HEALTH CARE EQUIPMENT MANAGEMENT IN DEVELOPING COUNTRIES

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Introduction

Contrary to the old belief that the technical problems in hospitals can be solved by some handyman equipped with an impressive looking toolbox, experience all over the world shows that keeping equipment up to standard is an extremely complex task, involving not only technical staff.

All activities in connection with technical appliances are primarily management tasks and are only partially of a purely technical nature. To avoid misunderstandings, I am not talking about management in the sense of only the administration and some technical staff being involved. Equipment management basically involves all personnel in a hospital. This concerns in particular the role of medical and paramedical personnel who normally operate the equipment, commonly called the "users". The objectives of proper equipment management are to guarantee a high quality of equipment related health care and to achieve this in the most economic way possible. This presentation mainly deals with the public health sector, though most suggestions or statements apply to private health care institutions as well.

Elements of an Equipment Management System :

Provisioning

When talking about a management system, the first fundamental question to be raised is the question of what is to be managed. A health care facility works, technically speaking, on the basis of a conglomerate of interdependent physical functions, such as :

- the building(s), including driveways and security installations
- installations for water, electricity, gases, vacuum etc.
- hospital plants (emergency generator, steam plant etc.)
- hospital services (kitchen, laundry, sterilization etc.)
- transport facilities
- general furniture
- furniture for medical purposes
- medical equipment
- office equipment
- workshop equipment.

All these items must fit the specific technical environment and must fit together. For example, a sensitive laboratory instrument, such as a flame photometer, must be protected against instabilities of the power supply in many countries and, at certain localities a highly sophisticated gadget such as a Coulter Counter cannot be operated due to logistical shortcomings.

These aspects point to the first and most important element in health care equipment management : **provisioning and procurement**. Apart from medical and operational considerations, in particular the need for maintenance demands proper decisions in any acquisition process. The main factors to be taken into account are :

- medical adequacy acc. to reference level
- overall cost
    * investment cost
    * preparation of installation (mounting base, power etc.)
    * staff cost including training cost
    * consumable items
    * energy consumption
    * maintenance and spare parts
    * replacement cost (lifespan)
- user friendliness
- service friendliness
- availability of maintenance & repair services
- availability of consumable items and spare parts
- availability of technical documentation in the right language
- suitability for climatic conditions & technical environment
- compatibility
- warranty terms
- training resources on the side of the manufacturer or agent.

The availability of spares and consumables also touches the logistical mechanisms of health administrations. In many countries, even threshold countries, the provisioning with such goods meets great obstacles. Apart from hard currency constraints, additional problems may stem from clumsy and costly custom procedures. In most cases it would be advisable to order all necessary spares together with new equipment. For parts with a short shelf life, a voucher system could be considered.

Second-hand equipment should be avoided where possible. For one thing, consumables and spare parts for used equipment might be difficult or impossible to get. Secondly, certain equipment, such as X-ray machines, might not be up to current safety standards.

At a higher organizational level it might be worthwhile to occasionally check the inventories of all health facilities in order to detect potentials for the redistribution of existent equipment, before thinking of buying new equipment.

In any case, where organizationally possible and socially acceptable, technical personnel (i.e. the in-house maintenance personnel) should be consulted during the decision process for provisioning.

Inventories

Returning to the question of what is to be managed, it is obvious that only a proper inventory can meet the administrative and technical needs for information.

Different inventories may be necessary at different administrative levels. In our case, we are talking about inventories at facility level. The minimum information for the purposes of equipment management are :

- make, brand & model
- type and model number
- serial number
- inventory number
- year of manufacture
- location (section, department etc.)
- price.

For a technically satisfactory inventory at the level of a hospital maintenance workshop the main additional information required would be :

- warranty period
- period of service contract
- availability of operational manual
- availability of service manual
- addresses of manufacturer and agent.

Such an inventory may also be compiled in the form of equipment record sheets in combination with equipment histories.

Users and Operators

In developing countries more than 50% of all technical break-downs are caused by the user of equipment or are due to improper installation and commissioning. This rate is certainly lower in threshold or newly industrialized countries, but probably high enough to cause deep concern.

Cautious and correct handling of technical items depend basically on two factors which are interrelated. Technical knowledge and motivation. Sound technical knowledge and skills are essential, but without the right motivation, the equipment, and eventually the patient, will suffer. The other extreme is illustrated by the following example usually found in everyday life. Someone does not really know what makes a car move. But does everything to keep the vehicle, especially when new, in "top condition" by polishing it more often than the paint may be able to stand.

Motivation can be positively influenced by :

- improving knowledge and skills
- working with adequate and well maintained equipment
- being personally and formally responsible for the equipment under use
- working within a cooperative environment (team).

The latter demand clearly meets more or less natural limitations within an medically oriented institution such as a hospital.

All these demands lead to the necessity to facilitate the assumption of more technical responsibility by the users by creating training opportunities and a continuous follow-up.

Possibilities for technical training of users are :

- most important : technically relevant subjects during basic training
- seminars organized by technical training institutions
- seminars organized by manufacturers and agents
- obligatory familiarization of users on delivery of new items by the agent or manufacturer
- hands-on-instructions by colleagues, in particular from the service department.

In addition, the technical documents must be available and written in some comprehensible language. Who knows German apart from the Germans?

The training would mainly concentrate on :

- review of physiological, physical and chemical principles of the equipment in question
- basic function of the item
- application
- safety for user and patient
- base-line maintenance
- limitations of technical interventions of users.

Close cooperation between users (mostly medical & nursing staff) and technical staff of the service department, if existing, is highly desirable but also highly difficult. Cultural and social barriers hinder such working contacts due to acceptance problems. The persons in charge of any health institution must be aware of this circumstance and advance the status of maintenance staff by, for example, granting them adequate responsibilities on deciding technical matters in meetings or by making them members of relevant committees of the hospital.

Maintenance and Repair Services

A maintenance and repair system constitutes the focal point of any equipment management approach. It carries out two basic functions, keeping up the technical operability and providing information vital for the equipment management system itself.

Ensuring technical operations (installations, plants, means of transport and medical equipment) requires :

- inspection >
- service > preventive maintenance
- repair >
- managing the maintenance workshop
- (informal) training of technical and user staff
- reception procedures for new equipment
- monitoring external technical services
- providing and maintaining technical information (manuals, diagrams, literature etc.)

It should be noted that emphasis is to be given on systematic (planned) and preventive approach. Thus it is expected that by preventing major break-downs through inspection and service drastic savings can be achieved. The aim should be to keep portion of repair works below 50%. Maintenance is not expensive, repair is!

Providing information for management purposes, for example, monitoring and evaluation, mainly includes :

- keeping records such as inventories, maintenance reports, safety etc.
- compiling relevant data on
    * equipment failure rates
    * causes of failures
    * types of maintenance work carried out
    * spare parts required and used
    * working hours used
- equipment histories

These data must regularly be processed and analyzed to extract information for :

- budgetary planning for maintenance etc.
- budgetary planning for equipment replacements and new equipment purchase
- suitability of equipment
- economy of equipment
- provision of spare parts
- maintenance of workshop
- deployment and planning of service staff
- monitoring of the operability of technical functions and equipment.

The monitoring, evaluation and planning activities involve all levels of care, including normative bodies such as regional (e.g. provincial) health authorities and the ministry in charge. It also means that processing and analysis of the data generated by the technical services must be done at the respective administrative levels requiring the information.

Attention :

Monitoring and evaluation does not only involve information processing but also follow-up programmes to strengthen maintenance units in the field. This kind of supervision is indispensable for newly implemented maintenance services. Nevertheless, a continuous supervision within the possibly existing supervision system for health care is highly desirable in the long term.

After having explained the main features of what has to be done regarding maintenance and repair, the question of who should be doing all that comes up. Except for all activities concerning the overall technical management in the administrative sense, the actual maintenance and repair work is basically carried out by :

- the users and operators
- in-house maintenance staff
- external services to be hired and paid for
- external services from other facilitating governmental bodies (e.g. Ministry of Works).

To what extent all these possibilities are utilized largely depends on the economic situation and the availability of qualified maintenance personnel. And of course, the administrative infrastructure of a region or a country dictates certain dependencies. It is therefore in no way advisable to try to establish a new and seemingly independent maintenance organisation parallel to the existing structures. This can only be done in a successful way, if the financial sources for the new maintenance system were to be provided by other bodies than the regular administration, which is highly improbable.

No doubt, private maintenance services can be very efficient, so why bother about in-house solutions? Two important reasons not to depend on external forces have to be accounted for. If it is true that preventive strategies in maintenance are the most economic approach, we need the continuous presence of technical staff at the health facility in question, in particular for all inspection and service tasks. No health care system in developing or newly industrialized countries could afford to pay a service company to do so. It is much cheaper, at least in the end, for a health facility to employ its own staff for preventive routine jobs and simple repairs. Equally important is the fact that no health institution can adequately deal with private technical firms without possessing a minimum level of technical competence itself. Therefore, in-house maintenance staff is an indispensable asset for monitoring the quality and the economic relevance of external services.

As a crude rule-of-thumb for looking at the question of how to value in-house maintenance against commercial maintenance one may assume that approximately 70% of all maintenance works can be carried out with 30% of the overall service cost by in-house service unit of moderate sophistication. The rest of the works are specialized jobs, mainly complicated repairs, representing 70% of the total cost. Parts of these complex tasks may be taken over by in-house staff after gaining sufficient experience and given that further training is systematically being carried out for them.

Ancillary Technical Concerns

Intending to introduce a quality improving and cost effective technical management system should encourage us to look at more than only equipment. It is, for example, obvious that maintenance and repair of building facilities must come under the same managerial umbrella to avoid idle motion and other snags. Less obvious additional concerns are :

- energy management
- solid and liquid waste management
- hygiene in connection with hospital equipment.

Energy management starts with monitoring energy consumption and staff habits. It starts with energy-conscious procurement of equipment, introducing energy saving regulations for staff, priority switching devices for equipment with high energy demand, changing to cheaper energy sources etc.. Energy management may end with the service department modifying equipment to increase its energy efficiency, such as by improving heat insulation of instrument sterilizers.

Waste management in developing and threshold countries is mostly characterized by great helplessness. This stems from lack of knowledge, lack of appropriate waste disposal methods and, especially in the case of waste water disposal, lack of funds. A major contributory factor to the largely desolate situation in this field originates from lack of awareness and therefore, lack of motivation. For example unprotected waste pits are a permanent source of health risks, specifically for children playing at such interesting places. In the long term, uncontrolled waste removal constitutes a time bomb which is very expensive and complicated to defuse later on. Problems like this materialize literally daily in industrialized countries such as Germany.

The overall hygienic hazards which are tied to equipment are numerous. One should assume that medical and nursing staff would be sufficiently qualified to be able to control the hygienic situation of a hospital. The reality, notably in less developed countries, speaks a different language. There are, often visibly, hygienic principles in, for example treatment of wounds, are only followed superficially, or for example, infection-minimizing procedures for entering operating theatres have degenerated to some mechanical and meaningless gestures. The less obvious shortcomings are encountered while handling certain equipment, such as sterilizers. Sterilizing times, pressures, temperatures or loads are not properly known or not being observed (Knigge/Morr 1990).

Intraoperative infection rates at some health facilities in developing countries have been found to be in excess of 90%! Not only the patients are endangered by sloppy hygienic management or technical deficiencies, but also the health staff. The maintenance personnel is particularly exposed because they may for example disassemble and manipulate contaminated items, such as surgical suction machines.

Requirements for Implementing Rational Equipment Management

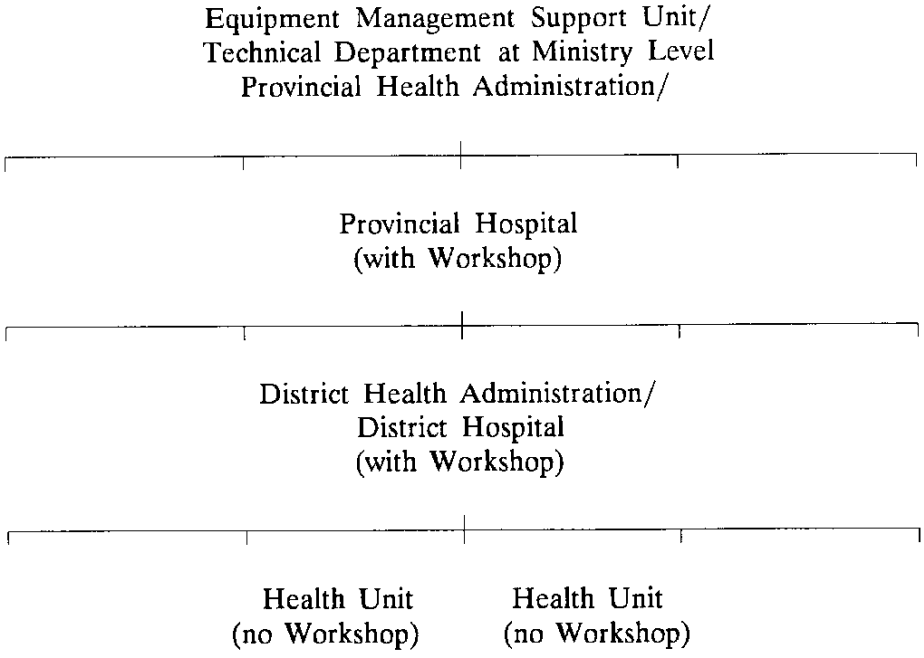
Organizational Structures

As emphasized earlier, equipment management structures parallel to the existing administration, must be avoided. This actually means that administrative principles within the public sector for tasks such as :

- procurement
- personnel planning
- store keeping
- budgeting
- etc

must normally be accepted. Often the efficacy of these principles or structures are being questioned without being analyzed to whether the structure is deficient or its interpretation is inadequate. Also often these structures are too deeply rooted in the overall governmental system as to be alterable to a great extent.

In any case, before designing an equipment management system, a thorough analysis about potentials and shortcomings of existing administrative structures, including its financial capacity must be undertaken. According to this information and on the basis of a need assessment of the health facilities to be covered, the management system can be designed and step-by-step be established. This strongly implies the necessity of qualifying administrative staff for their role within equipment management. As for users and operators, relevant subjects should be incorporated into the administrators' basic training and also be taught in special seminars. The system should in the end be structured similarly to other technical functions within health care, such as radiological services. A typical example would be :



The district workshop would carry out routine (preventive) maintenance and simple repairs. The workshop (minimum 100 square metres) should be fitted to primarily cover :

- electrical engineering
- mechanical engineering including plumbing and welding
- electronics including medical engineering
- carpentry
- eventually vehicle maintenance.

It would also cater for health facilities below district hospital level (Halbwachs 1990).

The provincial workshop, which would be better equipped, would take care of the provincial hospital and, at the same time, for works which are too sophisticated for the district workshops.

For countries with highly developed transport systems or which are small enough to cross within one or two days, a central workshop instead of or in addition to provincial workshops may be feasible. But this should remain an exception, since decentralized services are much more effective, though the initial costs are higher.

The hospital workshop should be a separate department directly under the head of administration (administrative director, hospital secretary) and treated as any other department, including budgeting aspects. The demand characterizes a final state or objective at the end of a, certainly difficult, process of maturation and mutual adaptation. In this sense, the demand for a follow-up programme and continuous supervision - ideally from the next higher level of technical services - gains a quality of management consultancy. Also the foundation of a professional society for maintenance personnel in health care would immensely contribute to improving their professional and social status. To improve status and the maintenance work itself, professional links to relevant national training and/or research institutions are of great help. This mainly applies to countries with a rather well developed infrastructure.

The support unit at ministry level could be a separate department or a division of an existing architectural or even a planning department. The feasibility of these and other models depends on many factors. Considering the sensitive web of interests and dependencies within a health system, the creation of a technical unit at whatever level calls for caution and delicacy.

Personnel

As already pointed out, most health staff are more or less involved in realizing an equipment management concept. Apart from maintenance personnel and specialized staff for a ministerial technical department no additional personnel are needed under normal circumstances.

The staff requirements for the different levels are for developing countries:

LEVEL	POSITION	EDUCATIONAL LEVEL	NUMBER
Ministry	HOD	MSc	1
	Officer	BSc or H.Diploma	2-4
Province	HOD	BSc or H.Diploma	1
	Staff	H.Diploma or Technologist	2 per 100 beds
	Handyman	C. of Guilds	3 per 100 beds
District	HOD	H.Diploma or Technologist	1
	Staff	Technologist or equivalent	2 per 100 beds
	Handyman		3 per 100 beds

For a better assessment of the professional levels see the report on the WHO Inter-Regional Meeting in Campinas 1989 on maintenance training.

The staff numbers below ministerial level may be halved if no subordinate health facilities are to be serviced. The numbers suggested are approximate figures which have to be adapted to the special situation of each country and facility. Other formulas based on capital investment, patient flow etc. seem to me to pretend unrealistic precision or reliability.

The qualifications of the cadres mentioned is a difficult theme. The international confusion on the types of professions said to be suitable for maintenance work and other tasks within equipment management is remarkable. Most experts these days agree that we should talk about hospital engineering. This term covers more or less all the tasks reflected in the previous chapter on maintenance and repair. Further explanations are contained in the Campinas report.

Hospital engineering staff, even on less respective training, seldom can be found in developing or threshold countries. Consequently, this kind of manpower must either be developed in another country, or a national training opportunity must be created. Since not only public health care services, but also private services, universities, veterinary services and even hotels are potential clients, a national training course may turn out to be the more economic, if not a lucrative option.

Some reasons speak against primarily utilizing "traditional" manpower resources, such as mechanical or electrical engineering vocations. Experience in less well developed countries show that such persons cannot cover the total spectrum of tasks, even if they have undergone additional training. Even in better developed countries this implies that maintenance works have to be covered by more personnel than necessary when employing polyvalent staff.

Obviously, but a fact often neglected, officially accepted job descriptions for the different levels would be the precondition for manpower development and the integration of this manpower into the existent health system.

Running Costs

Apart from investment costs for manpower development, workshops and tools etc., which will not be dealt with in this paper, the question of the running costs for maintenance activities is of major interest. Generally, health care providers regard maintenance as necessary but shy away from what they believe to be additional costs. Under the condition that the equipment to be maintained is of appropriate sophistication and number and that the ratio of in-house services to external services ranges somewhere at 70% to 30%, the costs will be at least balanced by savings through the extension of equipment life spans (break-even-point) within several years. Some American hospitals even regard in-house maintenance not as a cost centre but a profit centre.

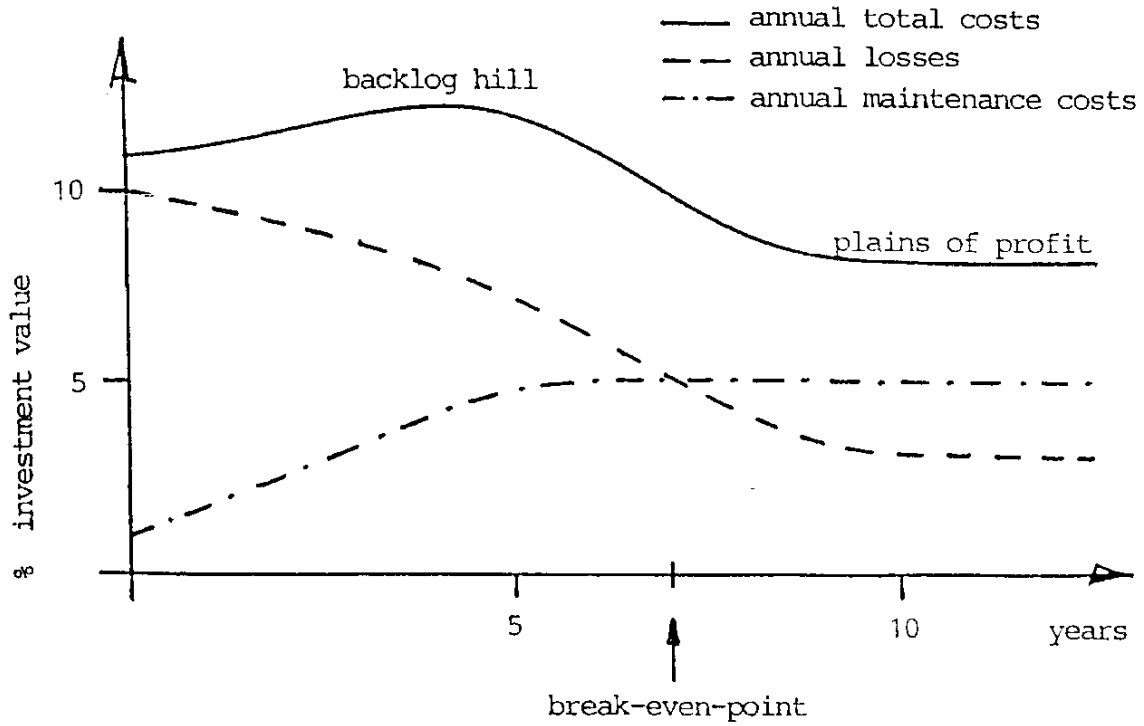
The running costs for hospital equipment maintenance vary significantly between types of equipment, less clearly between countries, be they developing, newly industrialized or already developed in the technical sense. It seems that the three major cost factors in maintenance, namely personnel cost, material cost and technical environment are interacting in a mutually compensating way. For example, unsuitable technical conditions and high spare part costs in a country may be balanced by low labour costs. Typical maintenance running costs (% of investment value per year) for some equipment categories are estimated to be :

- laboratory equipment	5 - 12%	
- sterilizers	3 - 10%	
- refrigeration equipment	5 - 8%	
- anaesthetic machines	8 - 15%	per year
- water & electrical installations	2 - 4%	
- building fixtures	1 - 3%,	

Other authors, Mehta (1983) for example, arrive at higher figures. More precise figures have to be determined on the basis of local conditions and experience. The average annual maintenance costs for a 50 to 200-bed hospital ranges between 5 and 8%. For initial planning 5% constitutes a realistic target.

Five percent of investment value represents a very substantial portion of an annual health budget. When newly introducing an equipment management and maintenance system, it would be unrealistic to assume that this sum can be provided at once. Even if this were possible, a maintenance system can only be introduced gradually, more or less in line with the progress of manpower development. It must also be conceded that until reaching an economic balance between preventive and repair activities, in most cases a considerable backlog of repair and rehabilitation works has to be cleared first. Setting priorities for these works is essential in the initial phase.

The general timing of the two main financial factors is shown in the following diagram.



The financial losses (insufficient maintenance, shortened life spans) combined with the maintenance costs result in a curve with characteristic features, the "backlog hill" and the "plains of profit", as we might term it. The diagram can certainly only give an idea on the subject. To better project a possible financial scenario, a scrupulous baseline survey would be required.

Outlook

Establishing an equipment management system and maintenance service, is a long lasting and painstaking process until it shows first economic and medical effects. Apart from financial requirements for initial investments, most developing and threshold countries lack the specialist know-how.

For least developed countries a moderate strategy starting from the bottom up to district level only, must be acquired. Substantial input for running such programmes by those countries cannot be expected. Therefore, equipment management must to a great extent be tackled within the existing resources. It would mean integrating equipment management into the district health management and supervision system. It could comprise a rudimentary monitoring system, assignment of technical responsibilities to the users and user training. Assistance by competent external donors, GTZ is one example, in particular for providing the necessary consultancy services, appears to be essential. Better developed countries may even try to cover all levels up to ministry level. Still, in most cases the specific expertise has to be (temporarily) imported. But one word of warning :

The import of models from industrialized countries must be avoided. These models do function on the basis of what we might call technical culture, which has not yet had an opportunity to develop sufficiently in most developing countries.

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