching hospital</td>
<td>Superspecialist</td>
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<tr>
<td>(central)</td>
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It should be noted that, in practice, the medical facilities of higher levels also provide care of lower levels. For instance, a national hospital will also deliver tertiary care (through clinical specialists), secondary care (through general duty medical officers) and primary care (through medical assistants). Whether it will be in the hospital proper or in separate facilities is a matter of policy. Whatever the policy adopted, efforts must be made to avoid patients being cared for at an unnecessarily high level of facility.

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¹ Editors' note:


In 1973 the WHO Executive Board identified three levels of care and adopted for them the following definitions (WHO Official Records, No. 206, p. 113):

- "Primary care services are general health practice services which are offered to the population at the point of entry into the health service system."

- "Secondary care comprises the care provided through specialized services on referral from primary care services."

- "Tertiary care includes highly specialized services and eventually the superspecialities, such as plastic surgery, neurosurgery and heart surgery."

The reader may be surprised by discrepancies between the four levels of care identified in this paper and those described in the papers cited above (three and five levels, respectively). The editors have refrained from standardizing the nomenclature here (although they have done so in other instances) as it illustrates the wide variations to be found between countries. These variations are not merely due to semantic differences but reflect real differences in the organization of services, in the tasks of health personnel and in the patterns of utilization of services by the population.
The medical assistant is an assistant to the doctor who works formally (for legal reasons) under the responsibility and supervision of the doctor. In fact, he commonly works on his own, far away from a doctor's support and supervision, particularly at the health centre level.

It is generally agreed that primary care should be provided near the patient's home (i.e., in the community), while secondary care has to be concentrated in towns for reasons of economy, communications and availability of higher-level staff.

The four levels of care and facilities are, ideally, linked by a referral system, i.e., patients who cannot be adequately cared for (in terms of diagnosis or treatment) at the lower level are referred to a higher-level facility.

The referral rate, which should be controlled by the staff, must take into account the capacity at each level to provide adequate care at that level; otherwise, the quality of care will deteriorate. In East Africa, the referral rate at each level is in the range of 5-10%, i.e., for 1000 patients treated at primary care level, 50-100 will be treated at secondary, 5-10 at tertiary, and 1 at quaternary care level.

The term "external referral" means referral between geographically separated units (e.g., from health centre to district hospital); the term "internal referral" means referral within the same unit or building (e.g., from medical assistant to doctor in the same hospital outpatient department).

The referral system implies communication both ways (i.e., up and down) and should also serve educational purposes. It requires an elaborate administrative system.

Desirability, feasibility, acceptability

In any discussion it is important to distinguish between what is desirable from the operational point of view, what is feasible from the point of view of availability and use of resources, and what is acceptable to staff, patients and community. Thus, demanding fees, which may reduce demand for services, may be desirable but socially and politically unacceptable. Similarly, the institution of a filter system (aimed at identifying the potentially serious cases and at ensuring adequate attention to those patients who need it most) may be desirable and feasible as well as acceptable to those who benefit from it but unacceptable to those who do not obviously benefit, to the community at large and possibly to the staff.

New and redesigned facilities

There are two possible points of departure in planning an outpatient department: either there is nothing at present and the health planner and architects are entirely free to design whatever they like, given resources (money, manpower, materials) and constraints (in terms of resources, as well as social, cultural and political constraints), i.e., planning and programming can be done ab initio; or there is a building where some service is provided and the building may have to be expanded or remodelled or the service expanded or upgraded, and planner, health administrator and architect have to a large extent to take into account the given situation.

Planning for future demands and needs

Planning for an outpatient service and facility requires predictions or assumptions regarding population growth, needs and demands for services, changes in catchment areas and populations covered, staff and other resources required and available, and changes in operational policies and procedures. Thus, planning must take into account many factors which may be difficult to predict for the next decade let alone for a longer period. It may be wise therefore to include in the plan for a medical facility a high degree of flexibility, expandability and upgradability.
2. CONCEPTS, PARAMETERS AND THE DATA BASE REQUIRED

The right to health care

The concept that health care, at least at the primary care level, is to be considered an elementary right of every citizen is nowadays widely accepted. Consequently, there should be few obstacles to those who demand care and who want to utilize services, even though they may not need the care badly; demand for care and utilization of services should not be equated with need for care. King (1966, p.1:11) states that there is a tendency "to upgrade the standard, complexity and amenity of medical care before extending its coverage". He argues that there should be minimum provision for the many rather than lavish provision for the few and that patients should be treated as close to their homes as possible in the smallest, cheapest, most humbly staffed and most simply equipped unit that is capable of looking after them adequately.

When considering the relevant parameters and the data base required it may be well to recall "Finagle's Laws on Information": the information you have is not that which you want; the information you want is not that which you need; and the information you need is not that which you can obtain. Routine outpatient department statistics are usually irrelevant for purposes of planning and management of the operations. To collect relevant information, specially designed surveys and operational studies may be required.

Demand, utilization and coverage

The term "demand" is commonly used to mean effective demand (i.e., the potential user manages to reach the facility, to get into it and to demand service) and is equated with utilization of service. Demand is commonly measured in such parameters as:

- Number of outpatient visits per person per year from the population living in the formal catchment area;
- Reattendance rate per new outpatient registered;
- Proportion of pregnant women attending antenatal clinics;
- Proportion of children adequately immunized against various communicable diseases.

The average number of outpatient visits per population per year is the most commonly used and simplest parameter of outpatient department utilization at the primary care level. As utilization of services varies with population characteristics (sex, age, economic class, level of education, etc.), disease pattern (frequency and causes of morbidity and mortality), distance from the clinic and communication facilities, it is worth while to collect information on these variables. In any case, data on the number of outpatient visits have to be compared with information on the population covered, i.e., the population from which the clinic draws its patients. An important factor in the utilization of services is the distance to the clinic; King (1966) has described the "outpatient care gradient" and the "isocare lines".

In order to calculate the number of visits per population per year, the denominator, i.e., the population in the catchment area, must be known; this area may be a geopolitical unit or it may be described in geographical terms and expressed in km² or the diameter or radius of a circle at the centre of which the facility is situated. The catchment area may be either the de facto or the de jure area covered by the facility.

The term "coverage" refers, generally speaking, to the proportion of a target group which can utilize a facility or a service (e.g., proportion of the total population who can utilize the outpatient department; proportion of the pregnant women who can use antenatal consultations; proportion of infants who can be immunized, etc.). Determinants of coverage are availability of service, accessibility of service and acceptability of service.

What is most generally measured is the utilization rate, either in terms of contacts per person per year in the target population or of proportion of the target population having had
contact. When it can be assumed that all the target population was in need of care (e.g., pregnant women for antenatal care or infants for immunization) a measure of utilization is at the same time a measure of coverage. In other cases it is not; even if the coverage is 100%, a large percentage of the population will not be in need of, and consequently not use, health care services.

It must be realized that patients may have a choice, e.g., 10 km to the nearest health centre, 15 km to the nearest district hospital, 20 km to the nearest mission hospital and 25 km to the nearest private medical practitioner. Here the patient is obviously faced with some alternatives and his criteria in the decision-making process may include: cost of travel and medical care, expected satisfaction, expected quality of care and courtesy. In order to obtain the relevant data, a population-based survey must be carried out in the community.

Services offered by static units may be complemented by mobile services, though experience shows that transport problems often are a major obstacle to this form of extension of medical care towards the people and into the community.

Data required to calculate parameters as mentioned above include:

- Number of outpatient visits to a medical institution per year;
- Distance (in kilometres or travel time) from their place of residence to the institution;
- Population of the catchment area;
- Size and population density of the catchment area.

Of course, a more refined picture may be drawn using the variables mentioned earlier as well as those referring to the status of the patient (new patient/reattendance, new condition/follow-up, type of care demanded, etc.) and by establishing seasonal and daily variations or trends.

Further, the term "increase in demand" will be mentioned repeatedly. It should be realized that this term may refer to:

- Increase as a consequence of population growth;
- An autonomous increase per capita for whatever reason;
- More demand for higher-quality care;
- Demand for a wider spectrum of services.

The flow concept

In a clinic where large numbers of patients have to be handled daily (say, over 500 per day) the only feasible policy to process them more or less adequately is in a flow, i.e., patients are processed in a system where they attend one or more units as the need may be. Units are arranged in series. Although there is some similarity with the conveyor belt system, it is evident that a health worker cannot be equated with an industrial labourer or a patient with a piece of metal or paper. Another difference is that not all patients have to undergo the same procedures.

The flow concept implies a breakdown of the total task of caring for a patient into parts to be allocated to the appropriate unit and a distribution of labour among the various units and health workers involved. This requires information on the distribution of patients attending various units in order to calculate the daily workload per unit or the required capacity of the unit.

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2 See the chapter by M. Torfs later in the present volume.
The flow concept has far-reaching implications for layout, organization and management of the outpatient department. It implies the need for: a series arrangement of units, close coordination of activities of units, unity of command, and high motivation or strict discipline among the staff.

A flow is likely to have a bottleneck (limiting factor); if one bottleneck is eliminated another may become prominent. In a primary care facility such as an outpatient department it is frequently found that the limiting factor is the medical assistant unit's capacity (depending upon the number of medical assistants and the time required per patient).

The flow is controlled by the crucial person in the process; this is usually the medical assistant or doctor who is in the decision-making position and who may constitute the bottleneck in the whole process. Though there may be some minor variations (e.g., some categories of patients may bypass him) the crucial position of the medical assistant in the flow process is illustrated by considering that he determines:

- The quality of care (diagnosis, therapy, referral);
- The time the flow can start (if he is early the flow can start early; if he is late the whole process is likely to be late, resulting in long queues and waiting times);
- The rate of output of the whole outpatient department;
- The daily workload of the therapeutic units downstream;
- The rate of input into the units downstream at various times of the day;
- The cost of treatment (by his prescription preferences and habits) and diagnostic procedures (laboratory tests, X-ray);
- Whether standardization of procedures is successful (e.g., writing diagnoses in code, prescribing commonly used drugs in code).

If an existing outpatient department system requires review, it is wise to focus upon the role and task of the above-mentioned decision-maker; any change or improvement is likely to require consideration of his position and depends upon his ability and cooperation.

Parameters of outpatient department operations

The internal mechanisms of the organization and services of an outpatient department are a function of four sets of parameters:

- Operations;
- Quality of care provided;
- Cost and efficiency;
- Expectations and satisfaction of patients.

Whether a choice is made or whether all sets of parameters are utilized depends upon the objectives of the viewer; the choice may be different for the health planner, the health administrator, the manager of an outpatient department or the architect.

Operational parameters

Operational parameters include:

- Arrival pattern (or input rate) of patients at the waiting-room;
- Input and output rates per unit of time at various units;
- Service times at various units;
- Queue length at the waiting-room and at various units;
- Waiting times of patients at various units;
- Proportion of referrals (external and internal) to higher levels of medical care.
Obviously these parameters are not independent of each other. Queue length and waiting times at the central waiting-room are related to the input rate at the waiting-room and the output rate of the medical assistants. Duration of service time is related to the output rate at that particular unit; it is only meaningful to measure the output rate at a unit if there is a queue at that unit. Duration of service time, of course, varies with the level of care, e.g., at primary level 2-3 minutes, at secondary level 5-10 minutes, at tertiary level 20-30 minutes.

Methods of collecting relevant data include a survey, activity sampling and time studies. Data required for the measurement of the above-mentioned parameters to be collected in a survey include:

- Times of arrival of patients;
- Times of processing at various stations;
- Distribution of patients over various units (i.e., internal referral to various diagnostic and therapeutic units).

Some of these parameters will be discussed in more detail because they measure, and help in understanding, the most obvious problems in many an outpatient department: queueing and long waiting times.

The long queues present problems for both staff and patients and the long waiting times present a problem for patients. The queues in the central waiting-room are caused by:

- The large numbers of patients arriving early in the day;
- The late start of the clinic and the relatively low output of the first unit (often the medical assistant's).

Clearly, the arrival pattern of the patients is beyond the control of the staff and thus queueing in the central waiting-room is hardly avoidable. Once the patient has entered the system, he or she should be handled fast; consequently, queueing downstream from the medical assistant must be avoided as it hampers the work of staff and requires much space for waiting bays.

The relationship between arrival pattern, output rate at the medical assistant's unit, queue length and waiting time can be shown in a diagram presenting cumulative input and output of patients (in the central waiting-room). This diagram may show numbers of patients in absolute numbers or, for comparative purposes, it may depict percentages.

Figure 1 is an example of such a diagram. It shows that in a particular outpatient department (which handles 1000 patients on a certain day) with the arrival pattern and the speed of work of the medical assistants as indicated, at 10h30 the queue length is approximately 420 patients and patients arriving at this time have to wait for an average of 4 1/2 hours.

Queueing as a problem is made much worse if there is no space for the waiting crowd; waiting patients may start moving or pushing and, if they are waiting in the corridor, are likely to block it and thus impede traffic of both staff and other patients. As queueing apparently is unavoidable, waiting bays at units are a must.

Quality of care parameters

Quality of care is difficult to define and even more difficult to measure. Yet it is the quality of care provided, in particular to the seriously sick patients, that determines the value of an outpatient department to the health of the community.

Quality of care in terms of structure is an issue to be considered in assessing the efficacy of the referral system or the filter system (see the discussion of quantity and/or quality in the following section). The average quality of care may be found to be acceptable. It is, however, more important that those relatively few who need care badly do indeed get an adequate quality.
Quality of care in terms of process is best assessed using the adequacy (from the medical point of view) of treatment prescribed or referral as criteria. Standards of care should be defined; this can be done through peer review or by one or more experts. The instrument may be an audit system (using a score assessment in points) or a flat assessment (i.e., stating whether treatment is or is not adequate).

Quality of care in terms of outcome (i.e., the impact on the health status of the patient) requires a follow-up of the patient, either in the clinic or in the community, and is thus more difficult to assess.

Cost and efficiency parameters

Whatever the operational performance and the quality of care provided, the cost of services must be taken into account as resources may be scarce and constraints many. A cost analysis is essential if the possibility of cost reduction is to be considered.

Relevant cost parameters are:

- Labour cost and material cost as a proportion of total cost;
- Cost per operational unit;
- Cost per patient, injection, drug prescribed etc.;
- Drug cost per patient;
- Cost incurred per medical worker (medical assistant, doctor etc.).

Data required include:

- Number of staff involved and required;
- Salaries, emoluments and social security expenditure of staff concerned;
- Consumption and cost of drugs, chemicals, dressings, water, electricity etc.

FIG. 1. CUMULATIVE INPUT AND OUTPUT AT THE CENTRAL WAITING-ROOM OF THE OUTPATIENT DEPARTMENT
When efficiency is to be improved one may either assess the minimum cost to be paid to obtain some predetermined result or determine what results may be achieved with a defined input of resources. Given the constraints of limited inputs and considerable output expectations, the problem is to determine the best allocation of resources. In a wider context the question arises whether a study of opportunity costs\(^1\) could show that further expenditure on ambulatory care services - at the expense of some other type of medical service - would be a good investment. It is doubtful whether such a study could fruitfully be undertaken in the present state of knowledge in this particular field.

**Expectation and satisfaction parameters**

Whatever the opinion of those who have authority and responsibility as health administrators, the manager in charge of the outpatient department has to take into account the expectations and degree of satisfaction of patients, community and staff. This is the field of the social scientist who considers the outpatient department as an area of communication between patients and staff members each of whom have their own demands and expectations. Patients' opinions may be obtained through questionnaire or interview in the clinic; it is equally important to interview patients and people in the community, particularly as there may be many patients in need of services who, for various reasons, do not come to the outpatient department.

3. **COMMON PROBLEMS IN AMBULATORY CARE SERVICES**

**Is anything wrong with the outpatient department?**

By surveying existing facilities and services and asking critical questions we may learn from mistakes made in the past, when planning a new outpatient department. Thus, before deciding upon operational and architectural aspects of the desirable outpatient department we should ask ourselves:

- What are the problems in the currently operating outpatient departments with which we are familiar?
- What are the causes and effects of these problems?
- By which ways and means may we alleviate these problems?

This appears a sensible approach when planning for a new outpatient department. The same survey may be carried out for an existing outpatient department. The next step is to list and consider alternative ways and means of solving the problems, then a choice has to be made, and finally the changes must be made operational.

To identify the problems and to ask the right questions (see appendix) is as important as to find the best solution for a particular problem. Problems may be identified by a knowledgeable visitor by:

- Observation;
- Asking questions of staff and patients;
- Scrutinizing registers, files and records.

If a problem is identified in an outpatient department or a particular unit the next step is to find out who is doing what, where, when and how and to consider alternative and better or cheaper ways of carrying out activities (if the activity has to be carried out at all) through the processes of elimination, combination, rearrangement, simplification and delegation.

**Problems may be looked at in various ways.** Let us consider them in the following perspectives:

\(^1\)"Opportunity costs" measure costs in terms of alternatives or opportunities (here alternative services) that are forgone, i.e., that might otherwise have been made available with the same resources.
What are the problems?

- What are the problems?
- Who's view? - i.e., problems as seen by staff, patients and community.
- What cause? - i.e., what is the root of the problem?
- What effect? - i.e., how does it affect the operations of the outpatient department?
- Who can or must solve the problem? It may be health authorities, outpatient department manager, staff, patients, community, or some combination of these.

What are the problems?

Problems frequently mentioned and observed can usually be grouped as dealing with:

- Operations;
- Resources in terms of money, materials and manpower (both quantity and quality);
- Efficiency, i.e., use of resources;
- Layout of the building;
- Quality of care;
- Satisfaction or dissatisfaction among patients and staff.

Who's view?

The problems as perceived by the staff are likely to be different from those perceived by patients and community though there may be some overlap (e.g., queueing and long waiting times usually go hand in hand; the first mainly presents problems for the staff, the second for the patients).

Common complaints among staff (i.e., problems identified by staff) are:

- Shortage of staff;
- Equipment out of order;
- Drugs out of stock;

Common complaints by patients and community:

- Long waiting times;
- Long queues;
- Staff is not courteous and considerate;
- If referred to a hospital the patient may again be attended to by a medical assistant;
- There is no personal care;
- Staff starts late and leaves early;
- Staff gives priority to friends, relatives and VIPs.

Causes and effects of problems

The crucial question is: what are the causes and effects of problems? Sometimes it is difficult to distinguish cause and effect; however, the distinction is important. Measures should preferably be directed against the root of the problem; palliative treatment of the problems is seldom effective. Many problems have several causes; one cause may have several effects (see Fig. 2).
The impossibility of instituting necessary changes in policies and procedures usually reflects underlying shortcomings in the organization and its leadership and is frequently not only a managerial problem but may also reflect inadequate motivation and discipline.

Frequently, the organization is caught in concrete. Inadequacies in the building may often be alleviated by relatively minor modifications of the existing structure (adding a door, shifting a wash basin, partitioning a large room, demolishing a wall so as to eliminate an obstacle to a flow, etc.).

Excessive demand may be discouraged by a selective service charge; this requires decisions at a higher level and is beyond the competence of the outpatient department manager. In many developing countries, primary care services are free of charge as a matter of policy for social and political reasons.

The patient's behaviour is to a large extent beyond the control of the staff (e.g., the arrival pattern); on the other hand, patients can be taught or encouraged by the staff to behave in a certain way.
Shortage of resources is often relative. An apparent shortage of staff may reflect inadequate deployment of the staff available. There may be a shortage of drugs because previously drugs have been wasted through overprescription. The referral system will be discussed below.

Inadequate coordination of units is a major reason for queueing and long waiting times within the system. In order to reduce this queueing, there should be unity of command and collaboration between various units.

Ways and means to reduce costs and to improve efficiency include:

- Delegation of tasks to lower-paid staff;
- Application of economy of scale in units such as injection room and pharmacy;
- Standardization of procedures;
- Prescription of commonly used drugs in code;
- Prepacking of drugs, prebottling of mixtures and syrups;
- Automation (but even in cases where improved efficiency can be obtained at lower costs, the effect of automation on the labour market must be taken into account).

The twin problems of queueing and waiting times are mainly caused by:

- The fact that an appointment system is unfeasible (at least at the primary care level);
- The fact that most patients arrive at the same time, i.e., early in the morning;
- The late start and low output rate (not in absolute terms, but relative to the input) of the critical factor in the process: the medical assistant or doctor.

Ways and means of reducing queueing and waiting time include:

- Devising methods of spreading out arrival of patients, especially encouraging them to arrive later;
- Increasing the output rate of the medical assistant's units by time- and labour-saving measures (provided the therapeutic units can handle the increased input rate);
- Starting outpatient department operations earlier.

Special consideration will be given to: the discrepancy between demands and resources; the referral system; quantity and quality; equipment; and the physical structure.

**Discrepancy between demand and resources**

The most important cause underlying problems faced by staff and patients is the high and increasing demand for medical care by the community. As the resources to handle the patients do not increase proportionately, an imbalance develops between resources and workload. The only short-term solution in this situation is to strive for increased efficiency. This in turn requires reconsideration of the established operational policy and medical, technical and administrative procedures. This is usually a more meaningful approach than demanding more staff, more drugs, more equipment and a new building. There is, however, a limit to the possible increases in efficiency. As the demand increases there is a danger that the staff, unable to cope with the workload, will deliver a lower quality of care with the result that the patients - and in particular those who need it most - do not get care of an adequate quality.
The referral system

The external referral system, ideally a two-way communication system, often does not function properly for a variety of reasons:

- Referral upwards may not function well because the higher level is not adequately informed on the case or because information on the patient and advice for further care and treatment do not reach the lower level;
- Referred cases are often not given adequate attention when they arrive at the higher-level facility (or they may even again be attended to at primary care level);
- The patient may be unable (money, transport, escort) or unwilling (unfamiliar social or cultural environment) to go to a higher-level facility;
- At a higher level the capacity to absorb all referred cases may be inadequate, resulting again in a lowered quality of care provided; an appointments system for referred cases must be considered.

The internal referral system often suffers as a result of nepotism and favouritism resulting in preferential treatment for relatives and VIPs rather than for those who need it most.

If the distinction between primary and secondary level of care becomes blurred, there is a risk that referred patients who are entitled to attention from higher-level staff and more time per patient do not receive such treatment and that the community gets quantity of care at the expense of quality.

Quantity or quality?

As indicated above, the provider of medical services has to meet demands in terms of quantity and quality. Given the relative shortage of resources, these may be mutually exclusive. In such a situation it is medically imperative to reserve better quality of care for those who need it most and who run the risk of being lost in the mass of patients presenting minor medical problems (though these may reflect serious emotional problems).

In order to facilitate better quality of care for the most medically deserving patients, there are the following mechanisms:

- The use of a record so designed that high-risk patients are more easily identified;
- A filter system where selected patients are referred to a health worker at the same level but one who can spend more time on the patient (this mechanism implicitly recognizes the fact that many medical assistants work below their level of professional competence because of the pressure of the workload);
- Referral to a higher level of care if at that level there is an adequate capacity to cope with the workload.

Equipment: the demand for sophistication and the need for simplicity

Problems frequently crop up regarding equipment which does not function owing to a shortage of competent technicians for maintenance and repairs. In many countries, the political decision-makers favour large, well-equipped and sophisticated hospitals. Strong arguments against this tendency have been voiced by Morley (1975) and others. At the level of primary and secondary care, where facilities for maintenance and repair are scarce or absent, the case for simple, unsophisticated, breakdown-resistant equipment is even stronger.
The physical structure

The building may be unsuitable in terms of space and particularly in layout required for present-day and future needs:

- In view of desirable operational policy and procedures;
- In view of the increasing number of patients and staff and the increasing workload on the staff.

An existing building may be a serious stumbling-block to a change in policy and procedures as the layout may be unsuitable to organizing the work efficiently (e.g., in a flow). Of course, the size and layout of the building may also present problems when quantitative demand for service increases. As the outpatient department is commonly in use only 8 hours per day (at best), an attractive option is: to extend the opening hours; to work in two shifts (if the staff is available); and to inform and educate the public so that demand may be spread evenly over, say, a 14-hour period (e.g., 07h00 to 21h00).

In view of the facts that:

- Buildings have a lifetime of at least 50 years;
- Demand for services in quantitative terms is difficult to predict;
- Operational policy and procedures may be changed every decade;
- Construction cost is only a fraction of running cost over a 50-year period;
- An unsuitable building may induce additional operating cost (e.g., in salaries) for many years;

it seems wise to formulate in the architect's brief the following requirements: some degree of expandability, upgradability and flexibility.

It is frequently found that the users of the building (medical staff) are not aware of the function of units planned for by the architect. Often, an unsuitable building can be modified internally at relatively little cost. A review of the utilization of a building every 5 or 10 years is necessary and minor changes in layout may be worth the expenditure.

When an outpatient department has to be expanded or upgraded, the question arises whether "more of the same" or "something different" is required. The present situation may be unsatisfactory though routine and tradition may have made it acceptable to the staff. Yet there is reason to reconsider the present arrangements, particularly when an expansion is being planned.

Who should and could rectify the situation?

Sometimes problems are "beyond anybody's control". This statement can often be challenged as it is either a subterfuge for doing nothing or an exaggeration. Frequently staff explain that it is beyond their control and that it is really the fault of the boss; this may be so, but at the same time there may be other problems which are within the authority of the staff and yet they ignore the chance to attempt improvements.

People who may attempt to correct the situation include: health administrators at national and local level; the outpatient department manager; other outpatient department staff; architects at the ministry of works; and community leaders. Effective action may require collaboration by several or all concerned.

Frequently, problems and complaints by staff are exaggerated or, though apparently basically correct and justified, they can be alleviated by improved organization, by more delegation, through revised task allocation and job description, or by improved motivation and discipline. Most important: the inadequacies can often be corrected by the local health administrator or the outpatient department manager and staff; and many problems are staff-made
and the result of wrong or unclear instructions to patients or the result of inability or unwillingness of units to communicate and collaborate.

Though it may be impossible to solve all of these problems, perhaps we should ask ourselves: Can we do better with what we have? Can we make better use of the scarce available resources? Can we improve efficiency? Can we improve motivation and discipline?

It is remarkable that there are seldom complaints about the building; its suitability is not questioned; it is there, it is accepted, and staff learn to work in it and to adapt to its shortcomings.

4. ASSUMPTIONS, PREDICTIONS, ALTERNATIVES AND DECISIONS

The unstable base in the planning process

In order to define the brief for the architect:

- The policy-maker, health planner and administrator have to decide what predictions to accept regarding population growth and expected demands in terms of quantity and quality (i.e., they have to choose between alternative predictions regarding population growth rates, etc.);
- The health planner must decide what prediction to accept regarding resources available and the use of these resources;
- The health administrator and outpatient department manager have to decide what predictions or assumptions to accept regarding patients' expectations and behaviour;
- The outpatient department manager and health administrator have to decide on policies and procedures for the internal outpatient department operations and the level of care to be provided.

All this requires considering various alternatives, determining criteria for choice between alternatives and deciding which to select. It is nowadays generally accepted that the local community should be involved from the planning stage onwards; in practice, this may mean deflating designs for large and luxurious hospitals.

Predictions regarding population growth can be made with a reasonable degree of confidence, assumptions regarding the utilization of services are hazardous to make, while predictions about patients' behaviour and expectations in the future may be mere guesswork.

Any need for research and experiments?

If there is a difference of opinion, the combatants may argue, using or ignoring hard facts, and often the senior person or the more combative or the better debater gets his way. These discussions often involve a degree of conjecture, e.g., regarding the level of discipline or motivation prevalent among the staff, the time various staff start work, what constitutes a reasonable workload, the time required for a particular procedure, etc. Staff behaviour and reaction is often hard to predict; there is usually resistance to change among tradition-oriented medical and nursing staff. Commonly, diverse opinions go through the stages controversy-conflict-compromise. There is, however, another way to go about it. Rather than debate based upon opinions only, we would propose discussions to be held based upon:

- Data collected in routine services, as available data are often inadequate for decision-making purposes;
- Experiments in an operational setting;
- Experiences in pilot projects.

Operational studies and experiments are often required. What may appear to be a good idea or a great innovation may turn out not to be or, even if successful, it may carry unexpected and undesirable side-effects. Results of operational studies and experiments have
to be put into operation through a feedback process. Such studies and experiments are always useful and often necessary; they are a good investment. It must, however, be realized that the success of pilot projects is often not reproducible for a variety of reasons.

To study experiences from elsewhere is important; to learn from other's successes and failures may mean a shortcut to improvement. The causes of a success somewhere at some time are, however, often hard to identify; adoption of a system developed elsewhere may mean an invitation to trouble. Probably, we should try to adapt rather than to adopt. In any case, there is no standard solution to the multiple problems facing outpatient services in many countries. It should be stressed that one is unlikely to find the superb solution to a problem. Each solution has its pros and cons and the optimal solution is likely to be a compromise in which some disadvantages have to be accepted; everything has its price.

As stated earlier, we must always look for bottlenecks and act accordingly (e.g., a bottleneck in an injection room could be found, upon investigation, to be due to the insufficient number of sterilizable syringes available; the solution is evidently to provide more syringes, while an attempt to reduce the bottleneck without looking for its cause might have led to add nurses, thus making the problem worse). Still, having eliminated one bottleneck, we are likely to create another one either in the same unit or in another point along the series of units.

5. PREDICTING DEMAND FOR OUTPATIENT SERVICES

General aspects of demand

A clear distinction must be made between expected demand for ambulatory care in an area among a defined population and expected demand at a particular ambulatory care facility - one of several facilities in the area - which has to provide service to some of the patients from the area, possibly at several levels of care (e.g., at primary and secondary level). Within limits, patients may choose which facility to attend and this may vary, depending upon the service required and the level of care sought. In most countries, a health care delivery system organized by the government is not a "closed" system, but "open" as there are private practitioners, voluntary agency hospitals, etc.

In order to make sure that everybody demanding care will get it at the level medically required, it is essential to have:

- A hierarchy of facilities (e.g., 10 health centres providing primary care plus one district hospital providing primary care for the local population and secondary care through external and internal referrals) preferably in a regionalized system providing coordinated services under unitary command; permanent facilities may be supplemented by mobile clinics;
- A referral system which should facilitate care for those who need it most.¹

As there is a tendency for primary patients to demand care at a higher level (i.e., secondary level), the higher-level facility must be protected against excessive demand by primary patients so that it may serve patients referred for, and presumably in need of, secondary-level care. The health administrator is faced with the problem of how to discourage demand by those who do not need care while encouraging those who do need care to seek it; how to make the community understand the difference and how to get the message across to the community.

Medical care should be equally accessible to all; accessibility (in terms of distance, communications, price and time) for those who need it most from the medical point of view should be stressed. Often accessibility (medical care gradient) is limited to the privileged who live nearby or who can afford the cost of transport; they may need service emotionally rather than medically. Also, urban people are at an advantage as compared with rural people. Thus, in fact, not all patients are equal, both medically and factually.

It appears that "better service" (as perceived by the patient) attracts patients. The implications are:

- If patients are given the choice, they go to the service point at which, in their opinion, service is better; they may even travel further and spend more money to go to that service point;
- If service at a particular clinic is improved, attendance is likely to increase and this may result in a reduced quality of care provided.

It may be appropriate to point out three fallacious notions in this respect: that improvement of health status of the population mainly hinges on more and better health services; that the state of health of a population is related to the demand for service; and that improved health leads to a lower demand for service.

Demand for ambulatory care is commonly expressed on a per capita per year basis. It varies widely depending upon:

- Cost to the patient;
- Distance;
- Communications and cost of transport;
- Level of facility and staff;
- Educational level of the population;
- Degree of urbanization and sophistication;
- Acceptability (social and cultural) of scientific medicine;
- Quality of care provided.

Demand varies from 1 to 10 visits per person per year including revisits (reattendances). In the following, models are developed based on two assumptions, i.e., 2 and 4 visits per person per year. There is no scientifically established standard for demand (either a minimum required, an optimum or a maximum allowed). As pointed out above, demand should not be equated with need. It is often found that many people who demand care hardly need it (in medical terms) while many who need care do not demand it for various reasons.

Models developed on the basis of various assumptions

A model to predict expected demand in the catchment area of a facility may be developed if the crucial factors determining this demand are known or can be reliably estimated. In the model below the following assumptions (including alternatives) are made:

- Population (1975) 300 000
- Population growth rate per annum 1% and 3%
- Demand for primary care (1975) 2 and 4 visits per person per year
- Demand for primary care (1995) 3 and 6 visits per person per year
- Referral rate: primary to secondary 2% and 5%

Table 1 shows the expected annual demand for the whole population in the area, based on these assumptions.
### TABLE 1. EXPECTED ANNUAL DEMAND FOR WHOLE POPULATION, BASED ON GIVEN ASSUMPTIONS

<table>
<thead>
<tr>
<th>Assumption: primary care demand (contacts per person per year)</th>
<th>Primary care contacts (in thousands)</th>
<th>Referral rate primary/secondary care (per hundred)</th>
<th>Secondary care contacts (in thousands)</th>
<th>Assumed growth rate per annum</th>
<th>Assumed primary care demand (contacts per person per year)</th>
<th>Primary care contacts (in thousands)</th>
<th>Referral rate primary/secondary care (per hundred)</th>
<th>Secondary care contacts (in thousands)</th>
</tr>
</thead>
<tbody>
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<td>2</td>
<td>600</td>
<td>2</td>
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<td>3</td>
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<td>65</td>
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</tr>
</tbody>
</table>

Note that the demand for primary care is beyond the control of the staff but that the demand for secondary care can and must be controlled by the staff through the referral system in order to prevent the secondary and tertiary level of care from becoming overloaded.

If $v$ is the number of visits per person per year, $p$ is population and $a$ is yearly growth rate, then after $n$ years, the yearly demand for primary care $D_1 = vp (1 + a)^n$, demand for secondary care $D_2 = rD_1$, where $r$ is referral rate from primary to secondary level.
Distributing service points to meet demand for primary care

If we wish to make primary care services available to the people, the service points (health centres, dispensaries) must be so located that they are accessible to the patients, bearing in mind distance, communications and cost of transport.

The demand for primary care at a given facility can be estimated on the basis of: catchment area; population density; and expected number of visits per person per year (see, for example, Table 2)

<table>
<thead>
<tr>
<th>TABLE 2. EXPECTED ANNUAL AND DAILY DEMAND (ASSUMING 300 WORKING DAYS PER YEAR) VARYING WITH CATCHMENT AREA AND POPULATION DENSITY</th>
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<tr>
<td>Radius of catchment area</td>
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<tr>
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<tr>
<td></td>
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<tr>
<td>5 km</td>
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<td>10 km</td>
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Table 2 shows that for a primary care facility daily demand may vary from 80 to 960 patients (that is, 12-fold) depending upon catchment area and population density if the demand is fixed at 3 visits per person per year on the average. Consequently, it would be unrealistic for the planner to try to devise facilities of a standard capacity. Space and staff necessary must be determined as a function of the expected demand from the population in the catchment area and the facility designed accordingly (if need be, by adaptation of a standard plan).

Most policy-makers and planners are of the opinion that services should be taken to the people; this implies a large number of smaller facilities with fewer and lower-level staff. For the people this is presumably an advantage if the level of care provided is acceptable. For the health service, however, it may present more problems in terms of logistics, transport and supervision required.

Determining the capacity for primary and secondary care at the outpatient department

As mentioned above, there is a risk that a facility (and its staff) may become overloaded. In particular, this may occur at a secondary care facility (e.g., a district hospital) where there may be excessive demand by primary care patients. Ways to reduce this common problem will vary according to circumstances:

- If no primary care facilities are available nearby, the only solution is to provide them;
- If they do exist, patients can be encouraged to attend them, or discouraged from addressing themselves to the secondary care facility by a service charge if primary care is free or by an increased charge if it is not free, or even accepted only upon referral from the primary level.

In any case, if the hospital outpatient department is to be protected against excessive demands, primary patients must be discouraged from attending.
When the outpatient department of a hospital provides care at several levels (primary and secondary, possibly tertiary), a distinction has to be made between two categories of patients: those referred from the outpatient department (internal referral) and those referred from outside the hospital (external referral).

This distinction is not made for theory's sake but because it has immediate practical consequences. Patients referred externally must get priority over those referred internally for the following reasons:

- They come from further away than those referred internally and returning the next day may present them with problems;

- The threshold is lower for internal referral than for external referral for the simple reason that while a dubious case will readily be referred to the higher level next door, it will take more serious reasons to send a patient to a higher level facility some 10-20 km away. Consequently, a higher proportion of patients referred externally will be found to be in need of secondary or tertiary care.

6. ALTERNATIVES AND DECISIONS REGARDING POLICIES AND PROCEDURES

The view at the operational level

As indicated above, the health administrator and the outpatient department manager must consider alternatives and at an early stage decide upon:

- Operational policies,
- Administrative procedures,
- Medical and nursing procedures,
- Technical procedures,
- Resources in terms of manpower (quantity and quality), money for recurrent expenditure and materials (equipment, chemicals, drugs, etc.),

taking into account the defined capacity of the facility (e.g., 1000 patients per day for primary care and 100 for secondary care) and various constraints (Vogel et al. 1975).

The policies and procedures to be decided upon must be described explicitly in manuals at two levels: the operational level; and the supervisory level, i.e., for the manager of the outpatient department (Vogel et al. 1977).

Operational policies

Operational policies to be decided upon include the following:

- The number of levels of care to be provided;
- Whether separate maternal and child health services should be offered under the same roof;
- Whether comprehensive curative, promotive and preventive care should be provided, in particular to mothers and children;
- Whether the flow concept be accepted;
- Whether a filter process will be instituted;
- Whether there should be unity of command and what should be the degree of coordination between various operational units;
- Whether there should be standardization of procedures;
- What should be the distribution of labour;
- What should be the workloads for units and staff;
- What should be the system of referral;
- What should be the registration and record system;
- Whether to operate in one or several shifts;
- Whether certain categories of patients should be grouped together or separated;
- Whether all patients should go through the same process;
- What are the traffic arrangements;
- Whether health education should be offered routinely for groups of patients;
- Whether the facility will engage in outreach activities (for instance, for immunizations);
- Whether the duties of staff will include supervision or in-service training of the staff of lower echelons;
- Whether the facility will be used for training purposes.

The number of levels of care to be provided. It must be decided whether, for instance, at a provincial hospital outpatient department all three levels or possibly only secondary and tertiary levels of care will be provided. In this context, the quality of care at each level of care has to be defined.

Whether separate maternal and child health services should be offered under the same roof. Such an arrangement, though contrary to tradition, is attractive from the point of view of the organization, deployment of staff and convenience for the patients and clients. The organization, though under the same roof, may be separate from the outpatient department.

Whether comprehensive curative, promotive and preventive care should be provided, in particular to mothers and children. This implies that sick and healthy children are attended to (treatment, immunization, nutrition advice) together with their mothers (ante- and postnatal care, family planning) daily. It means shifting sick children from the outpatient department to integrated maternal and child health services. This arrangement promotes utilization of various services, in particular of family planning and immunizations; however, it requires a complicated organization, it has far-reaching implications for the layout of the building and it demands multipurpose rooms and multipurpose staff (e.g., a community nurse). From the above, it is clear that this type of clinic offers more care to more clients, which implies that more work has to be done, more time is to be spent and more staff is required.

Whether the flow concept be accepted. As indicated in section 2 above, in the discussion on the flow concept, there is hardly any alternative in an outpatient department where a large number of primary patients (say over 300 daily) is to be handled. A disadvantage is that medical care for the patient becomes fragmented and less personal. If the planner opts in favour of the flow process then it is important to accept all the implications for procedures as well as the layout of the building.

Whether a filter process will be instituted. This may work very well in an even larger outpatient department (say over 500 patients daily) particularly if it has been observed that among the many primary care patients only few are seriously ill and that those are likely not to get an adequate quality of care. The disadvantage is that it means a further fragmentation of care, as a patient filtered in will be seen by a second-line medical assistant.
Whether there should be unity of command and what should be the degree of coordination between various operational units. If it is decided to accept the flow process, then unity of command is required in order to provide the required coordination between the various units - in particular the frequently used ones (registration, medical assistant's unit, injection room, dressing room and pharmacy) - which traditionally are in the hands of clerical, medical, nursing and pharmaceutical staff, respectively, who may have little inclination to collaborate. If unity of command is accepted then it has to be determined who should be the outpatient department manager: doctor, medical assistant, administrator or nurse. It also implies defining the degree of delegation, the limits of authority and the job descriptions.

Whether there should be standardization of procedures. Various medical, nursing and technical procedures may be standardized, thus saving time and money through delegation (e.g., standardization of treatments which may then be prescribed in code; the drugs can then be prepakcled or prebottled). This includes the question of central or decentralized sterilization of equipment. It may make the work of staff less interesting and more repetitive.

What should be the distribution of labour. Should there be separate or combined injection or dressing rooms? Should immunizations for infants be given in the injection room or in a separate unit? The answer may be determined by the volume of demand and the defined capacity of a unit. Should clerical work in the injection room be done by a clerk or a nurse? This again may be a matter of quantity rather than of principle (see also section 7 below).

What should be the workloads for units and staff. Maximum and minimum workloads must be defined with a view to minimizing costs and maximizing operating efficiency. When the workload for a unit drops below a minimum, the unit may be combined with another unit; the same holds true about a particular task for a worker. Larger units may be expanded or duplicated.

What should be the system of referral. See the discussion of the referral system in section 3 above.

What should be the registration and recording system. It is imperative to limit the administrative tasks to the minimum dictated by medical, administrative and legal requirements. In East Africa, the patient record card is given to the patient to take home. This system saves staff and work. Of course, the patient may lose the card and thus valuable medical information may get lost. Yet it appears that the system has worked well for many years to the satisfaction of staff and patients. Ultimately, this system will have to be abandoned. If it is considered not only desirable but also feasible for the outpatient department administration to file, store (and retrieve) the patient's record, then filing cabinets, space and staff are required. This latter system appears preferable (though a high price is paid for it in terms of money, space and staff). The type, material and size of record are equally important. A decision must be made as to who will do the administrative work (clerical, nursing or medical staff), where it is to be done, when and how. In many countries there is an elaborate system of registration, the results (and uses) of which hardly justify the expenses. The question is not how good the administrative system could or should be but what are the minimum requirements of an acceptable system.

Whether to operate in one or several shifts. Instead of the traditional one-shift system (08h00-13h00 and 14h00-16h00) a two-shift system (07h00-13h00 and 13h00-19h00) may be instituted. Under a two-shift system, space requirements may be less and construction costs will be reduced; a two-shift system may, however, require more staff. In an existing facility (working one shift) which is becoming overloaded, the introduction of a two-shift system deserves serious consideration; of course, it is likely that more staff will be required to cope with the increased workload. If a two-shift system is introduced, the public must be informed; it can only function adequately if patients and public cooperate. The chances of success appear to be greatest in an urban or semi-urban environment.

Whether certain categories of patients should be grouped together and separated. This is a major issue at the primary care level. All patients may be considered equal. As different patients may have different needs and demands, grouping them must be considered and we must ask what is desirable, feasible and acceptable. Some criteria used in this process include separation by:
- Sex: males and females;
- Age: adults and children; or small children (under 5) apart from others;
- Nature of medical conditions: internal, surgical, gynaecological, etc.;
- Type of service: curative or a combination with preventive/promotive (see above).

Any grouping of patients makes sense only in clinics with large attendances, e.g., over 500 patients daily.

Separation by sex is common and it may be required for sociocultural or religious reasons. There are, however, advantages in mixing patients and the rule that tradition prescribes may have to be questioned. One condition, of course, is that privacy in sight and sound is guaranteed. Separation by age and by nature of the medical condition may be justified if the providers of care are specialized (formally or informally); the advantages to patients are obvious but the arrangement may present problems for the rotation of staff.

Whether all patients should go through the same process. Patients coming for a follow-up injection may bypass registration and medical assistant's unit. This would reduce queuing at the medical assistants' units and give them more time for other patients; it would, however, imply increased queuing at the injection rooms.

What are the traffic arrangements. It must be decided whether only one-way traffic is allowed for patients; whether staff and patient traffic will be separated; whether corridors may be turned into waiting-rooms; whether there will be traffic direction and who will do it (see discussion of administrative procedures, below).

Whether health education should be offered routinely for groups of patients. It must be decided where, to whom and by whom it will be offered.

Whether the facility will engage in outreach activities (for instance, for immunizations). If so, space must be provided for an office, store and garages.

Whether the duties of staff will include supervision or in-service training of the staff of lower echelons. If so, the capabilities of staff for this function and their grasp of the responsibilities and attitudes involved must be ascertained. The inclusion of such duties also entails appropriate provision of staff.

Whether the facility will be used for training purposes. If so, not only must space be provided for a classroom and office for a tutor but also in various units additional space must be provided as required for teaching.

Administrative procedures

Administrative procedures include:

- Type, material and design of record (possibly records facilitating the identification of high-risk and serious cases; problem-orientated record) (see above);
- Where the record should be kept (by the clinic or by the patients, possibly by the patient for primary care, by the clinic for secondary care);
- Filing system, if required;
- What information to collect routinely, what intermittently, what on a sample base;
- What administrative tasks should be performed by clerical staff and what by medical, nursing or technical staffs;
- How administrative data will be analysed and by whom, and how they will be presented and used;

- Reporting and communications systems and procedures.

**Medical procedures**

Medical procedures include:

- What medical procedures are required, optional, or not permitted at a defined level;

- Standards of care, i.e., what to do in case of a certain critical observation;

- Definition of high-risk groups and instructions for identification and action;

- If a filter process is employed, instructions and indications for filtering;

- Instructions and indications for referrals;

- Whether the pharmacy should be provided with a limited variety of drugs only;

- Whether to shift penicillin treatment to long-acting preparations (requiring fewer injections and thus reducing the workload on the injection room).

**Technical procedures**

Technical procedures include:

- What equipment should be available and when and how it is to be used;

- What laboratory tests are to be employed, how the results should be read and how results should be processed and information passed on;

- Whether frequently prescribed drugs should be prepacked or prebottled;

- Whether the pharmacy/dispensary should have a separate counter for prepacked drugs;

- Sterilization procedures;

- Whether to use disposable or reusable syringes, etc.

**Resources**

Resources comprise mainly manpower (staffing pattern), equipment and the amount of money required for recurrent expenditure.

**Decisions regarding the staffing pattern include:**

- The quantity and quality (number of staff at a certain level); the quality of care to be provided depends upon both the quality and the quantity of staff; the quantity of staff required is determined by tasks, service times and the degree of delegation;

- Job descriptions;

- Single- or multipurpose staff;

- The question who should be in overall command; should the outpatient department manager be a layman, a nurse, a medical assistant or a doctor and what would be his authority and responsibility?

- The degree of delegation;
- The relationship between medical, nursing, technical, domestic and administrative staff;

- Whether some traditional tasks can and must be shifted; in particular, what administrative tasks can be shifted from medical and nursing staff to clerical staff.

The manager of the outpatient department must ensure that an acceptable level of motivation and discipline prevails among the staff. He should not, however, make the mistake of expecting anything near perfection to be reached.

The equipment required for the outpatient department at primary and secondary levels is usually simple, especially if laboratory and X-ray facilities (and possibly central sterilization) are in the first instance the responsibility of the hospital. When automation is contemplated, it must be considered whether replacing man by machine is socially advisable vis-à-vis the employment situation and what is the cost/benefit ratio, particularly in view of the fact that in most developing countries, labour is relatively cheap. Also, sophisticated machines require maintenance and repairs and spare parts often pose problems.

Financial resources required for recurrent expenditure mainly depend upon:

- The staffing pattern, as a high proportion of expenditure is commonly spent on salaries, wages and various emoluments;

- The level of care provided, which again is tied up with the quality of staff required and available.

Recurrent expenditure can be approximated by taking unit cost from a previous cost analysis and multiplying this by the number of patients expected; it may be wise to include a percentage for inflation. If recurrent expenditure is higher than acceptable either a choice has to be made between quantity and quality or efficiency has to be improved (through delegation, economy of scale, avoiding unnecessary prescriptions, etc.).

7. ALTERNATIVES AND DECISIONS REGARDING OPERATIONAL UNITS IN THE OUTPATIENT DEPARTMENT

The need for a functional analysis

For each operational unit, a functional analysis has to be made. This should include:

- A definition of the function of a unit;

- Daily and hourly capacity required;

- Service time (both average and distribution of service time);

- Number of staff working in the unit at the same time;

- Tasks of various staff members;

- Flow of work and patients;

- Requirements of furniture and equipment;

- Layout of the unit, taking into account positioning of staff, patients and furniture;

- Required links with other units.

Again, it must be stressed that many outpatient department buildings, though crowded with patients and staff during 7 hours a day, are underutilized as they are not used the rest of the time.
Single or multiple units?

A decision must be made as to whether units should be single, double or multiple, e.g., whether there should be one or more injection rooms, counters at the pharmacy, etc. This depends mainly upon the total workload and the workload which can be handled at a single unit or subunit. If 800 prescriptions are handed out daily at a pharmacy and 300 can be handled at one counter, then three counters are needed, working in parallel in one pharmacy.

"Economy of scale" must always be considered. This may imply increasing or reducing the size of a unit. If 400 injections have to be given daily, this may be done in one injection room handling 400 injections or in two, each of which handles 200 injections. If the capacity of one injection room is 250 patients daily, obviously two injection rooms are needed. It may, however, be contemplated whether the capacity of one room may be increased by a different layout and organization of labour; this may require more space but the "new-style" injection room is still likely to be smaller than the space required by two "old-style" rooms. Here the question of having a central sterilization unit for hospital or outpatient department (also serving the injection room) must be considered. Apart from the above considerations, the outpatient department manager may wonder whether

- The total workload on the combined injection rooms may be reduced, when penicillin therapy is indicated, by having the medical assistant or doctor prescribe one or two injections of a long-acting or combined penicillin drug; obviously, the cooperation of the therapeutic decision-maker is here vitally important; such a step means a considerable saving in time to staff as well as patients;

- The capacity of the (only) injection room can be increased by extending the opening hours while working in two shifts.

Parallel or series arrangements?

Another issue on which a decision has to be made at an early stage and which has implications for space as well as staff is whether the work in a unit should be organized in a parallel or series arrangement.

Going back to the example of the injection room, the planner may have to choose between two or three alternatives.

<table>
<thead>
<tr>
<th></th>
<th>One room</th>
<th>Two rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>12 m²</td>
<td>2 x 9 m² = 18 m²</td>
</tr>
<tr>
<td>Staff</td>
<td>2 nurses + 1 clerk</td>
<td>2 x 2 = 4 nurses</td>
</tr>
<tr>
<td>Daily capacity</td>
<td>400 injections</td>
<td>2 x 250 = 500 injections</td>
</tr>
</tbody>
</table>

Layout

- nurse 1 sterilizing + preparing
- clerk → nurse 2
- registering → injecting

or

- nurse 2
- clerk
- registering
- sterilizing
- preparing
- injecting
- as nurse 1
Another example is to be found in the pharmacy. Should one pharmacy technician handle all aspects of one prescription/patient or should there be an arrangement, and a division of labour, where frequently-used drugs are standardized (in terms of dosage and duration of treatment) and possibly indicated by a code. Such an arrangement requires the collaboration of the medical assistant and doctor. Standardized drugs can then be prepacked or prebottled.

**What units should be included?**

The outpatient department of a hospital is part of the hospital; the question is whether or to what extent it is an integrated part in terms of leadership, organization, staff and organizational units. The "hospital connexion" should be clearly defined.

Some units are commonly shared with the hospital, e.g., the X-ray unit because of the cost of the equipment, the technical expertise required and the limited demand for its services by the outpatient department. For other units, it is debatable whether the outpatient department should have its own or separate subunit, e.g., the laboratory and the pharmacy. For the laboratory, this will depend upon demand (volume of tests required) and the technology (equipment and staff) required; an intermediate solution is to have routine tests done at the outpatient department laboratory, more complicated tests at the hospital laboratory. For the pharmacy, this will depend upon demand and the spectrum of drugs prescribed or available; in view of the usually high demand, it seems advisable to have a separate outpatient department pharmacy where at least the primary care prescriptions are handled. A staff canteen may be provided separately or shared with one for hospital staff.

Separate units which are required in the outpatient department in any case include:

- Administrative unit;
- Consultation rooms for medical assistants and doctor(s);
- Injection room(s);
- Dressing room(s) (possibly combined with a minor theatre).

In larger and more complex outpatient departments separate units are required for:

- Minor theatre (while major surgical interventions are carried out in the theatre of the hospital);
- Dental surgery;
- Nursing officer's office.

Whether the emergency service (casualty), which has to be open 24 hours a day and which is particularly important after regular working hours, should be part of the outpatient department or of the hospital is a matter of discussion.

The following units will be discussed in greater detail below:

- Administrative services;
- Diagnostic services: medical assistant and doctor unit;
- Therapeutic services: injection room;
- Therapeutic services: dressing room;
- Therapeutic services: pharmacy.

The above choice is rather arbitrary. One reason for the choice is that these units are attended by all or many of the patients.
It is commonly found that out of primary care outpatients:
- 20-40% attend the injection room;
- 5-15% attend the dressing room;
- 50-70% attend the pharmacy;
- 2-5% attend the minor theatre;
- 5-20% attend the laboratory;
- 3-10% are referred to the secondary level of medical care (the doctor).

For all units which are visited by a large number of patients (e.g., over 50 per day) a flow-through system is advisable, requiring separate entry and exit.

It must be decided where patients should wait for treatment. The options are a waiting-room shared by various treatment units or separate waiting bays (subsidary waiting-rooms), one for each therapeutic unit. In any case, it is important to provide adequate waiting space to prevent the corridors from becoming crowded with waiting patients which would impede circulation of both staff and patient traffic. On the basis of the input and output rates of units, the required size of the waiting bay can be calculated. A therapeutic unit may be defined as one unit consisting of two parts: the therapeutic (sub)unit; and the corresponding waiting bay. Some queueing is unavoidable but tolerable; however, congestion, that is, queueing in too small a space, is unacceptable. In this one unit, a separate entry and exit will encourage flow-through of patients.

**Administrative unit**

The type and size of service, the staff and space required depend upon the system of administration and reporting.

Tasks to be performed usually include:

- Taking a new record for each new patient (and writing personal data on the record and in the register) or retrieving the old record from the filing cabinet;
- Filing old records (unless the record goes with the patient).

The question of patient records has been discussed above. If the patient record goes with the patient (at least for primary care cases), clerical staff and office space required can be minimal. It has been found useful in this eventuality to locate the office downstream from the diagnostic unit, so that registration (including diagnosis) is carried out after the patient has been seen by the medical assistant; thus one clerk may serve two or three medical assistants.

**Diagnostic units: medical assistant and doctor**

Tasks to be performed include:

- History-taking;
- Physical examination;
- Decision on diagnosis, treatment and management of the patient;
- Required writing on diagnosis, etc.

The number of units required is determined by the total daily demand and the capacity per unit. If the daily demand at a hospital outpatient department is 1000 primary care
patients and 100 secondary care patients (both internal and external referrals) while a primary care health worker (medical assistant) can handle 200 per day (an average of 2 minutes per patient) and a secondary care health worker (usually a doctor) can handle 60-80 per day (an average of 7 minutes per patient), then the staff required during office hours includes 5 medical assistants and 1-2 doctors (more likely three part-time doctors).

Of course, the workload on the medical assistant may be reduced by such measures as: having reattendances for further treatment (injections, dressings) bypass him (for which a channel must then be provided); shift administrative work to a clerk (for which space must then be provided); writing diagnosis in code; and prescribing treatment in code.

**Therapeutic units: injection room**

The injection room may be in one unit (with either series or parallel arrangement) or in several parallel units. The tasks to be carried out usually include:

- Registration;
- Sterilization (unless this is done centrally);
- Preparation of syringes;
- Administration of injections.

Some of these tasks may be performed by clerical or ungraded staff. In an injection room with a capacity of 200 injections daily, a clerk can do the administrative work while two nurses may work in a parallel arrangement (filling syringes and administering injections). Sterilization may be done in batches of, say, 100 syringes and needles, causing a minimum of delay. The limiting factor in the output rate should not be the number of syringes (or, rather, the time required for sterilization).

The layout of the injection room will depend upon the above-mentioned points. Discretion in sight is particularly important. It is a great advantage to have a separate entry and exit as many patients may attend.

**Therapeutic units: dressing room**

Usually one dressing room suffices. Tasks to be performed include:

- Registration;
- Undressing, cleaning and dressing of wounds and ulcers;
- Application of drugs and bandages;
- Application of drops or ointments to eye, ear or nose;
- Sterilization of materials and equipment (unless centrally done).

A so-called ulcer bench is usually found practical. Whether discretion in sight and sound is required is debatable; it probably is, though apparently many patients do not mind seeing ulcers or being seen with them. The layout is usually straightforward and presents few problems; here also a separate entry and exit is often found to be advantageous.

**Therapeutic units: pharmacy**

Usually the pharmacy is attended by a large number of patients (50-70%) and many of them require more than one drug (see above). There is a need for more than one counter, particularly as the large number of patients attending may quickly lead to queuing. Tasks to be performed include:
- Counting of tablets;
- Packing of drugs;
- Bottling of mixtures and syrups;
- Compounding;
- Writing usage on envelope or label;
- Registration of antibiotics handed out;
- Handing out drugs with instructions.

If commonly used drugs are prescribed in code by the medical assistant and prepacked (in little envelopes) and prebottled (in standardized bottles to be exchanged for a clean bottle to be handed in by the patient) - which can be done by unqualified staff (which is amply available and cheaper than qualified staff) - then the question arises whether one counter should be reserved for patients with coded prescriptions (who can be quickly served) while other patients are served at another counter. Many patients may come to the counter for prepacked drugs, but as the service time is short there should be no queueing. If prepacking is done, then it is advisable to separate the prepacking and prebottling unit from the dispensing unit and the pharmacy store.

Some elementary points to be included in the architect's brief

As indicated above, the building should be a shell around the outpatient department organization. Thus, the organization should be determined first and the relevant points must be included in the architect's brief. Otherwise, medical staff may be faced with an unsuitable building to which they will have to adapt as well as they can.

The architect's brief should include information dealing with:

- Expected demand (in numbers of patients) for various types of services and at various units, including projections of future demand;
- Opening hours of the clinics;
- Arrival pattern of patients;
- Whether there should be a flow system;
- System of circulation;
- Where the bulk of patients is expected to wait, either in a central waiting-room or in waiting bays at various units (the required size of the waiting-rooms can be calculated based upon input and output rates);
- Whether waiting in corridors should be discouraged;
- Whether there should be one-direction traffic (only or predominantly) or whether traffic both ways is allowed or encouraged;
- Whether frequently used units (and possibly waiting bays) should have a separate entry and exit so as to facilitate a flow through the unit;
- Whether the entrance/exit of a unit should be formed by a door, an opening only or an opening with a curtain;
- Whether there should be single-purpose rooms (with a clearly defined function) or multipurpose rooms (indicating what purposes they should meet);
- Whether a command post should be included (that is, if there is unity of command) in a strategic position;
- Whether there will be traffic control and traffic direction;
- Whether multiple units should be arranged in parallel or in series;
- What will be the system of administration and registration;
- Whether frequently utilized units (injection room, dressing room, pharmacy) should be separated from less frequently used ones (minor theatre, doctor's consultation room);
- A detailed programme of requirements for each unit, including information on space required (for furniture, staff, patients) and the required links with other units;
- The extent of flexibility, expandability and upgradability.

It should be pointed out that three modern developments, in particular, have far-reaching implications for design and layout of outpatient departments. These are: the filter system; the under-fives clinic; and the integrated maternal and child health clinics.

8. ACKNOWLEDGEMENT

The author gratefully acknowledges the critical comments by Mr W. Swinkels and Miss A. C. Sjoerdsmma (Kenya-Netherlands Project for Operations Research in Outpatient Services, Nairobi, Kenya).

9. REFERENCES


Appendix

CHECK LIST FOR ASSESSMENT OF AN OUTPATIENT DEPARTMENT

1. Methods of obtaining facts and opinions:
   - Ask questions;
   - Make observations;
   - Check registers, reports, sample of records.

2. Building:
   - Is design functional?
   - What is present use?
   - Would different use be an improvement?
3. Procedures:
   - Administrative;
   - Medical and nursing;
   - Technical;
   - Feasibility of standardization.

4. Staff:
   - Quantity of staff;
   - Quality of staff;
   - Service to patients;
   - Expectations;
   - Satisfaction.

5. Patients:
   - Expectations;
   - Demands for what they consider service and good care;
   - Satisfaction.

6. Organization:
   - External referral system;
   - Internal referral system;
   - Parallel or series arrangements of units;
   - Parallel or series arrangements of workers in a unit;
   - Batch-flow type of treatment;
   - Potential for delegation.

7. Workload:
   - Total workload for outpatient department;
   - Workload per unit;
   - Workload per worker.

8. Operational aspects:
   - Input and output rates of outpatient department and each unit;
   - Arrival patterns over year, week, day;
   - Average waiting times;
   - Queueing at stations at various times of the day.

9. Costs:
   - Personnel;
   - Recurrent cost for drugs, electricity, etc.;
   - Capital cost.

10. Key questions:
    - Purpose: why?
    - Place: where?
    - Time: when?
    - Person: who?
    - Method: how?
THE MINIMUM REQUIREMENT FOR SURGERY

John Cook *

CONTENTS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
</tr>
<tr>
<td>2</td>
<td>The operating suite</td>
</tr>
<tr>
<td>3</td>
<td>Surgical instruments</td>
</tr>
<tr>
<td>4</td>
<td>Sterilization</td>
</tr>
<tr>
<td>5</td>
<td>Use of disposables</td>
</tr>
<tr>
<td>6</td>
<td>Replacement of blood and tissue fluids</td>
</tr>
<tr>
<td>7</td>
<td>The relief of pain</td>
</tr>
<tr>
<td>8</td>
<td>Manpower</td>
</tr>
<tr>
<td>9</td>
<td>References</td>
</tr>
<tr>
<td></td>
<td>Appendix. Constitution of the general set of surgical instruments</td>
</tr>
</tbody>
</table>

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* International Federation of Surgical Colleges, c/o Royal College of Surgeons of Edinburgh, Nicolson Street, Edinburgh, Scotland.
In a developing health service much of the surgery will continue to be done by the staff of small hospitals. The systems needed for the complex surgical facilities of wealthy countries may no longer be appropriate to this type of practice. There is a minimum requirement without which surgery cannot regularly be undertaken, but with which a substantial range of treatment can be offered at a realistic cost. The concept of such a minimum requirement is examined in terms of its application to small hospitals.

1. INTRODUCTION

Modern surgery is a complex, expensive affair, and there is a widening gap between the expectations of, and the provision for, surgery in wealthy countries and the developing world. Indeed, the systems appropriate to the one are hardly transferable to the other. Failure to recognize this explains some of the difficulty in planning for surgery in an expanding rural health service. The reasons for the growing complexity of planning for surgery are themselves complicated but the difficulty is only partly a question of better surgery, that is to say, safer treatment over a wider range of disease. Surgical arrangements are complex because operation takes place in a complex society where the demand for a surgical cure steadily increases while such things as safety and quality control become more and more difficult to ensure. By contrast, planning for developing areas offers a refreshing opportunity to re-examine the provision for surgery in terms of the necessary rather than the desirable.

Any essay on surgical planning must be shaped by some concept of the whole health system into which surgery is to be fitted and this will vary from one country to another. For the sake of argument, it will be assumed that in a health service which is being expanded to serve a rural population the unit of primary medical attention is the health centre (the actual agent of primary medical attention being a health assistant or clinical officer, i.e. someone less qualified than a doctor).

Doctors are reserved for secondary or referral care as well as for a wide role in training and supervision of the subordinate cadres. This implies that they will tend to work in small groups in small hospitals. The most economical use of a limited health budget seems to dictate that the bulk of a country's secondary health care should be handled in these small hospitals. Manpower considerations suggest that specialization among doctors is inappropriate to this situation and that the doctors we are considering will be generalists. All of them must be ready to undertake surgery, which can be defined as the cure of disease by manual operation. It accounts for some 30% of secondary health care and, because of the urgency of some surgical conditions, it is an inescapable part of small hospital practice. The capability of the ordinary doctor will be one of the factors which define the surgery for which we are planning.

The model considered here is a hospital of about a hundred beds, staffed by one or more doctors, with nursing and other assistance, and offering definitive surgical, medical and obstetric care to a population of 100 000-250 000. The size of the hospital, the population served or the territory covered are relevant only to the number of doctors required, and an increase in size does not necessarily imply the introduction of specialist services. It should be realized that in practical surgery and obstetrics there must exist an absolute minimum requirement of instruments, systems and buildings without which operations cannot regularly be performed in safety. This is determined by biological considerations alone.

Given this minimum provision, a substantial range of surgery can be offered at a realistic cost and it is of a sort that can be undertaken by ordinary doctors. A good deal of it could even be done by health assistants. Differences in the naming of small hospitals are of semantic importance only, for the minimum requirement is the same for rural, district or mission hospitals, or for a private nursing home. The decision to extend surgery beyond the range permitted by the minimum requirement has to be made in the light of economic, political and other considerations, because it means entering a specialist field with its attendant spiral of cost and complexity. Such an enlargement of surgery is apt to result from public demand or from the appointment of a trained specialist of higher capability and expectations. The task here is to define the minimum requirement for surgery and to see how far this will sustain
the functional load likely to be imposed. It will be found that there is already a surprisingly large amount of appropriate equipment, and that the difference between minimum and actual requirements becomes a matter of satisfying the needs of local variations in surgical disease.

2. THE OPERATING SUITE

If a surgeon is to carry out an operation at all he must have instruments, a place in which to work, and basic services such as light, water and drainage. For his operations to succeed, three fundamental conditions must be satisfied: wounds must heal, the inevitable haemorrhage must be arrested and the blood loss made good, and the whole incident must be painless. So, to the surgical instruments must be added the apparatus of aseptic technique, intravenous infusion, and anaesthesia. In respect of every one of these factors, the practice of developed countries makes demands far beyond the minimum. Modern specialist surgery also presumes a high degree of cooperation between many sections of a stable society, conditions which can rarely be satisfied in developing areas. So the minimum provision for surgery must not only meet the basic requirements but also make the surgeon self-sufficient in his rural setting, if necessary through periods of political instability.

What determines the shape of a surgical unit, more than any other consideration, is the aseptic principle: that uncomplicated wound healing depends on the exclusion of bacteria from the tissues and all that comes in contact with them. To ensure this, an operating room is set aside near the surgical wards and other rooms and equipment are provided for sterilizing surgical materials. The aseptic principle applies equally to surgery and obstetrics, and in a small hospital the sterilizing facilities can be shared by both, although separate labour rooms are needed. The complex designs for operating theatres in large hospitals take account of a very heavy workload, and something simpler is quite enough for the purpose under discussion. Essentially, an operating room is just a clean, well-lighted room set apart from other uses. It should be spacious and plain with a floor area of some 40 m². The design is well understood and many suitable plans are available. The operating suite should generally be near the surgical wards with covered access to them. Detailed planning of the ancillary rooms will depend on whether or not the whole sterilizing process is carried out in the operating suite or in a central service area elsewhere in the hospital but if, as is usual, the sterilizing is done in the operating block, planners must take account of the heat load imposed on the surgical team. One feature of large hospital practice should be observed: the provision of a separate anaesthetic room leading into the operating room, and a recovery area outside it where patients can be retained until they are fit to return to the ward. Lastly, there should be some space where the surgeon can write up his operation notes and instructions for further care. This is especially important when he may be called to other duties from his operating list, and it is also important for keeping accurate hospital statistics. Many observers have commented that of all the records kept in small hospitals the operation register is the most reliable.

The whole operating suite must be drained and should have running water. What must be settled at an early stage is the nature of the hospital’s power supply. Is there to be mains electricity, a generator, or nothing? The answer determines much of the theatre and sterilizing equipment. In general, a rural hospital will be wise to have its own generator, for without electricity only the surgery of direst emergency will be tackled at night. Even with a generator it may be found cheaper to heat sterilizers by kerosene stoves and to work diagnostic equipment off storage batteries. The power supply is so central to the activity of a health unit, be it hospital or health centre, that much more attention should be paid to the development of appropriate generators and sources of energy. The sharply rising cost of oil must raise urgent doubts about its ultimate position as the prime energy source for all kinds of rural units, but most planners will rely on it meanwhile. One other point which may be raised in connexion with power, but will be a recurring theme throughout the consideration of equipment, is standardization. In terms of power supplies, this means standardization of voltage, outlet connexions, and output in kilowatts.

The operating room should be furnished as plainly as possible. There will inevitably be some items stored on shelves around the walls, but these should be kept to the minimum. The
room should be as well lit by indirect daylight as is consistent with control of the environmental temperature, and some artificial light source will be expected. A mains supply of electricity would permit ceiling-mounted, shadowless lamps which give the best light. It is not necessary to use the largest models: the medium range, with five lamps in the housing, are quite enough and much easier to support from the roof. If a generator is used, the best arrangement is one or two pedestal-mounted, shadowless lamps which, in emergency, can also be run off storage batteries. The surgeon's materials will be set out on moveable trolleys, and these should be standard - as should all the furniture - throughout the service. Trolley tops should be flat, without guard rails, and the whole unit should be of stainless steel. The capital cost of this material will certainly be recovered in the longer life it guarantees. The only other feature of the theatre which need be considered at this stage is the operating table.

The operating table is the most important and potentially much the most expensive piece of furniture, and some thought should be given to what is going to be required of it because the most versatile tables cost thousands of dollars - in rural circumstances as much as the theatre building itself. The absolute requirements for an operating table are that it support the heaviest patient with stability and comfort, be itself moveable and easily cleaned, be capable of a rapid, head-down tilt, and allow the patient to be placed in the lithotomy position. There are a number of designs which satisfy these requirements at less than US$ 1000.

3. SURGICAL INSTRUMENTS

For most operations, a surgeon uses about fifty instruments, sometimes called the general set, to which special tools are added as necessary. The catalogues show many variations in the pattern of even the simplest instruments, the differences between these often being very slight. Surgical instruments are hand-made, very beguiling, and surprisingly expensive. Surgeons, being craftsmen, are apt to be individualists demanding the precise shape of instrument which suits them best, but fortunately there is a large measure of agreement on the sort of tools which are absolutely necessary, so money is saved if the general set consists of standard instruments of popular design which can be duplicated throughout the service. An example of the make-up of the general set is given in the appendix. Two sets should be provided so that one can be resterilized while the other is in use. There are three ways of handling additions to the general set: all instruments are kept in the cupboard, plainly labelled, and selected for sterilizing when needed; or they are all kept sterile, autoclaved in individual wrappings to be immediately available during an operation; or they are made up into sets designed for the commoner emergency procedures, e.g., a craniotomy set, a tracheotomy set. The choice of method depends on the amount of surgery and the sterilizing facilities. In a quiet little hospital the first plan is usual. Most busy hospitals tend to use the second as a convenient compromise but, where the original plans have allowed for the greater capital expense, the third method is much the best. It can be extended to become a sterile service for all departments, the responsibility for cleaning and resterilizing the sets being laid on a central unit in the technical services area of the hospital.

4. STERILIZATION

Two of the most important developments in aseptic technique, central sterile supply and the concept of a theatre tray service centre, derive from the same premises: that the proper basis of sterilization is exposure to saturated steam in an autoclave and that the most economical use of the autoclave demands its application throughout the hospital. The most efficient use of the autoclave demands a trained operator in regular practice; it therefore makes sense to transfer the whole process of cleaning, packing and resterilizing to specialized staff, which in turn frees nurses for other duties.

There is such general agreement on the superiority of autoclaving over other methods of heat sterilization that it would be desirable to recommend this as standard practice, but there are still a number of problems to be overcome. The biggest is that the efficiency of an autoclave depends on good maintenance, which is not always easy to ensure in rural units. More could be done to simplify the design of autoclaves and reduce maintenance problems.
Again, autoclaves designed to run off a paraffin or gas burner usually have a long cycle of operation and they expose soft goods to damaging amounts of hot air as well as steam. Careful technique minimizes this damage but a short cycle and especially a short post-sterilizing drying phase are important. Other desirable features in an autoclave are a horizontal, circular drum, a single, circular door, and a small chamber capacity. On the whole, autoclaves tend to be too large and too complicated. The smaller the capacity, the shorter the whole process and the less the damage to soft goods. In the long run, it is more efficient to use a small autoclave several times a day than to use too large a machine once.

In the past, the autoclave was always located in the operating suite. It was used by the operating room staff to ensure a high standard of sterility for their own work, but there was a sharp decline in standards of asepsis in other parts of the hospital. Diagnostic equipment, dressing forceps and syringes were sterilized by boiling or by chemicals, neither of which was entirely satisfactory.

It may be unreasonable to expect the operating room staff to take on the responsibility for sterility throughout the hospital, but it is a short step from moving the autoclave out of the operating suite to establishing a central sterile supply unit to serve the theatre and all other departments.

The closely related questions of servicing equipment and of maintaining a dependable sterility throughout a small hospital require urgent reassessment for together they constitute one of the most important foundations of the efficiency of the unit and the morale of its staff. If autoclaving is accepted as the basis of sterilization, the economics of small hospital practice suggest a more general introduction of central sterile supply, a practice which is already well documented. There is still need for design studies on small "back-up" sterilizers for use in clinics and the operating theatre itself. Many available models are electrically heated small steam sterilizers which operate on a short automatic cycle of sterilization at a relatively high pressure and a temperature of 135°C. There is a need for even simpler models which could be heated by Primus stoves to give steam at lower pressure and temperature to minimize damage to soft goods and disposable plastics.

5. USE OF DISPOSABLES

There is another field of small hospital practice which demands attention. In larger hospitals and generally throughout wealthy countries there is extensive use of disposable materials. This is prompted by two considerations: the high labour costs of cleaning and resterilizing small bits of equipment, and the proposition that the most effective way to prevent case-to-case infection is to use such equipment once only. It may be assumed that the once-only use of disposables will be impossible for reasons both of cost and supply. In the context of the small hospital, disposables are better regarded as short-term equipment, the modern equivalent of breakable glassware.

Many disposables can be recycled but there is a wide range of variation in the resistance of different plastics to heat and chemicals. There is therefore a real need to formulate a code of practice for recycling disposables. This is all closely related to the detail of aseptic practice, and it seems sensible to allocate responsibility for recycling disposables to the persons running the central sterile supply.

6. REPLACEMENT OF BLOOD AND TISSUE FLUIDS

The problems of blood transfusion differ slightly from those of simple fluid infusions. Those of blood transfusion relate to the collection of blood, its storage and matching with that of a potential recipient. The taking of blood is technically simple but achieving an adequate supply depends on many factors, such as the number of staff available for this exercise, the organization needed to bring suitable donors together, and public attitudes to the practice of blood transfusion, which are not always favourable. Most of these difficulties are overcome by putting the service in the charge of a responsible, locally trained person of some standing in the community.
Storage of blood is a question of refrigeration and therefore of the power supply to the hospital. It should be possible to store blood for short periods in a refrigerator powered by paraffin (independent of mains electricity) and this will usually be compatible blood for particular individuals rather than a true bank of blood for any emergency. The demand for blood in a small hospital is likely to be sporadic, though none the less urgent, and is best satisfied by a pool of donors - staff or neighbours of the hospital whose blood groups are known.

The relatives of patients may also usefully contribute blood, though they may not provide blood that is actually compatible with that of the individual. The supply all turns on the blood transfusion staff; the personality of the chief technician and his relations with the public decide the success of this service. At best, there is likely to be a reasonably satisfactory response to intermittent demand. The transfusion of whole blood can be supplemented by the use of plasma substitutes, which are sterile solutions of bland substances of large molecular weight, produced commercially and marketed at prices which certainly allow the holding of small stocks for emergency. A number of preparations have been tried; among the most useful are Dextran and Haemaccel - the latter, a gelatin solution; the former, a slightly cheaper sugar product. These solutions have the advantage that they can be stored at room temperature, and, of course, their quality and sterility are the responsibility of the manufacturer.

The cleanliness and sterility of all the apparatus for blood transfusion has to be the responsibility both of the transfusion technician and the hospital's sterile supply service. The relative merits of disposable and permanent apparatus must be assessed; both types are available for collecting and giving blood. In summary, it can be said that a small hospital properly equipped for aseptic surgery should be able to arrange a modest scale of blood transfusion in keeping with its surgical commitment.

It is more difficult to advise on the larger question of intravenous infusion of salt solutions. Modern hospital practice makes prodigious use of intravenous infusions to correct deficiencies in body fluids and salts from a wide variety of causes and, indeed, to prevent such deficiencies occurring. Sterile, pyrogen-free, chemically defined solutions account for a large part of the drug bill. They are commercially prepared, comparatively cheap and, in a wealthy society, their use is hardly questioned. In the circumstances under discussion, the familiar difficulties of cost and supply again arise. There is no doubt that any hospital needs a steady supply of some intravenous fluids, and this stock can be suddenly depleted by an epidemic of diarrhoea, for instance, or even by one severely ill patient. Can a hospital produce its own fluids safely in an emergency? Is it economic to do so all the time?

There is, in theory, nothing very complicated about making intravenous fluids provided that there is power to heat a still and an autoclave. The usual fluids are simple solutions of glucose or inorganic salts in freshly distilled water, sterilized as soon as they have been made up. Unfortunately, quality control is difficult, the main dangers being from pyrogenic impurities of faulty sterilization, so the authoritative advice is to rely on commercial supplies where possible; if supplies do have to be prepared locally, this should be done in a regional centre serving a number of small hospitals. Having said this, it must be recorded that there are many small hospitals which do have to make up their own solutions, and have little trouble with them.

There are now some excellent stills on the market at reasonable cost which will produce enough purified water for a 100-bed hospital. There are improved methods of filtration to supplement heat sterilization. Appropriate packaging of formulae of salts could easily be arranged. It would seem possible to devise a code of practice for the preparation of intravenous fluids which would help to maintain quality control, and to describe a system of production which would ensure that few hospitals, however remote, need be quite without them.

7. THE RELIEF OF PAIN

It is somewhat easier to make recommendations on the subject of relief of pain during surgery. There are substantial differences in the fashions in anaesthesia between one
country and another and, as in so many other ways, the wealthy countries have developed their methods far beyond a minimum requirement. But detailed recommendations can be made about anaesthesia in small hospitals in the knowledge that they represent views which are generally acceptable. Three considerations determine the practice of anaesthesia in the rural situation. First, the general problem of maintenance dictates that the equipment must be as simple as possible. Secondly, the high cost and difficulties of supplying cylinders of compressed gases, particularly nitrous oxide and oxygen, mean that air must be the vehicle for bringing volatile anaesthetic agents to the patient. Thirdly, the surgeon remains responsible for the anaesthetic throughout the operation, since another doctor cannot usually be spared to give the anaesthetics.

What this means is that there is much more reliance on local and regional analgesia than is now the case in affluent societies, and general anaesthesia is achieved by the cheap, old-fashioned, but extremely safe method of ether-air mixtures supplemented by induction of sleep with intravenous drugs and, occasionally, muscle relaxants. The techniques of local and regional analgesia are well understood and widely practised throughout the world and they have improved over the years with the introduction of new drugs like lidocaine (lignocaine) and prilocaine. There have also been useful developments in basal sedation to support the local analgesia. The provision of appropriate analgesia is essentially a matter of training doctors and operating room assistants in well established techniques.

The use of simple draw-over apparatus (that is to say, apparatus which relies on the patient’s own respiratory efforts to draw a mixture of air and anaesthetic through it) for general anaesthesia with ether/air is now widespread, but there is still room for improvement in the standardization of equipment. The most useful of the ether/air machines is undoubtedly the EMO vaporizer (Epstein and Macintosh, Oxford), which is designed to deliver a controlled percentage of ether vapour in air, and to which can be fixed attachments for delivering other volatile anaesthetics. But even in respect of a well-known apparatus, variations appear on the market with connexions which are not interchangeable with other patterns. It should be possible for the individual government to ensure standardization of such minimum anaesthetic equipment and it may be that in time the work of the International Organization for Standardization will bear fruit in this field.

The savings made by reverting to ether/air anaesthesia more than justify some expenditure on equipment for endotracheal intubation, on suction pumps and even on a modest store of oxygen to supplement anaesthesia in small children and severely ill patients. Oxygen can be fed into the EMO vaporizer with all the necessary precautions against anaesthetic explosions which then become a very real risk, and an economical delivery can be achieved by the Penion air entrainment device which fits the EMO system.

A drug that has recently found favour in the developing countries is ketamine. This is expensive and has some disadvantages in the adult, but it allows the induction of short, profound anaesthesia by one intravenous or even intramuscular injection, and is of particular value in anaesthesia of children.

Effective anaesthesia in small hospitals comes down to the acceptance that a high standard of care can be maintained with simple, inexpensive methods. Equipment should be standardized throughout a country’s health service. All doctors specializing in small hospital practice must be competent to give a general anaesthetic, to produce local and regional analgesia, and to train one or more of the operating room staff in these techniques.

8. MANPOWER

These are the essentials for surgery. Much else that concerns the whole hospital, design of buildings, outpatient facilities, the range of diagnostic equipment, drug policies, also concerns the surgeon, but this discussion has concentrated on fundamentals because appropriate provision for them has often been neglected and because dissatisfaction with inadequate surgical facilities is a very real part of the distaste the average doctor feels for a career in small hospitals. The movement of medical manpower over the past 20 years clearly shows that doctors will stay in rural health service only if the working conditions
and the career structure are arranged to their satisfaction. They are unquestionably needed at the core of an expanding health service, and this paper points to one small but important facet of their professional satisfaction.

The topic of staffing for surgery has been deliberately avoided but two comments must be made. It is obvious that with doctor:patient ratios of more than 1:100 000 some operations of surgery must be left to a surgeon's aides. This happens extensively: the past 10 years have seen much more responsibility delegated to medical assistants and, indeed, the inclusion of operative techniques in their training programme. Specialist surgeons have, on the whole, refrained from comment on this trend but it is perhaps time that the profession reviewed the related questions of delegation and responsibility for surgical operations. Lastly, it must be made quite clear that, in discussing the surgical needs of ordinary doctors in the small hospitals of an expanding health service, it is not implied in any way that surgery ought to be kept to this level. Every country does need properly trained specialist surgeons but, as has already been said, the scale of training and recruitment in this, as in other disciplines, depends on conditions beyond the medical profession's control. What is examined here is no more than what it takes to bring some safe surgery within the reach of everyone, even on a limited health budget.

9. REFERENCES


Planning and building health care facilities under conditions of limited resources, World Hospitals, XI (No. 2 and 3) 1975


### CONSTITUTION OF THE GENERAL SET OF SURGICAL INSTRUMENTS

(Reproduced from UNICEF packing and assembly centre (UNIPAC) price list, Copenhagen, September 1978.)

#### STERILIZATION-KIT FOR SURG INSTRUMENTS/DRESSINGS

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<td>FORCEPS STERILIZER CHEATE 265MM SS</td>
<td>07352000</td>
<td>EACH 1</td>
</tr>
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<td>FORCEPS TISSUE SPRING TYPE 1X1TEETH 125MM SS</td>
<td>07368000</td>
<td>EACH 4</td>
</tr>
<tr>
<td>FORCEPS TISSUE SPRING TYPE 1X1TEETH 225MM SS</td>
<td>07370000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>FORCEPS TISSUE 4X5 TEETH ALLUS 150MM SS</td>
<td>07380000</td>
<td>EACH 6</td>
</tr>
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<td>HOLDER NEEDLE STRAIGHT NARROW JAW MAYO-HGR 175MM</td>
<td>07400000</td>
<td>EACH 3</td>
</tr>
<tr>
<td>KNIFE-HANDLE SURGICAL FOR MINOR SURGERY +3</td>
<td>07450000</td>
<td>EACH 2</td>
</tr>
<tr>
<td>KNIFE-HANDLE SURGICAL FOR MAJOR SURGERY +4</td>
<td>07450000</td>
<td>EACH 4</td>
</tr>
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<td>KNIFE BLADE SURGICAL FOR MINOR SURGERY +10 PKT 5</td>
<td>07460000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>KNIFE BLADE SURGICAL FOR MAJOR SURGERY +15 PKT 5</td>
<td>07463000</td>
<td>PKT 20</td>
</tr>
<tr>
<td>NEEDLE ANEURISMS BLUNT SKELETON CUT 200MM</td>
<td>07472500</td>
<td>EACH 1</td>
</tr>
<tr>
<td>NEEDLE ANEURISMS BLUNT SKELETON CUT RIGHT 200MM</td>
<td>07472500</td>
<td>EACH 1</td>
</tr>
<tr>
<td>NEEDLE HYPO 0X18MM/19G5 1/2 Luer Disposable</td>
<td>07474150</td>
<td>EACH 50</td>
</tr>
<tr>
<td>NEEDLE HYPO 0X18MM/21GXT Luer Disposable</td>
<td>07474150</td>
<td>EACH 50</td>
</tr>
<tr>
<td>NEEDLE SUTURE ABDOM TRIP TRIP KIETH 33MM PKT 6</td>
<td>07356000</td>
<td>PKT 5</td>
</tr>
<tr>
<td>NEEDLE SUTURE ABDOM TRIP TRIP KIETH 44MM PKT 6</td>
<td>07358000</td>
<td>PKT 6</td>
</tr>
<tr>
<td>NEEDLE SUTURE ABDOM TRIP TRIP KIETH 55MM PKT 6</td>
<td>07358000</td>
<td>PKT 6</td>
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<tr>
<td>NEEDLE SUTURE ABDOM TRIP TRIP KIETH 66MM PKT 6</td>
<td>07358000</td>
<td>PKT 6</td>
</tr>
<tr>
<td>NEEDLE SUTURE ABDOM TRIP TRIP KIETH 77MM PKT 6</td>
<td>07358000</td>
<td>PKT 6</td>
</tr>
<tr>
<td>NEEDLE SUTURE CATIGU 1/2CIRC TAP TRIP MAYO +3 PK 6</td>
<td>07587000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>NEEDLE SUTURE CATIGU 1/2CIRC TAP TRIP MAYO +4 PK 6</td>
<td>07588000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>NEEDLE SUTURE CATIGU 1/2CIRC TAP TRIP MAYO +4 PK 6</td>
<td>07588000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>NEEDLE SUTURE CATIGU 1/2CIRC TAP TRIP MAYO +4 PK 6</td>
<td>07588000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>NEEDLE SUTURE INTEST STRAIGHT TAP 03MM PKT 6</td>
<td>07590000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>NEEDLE SUTURE INTEST STRAIGHT TAP 04MM PKT 6</td>
<td>07592000</td>
<td>PKT 10</td>
</tr>
<tr>
<td>NEEDLE SUTURE INTEST 1/2CIRC TAP MURPHY +4 6</td>
<td>07592300</td>
<td>PKT 3</td>
</tr>
<tr>
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<td>07592300</td>
<td>PKT 3</td>
</tr>
<tr>
<td>NEEDLE SUTURE INTEST 1/2CIRC TAP MURPHY +4 6</td>
<td>07592300</td>
<td>PKT 3</td>
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<td>NEEDLE SUTURE 3/8CIRC TRIP TRIP +3 PKT 6</td>
<td>07593500</td>
<td>PKT 6</td>
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<tr>
<td>NEEDLE SUTURE 3/8CIRC TRIP TRIP +3 PKT 6</td>
<td>07593500</td>
<td>PKT 6</td>
</tr>
<tr>
<td>NEEDLE SUTURE 3/8CIRC TRIP TRIP +1B PKT 6</td>
<td>07593500</td>
<td>PKT 6</td>
</tr>
<tr>
<td>PROBE GENERAL OPERATING FLEXIBLE WITH EYE 200MM</td>
<td>07598910</td>
<td>EACH 1</td>
</tr>
<tr>
<td>RETRACTOR ABDOM DECKER 25X32MM SS</td>
<td>07660000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>RETRACTOR ABDOM DECKER 25X32MM SS</td>
<td>07660000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>RETRACTOR ABDOM ROUX 23X33MM BLADES X 175MM LONG</td>
<td>07670000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>RETRACTOR ABDOM ROUX 35X48MM BLADES X 175MM LONG</td>
<td>07672000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>RETRACTOR ABDOM ROUX 35X48MM BLADES X 175MM LONG</td>
<td>07672000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>RETRACTOR GEN OPER 4 PRONG MURPHY 200MM SHARP SS</td>
<td>07691000</td>
<td>EACH 2</td>
</tr>
<tr>
<td>RETRACTOR GEN OPER SET OF 2</td>
<td>08015000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>SCISSORS BANDAGL ANGULAR LISTER 182MM SS</td>
<td>07700000</td>
<td>EACH 2</td>
</tr>
<tr>
<td>SCISSORS DISSECT CURVED MAYO 200MM 8/8 SS</td>
<td>07708000</td>
<td>EACH 2</td>
</tr>
<tr>
<td>SCISSORS DISSECT CURVED MAYO 200MM 8/8 SS</td>
<td>07708000</td>
<td>EACH 2</td>
</tr>
<tr>
<td>SCISSORS DISSECT CURVED MAYO 170MM 8/8 SS</td>
<td>07712000</td>
<td>EACH 2</td>
</tr>
<tr>
<td>SUTURE CLIP MICHIEL 1MM SS BOX OF 1000</td>
<td>07810000</td>
<td>EACH 1</td>
</tr>
<tr>
<td>SUTURE CLIP MICHIEL 1MM SS BOX OF 1000</td>
<td>07822000</td>
<td>EACH 50</td>
</tr>
<tr>
<td>SYRINGE HYPO 2ML Luer Disposable</td>
<td>08240000</td>
<td>EACH 50</td>
</tr>
<tr>
<td>SYRINGE HYPO 5ML Luer Disposable</td>
<td>08240000</td>
<td>EACH 50</td>
</tr>
<tr>
<td>LIDOCAINE HCL 2% INJECTABLE VIAL OF 50ML</td>
<td>15553000</td>
<td>VIAL 4</td>
</tr>
<tr>
<td>BAG HAND 230X30X10MM BLUE NYLON</td>
<td>50010000</td>
<td>EACH 1</td>
</tr>
</tbody>
</table>
RADIOLOGY IN BASIC-CARE HOSPITALS AND CLINICS

P. E. S. Palmer

CONTENTS

1. Introduction ........................................... 85
2. Diseases which can be diagnosed by radiography .......... 86
3. Where to situate the radiological facility ............... 87
4. The X-ray suite ...................................... 88
5. Building materials .................................... 90
   The X-ray room .................................... 90
   The darkroom .................................... 91
   The darkroom entrance ......................... 92
   The office/storeroom ........................... 93
6. Electrical supply .................................... 93
7. Colour of buildings .................................. 93
8. Requirements for radiation protection and safety .......... 94
   Wall thicknesses for radiation protection .......... 94
   Are there any specific areas of high radiation risk in the X-ray buildings? 95
   How are the X-ray operators protected? ........ 96
   Are windows permitted or desired in an X-ray room? 96
   Which is cheaper: larger X-ray rooms or increased protection of the walls? 96
   Radiation safety monitoring .................... 97
9. How is the power for an X-ray unit obtained? ........... 97
    Which generator and control to choose? ........... 99
    X-ray tube support ............................ 100
    What designs of patient support or X-ray table are available? .......... 104
    How are chest X-rays taken in the erect position? What is a “chest stand”? 105
    What is a grid? ................................ 106
    What X-ray tubes are available? ............... 106

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4 This article is based on: Palmer, P. E. S. (1978) Radiology and primary care, Pan American Health Organization, Washington, DC, (PAHO Scientific Publication No. 357).
5 Professor of Radiology, University of California, Davis, CA, USA.
10. Choice of X-ray equipment *(continued)*
   How can the X-ray tube be protected against accidental excessive exposure?  ... 107
   What should the control panel indicate?  ... 107
   What are requirements for X-ray cables?  ... 108
   What are “cones” or “collimators”? Are they necessary?  ... 108
   How is the X-ray tube aimed at the correct part of the patient?  ... 109

11. X-ray film equipment  ... 109
    What size and pattern of cassettes should be chosen?  ... 109
    What are fluorescent screens?  ... 110
    What films should be chosen?  ... 111
    How long can films be stored?  ... 111
    What sizes of films should be chosen?  ... 112
    Can two exposures be made on the same film?  ... 112
    What equipment is required in the darkroom?  ... 112
    How are films processed?  ... 112
    What is a dry workbench?  ... 116
    What lights are needed in the darkroom?  ... 116
    How are films suspended in the chemicals?  ... 117
    How many cassettes and film hangers should be supplied?  ... 117
    How are films dried?  ... 117
    How are cassettes transferred from the X-ray room to the darkroom?  ... 118
    Records and storage  ... 119

12. Location of equipment  ... 121
    How should X-ray equipment be located in the X-ray room?  ... 121
    How should the equipment be located in the darkroom?  ... 122

13. X-ray unit staff  ... 122
    Is a qualified X-ray technician necessary  ... 122
    Who can be trained to operate simple radiological units?  ... 123
    Where should training be undertaken?  ... 123
    How is the standard of work maintained?  ... 123
    Do physicians require special training?  ... 123

14. Maintenance  ... 124
    What maintenance will be required?  ... 124
    How should a maintenance service be organized?  ... 124

15. What is the growth capability of a basic radiological unit?  ... 124
Simple diagnostic X-ray installations have a very significant and valuable part to play in the medical care of rural and other underserved populations. Such installations need not be costly in terms of building, investment or maintenance; modern equipment is simple to use and does not require prolonged operator training. The cost of basic X-ray installations may be more than balanced by the speed and efficiency with which the patients are treated and returned home or to work, and by the prevention of further spread of infectious diseases, particularly those which may be first recognized on a chest radiograph.

This paper provides in simple terms all the information needed to establish X-ray facilities at a rural or isolated hospital or clinic. The choice of building and equipment can be based on local conditions: simple rules for radiation safety are included. All the information has been made as simple and economical as possible so that local labour and skills can be utilized for almost everything except the X-ray and processing units. Guidance is included on the choice of equipment and on the way in which local staff can be trained.

1. INTRODUCTION

It has been estimated that less than one-third of the world’s population has access to diagnostic radiology; but such a figure is misleading because the majority of X-ray units are concentrated in larger cities and, owing to poor maintenance, in many countries, even where there are X-ray units in rural areas, up to 30% may be out of order at any one time. In the majority of developing countries, most of the population live in rural areas and about half the rural hospitals in these countries do not have X-ray units.

Yet every physician, in his or her training, is taught the use of radiology, learns to depend on radiographs for the accurate diagnosis of many diseases and for the management of trauma. In rural practice, the overwhelming majority of all patients are suffering from trauma, chest disease or, less frequently, an acute abdominal condition. Some 80% of such rural patients can be treated more satisfactorily (and rapidly) following a simple radiographic examination.

This paper is only intended to provide guidance for the installation of one X-ray machine to serve one hospital or clinic, i.e., to provide a complete X-ray system for a rural or isolated medical facility. Such facilities were called "level C" and "level D" in the report of a WHO seminar on the use of medical radiological apparatus and facilities, held in Singapore, 9 to 12 November 1970. In brief, these levels may be described as follows:

**Level C** includes district hospitals or rural hospitals staffed by a small number of doctors and undertaking general medical care together with minor and emergency surgery. Abdominal and other major surgery would only be attempted on an emergency basis. Such a hospital could have 100 (or a few more) beds and perform extensive outpatient work. It might serve a population of 50,000-500,000.

**Level D** includes the small clinic, health centre or general practice under the supervision (at least part-time) of a general medical practitioner, undertaking only general medical practice, emergency work and screening patients for referral to larger facilities. The work would be predominantly with outpatients, with a few beds for routine maternity care and for those awaiting transfer to other hospitals. The population served would be from 10,000 to 100,000.

The equipment recommended and described does not provide fluoroscopy. The majority of experts agree that fluoroscopy requires greater skill on the part of the physician and therefore extra and specialized training. Moreover, the equipment becomes increasingly complex, and the radiation hazards increase significantly. Diseases of the type for which fluoroscopy is required also need other diagnostic aids and greater facilities (and skills) for treatment, usually available only at larger hospitals with specialist staff.

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1 Unpublished WHO document RHL/71.2.
Meetings sponsored by the Pan American Health Organization, Regional Office of the World Health Organization, in Washington, DC (1975), and by the World Health Organization in Geneva (1978) unanimously agreed that fluoroscopy was not recommended (indeed, contraindicated) at this level of rural or isolated medical facility.

2. DISEASES WHICH CAN BE DIAGNOSED BY RADIOGRAPHY

Surveys in many parts of the world have shown that the majority of the health problems of rural populations result from trauma and infectious diseases. Many infections are caused by parasites and diagnosis only requires simple laboratory confirmation but others, especially chest infections (which account for over 30% of all rural illness), may be more accurately diagnosed and treatment better guided by radiography than by clinical examination and laboratory tests. Pneumonia and tuberculosis are common primary causes of illness and, also, are often complications of other diseases, causing both acute and chronic ill health. Tuberculosis in particular is a universally common community disease with public health and economic significance. The initial diagnosis in one patient must lead to a search for other cases among relatives, friends and co-workers. Many cases of tuberculosis are (in the early stages) "clinically silent" and may only be detected by radiography. Every child with tuberculosis is an indication that it is necessary to X-ray mother and siblings, and vice versa. Accurate diagnosis, and therefore rapid treatment, reduces the spread of chest diseases and improves the general health of the population. Money invested in X-ray facilities will be returned over the years by public health improvement and progress in community health care.

Equally, the diagnosis and treatment of trauma, especially of the common limb injuries, is much advanced when radiography becomes available. A fracture can be accurately diagnosed, realigned and treated: progress can be checked and the patient returned to work rapidly and efficiently, with the minimum of disability. When progress is unsatisfactory, or when fractures are difficult to manage and require surgical treatment, the patients can be referred (with their radiographs) to a larger centre. It is cheaper and more efficient to treat the patient closer to home than to make the wrong diagnosis or give the wrong treatment for a relatively simple condition: unnecessary referrals, involving transport (as well as patient-shock or discomfort), can often be avoided. But this depends on accurate diagnosis, which in every case of trauma depends on radiography; the knowledge that there is no broken bone may be as important as the diagnosis of a fracture.

The diseases which can be diagnosed by radiography may be summarized as follows: all trauma to any part of the skeleton, but especially the limbs, and all chest diseases. In particular, the many types of infection may be recognized, e.g., differentiation may be made between acute pneumonia and tuberculosis, conditions for which the treatment is totally dissimilar in terms of drugs and time, and for which the wrong type of drug may not only be useless but disastrous. Clinical differentiation may be impossible until it is too late; radiological differentiation in the majority of patients is relatively simple and immediate; moreover, progress of treatment can be accurately followed.

Radiography of the abdomen is often important; for example, for the diagnosis of intestinal obstruction, an emergency requiring immediate surgical correction and in which delay in making the diagnosis can be fatal for the patient. Acute abdominal pain has many causes; obstruction is one requiring surgery, but other conditions may be better treated by drugs, and surgery may be contraindicated. Abdominal radiographs will materially assist an accurate diagnosis in the majority of such cases, even if only by exclusion. The administrator with financial responsibility will appreciate the prevention of unnecessary surgical procedures as much as the patients. The saving of lives, time and money may be considerable.

Radiography is not the answer to all problems of diagnosis, and many illnesses will require sophisticated equipment and specialized physicians to resolve the diagnostic (and thus the therapeutic) problems. Such conditions, however, afflict at most 20% of patients,

1 A comprehensive list of diseases which can and cannot be diagnosed by radiography is given by Palmer (1978) op. cit.
even in major referral centres such as university hospitals; more important, care of such patients is equally complex and far beyond the resources of a rural hospital and a general practitioner. A simple X-ray installation can help the majority of illneses for the majority of people, particularly in a rural population, and may guide the selection of those needing additional care.

One other factor should not be forgotten, although it is difficult to quantify. This is the professional enthusiasm of the rural practitioner. Caring for many sick patients, often in isolation and with simple facilities which are radically different from (and often inferior to) those in which the physician spent his or her student years and subsequent training, requires not only dedication and enthusiasm, but also perception that satisfactory results are being achieved: the correct diagnosis made and the right treatment given. The frustration of treating injuries without X-rays, of attempting to diagnose chest infections without a chest radiograph must inevitably lead to a lowering of standards and acceptance of the second-best because that is all that is possible. The rural physician with X-ray facilities is not only a better doctor but a happier person. The value of the installation cannot only be measured in local currency but must include all the good it can do for both doctor and patients.

3. WHERE TO SITUATE THE RADIOLOGICAL FACILITY

Having decided to provide a basic radiological facility, where should it be situated?

There are no absolute guidelines because local needs and conditions will dictate variations and there are many factors which may be significant. But the following principles will be universally applicable:

- There must be a doctor (or at least a responsible health practitioner) either based at the same hospital or visiting it several times a week (i.e., medical facilities of levels C and D, as described above);

- There must be easy access for a significant number of patients: ideally, no patient should travel more than 50 km or for more than 3-4 hours to reach the unit, access should be possible throughout the year, and communication with the larger regional centre (either by telephone or by radio) and transport to the major centre should be continuously possible.

Exact population figures which justify an X-ray installation and make it economically worth while are also difficult to delineate, because populations vary in their demands for "Western" medical services. One unit (one X-ray machine, one operator, one darkroom) can meet the radiological needs of populations from 10 000 to 100 000. An X-ray installation is useful if only 4 or 5 patients a day (or 25-30 a week) are X-rayed but the same machine and X-ray room can, when adequately staffed, make 50 examinations per day. It is certain that, following installation, the demand will increase.

The principles of site-planning are similar to those of any health care facility. In summary, the process of locating the unit is as follows:

- Study the map of the country or territory concerned;

- Identify population densities and groups;

- Circle populations to include 10 000 or more within a 50-km (or 4-hour) radius;

- Identify existing health care facilities (of all categories) and relate them to the population;

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- Relate the population to roads, transport (buses, trains, boats) and, in particular, identify any major obstruction, e.g., a river which becomes impassable because of flooding, mountains with snow-covered roads, etc.;

- Check communications with major regional centres, both for medical care and supplies, maintenance personnel, etc.;

- Choose the most suitable hospital or clinic with reference to the above (it may not be the largest in the area);

- Check the rural population that will not have access (how many will not benefit from the proposed location?)

- If there is a dense population, i.e., 100,000 or more, then decide whether two units should be installed at the centre or whether there should be a unit in each of two individual hospitals or clinics: which will best serve the population? (Installing two units of this basic pattern in one hospital does not alter the type of work done, only the quantity: two units together will necessitate a larger darkroom and larger store/office; separate installations are not always more uneconomical and may provide better patient care.) There is a limit to the examinations which can be done with a single unit, and planning must recognize this at the start.

Two of the above factors need emphasis. First, in considering existing hospitals or clinics, the utilization pattern may be of more importance than the size of the facility: obviously, a large maternity hospital has less need of X-ray facilities than a busy clinic with a large number of casualty patients and chest infections. Secondly, to be justified economically, an X-ray unit must be fully used and access is essential. Patients may be referred daily, or on certain days a week an ambulance or other transport may bring patients from a nearby clinic or hospital which does not have its own X-ray unit: such patients will usually be returned with their X-ray films. Imagination must be used to visualize the X-ray unit serving a whole community, and its location should be chosen with this certainty in mind.

Where should the X-ray department be situated in the hospital or clinic complex?

Again there are numerous possible variants but also some basic principles:

- Patients will come for radiography from every part of the hospital: the wards, operating suites and outpatient department.

- Patients may walk, come in wheelchairs, on crutches, stretchers or trolleys, or even in their beds. There must therefore be no steps and no hindrance for wheelchairs, trolleys or beds. The majority will be able to walk, but must be able to rest when they reach the X-ray department.

- It is essential for the X-ray facility to have an electrical supply; a water supply and drainage, though not strictly essential, are highly desirable. Cold water is adequate; hot water should also be available if possible, though in hot climates it is not necessary (these individual needs are discussed fully below in section ll).

4. THE X-RAY SUITE

The X-ray room and darkroom have minimum size requirements (see below) and should be adjacent. The X-ray suite can be part of the hospital or clinic building (provided the access requirements and radiation protection needs can be satisfied) or may be in an adjoining building. In hot climates, the X-ray suite (and the darkroom in particular) should be on the coolest side of the building.

An X-ray suite consists of three rooms:

- The X-ray room;
- The darkroom;
- The office/storeroom.

When planning, it is essential to realize that the X-ray room and darkroom are built for specific purposes and cannot be put to any other use. It is not feasible to hold an out-patient clinic in an X-ray room or to store hospital supplies in the darkroom, for example.

All these rooms should be adjoining. The X-ray room and the darkroom should be side by side. The office/storeroom should be in close proximity (possible alternatives are shown in Fig. 1). If space is at a premium, the office/store may be considered the least essential, but alternative and nearby storage for both used and unused X-ray films, chemicals, etc. will have to be provided somewhere.

**FIG. 1. THREE ALTERNATIVE RELATIONSHIPS IN PLACING THE RADIOLGY ROOMS**

Radiation protection is an essential part of the design but not a prime consideration in the choice of location. Almost any room can be made radiation safe but it may be less expensive to build a new suite than to adapt an existing site (see section 8, below).

The size of the three rooms should be (approximately) as follows. The size of the X-ray room and its shape are controlled by the size of the X-ray equipment and the movement of patients and staff. In general, the smaller the X-ray room the more hazardous it becomes and the more difficult to meet radiation protection requirements. For these reasons, the X-ray room cannot be less than 18 m²; if all dimensions can be 1-2 m larger, it will be a better room. A very large room can, however, be a disadvantage. The shape should be rectangular and not less than 4 m on the narrowest side.

The size of the darkroom is dictated by the size of the processing benches and tanks and the need to work in almost total darkness. Moreover, the dry working area must be separated from the wet processing area, and space may be used to dry films after processing. Despite this, too large a darkroom can be a difficult room in which to work and be very wasteful of operator time. The darkroom should be at least 5 m² internally, not including the entrance (see Fig. 1): it may be a little larger, but a very large darkroom is inconvenient. It should be square, or almost square, e.g., 2 m x 2.5 m (minimum).
The size of the office/storeroom is more flexible, but making the space too small initially is a false economy; 8 m² should be considered a minimum. Shelving will be needed to store used and unused X-ray films. The number of used films will continually increase; most hospitals keep films for 5 years, but rural hospitals with a more stable population may usefully keep the films longer. They are an essential part of the patients' records and it is almost impossible to have too much storage space. In addition to films, chemicals and some written records must be kept. The office area will be used by the doctor to see the films of the patients and a daily name/examination record must be maintained. It is possible to store films etc. anywhere in the hospital complex, but storage close to the X-ray room is preferable in every way.

What should be the relationship of the three radiology rooms? There are many alternatives (see Fig. 1) but it is essential that the X-ray room and the darkroom be adjoining. It is preferable to have the office/storeroom next to the darkroom, but it can be opposite or next to the X-ray room.

5. BUILDING MATERIALS

Almost any local material is suitable, providing it is:

- Waterproof and dustproof;
- Strong, especially the floor;
- Durable, lasting about 20 years or longer.

Various materials differ in their radiation protection potential: wood is the least satisfactory; brick and concrete are ideal. Thick mud walls are satisfactory; wood which is covered with plaster, preferably two or more layers, can be utilized but is less satisfactory than brick or concrete. Details of required wall thicknesses for radiation protection are provided in section 8.

The X-ray room

The floor must be firm and capable of carrying the weight of the X-ray generator, the tube support and either the X-ray table or patient's trolley. The weight of the equipment is approximately 400 kg. The floor must be level, both overall across the width of the room and in localized areas, so that trolleys and equipment can be easily moved across it. It should be waterproof, washable and free from dust. It can be constructed of concrete, wood, brick, tiles, or any other suitable hard compound.

The walls must be strong enough to carry the weight of the ceiling and the roof. They must be completely waterproof and windproof. There should be one or more windows in two walls. The walls can be constructed of brick, concrete blocks, or thick plaster covering wood (for details of thickness for radiation protection, see section 8).

The ceiling must be a minimum of 2.5 m and preferably 3 m above the floor. An X-ray unit can be installed in any room even without a ceiling, but an inner covering to the roof is advisable for protection from dust, insects, bats, etc. The ceiling will not be required to support any weight, except for some lateral thrust with one pattern of tube support (see Fig. 9, below). The room must have lighting, preferably from the hospital electricity supply. Three or four lights around the room are better than a single one: two or more fluorescent tubes each 1.5 m in length will be satisfactory and are economical. The ceiling can be constructed of plaster boarding, wood, hardboard or any suitable local material.

The roof must be well fitting and weatherproof, because moisture will damage X-ray equipment beyond repair. Any suitable local material such as wood, tiles, slates, thick thatch, corrugated iron, corrugated iron with thatch, roofing felt, asbestos, etc. will be suitable. An inner ceiling of plaster or fibreboard is essential if thatch forms the outer roof. There are no radiation protection requirements for the roof. Local practice will dictate the width of the eaves, the availability of guttering, etc. The roof should extend
out over the doorways of the X-ray room and the darkroom door and preferably should connect with a covered way to the hospital and to the outpatient clinic (see Fig. 2 and 3). If this corridor or covered way is continued alongside the X-ray room, darkroom and the office space, it forms a suitable covered waiting area, providing protection from both the sun and the rain. Any local construction material - thatch, corrugated iron, wood, etc. - can be used. This covered passage must be without steps and wide enough to permit movement of a bed, a trolley or wheelchair. The roof should be waterproof with wide eaves.

FIG. 2. ROOF EXTENDING OVER DOOR OF X-RAY ROOM AND DARKROOM CONNECTING WITH COVERED WAY TO HOSPITAL

A door into the X-ray room is very desirable. It should be made of wood; provided it is in the correct location in relation to the X-ray equipment it does not require specific additional thickness for radiation protection (see section 8, below). Its minimum width should be 1.4 m, so that beds or trolleys can enter without difficulty.

A door for the darkroom is essential and must be lightproof (see Fig. 5, below). It should be 1 m wide, so as to permit the easy installation of equipment.

Neither the door to the X-ray room nor that to the darkroom should have steps or any obstruction.

The darkroom

The construction requirements for the darkroom are similar to those of the X-ray room (see above). In particular, the wall between the X-ray room and the darkroom will need to provide some radiation protection (see below, section 8). Apart from this, the main requirement is that the room shall be waterproof and, of course, the darkroom must be lightproof. One outside wall will need to be strong enough to support plumbing; all the walls will have to carry some minor weight, such as ventilators; and the construction must include
either a shielded ventilator or some other lightproof ventilation, such as that shown in Fig. 4. A shielded extract fan is ideal if electrical supply permits. A window is desirable but it also must be lightproof. The door should be constructed of wood but must be lightproof. A rubber flange should be fixed to the lower part of the door to prevent light from filtering under it (Fig. 5).

FIG. 4. LIGHTPROOF VENTILATOR

FIG. 5. RUBBER FLANGE FIXED TO LOWER PART OF DOOR ACTING AS LIGHT TRAP

The darkroom floor should be waterproof, level and preferably washable. A corner drain into which moisture can be swept is useful; it can be under or close to the processing tank. Removable platforms or wooden slats can be utilized across the floors when they are damp or uneven.

It is desirable, though not essential, that the darkroom should have a ceiling to keep out dust, insects, etc.

The darkroom entrance

A lightproof door may be sufficient as the entrance into a small basic darkroom but, if space permits, a light-trap entrance may be included. When the daily workload exceeds 10 patients, such an entrance without doors is desirable and gives increased efficiency and ventilation. The design is simple, as shown in Fig. 6.

FIG. 6. LIGHT-TRAP ENTRANCE FOR DARKROOM

The entrance passage should average 1 m in width throughout. To function efficiently, the inside of this light-trap must be painted with a matt-black finish and there should be a white line about 3 cm in width on either wall at eye level, following the passage throughout its length. No lights are needed within the passage, but a safelight installed in the light-trap ceiling is a useful addition. The space is not entirely wasted, as the ceiling of this passage can be lowered to 2 m and the space above at either end can be utilized for storage.

If a light-trap is provided, the processing equipment and workbench must be installed before the entrance is completed; alternatively, the light-trap must be constructed of some easily movable or replaceable material.
An alternative design utilizing two doors into the darkroom with a small intervening space is unsatisfactory unless some interlocking mechanism is included to prevent both doors opening at once. Such a mechanism tends to be complex and requires maintenance to work satisfactorily. Curtains do not provide an adequate light barrier. These latter two alternatives will permit light to enter the darkroom when someone walks in unexpectedly. Therefore, when a light-trap cannot be provided, a single lightproof door will have to do and all precautions will have to be taken to avoid it being unexpectedly opened.

The office/storeroom

This room can be built of any standard local material, provided there is a strong floor capable of supporting the weight of the shelving to hold both used and unused X-ray films, chemicals, etc. An inner ceiling, windows and a relatively weatherproof door are very desirable but not essential.

The thickness of walls required for radiation protection in these rooms is discussed in detail in section 8, but standard bricks or concrete blocks are usually sufficient. Section 8 should be studied carefully.

6. ELECTRICAL SUPPLY

The electrical supply to the X-ray room will depend on the X-ray generator chosen. If it is a battery-operated unit or a condenser discharge unit, a single wall outlet of about 15 A at 220 V (or equivalent) is required to recharge the batteries or condenser. If a standard X-ray generator is used, there must be a main electrical outlet and a circuit breaker; with a 220-V simple phase AC supply, a slow 25-A fuse will be required and the mains impedance should not be larger than 0.5 ohm. The power required will depend on the load needed by the X-ray unit. It may be 25 A/220 V (or equivalent); the manufacturer's specifications will provide this information. Apart from the main supply, it is wise to provide at least one additional wall outlet on each of the two walls of the X-ray room, if this is possible (10 or 13 A/220 V or equivalent).

Artificial light will be required for examining emergency cases at night. Three or four single lights in the X-ray room (or two or more fluorescent tubes) are preferable to one large light.

The electrical needs in the darkroom include a fan, and at least two safelights: one 15 A/220 V (or equivalent) wall outlet is desirable, especially if the ambient temperatures fall below 19°C and any form of water heater is anticipated. One "white" light is needed for mixing chemicals etc. The switch must be in the darkroom.

The electrical supply in the office must provide standard room lighting (preferably fluorescent), sufficient to illuminate film files. A standard wall outlet for X-ray film illuminators is necessary.

Note that the above are minimum requirements only.

7. COLOUR OF BUILDINGS

What colours should the buildings be outside? All three rooms will contain X-ray film which can be damaged by heat; it is thus preferable to paint the outside of the buildings and the roof white or some heat-reflecting colour. Apart from this, there are no requirements.

What should the colour be inside the rooms? All the rooms, including the darkroom, should be of a light and cheerful colour.

The X-ray room should be white or cream. The finish should be glossy or semiglossy so that the walls can easily be cleaned. The ceiling should be white or blue and a matt surface is to be preferred. The floors can be any suitable colour, but should be easy to clean.
The darkroom should be cream, white or pale pink; a darker colour is definitely not required. The finish should be glossy or semiglossy and easily cleaned. The ceiling should be white with a glossy or semiglossy finish. The floor can be any desired colour but should be washable. If there is a light-trap at the entrance, the inside walls of the passage must all be matt-black (see above).

The office/storeroom can be any locally desired colour.

8. REQUIREMENTS FOR RADIATION PROTECTION AND SAFETY

In general, the amount of radiation in a small basic radiological facility is so little that radiation protection is not a major problem. If the equipment is correctly installed and if the construction material is carefully chosen, there is no reason to anticipate any additional cost in this respect.

Wall thicknesses for radiation protection

The wall thickness will depend very much on the situation of the X-ray room relative to other buildings and on its size. If the room is isolated and built so that persons cannot come within 1 m of its outside walls, then no particular protection is needed; if the building has to be made of wood, it may be cheaper to fence off an area around it rather than to use heavier wall construction materials. If the X-ray room adjoins the hospital, extra care is required and the occupancy of the adjacent room will be a significant factor.

The recommendations which follow are based on a room size of 6 m by 4 m. Average figures provided in various manuals\(^1\) calculate the desired thickness of material on the basis of a total radiation exposure of 150 mA-minutes a week at 100 kV. (The number of milliampere-seconds used for each exposure multiplied by the number of seconds provides the milliampere-seconds (mA.s) for each exposure; the milliamp-seconds per day can be calculated by multiplying the number of exposures per day by the average exposure used.) The average basic radiological facility, examining about 10 patients per day mainly for chest and extremities, will use less than 20 mA-min a day at 100 kV, or at the most 100 mA-min per week. This is less than half the figure used as the basis of standard calculations in busy X-ray departments. Even these standard calculations are generous, because they assume an average radiation of 100 mA.s per patient; a more realistic assessment would be that the basic radiological facility will use half that amount. Recent calculations\(^2\) have shown that the actual radiation used, when accurately measured, is usually much less than the theoretical calculated dosage.

In basic radiological facilities it is, therefore, permissible to utilize a wall-thickness design-figure of 1 mm of lead-equivalent. This incorporates a sizeable safety factor and will be satisfactory until at least 30 patients are examined daily; at that stage, tests should be made to determine if additional protection is required. In many instances the 1 mm of lead-equivalent will continue to be sufficient.

A standard poured concrete wall about 8-12 cm in thickness would be required to provide a lead-equivalent of 1 mm. If cinder-blocks or bricks are used, a thickness of about 12-15 cm will be required, depending on the density of the material actually used. Many concrete blocks have central air spaces and the recommended thickness refers to the amount of actual concrete or brick and not to the overall dimensions of the block. Architects may wish to

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know that these recommendations are based on standard poured concrete with a density of 2.35 g/cm$^3$. If a similar material of different density is used, the required thickness can be estimated as follows:

\[
\text{(thickness of concrete) } \times (2.35 \text{ g/cm}^3) = \text{(thickness of similar material) } \times \text{(density of similar material)}.
\]

**Are there any specific areas of high radiation risk in the X-ray buildings?**

Within the X-ray room there are two specific high-risk areas:

- The wall behind the chest stand;
- The wall of the darkroom.

Provided that the X-ray unit is properly positioned, the wall of the darkroom will need no special protection if it is constructed of at least 10 cm of brick or concrete. At no time should the main X-ray beam ever be pointed at the wall of the darkroom (to prevent radiation fogging the stored films). If this is unavoidable for some particular local reason, then the wall thickness must be doubled (to approximately 20 cm) for the full extent of the wall between the darkroom and the X-ray room.

The X-ray tube must be located so that, whenever erect chest X-rays are taken, the radiation beam is pointed away from the darkroom to another wall. There will then be a radiation hazard on the far side of this wall. There are two ways to overcome this:

- Increased protection as part of the chest X-ray cassette stand;
- Increased protection on the wall itself behind the chest stand.

If the first method is chosen, then the chest-cassette holder (whether it be independent or an integral part of the unit) must carry 2 mm of lead (or equivalent) covering an area exactly that of the largest cassette that will be used. When the second alternative, that of reinforcing the absorption capacity of the wall itself, is chosen, then an area 2 m in height and 1 m wide, centred immediately behind the chest stand, must have the same 2 mm of lead-equivalent. This can be obtained by doubling the thickness of the brick or concrete (20 cm) or utilizing lead sheeting 1 mm thick or steel sheeting 5 mm thick. In some circumstances it is worth remembering that simple plate glass of 1 cm thick is equivalent to 1 mm of lead and provides a very satisfactory radiation barrier, (glass, however, is variable in content and therefore in lead-equivalent, and a sample should be checked by a radiation physicist).

Such protection will make it quite safe for the workers in the adjoining room (if the X-ray department is part of an existing building) and it will permit persons to stand outside or lean against the wall of the X-ray room for an indefinite period while the unit is working at the normal load of a basic unit.

It should be re-emphasized that these calculations provide far more of a margin of safety than is likely to be necessary in a basic radiological facility. Such details may be incorporated cheaply and simply at the time of construction and the amount of work may be allowed to increase somewhat without further building difficulties. However, any change in room dimensions, a more powerful generator, or a large increase in the number of patients will alter these requirements.

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1 Further detailed information is contained in: National Council on Radiation Protection and Measurements (1976) **Structural shielding design and evaluation for medical use of X-rays and gamma rays of energies up to 10 MeV.** Washington, DC, NCRP Report No. 49; and in: Great Britain, Radioactive Substances Advisory Committee (1971) **Handbook of radiological protection.** London, HMSO.
How are the X-ray operators protected?

No X-ray exposure should be made unless the operator and any other person in the room (other than the patient) are behind the control panel. If it is necessary for the patient to be held, then (lead) protective clothing must be worn (see below). The X-ray control must be designed in such a way that the switch is an integral part of the unit and protection should be incorporated in the design of the control panel. This should be a shield of 1 mm lead-equivalent, at least 75 cm wide in front of the control panel and extending 50 cm on either side. It should be 2 m in height and should have a lead glass window with at least 1 mm lead-equivalent (approximately 25 cm x 25 cm in size) situated in the central panel at eye level, so that the operator can see clearly through it and has no need to look around the edge of the screen while making the exposure. The height and size of the window should be adapted to the average of the local population. The equipment must be installed so that the X-ray beam never points at the control panel. This control screen should be integral with the equipment and not a later addition; it should not be possible to separate it or move it apart from the control panel (see Fig. 7).

FIG. 7. CONTROL SCREEN AND CONTROL PANEL

Are windows permitted or desired in an X-ray room?

Standard glass windows do not provide much radiation protection. However, there is no radiation hazard provided people do not loiter within 1 m of the window of a standard-sized X-ray room. If patients wait outside the room, the window should be 2 m from the ground outside and at least 1.5 m above the floor inside. Windows are very desirable for both ventilation and light. The windows in the darkroom must be lightproof. Thick black paint may be enough; or the glass may be replaced by wood or steel. Shutters will probably be required.

Which is cheaper: larger X-ray rooms or increased protection on the walls?

This will depend on local building material and the availability of both land and labour. In many rural areas it is cheaper to build somewhat larger rooms than the minimum size quoted rather than purchase lead sheeting. Locally made bricks may be cheap and a double brick wall probably provides all the protection that can possibly be required, even in such high-risk
areas as the darkroom and behind the chest stand. Increasing the distance between the X-ray tube and the walls is one of the best ways of providing radiation safety, because the dosage received from an X-ray unit decreases in proportion to the square of the distance.

**Radiation safety monitoring**

It is an internationally accepted practice that all personnel who work with ionizing radiation be continuously monitored to record the dosage received during their work. In diagnostic X-ray departments this is usually done by requiring each operator (or any other person who may be regularly exposed to ionizing radiation, e.g., a darkroom technician, or a nurse working in an X-ray department) to wear while at work a small film badge of standard design. At the end of each month the films must be sent to the radiation physicist (or laboratory) and a fresh film provided. A written record must be kept for each wearer. Such a film badge service can only be organized and controlled on a central basis and the reports must be examined by a responsible person, e.g., a radiologist or radiation safety officer.

The need for such a service, the way the badge should be worn, the need for regular checking and exchange of films must be part of the operator training; badges can be exchanged by any regular transport - mail, air, etc.

Experience shows that this control is essential and, when an excessive dose is recorded, a visit to the X-ray facility concerned will be required. Written or telephone enquiries seldom solve the local problem: relatively inexperienced operators may perpetuate some error and be quite unaware of the source of the radiation exposure. In the past, because of poor instruction, some have even believed that the small film badge provided immunity. In no other area of training will more careful and explicit explanation and instruction be needed. The actual risk in a basic care facility is much less than in a busy X-ray department: there are fewer patients and the examinations do not require excessive radiation; nevertheless, carelessness cannot be permitted. However well the X-ray unit is designed and however correctly installed, there is still some risk, particularly of operators not following correct methods, and this risk must be monitored. Keeping the badge safely in a drawer and never wearing it can usually be detected by the film badge centre, because sooner or later all badges worn by operators will record at least some exposure.

Other personal methods of protection include the routine use of a radiation-proof apron (lead-equivalent 2.5 mm). These are usually double-sided, and racks to support them should be provided in the X-ray room, preferably near the control panel, so that they are convenient and will be used. Protective gloves (lead-equivalent 0.3 mm) must also be provided and worn whenever a patient needs to be held by a nurse or aide who will be in the X-ray beam during the exposure. A shelf or support for the gloves is necessary near the rack for the apron. Without proper support, these items crack and cease to be radiation-proof; they must be tested regularly.

9. **HOW IS THE POWER FOR AN X-RAY UNIT OBTAINED?**

The required electrical power for an X-ray generator can be obtained in any of four ways - from:

- Mains electricity;
- The hospital electrical generator;
- A condenser discharge unit (capacitor);
- A self-contained battery supply.

Other power sources may become available but are not yet practical. A capacitor and batteries both require a basic small electrical supply, but do not increase the load during exposure.

Mains electricity can be utilized at 220 V or 110 V, alternating current. It can be at 50 or 60 cycles. Whatever the voltage or cycles, it must be steady and must not vary greatly
when there is a heavy load, e.g., when the rest of the hospital is utilizing electricity for sterilizers or cooking. There must be at least 25 A at 220 V (or the equivalent) in the X-ray room for a single-phase 11-kW X-ray unit. The main electrical transformer supplying the hospital must not be too far from the X-ray rooms unless an additional heavy cable can be provided. The impedance in a light cable can cause a significant voltage drop, spoiling the X-ray exposure. A 30-A contact-breaker and fuse will be needed in the X-ray room for direct connexion to this type of single-phase X-ray generator. This will be a permanent connexion and there should not be any other heavy electrical equipment on the same circuit.

Many rural hospitals generate their own electricity with a diesel, gasoline or kerosene-powered generator. It must produce the same alternating-current electrical supply as described above. Problems arise because small generators fluctuate beyond the acceptable limits, particularly under peak loads. Thus, an X-ray exposure made at night, when the hospital lights are in use, may be beyond the capacity of the hospital power source and the resulting films will be unsatisfactory. There is often considerable voltage loss in the cable leading from a domestic generator to the hospital, because generators are sited away from the buildings to avoid the noise and the odour. Before utilizing such a source as the power supply, a careful check on its output and load factors is essential. An X-ray unit will not function satisfactorily with a variable power input, or with a voltage drop of over 10% during the exposure.

There is a temptation, when equipping an existing hospital or clinic with an X-ray installation, to choose the X-ray unit to match the available electrical power. A low-power unit can only result in unsatisfactory films and can be an economically incorrect choice. X-ray installations require a capital expenditure which should be properly utilized. If the power available is insufficient for an 11-kW unit, either a better electrical supply must be provided or a battery (or capacitor)-operated X-ray unit should be chosen (see below).

Where there is doubt about the main (or hospital-generated) electrical supply, a condenser discharge (or capacitor) unit may solve the problem. Condenser discharge units store electricity which is released as steady power for X-ray generation. They provide a powerful but short exposure. There is an upper limit to their output and they must be recharged immediately (i.e., the local generator must be running continuously while the X-ray unit is working with patients, or else the condenser cannot be recharged for the next exposure). The main electrical power required for such X-ray units is low and the results are good.

Battery-operated units have a considerable power reserve (for example, up to 1000 chest X-rays between recharges) and can be recharged at any time when the local electrical supply is available, day or night. The electrical load required from the main supply for recharging is small but must be continuous. Provided the batteries are kept charged and in good condition they are always available and they are extremely flexible in use. They produce a very steady, constant power supply.

The batteries which supply the power to the X-ray generator can be lead-acid or nickel-cadmium: both have advantages and disadvantages. Nickel-cadmium batteries are currently very expensive but have a longer life. They need careful maintenance and regular recycling: maintenance is not easy, especially in the isolation of a rural tropical hospital, as visits from a central engineers department may be needed every 6 months (or, if the unit is heavily used, every 3 months). Lead-acid batteries are familiar to almost everyone: they are bulky, but need little maintenance. Modern batteries can be sealed: they are much cheaper than nickel-cadmium and, even if they have to be replaced more often, are likely to be more economical and are more readily available.

Of these alternatives, which is the best choice? If there is a satisfactory mains electrical supply or if the hospital electrical generator is adequate, then this is the best choice, provided there is no compromise in the power (11 kW or more) of the X-ray unit. If there are difficulties with the central power supply or if proposed hospital extensions will cause power deficit in the future, then a battery-operated unit is preferable and will prove satisfactory. Care should be taken to specify the ambient temperature and humidity when choosing the actual unit.
10. CHOICE OF X-RAY EQUIPMENT

There is a wide choice of X-ray equipment: all types, wherever manufactured, have basically 5 main parts. These can be considered separately because there are many alternatives for each, but all must be purchased from the same manufacturer. Wherever possible, the chosen complete units should be standardized throughout each area. The following together make up an X-ray installation:

(a) The X-ray generator and its control unit; these may be separate or combined.

(b) The X-ray tube and the tube support; these may be supplied separately or as an integral unit.

Combinations of (a) and (b) are available in which the control unit is separate but the X-ray generator and tube are combined within the same "tank" and supported on a column. The advantage of this design is that heavy, vulnerable and expensive high-tension cables can be eliminated. The disadvantages currently are those of size and weight and, in most "single-tank" units, some limitation in X-ray output. Modern techniques are overcoming these problems and in the next few years small but powerful single-tank units may become available.

(c) The patient support.

(d) Cassettes and screens.

(e) Processing tanks and darkroom equipment.

Which generator and control to choose?

X-ray generators are rated in terms of the mA (milliamperage) and the kV (kilovoltage) which they produce. The milliamperage provides the "brightness" or power for the X-ray exposure and the kilovoltage alters the penetration of the rays through the patient.

To radiograph sick patients, whether they are adults or children, a relatively short exposure time is essential. This means that the X-ray generator must have sufficient power because all X-ray exposures are a combination of mA and time (seconds). The specification for the generator must therefore require a minimum output of 100 mA for not less than 0.1 second but must also specify this output at 110 kV. It is an advantage to have a unit more powerful than this, but a more powerful unit will increase both the cost and the electrical supply required.

Note carefully that it is essential that the X-ray generator produce both 100 mA and 110 kV simultaneously for not less than 0.1 second. There are many cheaper generators which will produce 100 mA at a lower kV (e.g., 100 mA at 60 kV) or produce 100 kV at a lower mA (e.g., 100 kV at 50 mA). These are not acceptable alternatives and the power requirements must be 100 mA at 110 kV as a guaranteed minimum - specified as 11 kW (kilowatts).

What is the best type of X-ray generator and control? These two items may come as a single unit (as in a mobile X-ray machine) or in two separate units which can be installed in different parts of the room. When they are sold as one unit, the whole can be mobile or fixed: fixed is preferable. If they are supplied in two units, the generator (also known as the transformer) is likely to be fixed and the control may be supplied on wheels. It is recommended that the control be fixed also. Inability to move the equipment ensures that the most satisfactory layout is maintained and reduces the radiation hazard to relatively unskilled operators. If you have a choice, choose fixed equipment: if possible, insist on it.

How are the kV and mA controlled? How many kV settings are needed? The control of the kV and the mA must be separate and independent. Any link (other than to provide overload protection for the tube) should be unacceptable. The specification should require a minimum of 3 kV settings, preferably 115 kV, 80 kV and 60 kV. It is permissible to add 95 kV and 70 kV settings to these, but any more settings are unnecessary (although sales
literature will try to persuade otherwise). Note again that altering the kV setting should not alter the available mA, although it may, to protect the X-ray tube, restrict the length of the exposure.

The length of the exposure is controlled mechanically or electronically: electronic timers are more accurate and must be solid-state. The time-switch must provide exposures from 0.02 to 5 seconds and there should be a 26% interval change between the settings (a change of less than 26% is not effective radiographically).

If the mA is variable, it should be indicated either by a dial or by a positive lightsystem, or in some way so that the operator may know exactly what power is available.

It is preferable in basic X-ray units to indicate mAs (the combination of milliamperes multiplied by seconds): in the most modern simplified units the milliamperage is fixed, so that altering the length of the exposure effectively alters the milliamperage-seconds (mAs).

It is acceptable to have variable mA, controlled by a separate switch but this complicates matters and, in a basic facility, there will be more errors than with fixed mA and variable time only.

Where possible, choose a fixed mA setting and a variable time. Whatever unit is chosen, make sure that either a light or dial indicates when X-rays are being generated.

X-ray tube support

The support for the X-ray tube is available in 5 designs:

- Integrated with the control unit and the transformer (such as a standard mobile unit).
- A column mounted on floor-rails alone.
- A column mounted on floor-rails with a ceiling rail.
- A fixed column with a tube rotating on a central axis (a "C" or "U" arm).
- A column integral with the X-ray table.
- A carriage suspended from the ceiling on rails.

The last design can be disregarded for basic radiological facilities. It presupposes a strong ceiling, capable of holding over 400 kg, which adds complexity and cost to the installation and increases the maintenance. It is very desirable in larger hospitals but not in basic units.

The first design is also not acceptable, although a mobile unit which is complete with an integrated X-ray generator, control and tube support is simple and is often chosen. The main disadvantages are that it will need to be moved from the table and repositioned to examine chests; it is less easy to centre on the patient; and scattered radiation is often higher for the operator. Because the tube can be off-centred from the cassette very easily and because the unit can be moved around the room, it is not so easy to control radiation hazards. It does have the advantage that it can be used elsewhere in the hospital, but under basic hospital conditions it is better to bring the patient to the X-ray department than vice versa. Because of the hazards, a mobile (portable) unit is considered not acceptable.

A single column can be mounted entirely on floor rails, with three wheels arranged in a triangular form (Fig. 8.) To permit the column to move freely the floor must be solid and totally free from dust. The rails can be raised above floor level, or recessed into the floor. The latter is preferable because it allows easy movement of patients on trolleys over any part of the X-ray room, but it is more difficult to keep clean and more difficult to install. A column of this type provides reasonably stable tube movement.
A single column can be mounted on a floor rail (which may be either recessed or above the floor) which bears all the weight while the top of the column is steadied on a single ceiling rail which provides lateral stability (Fig. 9). No weight is carried by the ceiling but there are significant lateral forces. Both the ceiling and the floor rails must be entirely parallel throughout their length: any variation in height will lead to instability. Such floor-to-ceiling tube supports are adjustable at the time of installation from 280 cm up to 400 cm. Their installation requires care or derailment can occur, with the possibility of injuring the patient and the operator as well as the tube and the column itself. A good installation provides steady support but needs very good local construction skills and materials.

The X-ray tube can be held on one end of a "C"- or "U"-shaped arm which is supported on a single column. Exactly opposite the tube on the other end of the "C" or "U" arm is the cassette holder. The supporting vertical column must be fixed to the floor and steadied against the wall or ceiling (Fig. 10). Fixation to the floor without ceiling or wall support is not sufficiently rigid. Usually the wall is satisfactory for this additional support.
FIG. 10. FIXED-COLUMN X-RAY TUBE SUPPORT WITH A TUBE ROTATING ON A CENTRAL AXIS

This design of tube support has many advantages. It is rigid; it does not require a completely level floor beyond the base plate of the column; and it is easy to install without reference to ceiling timbers, etc. Patients can be examined either sitting, standing, or lying on a patient-support, with the beam in any direction. The centring of the tube to the film is accurate and fixed, thus eliminating technical error in either plane: the distance between the tube and the film can be similarly fixed. This type of design is easy to manufacture and maintain and has a minimum number of moving parts. It is the best available design for basic installations.

The tube support can be a column which is an integral part of one side of the X-ray table, with movement along the full length of the table (Fig. 11). This requires that the table is fixed to the floor and is well constructed: the design is excellent, but must be rigid and simple. The floor must be level and strong enough to carry the combined weight. The horizontal film holder can be linked to the column, thereby providing accurate centring in the vertical beam direction, but there can be no link between the tube and the chest stand when the patient is erect. This type of design is easy to install and maintain and is second in preference to the "C" or "U" arm design.

FIG. 11. COLUMN X-RAY TUBE SUPPORT INTEGRAL WITH THE X-RAY TABLE

With the exception of the "C" or "U" arm design, the first five designs listed all require a separate chest-cassette holder (Fig. 15 below shows examples of chest-cassette holder designs).

What movements of the tube are required? The tube must be usable with patients in two positions: horizontal, and vertical. It must also be possible to examine patients on the X-ray table or trolley when the patient is in a horizontal position and the beam is across the table in a transverse direction. There are therefore three basic beam directions: vertical, horizontal and horizontal-transverse (Fig. 12).
It must be possible to lock the tube at any height: with a standard upright column, either on rails or attached to the patient-support, the horizontal-lateral beam will require rotation of the column through 90° and the axis of the tube also through 90°. The "U" arm can provide these views with only two movements but needs a mobile patient-support to permit the horizontal-lateral view (Fig. 13).

**FIG. 12. BASIC BEAM DIRECTIONS WITH COLUMN SUPPORT**

![Basic Beam Directions with Column Support](image1)

**FIG. 13. BEAM DIRECTIONS WITH "U"-ARM SUPPORT**

![Beam Directions with "U"-arm Support](image2)

How is the weight of the tube supported? All tube supports must be capable of vertical movement, and as X-ray tubes are very heavy this requires some type of counterbalance. There are two basic principles available: counterweights, and springs.

Counterweights are simple lead or steel weights attached to a supporting cable which runs over a pulley at the top of the column. The pulley can be single or a variable-ratio pulley series.

Springs can be of variable or fixed tension and may be attached either at the base of the column connected to a supporting cable running over a pulley, or alternatively, provide direct suspension of the tube support from the top of the column (Fig. 14).

**FIG. 14. COUNTERWEIGHTS AND SPRINGS**

![Counterweights and Springs](image3)
Of these alternatives, the first with simple counterweights is the most reliable and is most easily altered in balance if a different tube is later used in replacement. Springs attached to a cable function well but may become fatigued and adjustment is less simple. Direct support with a spring is the least satisfactory and is less stable over a long period.

If the "C" or "U" arm tube support is chosen, the same counterbalancing alternatives exist and simple weights on the supporting cable with a single or differential pulley are preferred. It may be desirable with such units to have two supporting cables and counterweights. In any of the designs, the supporting cables can be replaced by chains running over a toothed pulley (a cog); this is equally acceptable.

Control of tube movement. All movements of the tube and the tube support are controlled by brakes. There are two main designs:

- Friction brakes locked by a simple screw or by an electronic mechanism;
- A fixed-position lock.

Friction brakes are best operated by simple screws, utilizing large contact surfaces with simple but large levers or knobs to rotate the screw. Electromagnetic brakes add complexity and require additional maintenance and repair. They are usually less efficient, collect dirt and fluff, and become unreliable. Moreover, they presuppose a constant electrical supply on an auxiliary circuit even when the generator is switched off: without electricity, electronic brakes do not function. They have no advantage over hand-operated brakes and because of their complexity are not suitable for basic installations.

Fixed-position lock points, e.g., at predetermined distances, utilize a bolt action to engage with a preset hole or catch. They provide good and accurate braking in the vertical position but they are not satisfactory for X-raying patients who are erect. Too many positions are required because patients vary considerably in their height.

What designs of patient-support or X-ray table are available?

There are basically two varieties: fixed, and mobile.

All fixed designs are a table, with a flat, X-ray-translucent top, usually just less than 200 cm long and over 70 cm wide. All must be able to support 120-kg patients without appreciable distortion. They can be supported on 4 legs, or on 2 legs with a cantilever arm. The design with 4 legs, providing support at each corner, is more rigid, less easy to distort and can be fixed to the floor. In any design, the top of the table should be 71 cm from the floor.

The same basic design is available for mobile tables and the dimensions are the same. Mobile tables can also be supported on 4 legs with 4 wheels or on a double cantilever support, again with 4 wheels. The 4-leg pattern is preferable and is less liable to distortion.

Each wheel must be equipped with a simple but efficient brake which must be foot-operated by a simple mechanism. The wheels must be at least 5 cm in diameter and rubber-treaded.

Neither the fixed nor the mobile version should have cross-bars between the legs of the table so that there is free access beneath the table. Either can be provided with a tray which runs beneath the table top, designed to support the X-ray cassettes. Above the trays but below the table top there may be either a fixed or moving grid (see below).

Either design, fixed or mobile, is suitable for any variety of tube support. The "U" arm support requires a mobile patient-support for maximum efficiency but will not require a grid or tray under the trolley or table.
How are chest X-rays taken in the erect position? What is a "chest stand"?

With all designs of tube support (other than the "U" arm) a separate vertical cassette-holder is needed for chest radiography (see Fig. 15). Any design must meet four basic requirements:

- It must be strong enough to provide good support for the patient;
- It must be rigid and stable;
- It must hold a standard-sized cassette (for chests) and be adjustable in height;
- It must incorporate either a fixed grid or a moving grid and be able to carry the cassettes either in front or behind the grid; alternatively, it must accommodate a grid-cassette (see below).

FIG. 15. VERTICAL CASSETTE-HOLDER DESIGNS

Chest stands can be supported on the floor and steadied by a bracket to the wall. Many patients who have their chests X-rayed will be ill, insecure and unsteady on their feet and they will lean on the cassette-holder for support. It must be strong enough to support a load up to 50 kg without instability. Any such unit which is fastened to the wall must be installed with the actual cassette-holder far enough away from the wall to allow patients to wrap their arms around it and obtain the support they require. This can be achieved by a bar or additional wooden blocks as spacers between the cassette holder and the wall but, whatever method is used, fixation to the wall must be firm.

When a choice is available, choose a cassette stand which is supported by the floor and also fastened to the wall (Fig 15 A). Those which are mounted on the wall itself are the second-best choice (Fig. 15 C). The free-standing unit (Fig. 15 B) should not be chosen; it is insufficiently secure and movement may increase the radiation hazards.

Some of the chest cassette-holders permit movement of the cassette from the vertical into a horizontal position. This added facility is not required in a basic unit: it presupposes more technical knowledge than the average operator will gain. Moreover, it can only be used with a tube support which runs either on floor-and-ceiling rails or on a floor-rail and can move across the X-ray room to the chest stand. It increases complexity and is not recommended for basic installations.

The "U" arm tube support incorporates its own cassette-holder, used in the horizontal position for chest examinations. No separate wallstand is required and it has the advantage that the tube is permanently centred in exactly the right position and at exactly the right height and distance when the patient is in front of the chest cassette.
What is a grid?

When any X-ray beam passes through a patient, some of the X-rays are scattered in different directions; if these aberrant rays reach the film they spoil the image. A grid is a metal screen which will absorb almost all the scattered radiation. It is properly called a "secondary radiation grid".

Grids allow only the direct beams to reach the film and absorb the other, scattered radiation (see Fig. 16). They are made in various patterns based on the number of grid slots per cm and the thickness of the grid. They may either be flat or focused (curved with a standard radius, such as 1 m, 1.8 m, etc.). They can be incorporated in a "Bucky" mechanism which allows them to move sideways and blurs out their image during the exposure. This movement can be mechanically triggered or electronically released by the control button.

**FIG. 16. SCATTERING OF RADIATION:**
(A) WITHOUT A GRID, AND (B) WITH A GRID

A simple stationary grid is preferred in basic units. It does not need the complex mechanism required in a "Bucky" or moving grid.

When is a grid used? A secondary radiation grid is necessary when examining the abdomen, the skull, the spine, the pelvis, the thighs and large shoulders and knees. It can be used for chest X-rays, especially of large patients. Grids are never needed for the elbows, hands, or feet of any patient.

What sort of grid should be purchased? It is recommended that the grid have 30-40 lines per cm, 8:1 ratio and is focused at 140 cm. This is suitable for any examination at standard distances between 1 m and 1.8 m. If the "L" arm tube support is chosen, a fixed anode-film distance can be utilized and the grid should then be matched exactly to this distance. It must be the same size as the largest film, usually 35 x 43 cm.

All grids are delicate: if they are bent they become useless, and if they are dropped they are easily damaged. They should be supplied coated in plastic for protection, or as an integral part of a cassette. With proper care they will last for a number of years.

What X-ray tubes are available?

There are two basic types of X-ray tube: the stationary anode, and the rotating anode. Both are vacuum tubes.
The quality of the radiograph is influenced by the size of the focal spot of the X-ray tube and the speed with which the exposure is made. Both are inversely related to the ability of the tube to absorb and cool all the energy which is produced by the X-ray generator and transmitted from the cathode to the anode. The higher the power (i.e., the higher the mA.s and kV), the hotter the anode becomes and the larger the focal spot required to absorb the heat. A rotating anode is basically a spinning disc which utilizes only a rapidly changing segment of the periphery as its focus. It can absorb much more heat than a stationary anode tube.

A stationary anode tube is simple and rugged but has a low heat capacity: it therefore requires a larger focal spot, usually 2 x 2 mm or more to permit exposures in the 100 mA, 110 kV range. A rotating anode is far more complex but is much more efficient and can have a smaller focal spot, in the range of 0.8 x 0.8 mm, which produces a significantly better radiographic image. X-ray tubes can be supplied with a dual focus which may be of different or similar sizes. In a basic unit there is no advantage in having a tube with a double focus; modern X-ray tubes have a long life and, despite its increased cost and complexity, a rotating anode tube is recommended. In practice, a good modern rotating anode tube will exceed 50,000 exposures and will last many years under basic hospital conditions. The manufacturer should be asked to provide a guarantee for a minimum number of exposures, or some other such meaningful guarantee.

Every tube supplied should meet the International Commission on Radiation Protection (ICRP) and the International Electrotechnical Commission (IEC) standards for radiation and electrical protection.

**How can the X-ray tube be protected against accidental excessive exposure?**

The combination of milliamperage and seconds which can be used at any time with a given X-ray tube is restricted by the heat capacity of that tube. All generators and controls must therefore incorporate automatic tube protection. This must prevent overload either mechanically or electronically. Such an overload-preventing mechanism should not incorporate a fuse, which needs replacement, but an automatic contact-breaker, which can easily be reset. The majority of control units have a simple mechanical system which does not require resetting but prevents excessive exposure. This can be adjusted in the factory or by the service engineer to match the tube provided: the more complex tube-overload protection (which is available against too frequent exposures and resulting heat build-up) is quite unnecessary in basic care radiological facilities.

The exposure must never be made unless the anode of a rotating anode tube is rotating satisfactorily, usually at about 2800 rev/min. The control switch must therefore incorporate a protective mechanism which first starts the rotor of the anode and only permits exposure when the correct speed is reached. It is possible to incorporate an additional indicator light in the control panel showing that the tube is ready but this is not essential: a switch which prevents premature exposure is more desirable.

Tubes must be matched to the output of the X-ray generator: e.g., for an 11-kW generator the tube must have a permissible load of at least 11 kW at 0.1 second. All tubes in basic installations must have at least 2.5 mm aluminium total filtration (to harden the radiation), which must be permanently installed.

**What should the control panel indicate?**

There should be a clear indication on the control panel:

- That the machine is switched on;
- Of the time and mA settings or the mA.s;
- Of the kV setting;
- When X-rays are being generated;

- That there is sufficient charge available or that recharge is necessary (for a condenser or battery-powered unit);

- Recharging is taking place or has been completed (for a condenser or a battery-powered unit).

All this information should be indicated by positive settings on a dial or by positive meters or lights. A light that shows "off" when the unit is ready may be misleading because the bulb may be faulty. The light must be "on" to indicate positive information.

The button which controls the exposure of the X-ray unit must be an integral part of the control panel, so that there is no opportunity to expose from anywhere except behind the control area.

As already noted, a protective screen should be incorporated as part of the control unit.

What are the requirements for X-ray cables?

High-tension cables, connecting the X-ray tube to the X-ray generator, should meet all IEC specifications and should be suitable for the local climate, especially in the tropics. They must be shock-proof and should be of high quality: cheap cables are a false economy. The length required will depend on the room layout and the equipment chosen, but the cables must permit full movement of the X-ray tube. The supplier should be required to provide cables of the necessary length to ensure this. All the connexions (at either end of the high-tension cables) must be of standard design and interchangeable. Modern design allows the incorporation of the generator in the same housing as the tube (the "tank" combined unit). This eliminates high-tension cables and is ideal: however, such "tanks" may be heavy and only now are they being reduced to a reasonable size and weight. Improvements are likely in the future.

What are "cones" or "collimators"? Are they necessary?

As radiation exposure to patients, staff and other personnel should be kept to the minimum required for performing the radiological procedure, metal cones and adjustable shutters ("collimators") are fastened to X-ray tubes to limit the size of the beam and to reduce scattered radiation. A further advantage of these devices is to increase the quality of the resulting radiograph by limiting X-ray beams and confining them to the exact size and direction required.

All tubes for basic care installations should be supplied with either a cone or a collimator and preferably be of a design which makes them irremovable except by maintenance personnel. Cones are simple metal horns shaped so that the radiation exactly covers the standard cassette when the X-ray tube is the standard distance from the patient. Smaller cones can replace them for smaller cassette sizes. Unfortunately, the ability to change the cone will mean that occasionally it is not replaced, and films are taken without any beam limitation. One design allows the cone to stay in place and the diameter of the field is altered by changing a small diaphragm at the top (see Fig. 17): this is also liable to error. Neither method is as satisfactory as a collimator (Fig. 18), which can be either widely adjustable or provide two or three alternative standard field sizes. It cannot be removed from the tube: the "U" arm unit which utilizes a fixed distance allows the maximum protection because the same field size is required in any position of the tube or the patient, and the number of cassette sizes can be limited and matched to the available apertures.

Collimators in major X-ray departments incorporate multiple shutters and a light system coupled with mirrors which clearly defines the field size being used. These mechanisms are complex and can be inaccurate and troublesome; and the bulb may need to be replaced. They are not recommended for basic units. Choose simple cones or limited variable collimators matching the film sizes.
How is the X-ray tube aimed at the correct part of the patient?

Tubes fitted with cones provide self-evident direction: positioning the cone over the patient (the average cone is about 30 cm long) indicates the exact area which will be examined. Tubes fitted with a collimator should have a pointer which can swing out in front of the tube. Operators can easily be taught to "centre", using this pointer (see Fig. 18).

The collimators fitted with a light beam have already been discussed and because of their complexity and maintenance problems are not recommended.

11. X-RAY FILM EQUIPMENT

What size and pattern of cassettes should be chosen?

All X-ray films are used in cassettes which must be lightproof. Within the cassette are two fluorescent screens (see below) between which the film lies. These screens fluoresce when irradiated and the film is exposed by this fluorescent light from the screens. X-ray films therefore have emulsion on both sides.

Cassettes must be:
- Strong and rigid, without warp;
- Able to provide firm pressure and good contact between the film and both screens;
- Light-proof;
- Easily opened in the dark;
- Long-lasting.

Metal cassettes are recommended for basic units. They should last 5-7 years at least. Plastic cassettes are excellent but have not been used long enough, especially in tropical conditions, to be sure of their wearing qualities.

Good screen contact is best obtained in the type of cassette which has two sprung steel straps across the back, fastened centrally on to the back plate of each cassette and clipping under each side under tension (see Fig. 19).

This pattern provides the best and longest life with the best pressure application. The backs of the cassettes should be steel and provide built-in radiation protection. Each screen is mounted in the cassette on felt to absorb the pressure. Hinges should be of the long "piano hinge" design, running the full length of one side of the cassette. The alternative cassette with small hinges (as shown in Fig. 19) and single clip fasteners may not be so long lasting.
The only part of a cassette (other than the screens) which requires replacement is the felt padding, because this may become compressed, or destroyed by fungus or moth: it has a life of about 3 years and requires professional replacement, usually when the screens are changed (see below).

What are fluorescent screens?

Fluorescent screens are made of a backing, often a type of cardboard, coated with chemicals which fluoresce when exposed to X-rays. There is a front (patient side) and a back screen in each pair. There are many different chemical combinations but they fall into three basic categories:

- Fast or high-speed screens;
- Medium or standard screens;
- High-definition, "detail" or slow screens.

Unfortunately, manufacturers do not use the same terminology and a screen which is designated as "high-speed" by one company may equal a "medium-speed" from another manufacturer. Fast, or high-speed screens require less radiation to provide a satisfactory exposure but give less detail because they have a coarser grain. Medium screens provide good detail at moderate radiation levels: high-definition or slow screens give excellent detail with very fine grain but require much more radiation per exposure.

There is no indication for high-definition screens in a basic unit nor will the X-ray generator be adequate for their use. A fast or medium speed screen is required. All screens, films, cassettes, etc. should be standardized.

"Rare earth" screens are currently more expensive but provide more speed with moderate but satisfactory definition. If they are not too expensive, such screens are an excellent compromise for basic units but they are by no means essential. The less expensive medium or fast screens are entirely satisfactory.
All screens within cassettes are damaged by dirt, chemicals, handling, scratching, etc. They will need to be cleaned every month with a soft cloth and a little soapy water, and must be allowed to dry thoroughly before the cassette is reloaded (follow the manufacturer’s instructions). Under basic conditions, they should last 3-4 years; but they may then need replacement because once a screen is damaged a significant mark appears on the film which may either by misinterpreted as a pathological finding or obscure some abnormality in the patient. By this time, the felt padding will probably be compressed and also need replacement.

What films should be chosen?

The majority of X-ray films are polyester-based and this is recommended. They come in various speed categories: fast, standard, and slow.

In general, the faster the film, the less the definition: a standard, or medium-fast, film is recommended. Unfortunately, various manufacturers use different terminology to describe their products but a middle speed range should be requested. All these films are designed for use with screens and the actual combination of screen and film must be tested together. As was mentioned above, all films (and cassettes and screens) should be standardized for all basic units.

It is possible to expose X-ray films without screens, by direct radiation. The use of "nonscreen film" requires that the films be supplied and used in light-proof containers. The results provide excellent detail but a much longer exposure is required compared with the use of screens. Nonscreen techniques are of particular use for wrists, hands and feet but for little else. Such film can be utilized in a basic facility but this will depend on the skill of the operator, the amount and the character of the work. Nonscreen films are by no means essential; they provide an additional technical complication, necessitate additional supply requirements and may lead to the wrong exposure. If the unit is fortunate enough to have a qualified and skilled radiographic technician, they can be useful.

Every X-ray film can be damaged by heat or moisture and, of course, fogged by light or external radiation (which can penetrate the box).

How long can films be stored?

The life of X-ray film depends on storage conditions, particularly on temperature and humidity. Until films have been tested in a specific climate, the life cannot be estimated. Even under tropical conditions, good films should last for 6 months without appreciable deterioration. In less extreme climates, films may last a year. It is suggested that they are tested in the following way, before embarking on bulk purchasing.

Several boxes of films of different sizes should be obtained from the supplier and a few films taken from each box and exposed in a standard cassette, using a known exposure combination. The films should be processed in fresh chemicals under standard time and temperature conditions. The boxes should then be resealed and left on the shelf in the local storage office at the basic unit: further films from these boxes should be exposed after 3 months and then after 6 months, utilizing the same exposure factors and the same processing technique each time, with fresh chemicals. Comparison should then be made by the radiologist with the original "fresh" films.

Manufacturers can provide films in "tropical packs" with special interleaving and wrapping materials suitable for the excess heat and humidity. Smaller boxes containing 25 films are recommended although films of the large size (for chest) may be ordered in boxes of 50 sheets if the unit makes a sufficient number of examinations per week to provide a rapid turnover of film.

The manufacturers should indicate on each box the date the films were made. The delivery date and expiry date of the films should be stamped on every box when they reach the hospital. Unused films must be stored vertically (as books in a library) and not laid in boxes on top of each other, to avoid damage. Shelving must be allowed for this.
What sizes of films should be chosen?

There is a wide range of film sizes available but most are unnecessary in a basic facility. Two film sizes are all that are really required: a large (35 x 43 cm) and a medium size (24 x 30 cm). Cassettes must match the film sizes and this will simplify both darkroom practice and X-ray examinations, in addition to being less expensive (Fig. 20).

FIG. 20. SIZES OF FILMS AND CASSETTES REQUIRED

Can two exposures be made on the same film?

If one part of the film is covered with a piece of lead rubber, 0.5 mm lead-equivalent, then two exposures can be made of the same arm, hand or wrist, in different positions (e.g., antero-posterior and lateral) on one film. Three or four pieces of lead rubber, each 12 x 30 cm should be available in each department.

What equipment is required in the darkroom?

The darkroom will need a master processing tank, with two insert tanks for chemicals fitted within it. There will be a "dry" work-bench, safelights, film hangers, storage for films, a film marker and, if powdered chemicals are used, two auxiliary tanks or buckets for mixing, complete with mixing rods (mixing is usually performed outside the darkroom because of chemical fumes).

How are films processed?

There are basically two types of film processors: automatic processing, and processing by hand.

It is doubtful whether automatic processing is ever needed in a basic radiological facility; only if the hospital or clinic has 2 or 3 physicians and is X-raying more than 20-30 patients per day, has a good water supply and electrical supply, need such equipment be considered. Price is not the main limitation, but complexity; water and power needs are critical. An automatic processor requires regular maintenance and is economical only if a large number of films are being processed every day. There are many different sizes, capacities and makes. No unit will function satisfactorily if the ambient temperature of the water is wrong, if the water pressure is inadequate, or if there is much voltage fluctuation. The automatic processors do have the advantage of simplicity while working and give standardized results. They produce a complete, processed, dry film: however, careful studies
should be made of all factors before recommending such a complex machine in a rural installation.

Hand processing is the traditional way, particularly in basic facilities. The needs are less critical and it is more flexible. It is easy to teach and little maintenance is required. It produces a wet film which must be dried, and the process can give rise to film faults, but when there are less than 20 patients per day no other form of processing is justifiable.

What sort of processing tanks should be used? There are three alternatives for the master tank. It can be made:

- Locally of concrete;
- Of stainless steel;
- Of plastic.

The third alternative, plastic, should be disregarded. Currently, plastic tanks are cheap but they do not last, they warp, especially in the heat, and they are easily damaged. They are difficult to handle when full and are not recommended.

Locally manufactured concrete or cement makes a satisfactory tank: the inside should be smooth and the edge and the operating long side should be tiled outside if possible.

Commercially-made stainless steel tanks are preferable. They must be manufactured of special 18-gauge (1.8 mm) chemically resistant steel: any other stainless steel perforates in less than a year when used with X-ray chemicals. The correct steel is initially more expensive but lasts virtually forever (e.g., American Iron and Steel Institute type 316 or 317).

Fig. 21 provides the dimensions for a processing tank made of concrete or steel. The water supply should come in at one end, preferably with the control tap just above the tank. If the local climate gets sufficiently cold and if a hot water supply is available, this should be joined to the same inlet. The water should be allowed to run while the tank is in use, draining through an overflow pipe at the opposite end, as shown in Fig. 21. The taps must be positioned so that when films are lifted out of the tank they do not get in the way, i.e., they should not overhang the master tank.

The overflow drainage tube should be removable and the installation should be designed so that the water flows in from the end which contains the chemical insert tanks and leaves from the far end, the washing area.

What are the "chemical insert tanks" and what are they made of? Separate tanks are required within the master tank to hold the developer and fixer. As in the case of the master tank (see above), stainless steel of the highest quality for X-ray chemicals is the most economical material in the long run. If the master tank is made of concrete, the insert tanks can be steel or plastic but steel is preferable. The approximate size of the tanks is indicated in Fig. 21 but they must fit firmly into the master tank. Each must have a sloping base, running towards the drain plug. Each should be supported on the floor of the master tank and kept steady and in place by resting on the sides of the tank. They must be surrounded by water, up to the top rim.

All insert tanks must be large enough to contain standard size film hangers suitable for holding the large film size, 35 x 43 cm. Insert tanks of the type and size shown in Fig. 21 will hold 5-6 films simultaneously: the films will be in the developing insert tank for about 3-5 minutes at standard temperatures and in the subsequent "fixer" tank for twice as long. As the amount of work increases, additional fixing space will be required and a further insert tank should be purchased. The washing space shown in Fig. 21 will accommodate 30 or more films in hangers and usually allows a washing time of at least one hour. Running water is preferable, otherwise water must be changed at least every week.
FIG. 21. PROCESSING TANK

Is there any need for a wetting solution? There is no indication for the use of a wetting solution in basic facilities. It adds an additional complication, an extra tank and serves no useful purpose.

How is the water temperature controlled? It is seldom practical in a basic facility to cool an incoming water supply by refrigerator. Such a refrigerator requires a large electric power supply, is expensive to purchase and to use and has high maintenance needs. It is better to match the chemicals to the average ambient water temperature. X-ray chemicals can be provided in two standard ranges, originally designed for the temperatures of hand or automatic processing. The temperature ranges are:

65-75°F 18-24°C Standard chemicals
80-105°F 27-40.5°C Automatic processor chemicals

Within each range there is an optimum temperature, e.g., 20°C for the range 18-24°C, and this will require either 5 or 3.3 minutes developing depending on the chemicals used. The temperature should be measured with a simple thermometer whenever processing starts and a simple chart can provide the correct developing time, measured by a darkroom timer. For example, if 5 minutes are required at 20°C, then 4 minutes are required at 21°C and 6 minutes at 19°C. A scale for such time-temperature development can be produced for each temperature range and technicians can be taught to develop strictly following these charts.
In some countries the winter and summer temperatures may be so different that different chemicals are required at different times of the year; or there may be a considerable temperature drop at night and heating the chemicals may become necessary. In an emergency, this can be done by placing very hot water in a suitable container, such as a large glass bottle or hot-water bottle, and submerging it within the developer tank. The effect does not last, but it is suitable for occasional use. Only if the master tank has to be heated by the addition of hot water to cope with the X-ray films of a large number of patients should a hot water supply or an immersion heater be considered.

The provision of an extra water tank in the roof of the darkroom may serve to stabilize the water temperature in the processing tank and provides additional insulation. Of course, it adds weight and complicates the construction but, if feasible, it is a useful arrangement.

Electric immersion heaters especially designed for X-ray chemicals are available. X-ray chemicals destroy the casing of heaters very rapidly if a normal household immersion unit is used, so only the specially designed type is satisfactory. Its use presupposes a satisfactory continuous electrical supply in the darkroom.

Chemicals. As far as results are concerned there is little to choose between liquid or powdered chemicals. Cost and local conditions will be the deciding factors.

Liquid chemicals have the advantage that they are easy to mix, clean and efficient. They provide a standard solution with considerable accuracy and little possibility of error. However, they require a little more storage space than dry chemicals.

Powdered chemicals need thorough mixing and may require special buckets or plastic tanks and stirring rods kept for the purpose. The rods can be broom handles or other suitable sticks. The process produces unpleasant odours and mixing should take place outside the darkroom. Powdered chemicals should be delivered either in plastic or in tin containers. Paper bags are vulnerable if stored for any length of time.

Whichever alternative is chosen, chemicals should be delivered in bottles or packages so that the contents of each container are exactly correct for the size of the insert tanks being used. Preferably, one packet or bottle should provide sufficient chemicals for one tank, whether it be developer or fixer. Standardization prevents errors.

Finally, if cost permits, choose concentrated liquid chemicals.

How often do processing chemicals have to be changed? There is no difference in the average life of chemicals supplied as liquid concentrates or as powder. With average use (5-10 patients per day) the chemicals will need to be changed every month. In the interval they will need "topping up" with both developer and fixer, and a stock of both should be kept available (in large glass bottles with stoppers).

Once they have been mixed and are in solution, no chemicals are satisfactory after 6 weeks, even if they have not been used at all. This should be the maximum interval between changes.

Many companies offer a "replenisher", a solution which provides a proper balance as the chemicals are used. In practice this is a luxury: chemicals in small basic units can be kept filled by a simple replacement process, utilizing chemicals matching those in each tank. Supplying replenisher introduces yet another type of chemical and adds to the possibility of errors.

As already noted, wetting solutions have no place in the radiological facilities under discussion.
What is a dry workbench?

The "dry bench" is where cassettes are loaded with films and films are removed from cassettes after exposure. It is in the darkroom. The dry workbench is best situated under the cassette hatch, against the X-ray room wall (see Fig. 22).

**FIG. 22. DRY WORKBENCH**

The workbench needs to be 75 cm high, 130 cm long and 50 cm deep. The top must be smooth, either polished wood, vinyl (such as vinyl tiles), standard porcelain tiles or laminated plastic sheets. The colour of the top should be deep red or deep blue: light colours can cause film fogging. Beneath the work surface there should be one shelf with enough space to store X-ray film boxes standing side by side. This requires a 40 cm shelf height, and the shelf will need to be strong enough to carry a considerable weight.

What lights are needed in the darkroom?

Every darkroom needs one or two safelights with coloured filters which will not fog X-ray film exposed for a short period to the light they emit. Standard darkroom filter colours are the brown-red tones, made of glass. The X-ray film manufacturer's requirements for the filters should be followed. In particular, the maximum recommended wattage of the bulb within the safelight should never be exceeded. It is a common fault to utilize too bright a bulb, which both produces too much light (and thus causes film fogging) and also overheats the safelight and frequently cracks the glass of the filter. A cracked filter often causes fogged films and must be replaced or carefully taped with opaque covering.

What types of safelights are available? There are two basic patterns of safelights:

- Suspended indirect beam (see Fig. 23, type 1);

- Suspended direct beam, fastened to the wall (Fig.23, type 2) or the ceiling (Fig.23, type 3).
FIG. 23. TYPES OF SAFELIGHTS

Usually the direct beam safelight (types 2 and 3) is required directly above the working bench (the dry bench) and the second, central, indirect beam light (type 1) is required hanging from the ceiling. If an additional light is required close to the processing unit, it should be positioned above the chemical tanks but not in such a way that films can be held in front of it (to prevent visual processing, which requires much experience to be successful). Also, in this position it will not be hit when films are lifted out. Keep all safelights away from the tanks.

**How are films suspended in the chemicals?**

After films have been exposed, they are removed from the cassette in the darkroom and clipped into stainless steel hangers. There are basically two patterns: channel hangers; and clip hangers.

The pattern with the channel supporting the film always causes marks around the edge of the film and does not provide such good support. Films can drop out of the hanger when in the chemicals or when drying. These should not be chosen.

The clip-type hanger holds the films under tension. If it is made of high-quality stainless steel, it will last for many years.

**How many cassettes and film hangers should be supplied?**

A basic radiological facility X-raying 5-10 patients a day needs two, or at the most three, large cassettes (35 x 43 cm) and three, or at the most four, medium-sized cassettes (25 x 30 cm). One dozen hangers of each of the above sizes is recommended.

If it is known that the clinic will have days which are exceptionally busy - for example, when there is a routine chest clinic once a week during which 10-15 patients will be X-rayed - then the number of hangers must be doubled to at least 24 of each size. Hangers are relatively cheap and it is better to have too many than too few.

**How are films dried?**

Films can be dried in the darkroom, in electric dryers, or outside. Electric dryers require a considerable electrical supply and are not usually required in a basic unit until the number of films per day has increased considerably, at which point it may be better to buy an automatic processor. Electric dryers must be outside the darkroom and properly ventilated.

A standard drying rack (Fig. 24) can be easily manufactured and should be situated on the wall opposite the dry workbench, next to the "wet" tanks.
It should be made of two parallel rods, which may be of either wood, bronze or stainless steel. It must be at a height where it will not cause an obstruction. Below it on the floor there should be a tray or tank to catch the drips, or the floor beneath it should be easily drained and must be waterproof. Films will drip chemical residues even after washing and the surface or the tray should be capable of accepting chemical contamination. If the darkroom is too small to house the drying rack, it should be placed in a nearby room which is not too dusty, or else the films will be coated with dust and insects. Films can be dried by simple suspension with clips from an outside line, provided there is not too much dust.

How are cassettes transferred from the X-ray room to the darkroom?

The cassettes can simply be carried by the operator from the darkroom, in which case the two rooms should be adjoining. A simple cassette hatch is recommended, however, passing through the wall between the darkroom and the X-ray room. It serves as a safe storage for cassettes and increases efficiency. The doors of the cassette hatch which face into the X-ray room will have to have additional lead or equivalent protection.

Commercial cassette hatches are made of metal, have double doors and are divided internally into "in" and "out" compartments (Fig. 25). The doors interlock so that only one pair of doors can be opened at any time and no light can enter the darkroom. These cassette hatches are generally well made, but they are heavy, particularly with cassettes inside. Additional support is required on either side of the average wall.

Alternatively, a simple cassette hatch can be constructed locally (Fig. 26). A divided box (minimum internal height 40 cm) runs through the wall and at either end there is a counterweighted single door moving vertically. Above the box and parallel to it is a tube through which a brass rod can slide. Its movement is restricted to 3 to 4 cm either way. When either door is let down the rod protrudes at one end over the top of the door but allows the other door to be vertically lifted and thus opened. With the door lifted, the rod cannot be pushed back and the other door must remain shut. Only when the first door is closed can the rod be pushed through again and the other door opened. The doors must be wide enough to give good overlap of the divided box and must be lightproof. Counterweighting can be simple weights on pulleys. Additional protection on the X-ray side can be provided with 1 to 2 mm of lead rubber. The counterweighting will have to be adjusted to balance this.
Records and storage

How are films identified? Films can be marked with a name and, if necessary, the number of the patient by writing in pencil on them in the darkroom before they are processed. When they have been finished and dried the name can be rewritten in white over the pencil.

A quicker and more reliable way is to mark the films photographically so that the name appears in the corner of the film. Commercial film markers are available and the cassette must be adapted by shielding one corner to prevent exposure. The name of the patient is put on to transparent paper in the darkroom and inserted under the film, above the small light which flashes to make the photographic image.

The equipment is cheap and the process simple and as soon as more than 4-5 patients are being examined each day, a film marker becomes a useful item; it should be positioned at one end of the dry bench. However, it is a luxury and a pencil will suffice.
What is required in the storage and the office room? The third room in the basic radiological facility should be an office/storeroom which must be situated either next to or close to the X-ray room and the darkroom (as noted above in section 5). Its size is optional but should be at least 8 m² and preferably 10 m² or more. It will serve the following functions:

- A room in which X-rays can be checked and examined when processed;
- A room in which patients' X-ray records are kept;
- Storage room for X-ray films, both used and unused;
- Storage for chemicals and film envelopes;
- Storage for linen, gowns, etc.

The close proximity of this room to the main X-ray room and darkroom will allow doctors to examine their films other than in the darkroom or the X-ray room itself. A 3- or 4-panel fluorescent viewing box should be located above a table in the office and provided with a drip tray so that doctors may view both wet and dry films.

What records should be kept in an X-ray department? Some type of record should be kept of every patient examined. A simple daybook utilizing one line per patient, recording the name, the dates and the examination is essential. Where possible, a hospital number should be included.

Radiographs should be kept for 5 years, or longer if possible, and are best filed under the hospital number or alphabetically under the patient's name. Records do not need to be complicated: they should be kept because they provide not only patient reference but information indicating the number and type of examinations made each year (i.e., the amount and type of work done by the unit).

How should patients' films be stored? Completed X-ray films should be kept in film envelopes (packets). The envelope size is about 1-2 cm larger than the film size. This will be approximately 38/45 cm. No other size is needed. Shelves with adequate space must be installed in the storage room so that the films can be stacked in the vertical (library) pattern. Packets of exposed X-ray films are heavy and the shelves need to be strong, with internal support and division every 25 cm. They do not need to be solid: squared timber slats can be efficient. Strength is the deciding factor in the choice of material.

Where should unused X-ray films be stored? Unused films are best stored in the darkroom if there is enough space, with excess films in the office storage space. Wherever they are kept, the walls must be thick enough to prevent radiation fogging the films. They need to be above floor level, kept dry, stored vertically and in the coolest, darkest area. Each box must be dated with its delivery date and expiry date. Careful stock rotation is necessary to avoid keeping films too long and thus wasting them. A 3-months supply of film is normally sufficient, provided there are regular deliveries available from a central supply depot.

Similarly, a 3-months supply of processing chemicals should be kept in the office storage space, in plastic or tin containers. Paper chemical packets should be avoided. Chemicals may stand directly on the floor beneath the shelving, provided it is dry, but they must be kept away from the films to avoid damage. The storage life of chemicals is excellent under good conditions.
12. LOCATION OF EQUIPMENT

How should X-ray equipment be located in the X-ray room?

There are four basic principles in the layout of a diagnostic X-ray room:

- The X-ray tube should never point towards the control unit;
- The X-ray tube should never point towards the darkroom;
- The X-ray tube should never point towards any window or door; sometimes this is unavoidable, especially during a cross-table lateral view, but no one should be allowed to stand next to a door or a window when these films are being taken;
- The controls should be as far away as possible from the X-ray table.

The main radiation danger in any X-ray room is scattered radiation, because with proper cones or collimators (see section 11) the primary beam will be controlled. Radiation decreases in proportion to the square of the distance, and distance is the most important single factor in radiation protection.

The actual position of each item of equipment is dictated by the room size and the design of the equipment itself. The first item to be installed should be the chest cassette holder, which must be on the wall furthest from the darkroom. The patient support is then positioned in such a way that when the X-ray tube is immediately over the end of the table it is exactly 1.6 m from the film in the chest stand. This locates the table, which must be parallel with the long wall of the room. A line drawn down the centre of the table should be in exact alignment with a similar line drawn up the middle of the chest stand. A typical layout is shown in Fig. 27.

FIG. 27. LOCATION OF EQUIPMENT IN THE X-RAY ROOM

Normally, there will be a distance of about 60 cm between the tube support and the wall of the room. This will usually be the wall opposite the entrance door. In a standard-sized room this provides ample space to manoeuvre trolleys or wheelchairs or even beds around the X-ray table and under the X-ray tube. If tube rails are utilized they must be on the far side of the table, between the wall and the table. The space on the door side should remain free of any obstruction on the floor.

If the "U"-arm design is chosen, then it should be located with the tube in the horizontal position so that the cassette holder is close to the end wall of the X-ray room. This locates the whole unit, and the supporting column should be not more than 60 cm from the wall behind it. A "U"-arm unit may use a little less space than this and will usually have the column supported by horizontal brackets from the wall, reducing the space to 40 cm.
The X-ray generator and control should be as far away from the table as possible. The generator may be against an outside wall if it is a separate item. The control will be situated as close to the darkroom wall as is possible.

Such a layout satisfies the basic principles. The X-ray tube will always point away from the control area and the darkroom, and the distances will be as large as possible. Only the occasional horizontal view across the table will allow the tube to point towards the door.

How should the equipment be located in the darkroom?

The layout of the darkroom is dictated by the position of the X-ray room and by the entrance door or light-trap.

The dry workbench is best situated under the cassette hatch, against the X-ray room wall. Space permitting, it should not overlap the "wet" bench.

The processing unit will usually be on an outside wall to permit easy plumbing. Drainage from the master processing tank must be through porcelain or earthenware pipes or special-quality plastic pipes (standard metal pipes will leak after a few months because of the chemicals). The master tank will therefore stand a few centimetres away from the wall. The drying rack will be situated on the wall opposite the dry workbench. Tiling is not too expensive and is helpful behind the workbench and the drying rack. Fig. 28 shows the layout of a typical darkroom.

FIG. 28. LOCATION OF EQUIPMENT IN THE DARKROOM

A logical work sequence must be followed from the dry workbench, to the developer, to the intermediate rinse, to the fixing tank, and to the wash. The films then go to the drying rack. This sequence can be from left to right or from right to left.

The safelights in the darkroom should be situated so that one is over the dry workbench and the other is centrally located. They should be controlled by switches with pull-strings because the darkroom technician or operator may have wet hands. All the switches for this room must be inside the room and not outside. If used, the film marker should be on the dry bench. One white light on a different switch should be provided.

An additional safelight in the inner part of the light-trap entrance will help those who walk through. It should be able to be switched on from outside the entrance.

13. X-RAY UNIT STAFF

Is a qualified X-ray technician necessary?

The quality of work obtained from any unit is dependent on the operator more than the unit. The basic units, especially the "U"-arm and battery-operated combination, can be
utilized by relatively unskilled personnel to produce a series of standard X-ray views of good quality. Used by a skilled medical radiological technician the same unit will produce a much wider range of views and satisfy a greater need. The medical radiological technician must, however, be orientated (under basic facility conditions) to assume full responsibility not only for the radiographic positioning and exposure, but for processing, secretarial and clerical work, stores and records, cleaning the facility and basic care of the unit. If the medical radiological technician will accept this community responsibility, it will be of benefit to both patient and doctors. If no medical radiological technician is available, others can be trained as operators.

Who can be trained to operate simple radiological units?

There are two categories of employees who can be trained for radiographic work:

- Those who have previous medical and therefore anatomical knowledge;
- Those without previous medical knowledge.

Those who already have some medical training and a knowledge of anatomy (nurses, orderlies, aides) can usually be trained in 1-3 months to produce good standard X-ray films with almost any of the simple equipment described. Those who do not have previous training will have to be taught some anatomy and this may add an additional 6-8 weeks. A basic knowledge of skeletal anatomy and patient care is essential.

Where should training be undertaken?

To provide an adequate flow of work and supervision while learning, training is best carried out at a busy X-ray department. It is, however, essential that training be with equipment identical to that which will be installed in the basic radiological facility. Operators will have to learn each procedure step by step with pre-ordered positioning and techniques for each examination. They must follow fixed time-and-temperature processing and their training will only be successful if all the equipment used is exactly the same as that with which they will eventually work. Standard procedures can then be laid down and followed.

After completion of this central, basic, training, an experienced teacher-technician, who has been orientated to basic hospital needs, must be sent to the specific radiological facility to work with the trainee for a period of 2-3 weeks, supervising every aspect of day-to-day work. Such a visit serves the double purpose of completing the training of the individual and checking the equipment and the installation for satisfactory operation. It also permits the instructor to become familiar with any local variations, and when subsequent difficulties arise the inexperienced operator can telephone or send a written report asking for help from someone at the central department who knows the problems of that local facility. This may save a lengthy journey for a relatively minor problem.

How is the standard of work maintained?

Once training has been completed and the unit is working satisfactorily, it is still necessary that there be a regular visit, at least every 6 months, by a specifically trained supervisor to each facility. This will encourage and maintain standards, check work and equipment and continue the education of each individual. In the majority of such basic units the persons performing the radiography, e.g., a nurse or orderly, will have other duties which occupy rather more than half their time. As the radiological workload increases, this percentage may vary and a successful operator may wish to progress and assume more responsibility. Such a career structure with promotion possibilities should be encouraged.

Do physicians require special training?

Every physician who is to work in a basic care area should receive training, either when a medical student or after qualification, in the operation, the possibilities and limitations
of the standard X-ray equipment. He or she should know how it works, what it can and what it cannot do. Equally important, the physician should be trained to interpret the standard X-ray views and become familiar with them. Routine follow-up visits, preferably at least every 6 months, to each radiological facility by the area specialist radiologist are most valuable. Ideally, these visits should be at the same time as the supervising technician makes a visit, so that films can be reviewed for technique as well as the diagnoses discussed with the local practitioner. Continuing education and encouragement is a valuable investment. Isolation for either technician or physician encourages quite involuntary bad habits and perpetuates errors. Regular contact stimulates interest and renews expertise.

14. MAINTENANCE

What maintenance will be required?

This will depend very much on the equipment which is chosen, and whether it is battery-operated or run from a main power source (see section 9). The amount of work undertaken daily will also influence the maintenance problems. Many basic installations will need only a yearly service visit. The main sources of mechanical breakdown are loose screws and other simple mechanical defects which the local operator can prevent or rectify. Batteries need maintenance; tubes and switches are remarkably reliable. Timers, indicator lights and, occasionally, meters may need attention or replacement. After some years of operation contact breakers may become faulty, especially in tropical areas. Properly made equipment should, however, continue to produce X-ray films without much care or attention for many years. The operator can be taught simple maintenance such as lubrication of pulley wheels and moving parts, tightening screws, etc. This can be checked at each 6-monthly routine supervisory visit (see above).

How should a maintenance service be organized?

An equipment breakdown should lead to a telephone call or other communication to the area supervisor and central engineer. Often the fault can be identified over the phone. Inexperienced operators may make simple mistakes; they may even forget to turn on the main switch. A central maintenance depot is essential, carrying a supply of spare parts which will include, at least, the following: replacement tubes, cables, timers, contactors, bulbs, switches, circuit breakers, batteries and/or condensers.

The location of the service engineer and this stock of spares will depend entirely on the local terrain and transport difficulties.

15. WHAT IS THE GROWTH CAPABILITY OF A BASIC RADIOLOGICAL UNIT?

One complete X-ray facility (the X-ray room, darkroom and office/storeroom) can work 12 or more hours daily: its output is limited more by staff than by equipment. Simple equipment can perform 80% of all the radiographic procedures ever required in a basic care hospital (see section 2). The basic radiological unit does not provide fluoroscopy, because the physician concerned would need much extra training to make this a safe and productive procedure: fluoroscopy requires specialist skills. Gastrointestinal and vascular examinations are therefore not possible. Nor can such patients be managed in a basic clinic or hospital: they need referral. Utilizing appropriate contrast material, the basic unit could provide adequate examinations of the kidneys and the gallbladder. One such unit can therefore satisfy the radiological needs of 3 or 4 physicians but extra technical help will be needed as the work increases. When the workload exceeds 20 patients per day, an additional operator will be necessary. A darkroom technician may also help with the clerical work.

The growth of the hospital or the clinic does not necessarily mean new X-ray equipment: the increased work may mean that radiation protection needs checking. The basic radiological facility will provide a firm foundation on which the whole service of that hospital/clinic can expand.
EQUIPPING HOSPITALS AND OTHER HEALTH CARE FACILITIES IN DEVELOPING COUNTRIES

J. Cooper-Poole *

CONTENTS

1. Basic principles .......................................................... 127
2. Importance of suitable design brief .................................. 127
3. Importance of suitable operational policies and procedures .... 128
4. Importance of taking local conditions into consideration ....... 128
   Adequacy of fuel supplies, including electricity .................. 128
   Maintenance .............................................................. 129
   Operating staff ......................................................... 129
   Value for training ..................................................... 129
   Running costs .......................................................... 129
5. Preparation of equipment schedule ................................... 129
   Room loading sheet .................................................. 129
   Grouping of equipment .............................................. 130
   Equipment classification system .................................... 131
   Card index ................................................................... 131
   Consolidated schedule ................................................ 131
   Specifications and descriptions ...................................... 131
6. Purchasing programme .................................................... 131
7. Choice of suppliers ...................................................... 132
   Local manufacturers ................................................... 132
   Local importers .......................................................... 133
   The turnkey firms ....................................................... 133
   Direct purchase from foreign manufacturers ...................... 133
   Open or restricted tendering ........................................ 134
8. Importance of maintenance facilities ................................ 134
9. Spare parts .................................................................... 134
10. Inviting tenders .......................................................... 135

* Institute of Health, Ahmadu Bello University, Zaria, Nigeria.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Evaluation of tenders</td>
<td>135</td>
</tr>
<tr>
<td>12. Commissioning</td>
<td>136</td>
</tr>
<tr>
<td>13. Defects liability period</td>
<td>137</td>
</tr>
<tr>
<td>14. Conclusions</td>
<td>137</td>
</tr>
<tr>
<td>Appendix 1. Example of classification scheme for equipment in health service buildings</td>
<td>138</td>
</tr>
<tr>
<td>Appendix 2. Example of a typical purchasing programme in chart form</td>
<td>140</td>
</tr>
</tbody>
</table>
Because a substantial part of the cost of any building in which health services are provided consists of the cost of furniture and equipment, and because the provision of services of an acceptable standard depends on the right sort of equipment being available and maintained in good order, careful attention must be given to the equipping of any new health service building, whether it be a dispensary in a village or a national referral hospital. This paper aims to set out some of the considerations which should determine what equipment is bought and to describe the practical steps which need to be taken to ensure that the equipping of the hospital proceeds smoothly.

1. BASIC PRINCIPLES

The following fundamental principles should underlie the choice of equipment for all health service buildings whether in developed or developing countries:

- Reliance on mechanical or electrical equipment should be kept to the absolute minimum;

- All equipment should be the simplest which will carry out the function for which it is required;

- The equipment chosen should be that which requires the least amount of maintenance, and for which maintenance resources will be available locally.

These principles have been stated over and over again¹ and lip service is continually given to them. Yet because in practice they are so often ignored, no apology is offered for stating them again. As already mentioned, they are applicable to health service buildings anywhere in the world but particularly to those in developing countries where funds may be more limited, where there are very few skilled maintenance personnel and where, therefore, failure to observe them can easily render expensive buildings virtually useless in a short time. Moreover, since in developing countries there is a huge need for basic preventive health services, the decision to divert funds from them into the provision of expensive buildings and equipment which can only serve a relatively small part of the population is one which cannot be taken lightly; once taken, every effort must be made to ensure that the funds so diverted are spent wisely.

2. IMPORTANCE OF SUITABLE DESIGN BRIEF

If the planners of health service buildings are seriously determined to adhere to the principles set out above, they must start at the earliest design stage of the building and ensure that in the brief to the architects it is clearly stated that there must be the minimum reliance on mechanical equipment. This means, in particular, that full use should be made of natural ventilation; and air conditioning, if used at all, should only be installed in limited areas. It follows from this that "deep-plan" buildings should be avoided.

Similarly, the use of lifts should if possible be avoided and, therefore, the building should not be more than three storeys high, preferably less, and floors should be connected by gently sloping ramps as well as by staircases. Clearly, these two considerations of ventilation and lifts will have a profound effect on the general shape of the building.

Economy of equipment should be borne in mind when designing the layout of each department within the overall shape decided on. Division of departments into an unnecessarily large number of small rooms can result in duplication of equipment. For example, small offices for one person each tend to have waste-paper baskets, filing cabinets and telephones; these could be shared if two people shared the same office. If a delivery suite is designed with a number of individual delivery rooms, the tendency is to equip each one of them with an infant resuscitator, suction unit, baby scales, etc., which will be in use for only very short periods whereas, if the delivery beds were grouped together in large rooms, much of the equipment could be shared by several beds and big economies made. Similarly, the division of ward areas

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¹ See, for example, Richter, H. B. (1975) Planning and building of health care facilities in view of operational techniques: the supply system. World Hospitals, XI (No. 2 and 3): 124-128.
into single rooms or rooms containing only a few beds will lead to an increase in the total number of such items as suction machines and oxygen cylinder trolleys and will tend to make the provision of a nurse call system necessary. As a general rule, it is probably safe to say that the larger the number of rooms in a hospital the greater will be the amount of equipment and staff needed. Building costs will also be higher.

Once the general building shape which will need the minimum amount of mechanical equipment has been decided, careful consideration must be given to the type and extent of services required. Is it necessary to provide hot water? If so, to how many rooms? Is a patient-nurse call system necessary, and to how many beds and rooms? Will the patients understand how to use it anyway? Is piped suction necessary and, if so, to which areas? It may be easier to maintain a central piped system rather than a large number of portable suction units, but what happens if the central system breaks down?

In asking the architect and mechanical and electrical consultants to make this kind of critical appraisal of the services and equipment which should be built into the hospital, it should be recognized that because their fees are assessed as a percentage of the cost of the project it is not in their short-term interest to reduce services. If architect fees could be related to the extent of the patient facilities to be provided, for example, the number of beds or outpatient attendances, rather than to the cost of the project, it is possible that there would be a lot less broken-down equipment lying idle in over-designed buildings. The more responsible architects and mechanical and electrical consultants will, of course, cooperate fully in keeping buildings and services as simple as possible, but the client who is determined to adhere to these principles must always remain vigilant to ensure that his architect and consultants observe them and, in any case, must ensure that the architect and consultants are properly briefed from the start of the project. Consultants will tend to put in facilities unless told not to.

3. IMPORTANCE OF SUITABLE OPERATIONAL POLICIES AND PROCEDURES

At an early stage in the design of a project, decisions must be made as to the activities to be carried out in the building (operational policies) and the way in which these activities are to be performed (operational procedures). The operational procedures, in particular, will have a direct bearing on the type of equipment to be purchased. For example, the operational procedure for the linen services will establish the way in which clean linen will be distributed to the wards and hence the type of equipment needed to do it: either an enclosed trolley or boxes or bags carried on an open trolley. This procedure will also determine whether or not a linen-marking machine is needed.

Because the operational policies and procedures will have implications for the design of the hospital they should be prepared right at the start of the project. This ideal is not always realized in practice and it is not unknown for the person appointed to be responsible for commissioning a project to have to write the policies and procedures to fit a building which has already been nearly completed. Even if this is the case and proper coordination between architectural design and operational procedures is not possible, it is essential that there should be proper coordination between operational procedures and preparation of the equipment schedule.

4. IMPORTANCE OF TAKING LOCAL CONDITIONS INTO CONSIDERATION

It ought to be obvious that local conditions should be taken into consideration not only in the design but also in the equipping of any health service building. In practice, the factors which ought to be considered are sometimes ignored so it is worth stating some of them.

Adequacy of fuel supplies, including electricity

In the case of equipment needing fuel of some kind, is there an adequate and assured supply of the correct fuel at an economic cost? If not, equipment using a different fuel must be chosen or the process must be done, if at all, by some other means. Is the supply of fuel liable to be interrupted, for example, by political upheavals in a neighbouring country or the deterioration of roads during the rainy season?
Maintenance

There must be satisfactory arrangements for maintaining equipment. These include staff trained to repair and maintain each type of equipment, with tools and facilities for doing the repairs and access to spare parts. When choosing equipment from abroad, one of the major considerations should be whether or not the manufacturer has good agents in the country with trained personnel and stocks of spare parts. If it is unlikely that it will be possible to maintain a particular piece of equipment, then it should not be bought. If the equipment is not maintained, it will soon be useless, so why waste money buying it in the first place?

When considering maintenance and the supply of spare parts, thought should not only be given to the more complicated pieces of equipment but also to the simpler items such as trolleys and beds. An adequate supply of spare castors and someone to fit them will prevent the premature scrapping of these items, which happens all too often.

Operating staff

It is pointless to order complicated equipment if there will not be staff competent to operate it. This is a particular problem in the medical field where doctors may order some sophisticated piece of apparatus which they have seen in a teaching hospital abroad; they may understand it themselves but the actual day-to-day operation may be in the hands of staff who do not understand it.

Value for training

The equipment used in places where training courses are run must bear some relationship to the kind of equipment which the students will have to operate once they are trained. It is of little use training laboratory staff in the use of automated methods in a teaching hospital if after training they will be posted to a small rural hospital, perhaps even without a reliable electricity supply, where tests will have to be done by manual methods.

Running costs

There is no point in purchasing complicated equipment if there will not be enough money to run it. It is often fairly easy to find a donor for the capital cost of a project or piece of equipment, either at home or abroad, but it is usually much harder to find the running costs. Experience shows that the cost of running a new hospital is often much more than the cost of running an older one of the same size and so it is important, when considering a new project, that there is a real certainty that additional funds for running costs will be available.

Some pieces of equipment depend on special fluids or disposable accessories which have to be imported, and the cost of these can represent a significant increase in a hospital's running costs. If additional funds are not likely to be available, the new piece of equipment ought not to be bought or accepted.

5. PREPARATION OF EQUIPMENT SCHEDULE

The first step in equipping a new project, whether it be a very small one such as a rural dispensary or a very large one such as a national referral hospital, is to draw up a systematic schedule of all the equipment which will be needed.

Room loading sheet

A set of plans of the new building should be obtained from the architect to a scale of 1:100 or 1:50.\footnote{Editors' note: It should be noted that any equipment which may have an impact on architectural planning should already be mentioned in the brief.} Each room and corridor or other space on the plan should be numbered so that each room has a unique number. In buildings of more than one floor, the number should
indicate the floor as well as the room on the floor. For example, "Room 103" would indicate room 3 on level 1. The plan should show any services to be provided, such as sinks, electric sockets and piped gases.

A room loading sheet is prepared showing all the fixed and moveable equipment in each room. This will include items which would normally be kept in the room but which may be used elsewhere. For example, syringes might be listed in a treatment room even though they would often be used in other rooms. As far as possible, the equipment should be listed by groups (see below).

When making such a schedule, it is very easy to overlook items and if possible, a check list of some kind should be used. In any case, there should be full consultation with future users of the building to help ensure that nothing is forgotten.

**Grouping of equipment**

It is helpful to divide equipment into different categories according to who is going to be responsible for purchasing and procuring it. A useful classification is that used by the Department of Health and Social Security in the United Kingdom which is as follows:

**Group 1.** Items usually supplied and fixed by the contractor for the building works. These would include such items as wash-basins, electric lights, built-in cupboards.

**Group 2.** Items which are supplied by the health authority (client) and fixed by the main building contractor. These could include such things as wall-mounted thermometer holders and wall-mounted drug cupboards.

**Group 3.** Items having a significant effect on space or structural requirements which are supplied by the health authority and put in position by it independently of the building contract. These would include such things as beds, trolleys and free-standing cupboards.

**Group 4.** Small items of a kind usually kept in the hospital store such as linen, instruments, crockery, etc.

It is important to make some such classification as this in order to clarify who is responsible for the purchase and installation of each item of equipment. There can be some variation as to which group some items are included in, for example, a wall-mounted mirror could be in group 1 or group 2 or, perhaps, group 3 depending on the arrangements which are made for each project. Once the full equipment schedule has been prepared, each item in it should be assigned to its appropriate group.

In the case of larger projects, the preparation of room loading sheets and the listing of equipment in groups 1 and 2 is usually done by the architect in consultation with the client.

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1 This is now often part of the activity data sheet (see pp. 66-71 in: Kleczkowski, B. M. & Pibouleau, R. ed. *Approaches to planning and design of health care facilities in developing areas*, Geneva, World Health Organization, Vol. 1 (1976).

2 The series of *Health equipment notes* published by the Department of Health and Social Security in London and available from her Majesty's Stationery Office, 49 High Holborn, London WC1V 6HB, are very useful. There are notes on each department of the hospital. Obviously, in using the notes, it must be remembered that they are designed for buildings in the United Kingdom and suitable adjustments must be made for local conditions. There is a useful, short list for health centres adapted to conditions in developing countries in Appendix 19 of *A model health centre*, Conference of Missionary Societies in Great Britain and Ireland (1975), Edinburgh House, 2 Eaton Gate, London SW1W 9BL. This little book is a mine of useful and practical ideas on primary health care.
Equipment classification system

A good equipment classification and index system is a great help in the work of ordering equipment, particularly for larger projects. If the existing local system is considered inadequate, a new project is a good opportunity for the introduction of a better system. The object of the system should be to divide equipment into numbered classes and subclasses according to its function, and to give each item a number within its subclass. Thus, every item of equipment should have a unique classification number. An example of a classification system covering the equipment found in health service buildings is given in Appendix 1 below.

Card index

It is helpful to prepare a card index system of equipment based on the room schedules. For a major scheme it is worth while printing cards specially but for small schemes standard index cards can be used. A separate card is used for each item of equipment and it is helpful if the card is ruled so as to have lines and columns for each building and level of a project. From the room-by-room schedules the items are transferred to the appropriate item cards so that eventually the cards indicate the total number of each item required for the whole project and the number required for each building and level. This enables the correct numbers to be ordered and helps distribution to the proper place when the items arrive from the supplier.

Consolidated schedule

From the card index, it is a straightforward job to prepare a consolidated list following the classification and numbering system already worked out and listing the total number of each item required. This consolidated schedule will normally be used as the list against which tenders will be invited and, therefore, a large number of copies may be needed. It is helpful to include columns for the unit and total prices so that tenderers can simply enter the appropriate figures and return a copy of the schedule as their quotation. A copy of the consolidated schedule can be used to record the actual number of each item ordered, as this may sometimes differ from the number originally assessed. It can also be used to record the order numbers so that a readily accessible record of what has been ordered and what is outstanding is available. Alternatively or in addition, this information can be recorded on the index cards.

Specifications and descriptions

An advantage of compiling a card index following a suitable classification is that it helps to ensure that the descriptions and specifications of items are suitable and that there is as much standardization as possible. Once a description and specification has been decided, it is recorded for reference on the appropriate card. Specifications should be sufficiently detailed to ensure that suppliers tender for exactly what is required. As far as possible, the ordering of a variety of similar types of equipment to do the same job should be avoided. For example, it should be possible to have all dressing trolleys of one or at most two sizes and either all with glass or all with stainless steel shelves, preferably stainless steel because glass breaks so easily and is hard to replace. The smaller the range of items in use, the easier it is to keep a stock of spare parts that will be of wide use.

The kind of detail to be given in a description is illustrated, for example, by consideration of a dressing trolley. A minimum description should state whether the frame is to be of stainless steel or enamel finish, the number of shelves and the material of which they are to be made, the dimensions of the trolley, the size and type of castors and whether the tyres should be antistatic. Additionally, it might be stated whether a square or round section tubular frame is required, the size of tube and the type of fixing for the castors (expanding pin or screw fitting).

6. PURCHASING PROGRAMME

A purchasing programme should be worked out for each building project. The purpose of this is to ensure that the equipment arrives at the right time. The programme will depend on
delivery times, shipping times, availability of storage space and, in the case of equipment requiring fixing (groups 1 and 2), the dates when the building will be ready for the installation to commence. A good way to compile a simple programme is to list the various parts of the purchasing programme with the estimated time needed for each and then work backwards from the expected completion date of the building. It helps to convince colleagues and committees of the need for early action if the resulting programme is set out in chart form. It is important to allow enough time for the different parts of the process, making proper allowance for such things as the slowness of the post, delivery times from manufacturers, shipping times, time needed to clear goods through customs, time to ship them up country and time needed to process the orders through the office of whoever has to approve them; this last can take a considerable time. In a word, it is necessary to be able to make a realistic estimate of the time it takes to get things done in the place where the work is to be carried out. This time is often much longer than might be imagined. An important thing that a purchasing programme will highlight is the date by which storage space for the equipment must be available. Once this date is known, it is very important that steps are taken in good time to ensure that proper storage facilities are available. There are few more wasteful exercises than to go to all the trouble of ordering equipment, shipping it and getting it to site only to have it stolen or ruined by rain through lack of a proper store.

Another important date which can be worked out from the purchasing programme is the date by which any necessary stores staff need to be at their posts. In some cases, staff will already be available but if the project is a new hospital it may well be that it will be necessary to recruit and perhaps train a senior storekeeper and supporting staff. Another short programme can be made for this to show when the recruiting process needs to begin if the necessary staff are to be at their posts in time; this also can take a long time. An example of a purchasing programme in chart form is shown in Appendix 2.

7. CHOICE OF SUPPLIERS

Consideration must be given to the various sources of supply available and an assessment made of the advantage and disadvantage of each. The following are some possible sources.

Local manufacturers

Much of the equipment needed in a hospital is of a kind which can be manufactured in light engineering or carpentry workshops, such as are likely to be found in most developing countries. These workshops can manufacture most of a hospital's general and specialized furniture using wood and imported steel sheet, tube and castors. Trolleys, beds, drip stands, office furniture, examination couches and simple obstetric beds and operating tables can all be made in very simple workshops.

As a general rule, every effort should be made to locate possible manufacturers of hospital furniture within a country rather than buy from abroad. To manufacture as much as possible locally saves valuable foreign exchange and helps to provide employment. Other advantages of using local manufacturers include the probability of lower costs, freedom from problems of import and foreign exchange regulations, and the possibility of direct liaison with the manufacturer so that designs can be made or modified to suit particular requirements. Even if no current manufacturer of hospital furniture can be found, it may be possible to find a small engineering works which is willing to experiment with the manufacture of one or two of the simpler items. As experience is gained, the range made can be widened until a valuable industry has been developed.¹

¹ Designs for a bedside table and locker, ward screen, dressing and instrument trolley, wheelchair, drip stand and patients' trolley are available from Intermediate Technology Publications Limited, 9, King Street, London WC2E 8HN. Designs for a drip stand and labour ward bed and wheelchair and bicycle ambulance are given in King, M., ed. (1966) Medical care in developing countries, Nairobi, Oxford University Press, chapter 28.
Local importers

Even if full scope is given to local manufacture, there are many items which it will not be possible to make locally and which will have to be imported. It will therefore be necessary to find out what locally established importers there are and for what equipment they are agents. A careful distinction has to be made between the firms which are only interested in buying and selling goods of any kind as long as a profit can be made and the more specialized firms which hold agencies for overseas manufacturers and whose staff have received training in the maintenance of the equipment they sell. Unless a firm can show real evidence that it is able to provide a proper maintenance service for the goods it sells, it should not be seriously considered as a supplier.

An advantage of dealing with a locally based importing firm, whether it be locally owned or a direct subsidiary of a foreign company, is that the firm will be responsible for all the arrangements for shipping, insurance, customs clearance and transport to site. It should also be possible to pay the importer in local currency, avoiding the problems of remitting money abroad. A possible disadvantage of local importers is that they may add a very substantial margin to the f.o.b. price (this can be as much as 100% or even more) so that, even allowing for shipping and clearance charges, it may well be cheaper to deal directly with the manufacturer.

The turnkey firms

For larger projects, such as a big health centre or dispensary building programme and especially the larger hospitals, consideration will have to be given to the possibility of using the services or one of the firms which undertake to supply and install all the equipment needed as a package.

These firms will probably also be prepared to draw up a complete schedule of the equipment needed, working from the architect's drawings. Where a client does not have his own staff to undertake the basic scheduling and the work of ordering, importing and installing, such an arrangement has obvious attractions. None the less, care must be exercised in entering into such an arrangement. It must be remembered that the interests of a turnkey firm and those of a client are not the same; it is in the supplier's interest to sell as much expensive equipment as possible, whereas it is in the client's interest to buy the simplest equipment that will do the job he wants. If a turnkey firm prepares the equipment schedule, it may well include a lot of unnecessarily elaborate equipment and even equipment which is completely unsuited to the local climatic and working conditions; the client should scrutinize the list very carefully before accepting it. Another possible disadvantage of such firms is that they may have close ties with particular manufacturers whose equipment they supply, so that the client's freedom of choice may be reduced. This can be a problem where equipment of a particular kind to which staff are accustomed is already in use and for which servicing facilities are available whereas the turnkey firm wishes to supply equipment of a different kind. Care must also be taken by obtaining competitive quotations to ensure that the cost of a turnkey package is not significantly greater than would be the cost of buying from specialist manufacturers or their agents.

Direct purchase from foreign manufacturers

In some cases, it may be cheaper to purchase direct from foreign manufacturers. This is an especially attractive possibility in the case of equipment which does not need specialist installation or maintenance afterwards. Surgical instruments are an example of items which can be bought with advantage direct from foreign manufacturer, provided arrangements can be made for payment and customs clearance. The extent to which direct foreign purchases can be made with advantage will depend to some extent on whether or not the client can use the services of a reliable agent in the foreign country to contact manufacturers, invite quotations, evaluate the quality of goods, follow the progress of orders and arrange payment. Where the services of such an agent are available, it may well be advantageous to buy a considerable proportion of the imported equipment in this way rather than through local importers.
Open or restricted tendering

A decision will need to be made as to whether tenders will be invited by public advertisement or selectively. It is quite usual for financial regulations in the case of publicly financed projects to stipulate that tenders should be invited by public advertisement but this has the disadvantage that one may be faced with a great many tenders from small or inexperienced firms, and it can be very difficult to sort out which are the most suitable ones. The only way by which to restrict the tenders to suitable firms is to charge a fairly substantial nonrefundable tender fee, on the assumption that only the more serious firms will consider it worth while to tender.

In most cases, it is likely to be better to invite tenders from selected firms about which it has been possible to make satisfactory enquiries or which already have a record of proven reliability.

8. IMPORTANCE OF MAINTENANCE FACILITIES

The most important factor which should influence the choice of suppliers of equipment is whether or not proper maintenance arrangements can be made. This is even more important than the question of price; there is no point in buying a piece of equipment cheaply if after a few months it breaks down through lack of maintenance and lies idle indefinitely because there is no one to repair it. It is far wiser to pay a little more in the first place, if that is necessary, for equipment which can be maintained and kept running. It should not be regarded as bad practice or extravagant to accept a higher initial price if by so doing the risk of premature breakdown can be lessened; in fact, it is safe to assume that the price of good service may be a higher initial cost.

Before any prospective supplier can be considered a serious competitor, the client must take steps to ascertain what servicing facilities he can offer. It is not sufficient to accept the supplier's statement that he has proper servicing facilities and workshops; such assurances may not always be backed by reality. If possible, the client should visit the supplier's workshops and form his own opinion of their capacity. Another way of assessing a firm's reliability in providing service is to find out what other health or hospital projects have been supplied by the firm and to ascertain from the people working there what their experience is of the suitability of the equipment supplied by the firm and what kind of maintenance service the firm gives. The opportunity should be taken to ascertain how much equipment the firm has supplied; it is not unknown for a firm seeking business to claim that it had "equipped" a particular hospital whereas, in fact, it had only supplied a very few items. An interchange of information among health service staff can be most valuable in identifying which firms are reliable and which are not.

In the case of a local importer dealing in the equipment of a reliable overseas manufacturer, it is worth while to write to the manufacturer, asking him whether he is satisfied that the local importer can give an adequate service for his equipment.

An important factor to take into account is where the workshops of the servicing firm are based and how quickly they can be contacted and can reach the client in the case of a breakdown. The value of even the best of workshops and maintenance staff is reduced if they are 800 km away at the end of a telephone line that does not work and along roads that are liable to be washed out during the rains.

9. SPARE PARTS

A generous allowance for spare parts should be made in the equipment schedule, and adequate stocks should be ordered at the start. As each piece of equipment is listed, thought should be given to the spare parts it may need. For example, suction machines need a good stock of spare jars. In the case of larger equipment, it is a good idea to ask the firms tendering to recommend a list of spare parts and to quote for them.
10. INVITING TENDERS

The basis of the invitation to tender will be the consolidated equipment list. If
tenders are invited from turnkey firms which will be interested in supplying a substantial
part of the equipment, they can be sent the whole list. Firms which are specialist
manufacturers or suppliers of particular kinds of equipment need only be sent the relevant
pages of the list; this is one reason for arranging the list systematically by categories.

If the consolidated list has columns for the unit and total prices, firms invited to
tender can be sent two copies. They enter their tender price on both and return one,
retaining the other for reference. This means that all the tenders are in the same form
and makes comparison between them easier.

The equipment schedule sent to firms should be accompanied by a formal letter of
invitation to tender which either contains or is accompanied by a separate document
containing the terms to which suppliers will be expected to adhere. In the case of the
larger items of fixed equipment such as boilers or laundry machinery, a detailed specification
will be needed setting out the capacity of the machines required and their technical
characteristics as well as giving the tenderer information about the services such as water
and electricity which are available. The writing of a specification of this kind would
normally be done by a mechanical or electrical engineer.

The terms of supply should include conditions about the commissioning and servicing of
equipment. In particular, it should be made clear that any purchase is conditional on the
supplier providing not only user's manuals but spare parts lists and full repair manuals in
an appropriate language for all but the very simplest pieces of equipment. This is particu-
larly important where it is likely that major servicing and repairs will have to be
carried out by engineers who have not been trained by the supplying firm.

Terms should also be stated regarding the length of the guarantee period. Often this
is six months but in the case of a large project it may be possible to have this extended
to a year.

It must be stipulated in the invitation to tender that offers must be accompanied by
full descriptions and manufacturers' literature relating to the items offered. This is
essential in order that the tenders can be compared and in order to ensure that the items
offered are exactly what is required.

The invitation to tender must, of course, stipulate the closing date and time for the
receipt of tenders. Ample time should be allowed for tenders to be prepared and sent
by suppliers remembering that, in some cases, local firms will have to consult their
principals abroad to obtain prices. A period of 3-4 months is probably reasonable in most
cases. If all the firms invited to tender are based locally and communications are good,
the period can be reduced.

11. EVALUATION OF TENDERS

The task of comparing and evaluating tenders can be a lengthy one. It is necessary to
construct a schedule based on the equipment list which enables the prices quoted by the different
firms to be compared item by item. It is also necessary to compare the terms of delivery
quoted by the different firms and to note whether f.o.b. (free on board) or c.i.f. (carriage,
insurance and freight) prices are quoted (the invitation to tender should stipulate which
is required); it may be also necessary to convert prices to a common currency. The task of
comparing tenders is made easier if there are not too many tenders for each category of
equipment and this is another reason for preferring selective to open tender. To have more
than 6 or 10 tenders for each category merely complicates the task of evaluation and
comparison without obtaining any significant advantage of price or delivery, provided the
tenderers invited have been carefully chosen.
As well as comparing the tenders from the point of view of price and delivery time, an evaluation must be made covering at least the following points:

- Reliability of the tendering firms and their capacity to supply;
- Ability of the tendering firms to provide a satisfactory maintenance service;
- Quality of the goods offered, and suitability to local conditions.

The investigations made before selecting firms to be invited to tender will be of great help in evaluating the first two points.

The tenders should all be numbered and kept carefully, because they and the manufacturers' literature which accompanies them will prove to be of great value when the time comes to order replacements or spare parts for the equipment initially ordered. Prices will presumably have changed but the information the literature contains regarding addresses of firms and catalogue numbers etc. will be of use.

An assessment of quality depends to a large extent on a knowledge of the equipment offered, which is why it is essential to ensure that the firms give full details of what they are offering, including the name of the manufacturer. In some cases, it is appropriate to ask for samples, for example, of plastic goods, linens and glassware, and it may be possible to have these and other samples tested by specialized testing institutions, which will be able to report on the quality and performance of the samples submitted to them and also to give an opinion as to which constitutes the best value for money.

In the case of items manufactured locally, such as furniture, every opportunity should be taken to inspect samples of the products offered.

The arrangements for ordering, receiving and distributing the equipment should be worked out well in advance. If an existing ordering and documentation system is to be used, it must be examined carefully to make sure that it is really suitable for dealing with the equipment of perhaps a large project. Responsibilities must be clearly allocated among the various officers concerned, who must be fully conversant with the procedure to be followed well before the equipment starts to arrive. It is no good waiting until a pile of crates has arrived in store before deciding how receipts are to be recorded or who is to be responsible for opening and checking the goods. Unless ample preparations are made in advance, it is inevitable that goods will be misplaced and all kinds of difficulties will arise with suppliers over payments and suspected missing or damaged items. If the project is large and the staff are relatively new or inexperienced, it is a good idea to have a dummy run to practise the procedure before equipment actually begins to arrive. This should help to ensure, for example, that the documentation is adequate and that the necessary people receive the information they need. It is essential to work out exactly where and how the equipment will be stored as it is received, pending distribution. It is also important to ensure that the necessary tools are available for opening boxes and that arrangements are made for disposing of packing materials.

12. COMMISSIONING

Once equipment of any mechanical or electrical complexity has been installed, it must be fully tested and formally handed over to the user. Ideally, the client should be represented not only by the person who is going to use the equipment but by an experienced engineer who is qualified to understand the working of the equipment thoroughly and to notice any defects in manufacture or installation. All defects noted must be recorded. An essential feature of the commissioning process which should be written into the terms of contract with the supplier is that the supplier should provide full training for all staff concerned in the use and routine maintenance of the equipment. Only when the client is satisfied that the equipment is fully operational and that his staff have been trained to operate it, is the equipment accepted and formally handed over. A proper record should be
kept of the handover, usually in the form of a certificate signed by the supplier and the
purchaser. At the time of handover of the equipment, the supplier will also be expected to
hand over the full maintenance manuals and spare parts lists, as well as all spare parts
ordered with the equipment.¹

13. DEFECTS LIABILITY PERIOD

The hospital engineer or the client's engineer responsible for maintenance should have a
system of recording the history of each piece of mechanical or electrical equipment. On this
should be noted all servicing carried out and all breakdowns and repairs. Such a record
is important in establishing claims against the supplier during the defects liability or
guarantee period.

14. CONCLUSIONS

Strong emphasis must be given to ensuring that the equipment installed in health service
buildings is suitable. In the case of developing countries, in particular, this means that
the amount of complicated equipment should be kept to the absolute minimum in order to
minimize capital cost, running cost and maintenance problems. This concept should be part
of the design brief of all health service buildings from the start and should be fully
reflected in the designs produced by architects.

Schedules of all equipment required must be drawn up systematically and must be based
on good systems of classification and cataloguing. The preparation of proper schedules
helps to ensure that there is as much standardization as possible and no unnecessary
duplication.

All possible sources for the supply of equipment should be investigated so that
reliability and capacity may be assessed. Purchasing arrangements should be such that
equipment is only ordered from suppliers of proven reliability. Adequate arrangements
for servicing and the supply of spare parts should be incorporated in all purchasing
contracts.

¹ Commissioning hospital building published in 1975 by King Edward's Hospital Fund for
London, 14 Palace Court Road, London W2 4HT, is a useful guide to the commissioning of
hospital buildings, and contains a list of the many tasks which have to be undertaken as part
of the commissioning process. A series of Commissioning manuals covering the major
mechanical and electrical installations of a hospital is published by Her Majesty's
Stationery office, 49 High Holborn, London WC1V 6HB. These give detailed guidance and a
check-list of the points to be covered when commissioning particular types of plant and are
of particular use to the engineer who takes over the mechanical and electrical services on
behalf of a hospital authority.
Appendix 1

EXAMPLE OF CLASSIFICATION SYSTEM FOR EQUIPMENT IN HEALTH SERVICE BUILDINGS

The following is a suggested classification of the equipment likely to be found in health service buildings. It does not cover consumable items such as cleaning materials, stationery, drugs, etc. for which separate headings could be created if so desired. The numbers of classes and subclasses do not follow consecutively so that there is ample opportunity to add new classes or subclasses within the general scheme.

Every item would be described by a 4-figure class and subclass number, followed by a 3- or 4-figure item number; thus an artery forceps might be 6505.001.

39. Materials handling equipment
   3900 Materials handling: trolleys and conveyors

41. Refrigeration, air conditioning and circulation equipment
   4110 Refrigeration equipment
   4112 Air circulation equipment

62. Lighting fixtures and lamps
   6230 Electric, portable and hand lighting equipment

65. Medical, dental and veterinary equipment and supplies
   6505 Medical and surgical instruments
   6510 Medical and surgical equipment
   6520 Medical and surgical sundries and supplies
   6525 Mortuary equipment, instruments and supplies
   6530 X-ray equipment and supplies
   6535 Hospital furniture
   6540 Sterilizers
   6545 Utensils and stainless steelware
   6550 Hospital and surgical clothing and linen
   6555 Staff uniforms

66. Instruments and laboratory equipment
   6640 Laboratory equipment and supplies
   6650 Laboratory glassware
   6660 Time-measuring instruments
   6670 Optical instruments
   6680 Scales and balances

69. Educational equipment
   6910 Training aids

71. Furniture
   7105 Household furniture
   7110 Office furniture
   7125 Cabinets, lockers and bins
   7126 Miscellaneous fixtures
73. **Food preparation and serving equipment**
   7310 Food cooking, baking and serving equipment
   7320 Kitchen furniture and appliances
   7330 Cutlery and plateware
   7350 Tableware and crockery

74. **Office machines, visible record and data processing equipment**
   7420 Accounting and calculating machines
   7430 Typewriter and office type-composing machines
   7450 Office recording and reprographic equipment
   7460 Visible record equipment

79. **Cleaning equipment and supplies**
   7910 Floor polishers and vacuum cleaning equipment
   7920 Brooms, brushes, mops and sponges
### Appendix 2

**EXAMPLE OF A TYPICAL PURCHASING PROGRAMME IN CHART FORM**

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USE OF MOBILE AND TRANSPORTABLE HEALTH FACILITIES IN DEVELOPING COUNTRIES

M. Torfs

CONTENTS

1. Introduction ........................................................................................................ 142
2. Conditions for use of health facilities .............................................................. 142
3. Mobile or transportable facilities .................................................................... 143
   Non-permanent transportable hospitals ............................................................. 143
   Mobile health centres or dispensaries ............................................................... 143
   Groups of mobile facilities .............................................................................. 144
   Flying-doctor health services .......................................................................... 144
   Ships or boats ................................................................................................. 145
4. Possible uses and limitations ............................................................................ 145
   Mobile hospitals ............................................................................................. 145
   Mobile units: single or in groups .................................................................... 145
   Flying-doctor services .................................................................................... 146
   Ships or boats ................................................................................................. 147
5. Cost considerations ............................................................................................ 147
6. Conclusions ....................................................................................................... 147
7. Bibliography ...................................................................................................... 149

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1. INTRODUCTION

The balanced distribution of health services (even elementary ones) and, in particular, of those directly involved with medical care has proved difficult throughout the history of medicine. This has resulted in incomplete and insufficient coverage of the population. Financial and managerial considerations are very often coupled with accessibility problems and feasibility difficulties.

Apart from the capital investment and high level of recurrent expenses which limit the number of facilities, the systematic multiplication of static health facilities (rural hospitals, health centres, dispensaries and health posts) does not necessarily constitute an answer to the question of how to serve more people with better or more effective services, be it in urban socially deprived areas or in rural settings. Existing road networks are not necessarily appropriate and access to populations can be poor, difficult or, even, impossible (within reasonable time limits) owing to geographical and environmental difficulties. Moreover, populations may well be traditionally scattered or nomadic, rather than being concentrated in hamlets or villages. Water supply may be difficult. Usually, the building of static health facilities has been related to: the density of the local population; willingness to utilize the health facilities; relatively easy access (not exceeding 5-15 km, depending on the country); the availability of staff sufficiently qualified to deal with or screen for local morbidity conditions and able to treat patients or refer them when needed to higher or better equipped echelons; and the availability of equipment, supplies, drugs and disposables adapted and suitable to combat the main diseases plaguing local communities.

In many developing countries, the proportion of the population covered by static health facilities does not exceed 20-25%. As these facilities are mostly concentrated in urban areas, it is evident that the problem of providing health care to the majority of the population living in rural areas, who are grossly underserved or even not served at all by modern health services even in their most rudimentary form, is immense. National health authorities, fully aware of their responsibilities for health protection, have used and are still trying to use the new means developed by technological progress to serve a greater proportion of the population. The number of static health facilities could be multiplied if enough staff, equipment and financial means were available; but, so far, such means are not available and they will not be for many years to come.

During the past two decades, countries - sometimes with the assistance of various international health organizations - have been trying to improve this situation either by developing their basic health services or by expanding their health care delivery systems through the enhancement of primary health care structures wherein the structure of the community prevails. Both solutions are still being implemented and in both a close cooperation ought to be established between the community (consumers) and the existing health services (providers). As has been recognized throughout the world, the proper functioning of these health services implies appropriate supervision and proper technical, managerial and logistic support.

2. CONDITIONS FOR USE OF HEALTH FACILITIES

As a general rule, health facilities (mobile or static) are utilized by the local population when they deal satisfactorily with felt or real health needs. Satisfactory service not only implies competent and disciplined professional or auxiliary staff and adequate equipment and supplies, but also the organization of services based upon acceptability, compatibility, regularity and effectiveness in terms of prevailing conditions, including the availability of drugs and the opportunity for treatment. As pointed out by Gish & Walker (1977), it is important to establish to what extent diagnosis and treatment are efficacious after a single contact or whether several contacts are necessary to treat and cure the patient. According to these authors' findings, only slightly over one-tenth of all patients are satisfactorily treated after one contact with a mobile team. In general, the qualities listed above should apply to both static and mobile facilities. It is evident that completely different criteria apply to disaster conditions (war, earthquake, flood) where there are a proliferation of emergency cases and where conditions tending to produce epidemics increase the morbidity and mortality risks.
3. MOBILE OR TRANSPORTABLE FACILITIES

Apart from the mobile facilities under consideration here, it is worth mentioning the small mobile units specifically constituted for epidemiological surveys and mass immunization campaigns. To some extent, the activities of these teams include elementary curative medicine and they have at their disposal some drugs for the treatment of common local diseases. These mobile teams (using car, boat, bicycle, horseback or camel as their means of transport) have as their main objective the control of one or more specific communicable diseases through detection, prevention (immunization) and treatment (including the tracing of defaulters). Their stay in a village, a community or a hamlet is limited in time (to a few hours or some days) according to their work schedule, based upon administrative and technical constraints. Their visits depend on local accessibility conditions (for example, a maximum of one to two visits per year in remote areas) and on the availability of sufficient financial resources. The curative impact of these teams is therefore very limited indeed.

The mobile and transportable health facilities with which this paper is concerned are better equipped and have more time at their disposal than the mobile units mentioned above. In general, they take the form of:

- Transportable hospitals, using tents, prefabricated materials or trailers;
- Mobile health centres or dispensaries;
- Aeroplanes, i.e., flying-doctor services;
- Ships or boats (floating hospitals, health centres or dispensaries).

These four categories of facilities are considered below.

**Non-permanent transportable hospitals**

This type of hospital is set up in tents, prefabricated buildings or trailers and is used very successfully to deal with emergencies or disasters (e.g., war, earthquake and flood). The hospital equipment is relatively light, easy to transport and fairly resistant to rough climatic conditions. The life expectancy of such a hospital is, by definition, short. If it is decided that the hospital is to remain for more than a few months, tents have to be replaced by more resistant structures such as prefabricated huts, shelters made of locally available materials (wood, stone, etc.) or trailers in which patients can be hospitalized, operated on or treated. These facilities generally include an operating theatre, X-ray unit, biological laboratory and pharmacy, as well as a kitchen for the preparation of food. The facilities are never permanent and, as environmental conditions improve, are either removed or destroyed, as they cannot be used for other purposes.

Experiments have been carried out employing mobile or transportable facilities for non-emergency use. Projects ranged from the erection of a complex hospital able to encompass a whole range of activities such as consultations, surgical care, obstetrics etc. to the provision of equipment to be used in existent buildings, usually for a single purpose such as ophthalmology or sterilization of males in family planning programmes.

It is clear that, before introducing such types of services, due consideration should be given, on one hand, to the comprehensiveness, appropriateness and cost-effectiveness of these mobile facilities as well as to the possibility of permanent delivery of their supporting services, and, on the other hand, to the appropriateness of the physical environment and to the availability of proper hygienic and technical conditions compatible with the activities to be undertaken (e.g., for sterilization).

**Mobile health centres or dispensaries**

Huge trailers have been built and equipped to deliver health services to people living in remote areas. They often include complete dental equipment, elementary X-ray equipment with a laboratory attached, a consultation room which can quite easily be transformed into an operating theatre, equipment and supplies for diagnostic purposes (microscope, ECG apparatus), supplies for treatment (drugs, bandages, etc.) and accommodation room for the staff.
These heavy trailers have to be pulled into position and can usually only be used in areas where good road and bridge connexions exist and are passable throughout the year, i.e., where the most remote places can be reached relatively easily. These conditions only exist in developed countries. In developing countries, this type of facility is generally ill-adapted to local conditions. Its use is limited to areas with permanent roads and bridges, usually located in the vicinity of large cities, where health facilities are already concentrated. The activities carried out by the staff of such units, though mainly centred on curative medicine, could quite easily cover the whole range of actions implied by the delivery of comprehensive health care (promotion, preventive, disability control, rehabilitation and treatment).

Groups of mobile facilities

These are an alternative to the mobile health centres described above. In the late 1960s, an experiment was undertaken in one African country in the use of groups of mobile facilities. Two groups were formed, each based in a major city. The groups were composed of 11 and 15 vehicles, respectively, and designated for large-scale health screening and health education campaigns, including some curative activities. Each lorry constituted a particular unit, equipped with the necessary instruments: a health laboratory, an X-ray unit, an outpatient department, an operating theatre, a registration office, a pharmacy, etc. It quickly appeared that moving such a large column of lorries was an extremely difficult undertaking under the prevailing sahelian conditions. As the mobility of the column was restricted by the necessity of avoiding settling in the sand or in the mud, the population had to be gathered and brought to the place where the column was stationed, thus creating a sizeable transport problem. Light motorcars had to go and fetch people and then drive them back after they had been examined. The experiment showed that only an estimated 300 000 persons would be examined per year and that the whole population of the country (3 000 000) would only be seen by medical staff once every 10 years, using such mobile facilities. This experiment turned out to be a failure and, after a few years, the groups of lorries and equipment were broken down into smaller and lighter units or into permanent static dispensaries or aid posts when no reduction could be realized in an appropriate and effective manner.

Flying-doctor health services

Advances in aeroplane design have led to the greatly increased use (e.g., in Papua New Guinea, the southern Pacific area and East African countries) of light aircraft to provide health services. These small aeroplanes are easy to land and take off and a number of runways have been built, more or less covering the areas to be served. The aeroplanes are usually equipped with two-way radio systems, allowing for the fast communication of alarm, advice or guidance.

A nurse serving a remote population can, in case of emergency, call the medical base for advice and initiate treatment of the patient following the instructions of the doctor. Further exchange of information may make the doctor decide to fly to the place in order to examine the patient and to take a decision related to diagnosis, treatment or referral to the base hospital. In the meantime, equipment, drugs and disposables can be delivered to the health post or centre if the need arises. This type of facility can deliver health care fast. It is, however, expensive (in terms of capital, recurrent and maintenance costs) and requires an extensive network of runways located as close as possible to the aid posts or health centres whose catchment areas do not usually exceed 10-15 km, according to local conditions.

The objective of a flying-doctor health service can only be curative and oriented to the individual patient. As such, the service constitutes an efficient linkage between remote areas, aid posts and hospital services. It cannot be used for community-based comprehensive primary health care services delivery although it can provide support and supervision to primary health care services. Flying-doctor services can be of use in expanded immunization programmes when the geographical and demographic conditions are favourable but are less effective when, for example, the accessibility of communities is difficult or population movements are too great. The provider of care should do his utmost to motivate the population
to use his services, as this will help him to a considerable extent. He must, nevertheless, always adapt to specific local conditions (acceptability of type of services, periodicity of markets, routes followed by nomads, taboos, etc.).

Ships or boats

Ships or boats have also been, and still are, used as floating dispensaries or floating hospitals. Their coverage possibilities are strictly subject to the water level and, thus, may depend on seasonal changes. According to their type, they can give access to some areas where an aeroplane cannot land and which a car cannot reach, e.g., swampy areas. Used as dispensaries with outpatient facilities, they may attract isolated communities living on the riverside and allow preventive activities, such as immunization and health education, to be undertaken, provided that regularity and continuation of services is maintained, e.g., once a week or twice a month.

Unless anchored for a given period at a fixed place, floating hospitals are hardly justified and play the same role as that of temporary hospitals discussed above. When moving regularly, they easily become mobile hotels where patients remain, waiting for repatriation. As for the flying-doctor services, their capital, recurrent and maintenance expenses are very high. Their main purpose is once again oriented towards the delivery of curative services.

4. POSSIBLE USES AND LIMITATIONS

Mobile hospitals

Emergency field hospitals are health facilities in which units can be organized to provide comprehensive care in accordance with the needs dictated by circumstances. The local population can be vaccinated to prevent epidemics of communicable diseases which may occur because of the deterioration of conditions of hygiene (for example, due to garbage accumulation, water and food pollution, putrefying corpses of human beings and animals). The population served by emergency field hospitals is limited to those living or working in the devastated areas. The hospital may also provide curative and disability control measures, according to local needs. Clinics for ambulatory patients may also be set up. The life of such field hospitals is limited; if they have to be maintained for extended periods, they should be replaced by shelters constructed from more resistant material in order to provide bearable living conditions for any inpatients waiting for referral. These field hospitals cannot become permanent mobile facilities, since their objective is primarily to face emergency situations and not to deal with day-to-day morbidity and mortality risks.

Although the capital costs of these mobile hospitals may not be as high as those of a permanent building, their running costs are very high. Their effectiveness is conditional upon: the availability of adequate means of transport; helpful environmental conditions (such as the availability of drinking water); the provision of acceptable working conditions (protection from wind, rain, heat, cold, etc.); and the availability of adequate manpower. It should be noted that auxiliary, maintenance and technical manpower requirements are high, owing to the particular conditions under which the field hospitals function. The maintenance of these facilities and of their equipment constitutes not only a problem of cost and of manpower but also of management and supervision.

Mobile units: single or in groups

At present, the effectiveness of permanent, single or groups of mobile units in developing countries is reduced as it is subject not only to the periodicity of village activities, the existence of a good road network and the accessibility of places where people can easily congregate, but also to the adaptation of such units to environmental and sociological conditions. For marketing reasons, these units have been conceived in accordance with conditions such as those found in developed Western countries and therefore do not render, in developing countries, the services which they are expected to deliver. Acceptance and utilization by the local population and the willingness of the local administration to collaborate also constitute potential bottlenecks. These units are
potentially able to deliver comprehensive health care, provided that appropriate solutions are found to the above-mentioned difficulties, as well as to the managerial and financial problems.

The basic idea of bringing health care facilities closer to remotely populated areas deserves encouragement. Mobile units provide support for village health workers (where they exist) as well as guidance, supervision, the possibility of referral, drugs and disposables, and contact with the communities. Before any programme is launched for the establishment of mobile health units, an in-depth study should be made of how the units can be adequately adapted to local conditions. Factors to be considered include: feasibility limits for transporting the units; the actual or felt needs of the population to be served; and the financial burden of the undertaking.

Save in exceptional circumstances, these units should not undertake any kind of major surgery due to the risks involved and the lack of follow-up. Preference should always be given to the referral of patients to better equipped and staffed facilities where drugs and disposables are available permanently. Another constraint affecting this mobile type of health care facility in developing country conditions is its limited autonomy in terms of fuel and spare parts. Although there is validity in the concept of mobile health units for use in developing countries, serious thinking and decision-making are required to ensure that these units respond to the health needs of local populations, that appropriate technology is applied in view of day-to-day conditions and that the units can provide adequate screening for referral to the central hospital. A realistic choice of the functions to be carried out locally will limit the size of the vehicle and the size of the mobile health team, and at the same time allow space for the equipment and drugs needed to deal with common priority conditions. Experience has shown that lighter four-wheel-drive vehicles are much more efficient and easier to handle and maintain. Obviously, mobile services should be an integrated part of the existing health system and their activities, including maintenance, should be properly programmed.

The bases for mobile units should be carefully located. They should be decentralized as far as possible, within the constraints of maintenance and the easy provision of supplies (fuel, disposables, drugs and spare parts), in order to avoid underutilization of the unit. The managerial aspects of a system of mobile units deserve careful consideration. The units form part of a supervisory system and help to maintain communication with the communities and the village health workers. Populations can only effectively be covered by a system of comprehensive primary health care, using both static and mobile health facilities, providing prevention, promotion, treatment and rehabilitation. The best conditions for achieving this imply appropriate coordination, management, motivation and discipline at all levels, supported by the improvement of environmental and transport conditions which often, in developing countries, have proved to be a paralysing factor.

The possible lack of regularity in the distribution of services suggests a concentration of activities on the preventive aspects of health care (immunization, health education) with elementary curative activities to be supported by self-help and village health workers.

Flying-doctor services

Flying-doctor services are an excellent way of dealing with individual emergency cases; they are, however, ineffectual in terms of population coverage since they are not capable of carrying out preventive measures (general immunization, health education, communication with communities). Since an aeroplane can only land on a runway, flying health teams can only deliver care to populations living within reasonable walking distance from runways or to neighbouring health posts. Preventive care is, thus, limited and curative care is insufficient locally because of lack of continuity unless it is decided systematically to refer patients to rural or regional hospitals. Not only are capital investment and recurrent and maintenance expenses high, limiting the number of flights to emergencies (regular services are not normally to be expected), but specialized manpower is needed for both radio and aeroplane maintenance. In most cases, this type of mobile facility is only used when outside funding from voluntary organizations is available to supplement the small allocation that
a government can divert from its regular budget provision. Flying-doctor services should, therefore, be considered as limited to emergency patient referral, drug provision and transport of health teams and equipment to areas inaccessible by road, in zones where the radius of action of the team is very limited. Serious consideration should be given by authorities to accelerating the development of road networks. These should constitute the basic link not only among remote communities but also between communities and all the socio-economic development sectors whose activities directly affect the health of the population.

**Ships or boats**

These are to be compared with aeroplanes. In so far as they constitute a means of transport for referral of patients, they should be small and equipped with high-speed engines. The same applies to floating facilities where staff deliver some curative and preventive care to limited populations, especially when they are operating in areas where the water level is subject to substantial seasonal changes and therefore does not permit them to operate on a permanent basis. In these cases, capital investment, recurrent expenses and maintenance costs are also high. Except in particular circumstances, floating hospitals should not be considered for day-to-day health care delivery to inpatients. They should be considered only as a means of transport for referral of patients to hospitals where staff (medical, nursing, paramedical and non-technical) can work under more acceptable conditions. Their equipment and staffing should therefore be geared to the maintenance care of emergency cases.

Floating dispensaries can be effective in conditions of good accessibility, provided that they are supported by static units located either on the mainland or on islands where adequate health services can be obtained.

It is unnecessary to stress the importance of requiring appropriate knowledge, motivation and discipline from the staff and the need for regular supervision of all activities. Mobile units should provide services which are feasible, coordinated and acceptable to the consumers.

5. **COST CONSIDERATIONS**

Very few studies have been made of the costs of mobile facilities. According to figures produced by Gish & Walker (1977) the cost per patient contact is roughly similar for fixed and mobile land clinics (£ 0.68 and £ 0.63 respectively); it is more than double (£ 1.39) for air clinics. Owing to the low percentage of patients for whom a single visit would be likely to result in efficacious treatment, it is more realistic to consider the cost per effective patient contact. This is £ 0.75 for fixed clinics, £ 5.87 for mobile land clinics and £ 10.64 for air clinics, i.e. a ratio of 1:8:14. Transport costs were found to be very high: they amounted to 27% of the total costs for land mobile facilities and to 58% for air clinics.

6. **CONCLUSIONS**

All transportable or mobile facilities have a common denominator: their dependence on environmental factors (climate and communication). Most, if not all, of these facilities are, in practice, curative-care oriented. They sometimes allow for some preventive care but always in limited areas. In addition, these facilities are often neither adapted nor appropriate to the actual needs of the community. They may, however, increase to a limited but significant extent the health coverage of the population, especially in areas where so far very little health care exists or is available. In principle, their technical objective is to cover more people and to refer emergency cases to better-equipped and better-staffed facilities. More often, however, no coordination (either vertical or horizontal) exists with other service levels so that there may be gaps and duplication in the service they provide.

Moreover, the repeated gathering of a population for reasons not always well understood, without proper provision of information, motivation or incentives, rapidly leads to a decrease in the active participation of community members so that the effectiveness of the mobile facility is gradually lowered.
The personnel in charge of mobile facilities are partly professional and partly auxiliary but also include specialists in the maintenance and repair of vehicle engines and equipment. The supervision of mobile facilities schemes is not easy because most of the time the facilities operate autonomously and are therefore not integrated into the overall health system. Their costs, of whatever type (capital, recurrent and maintenance), are always high while, for most of the time, their utilization is below the optimum because the facilities themselves are not adapted to local conditions and needs (their mobility is limited by road conditions, water levels or the existence of runways).

Unless environmental and transport conditions are of acceptable standards, heavy mobile facilities (trucks, lorries, boats) should not be utilized under present conditions in developing countries. Heavy facilities should be completely converted into small, light mobile units (able to gain access to places difficult to reach), equipped according to essential curative and preventive needs and staffed by teams of three health workers at the maximum (one nurse, two auxiliaries) and one driver-mechanic/clerk. Experience has shown that this is the only way of covering effectively, or in as regular a way as possible, villages and communities which would otherwise not receive any other assistance than that of the village primary health care worker, the traditional birth attendant or the traditional healer. Only in this way can mobile units fulfil a supervisory, referral, logistic, educational and supportive role which the heavier mobile facilities cannot achieve.

As long as the coverage problem remains high (i.e., in many developing countries 75-80% of the rural population are still underserved or do not benefit from elementary health care delivery) and because the primary health care concept has not yet had time to develop to the point where most communities have been reached and become actively involved, there is no doubt that efforts should be made to promote, wherever possible, periodic surveillance and better distribution and penetration of services.

Especially in the case of scattered or mobile population groups, the least costly though effective way of bringing some direct first action against disease and death is the use of light mobile units staffed with auxiliary personnel headed by one qualified health worker. The range of health activities of such light units will encompass elementary curative health services, prevention (including immunization) and health education.

As rural development improves the quality of life of communities through better nutrition, shelter and sanitation, additional health care delivery components will become more effective and produce complementary effects.
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