Clinical Engineering in Brazil: Current Status

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It is estimated that 20-40% of all existing healthcare equipment in Brazil is not working because of a lack of service, parts, or supplies, or because it has not been installed. Traditionally, equipment goes completely unattended until a complete failure occurs. Then, it sits idle, paralyzing those services provided by it, until its owner gathers enough money to afford the extravagant repairs provided by manufacturers and their representatives, with little continuing assurance of quality and efficacy. During the last 10 years, a few medical institutions have started to establish their own clinical engineering (CE) teams. Besides providing significant savings, these pioneers are contributing to the improvement of the process of managing the introduction of technology into healthcare. Now, about 10% of all hospitals with more than 150 beds have their own CE departments. Three years ago, the **Brazilian Association of Hospital Engineering and Maintenance** was created to promote the recognition of CE as a new profession. The main difficulties that inhibit the faster and wider adoption of the self-reliant approach are analyzed and some possible solutions are discussed.

Index Under: Maintenance, Equipment; Management, Equipment; Policy, Equipment; Planning, Equipment; Procurement, Equipment; Service Manuals; Spare Parts; Brazil, CE in; Developing Nations, CE in.

INTRODUCTION

During the second part of the 1960s and into the early 1970s, most developing countries, including Brazil, tried to follow the healthcare system models of wealthier nations. They imported large quantities of expensive and complex medical equipment in the belief that the health conditions of their populations would improve rapidly. After adopting this approach, the first few years were fine, except that many supplies had to be imported at high cost. When the inevitable deterioration of the equipment began, often earlier than expected because of the lack of preventive maintenance and user training, the situation became dramatic. There were no means to repair the equipment, nor resources to replace it. Health services had to be interrupted, creating enormous social problems (Kleczkowski, 1985; Bloom, 1989).

Although some efforts were made to establish maintenance and repair teams in Brazilian hospitals, serious endeavors with lasting results were started mostly in the early 1980s. This paper reviews the present situation of clinical engineering in Brazil, identifies the principal activities and participants, and analyzes the major difficulties. Possible solutions are presented. Before describing the present situation, some basic facts and data about Brazil and its health conditions are necessary to provide a framework for those who are not familiar with this country.

BACKGROUND

Brazil is the fifth largest nation in the world, having 8.5 million square kilometers of land, mostly between the equator and the tropic of Capricorn. The population is estimated to be around 150 million with an annual growth rate of 2.4%. The economy is fairly diversified, distributed among agriculture, industry, and services. Although it has the eighth largest economy of the world, the GNP, per capita, is only about U.S. $2,050 per year. This amount

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fluctuates significantly from year to year. The distribution of wealth is very uneven—the top 5% own more than 85% of the total assets.

About two-thirds of the population is concentrated in medium and large cities, where poor people dwell in slums known as "favelas." For these people and those living in remote rural areas, access to health services is difficult and the quality of care is poor. As a result, the infant mortality rate is as high as 63 per 1000. This rate is not consistent with the numbers of doctors and hospital beds available, about 4.2/10,000 and 3/1,000 inhabitants, respectively.

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These numbers are only slightly lower than those of more-developed countries.

Brazilian Health System

Until three years ago, the Brazilian public health system, like that of many other South American countries, used to be a "non-system." That is, it was made up of several parallel sub-systems, each autonomous from the other, without any coordination or cooperation. Four major segments were competing for resources and patients:

1) The **Ministry of Health** was responsible for the development and enforcement of a national health and sanitation policy, but had little to do with secondary and tertiary care;
2) The **Ministry of Welfare and Social Security**, through its *National Institute of Medical Services*, was responsible for financing the delivery of healthcare (by private and public institutions) to about 75% of the population, as well as for the operation of a few, albeit large, hospitals in major state capitals;
3) The **Ministry of Education**, through its federal universities, was (and still is) responsible for about 25 large and prestigious teaching hospitals, also located mostly in state capitals; and,
4) Some **State and City Governments**, although theoretically responsible only for primary healthcare, did maintain some large hospitals and even health research facilities.

Realizing that this "non-system" was both prohibitive and ineffective, the Brazilian government started in 1987 to integrate all the public health services and, at the same time, to decentralize its management. One goal was to improve the quality and coverage of care, as well as to use more efficiently the resources available. This process of reorganization is well under way now, in spite of enormous resistance by private healthcare providers, insurance companies, and many physicians.

In terms of facilities, the entire health sector (including private and public institutions) has approximately 5,500 hospitals and 11,000 out-patient clinics and health posts. There is a large variation in terms of size and complexity among the hospitals, ranging from small units with a few beds to large complexes with over 1,000 beds; but only about 750 of them have more than 150 beds.

Equipment Market and Native Production

Compared to developed nations, Brazilian hospitals employ, on average, very little modern medical equipment. However, there are exceptions, and most medical practices are considered advanced in large state capitals and cities, especially in the Southeast. In fact, uncritical acceptance of fancy, expensive equipment is the rule where and whenever money is available. For example, there are now about 500 CT scanners in Brazil, mostly concentrated in big cities, making the ratio between scanners and population higher than in most north European countries. On the other hand, basic medical and sanitation equipment is lacking in suburban slums and rural areas, and sometimes even in major hospitals.

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The Brazilian medical device market is estimated to be approximately U.S. $500-700 million per year, of which two-thirds is supplied by about 300 local companies, both native and foreign owned, producing over 13,500 different items within the country. The remaining one-third is imported, mainly from the U.S., Europe, and Japan, and consists of equipment costing more than U.S. $5,000 each. The total amount of exported equipment is about U.S. $40-60 million per year, while about U.S. $100-150 million is imported annually.

PRESENT STATUS OF CE IN BRAZIL

All the existing healthcare equipment in Brazil is probably worth about U.S. $5 billion. Of this, the National Institute of Medical Services of the Ministry of Welfare and Social Security estimated in 1986 that about 20-40% was not functioning because of such problems as: unfinished facilities, waiting for repairs, or a lack of spare parts or imported supplies. These data may be shocking, but are consistent with an estimate made by General Electric that about 30% of all X-ray machines in developing countries were not functioning because of lack of parts or service (Bray, 1982).

The Brazilian medical device market is estimated to be approximately U.S. $500-700 million per year.

Traditionally, repairs are carried out only by manufacturers or their local representatives. Whenever considered necessary, often without any clear rational criteria, service contracts are made, usually at the rate of 5-10% of the equipment purchase price per year. Although some companies are honest and provide reasonably good service, others provide poor assistance and may try to unnecessarily replace parts to increase their profits. A few are even more unscrupulous, refusing to service equipment after only a few years of operation, claiming "technological obsolescence" and recommending replacement. No significant differences in attitude have been found between natively owned and multinational companies, although smaller companies usually give greater autonomy to their regional service managers, which tends to be more flexible.

Over the last 10 years (after the onset of economic difficulties due to foreign debt and growing inflation in Brazil) some hospitals started to create their own maintenance teams. The basic idea was to carry out simple repairs and supervise service provided by manufacturers and third parties. This effort resulted in considerable savings, since many service contracts were actually unnecessary, and replacement of parts were unjustified. However, very few of these CE departments were able to grow from their maintenance and supervision role into full-scale technology management units.

In 1986, a survey of 15 major public and private hospitals within the City of Sao Paulo showed that, although most of them have something which can be considered as a genuine CE department, only a few of these were well staffed and equipped (Wang, 1986b). The majority were having difficulties in securing enough support and funds from the administration to hire and keep qualified BMETs and equip their labs and shops.

Although repairs were carried out on most simple and intermediate-level equipment, almost no preventive maintenance was being provided. Little or no input was sought by physicians and administrators when acquiring new equipment and even when deciding on service contracts. Maintenance was generally poorly managed: many did not have records of services actually executed, few computed response time, and very few knew how much they were saving for the hospitals. Except in few cases, very little financial and moral support was given by the hospital administrators and physicians, who would generally rather spend money buying new equipment than training and equipping their own maintenance department.

The situation in the rest of the country is similar, if not slightly worse. Only about 50-80 hospitals (about 10% of all hospitals with more than 150 beds) have their own CE department, staffed with at least an engineer and/or a few qualified technicians. The rest, about 90%, only have some unqualified handymen to take care of simple electrical and plumbing problems. Occasionally, these persons can manage to repair some medical equipment. However, one can never be sure that the instrument remained calibrated afterwards.

Very few clinical engineers and BMETs have knowledge of safety and performance standards and regulations on healthcare equipment, and even fewer have access to them. As a consequence, only a handful of hospitals have established safety programs for medical instrumentation. Access to international literature about hazards, technology assessment, and safety precautions is severely limited by the lack of hard currency and ignorance of their existence. Even recalls ordered by agencies of developed countries are often hidden from the engineers and physicians by manufacturers and their representatives.

Only about 50-80 hospitals have their own CE department.

In spite of the generally adverse conditions, a few CE departments did manage to grow and improve steadily. They were able to convince their superiors to let them establish high-level technical staffs capable of performing preventive maintenance and most repairs in-house, including radiological and imaging equipment. In this way, they were able to achieve much larger savings besides providing faster and more responsible service (Wang, 1986a). Some of these departments are also using the expertise of their engineers and technicians in other areas such as planning, procurement, evaluation, and installation of new equipment, enforcement of safety programs, and training of users and new technical personnel. These leading CE departments are: Dept. of Technology of the Federal District Hospital Foundation in Brasilia, Center for Biomedical Engineering of the State University of Campinas, Hospital Engineering Unit of the Federal Center for Technological Education in Curitiba, Technology Nucleus of Ceara in Fortaleza, Hospital Engineering Dept. of the Hospital das Clinicas in Porto Alegre, Biomedical Eng. Dept. of Catholic University's Hospital in Porto Alegre, and Center for Equipment Maintenance of the National Institute of Medical Services in Rio de Janeiro. The following departments are in Sao Paulo City: Albert Einstein Hospital, Hospital of the Paper & Cellulose Union, Sao Paulo Hospital, State Public Workers' Hospital, and University of Sao Paulo's Hospital das Clinicas.

In spite of the generally adverse conditions, a few CE departments did manage to grow and improve steadily.

Besides the growth of individual CE departments, a significant step forward was made in 1987 when **Sao Paulo State's Health Secretariat** decided to create an *"Equipment Advisor's Office"* to handle all matters related to planning, procurement, usage, and maintenance of healthcare equipment. This office established and implemented the first comprehensive policy for healthcare equipment within Brazil and created 14 new CE departments within public hospitals (Wang, 1990). The accomplishments of this program helped to increase the awareness of healthcare professionals about the usefulness and necessity of clinical

engineers not only within Sao Paulo State, but also throughout Brazil and other Latin American countries. This program set an example that is being followed elsewhere, such as in the recent establishment of a *Department of Technology* within the **Health Secretariat of the State of Ceara, Brazil**.

ANALYSIS OF MAJOR DIFFICULTIES

In spite of the evident need and unquestionable success of most existing CE departments, few hospitals have followed suit. It also has been difficult for some established CE departments to secure support for steady growth. A few institutions have even replaced their CE leaders after achieving significant accomplishments. These and other paradoxical attitudes can only be understood by an in-depth analysis of the major difficulties. To further highlight the social, cultural, and economic constraints, an attempt is made to compare the Brazilian situation with that of other developed nations, especially the United States. Of the many difficulties confronting CEs in Brazil, four are considered fundamental and summarized below, with a brief discussion of their respective origins and possible solutions.

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Personnel

At present, there are no established formal training programs for clinical engineers and BMETs in Brazil. An intensive BMET program offered by the *Dept. of Technology* of the **Federal District Hospital Foundation** in Brasilia was discontinued after one year of operation because of a lack of financial support. A proposal for initiating a BMET program at the high school level in the State of Parana has been approved and is waiting for funds to get started. A few sporadic, short-term courses and internships have been organized; however, the number of persons trained is too small to make a significant impact.

The engineers and technicians presently practicing CE are, therefore, pioneers with diverse backgrounds. Although most engineers are trained in electrical, electronics, mechanical, civil, or industrial engineering, there are also a few physicians, architects, and technicians. The technicians are mostly graduates from vocational high schools majoring in electricity, electronics, or mechanics, who have been further trained by manufacturers and/or in hospitals. Some had the benefit of supervised training, while most had to learn by themselves. Thus, capability varies greatly from person to person.

The lack of formal training explains, in part, why so few have knowledge and command of the codes, standards, and literature in general that are available from the more developed countries. It also accounts for the excessive emphasis on repair and maintenance, with less regard for safety, record keeping, and management. The need for certification of all practitioners was raised and discussed last year during a national meeting sponsored by the **Brazilian Association of Hospital Engineering and Maintenance**, which was attended by a few invited **International Certification Commission** board members.

Paradoxically and in spite of evident need, very few technical high schools and colleges are willing to set up programs in clinical engineering and/or medical instrumentation, claiming that there are no firm demands from healthcare institutions. The few universities and schools that are capable of setting up these programs prefer to devote themselves to biomedical engineering, apparently believing that research and design are more prestigious than service and management. In fact, the native industry is too small and weak to absorb the graduates of the one doctoral and six Master's programs in biomedical engineering that exist in Brazil currently. Only two of these programs offer a brief course in clinical engineering. The same cultural prejudice inherited from the colonial era also accounts for the difficulty in recruiting the brightest young Brazilian engineers to work in healthcare. They do not want to "get their hands dirty," especially when the financial incentives are not strong.

Another factor that contributes to the vicious circle of lack of qualified personnel is the unwillingness of the health sector to pay a competitive salary and provide adequate working conditions. Many well-trained persons drift to better-paying industries, such as industrial equipment maintenance and computers. Contrary to popular belief, competition from private service companies and representatives of equipment manufacturers has not been a serious threat. The reason seems to be their small numbers and unattractive wages when compared to other industries.

The only long-term solution is to establish training programs at all levels: in vocational high schools for BMETs, in colleges for clinical engineers, and in graduate schools for technology managers. The health sector must be willing to acknowledge the importance of these professionals and reward them with competitive salaries.

Spare Parts and Supplies

Interruption in the distribution of spare parts and supplies is often used as a threat by manufacturers and their representatives in Brazil against hospitals that do in-house maintenance. Although most CE departments have been able to find alternative sources and sometimes can even fabricate the parts themselves, this "blockade" of manufacturers has inhibited smaller hospitals from setting up their own maintenance teams and large institutions to cancel exorbitant service contracts.

In addition to the uncooperative attitude of some manufacturers, the importation of parts whenever native equivalents cannot be found is a major problem. Because of the foreign debt situation, the Brazilian government imposes strict con-

trols on all imports. Thus, a sorely needed part can take several weeks of paperwork to be imported, even when hard currency is available. The government is now reviewing its policy on importation and, hopefully, will give special consideration for goods essential for healthcare.

Besides problems from outside, the clinical engineer has to overcome three more challenges within his own institution. First, the CE has to obtain support for the inclusion of a requirement to supply spare parts in all purchase contracts. Spare parts should be obtained both as a kit together with the delivery of equipment, and as an obligation during its lifetime. Second, the CE has to fight for a yearly budget to be included in the operating cost of the hospital. Finally, the CE has to work with the procurement office to establish a fast mechanism for small purchases, so he or she can buy low-cost items directly, without the customary lengthy paperwork that does not distinguish spare parts from equipment.

In order to meet the challenges mentioned above, Brazilian clinical engineers have to plan for department needs well ahead of time. They must work diligently to get all elements in place. Otherwise, the overall performance of the department will suffer significantly and the CE will be considered the main culprit.

Technical Documentation

As part of a strategy of keeping for themselves the lucrative enterprise of servicing equipment, many manufacturers, and especially their local distributors, refuse to supply technical documentation that would enable others to repair and maintain the equipment. This practice can only be reversed when the clinical engineer manages to include in the purchase contract a specific clause that requires the submission of a complete set of technical documentation, including operating manuals, service manuals with instructions on troubleshooting, calibration, and acceptance testing, and parts lists, as well as complete mechanical drawings and electrical schematics. In cases where computer software is included in the equipment, a copy of the source code with adequate explanation also has to be required.

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However, as most of the equipment was purchased well before the clinical engineer was hired he has no option but to look for help elsewhere. Since 1985, a Technical Reference Center with over 700 manuals has been set up within the **State University of Campinas' Center for Biomedical Engineering**, with partial support of the **Pan-American Health Organization**. This reference center can provide operating and service manuals to all institutions that can prove that they own the corresponding equipment and need the documentation. Considerable help from outside is needed for this reference center to expand, to be kept updated, and to start new ones in other parts of Brazil.

Socio-Cultural Environment

The first hurdle clinical engineers have to overcome in hospitals is their relationship with clinicians and surgeons. It is quite difficult to convince the latter that they should accept engineers in hospitals and, especially, pay them salaries comparable to physicians. This is true even though there is already an oversupply of physicians in most cities and a lack of clinical engineers able to take care of millions of dollars' worth of equipment. It seems that, in part, physicians are often too ashamed to admit that they know little about the instruments they rely on so heavily and need help from someone they are used to "looking down on." It should be noted that the Brazilian educational system is different from those of some other countries.

Typically, physicians earn their diplomas through six-year college programs and specialize afterwards through one- to four-year, optional internships. In contrast, engineers can graduate after five years of college studies. Although registration is required for both to practice, there is no certification process.

Clinical engineers are usually better accepted by administrators once the latter learn about the economical and qualitative advantages of a well-equipped and well-run CE department. Unfortunately, administrators in Brazil often lack sufficient initiative and vision or are too intimidated by physicians to start a new CE department or provide adequate support and incentives to the existing ones. It is up to the clinical engineer to win support from both physicians and administrators with hard work and deft diplomacy.

Even when a CE department becomes well established and provides service considered satisfactory by most hospital departments, there is still no assurance that it will be able to grow with the institution. The chief officers of most public hospitals change periodically as part of the overall political renewal process. It is not uncommon to find a new director with little appreciation for clinical engineering, or somebody who needs a position for a political ally. So, clinical engineers often find themselves required to be as skillful in political maneuvers as they are competent in technical work in order to survice the periodic changes in administration.

Finally, there is a generalized skepticism about the efficacy and financial advantages of in-house maintenance efforts rooted apparently in the deep cultural bias against anything that is native. This is a result of centuries of colonialism and the lack of self-reliant spirit. This ingrained "better foreign" prejudice accounts for the preference for services provided by multinational companies, although their service personnel are almost always poorly trained natives who are underpaid in order to keep profits high.

COMPARISON BETWEEN BRAZIL AND DEVELOPED COUNTRIES

The present status of clinical engineering in Brazil is somewhat similar to that of the United States about 15 years ago. Some significant differences exist, however. First, the motivation for establishing CE departments in the United States was a combination of: claims of thousands of deaths caused by electrocution in hospitals each year (Dalziel, 1972); threats of malpractice suits; and the escalating costs of services by vendors (Boxerman, 1980). In Brazil, the motivation was primarily the large amount of inoperative equipment and the high costs and poor quality of services provided by manufacturers and their representatives.

Arising from public pressure and stiffer consumer protection laws, some hospitals and physicians have been successfully sued recently. This, hopefully, will translate into concrete actions in terms of medical equipment quality assurance and safety programs.

The second distinction derives from the intrinsic difference between the health systems. Most hospitals in the United States are privately owned, non-profit institutions that have to live with the money they earn from the government, insurance companies, and private patients. They have strong incentives for better financial management and, thus, may be more receptive to the money-saving ideas brought in by CE departments. In Brazil, the public hospitals are rarely responsive to expenditure-saving ideas, and the private institutions are not required to provide high-quality care. Thus, CE departments are often considered nuisances by physicians who want to purchase the fanciest equipment and by administrators interested in making lucrative deals. On the other hand, when a receptive health authority can be found, it is possible to make large-scale improvements (Wang, 1990) that would be virtually impossible in the United States. In terms of health systems, Brazil is more comparable to European countries with large, centralized public health systems.

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The third difference is the low cost of labor in Brazil, compared to the cost of imported equipment and parts. Thus, it may be worthwhile to troubleshoot at component level and even to fabricate some parts rather than to swap boards or subassemblies. This implies increased repair time and requires larger staff, but this is preferable when parts cannot be found locally. While many U.S. CE departments are downsizing and using third-party services, in Brazil it is still economical to hire more engineers and BMETs in order to increase in-house capabilities.

Finally, the profoundly different socio-cultural environments mean that clinical engineering will progress in different ways in Brazil as compared to the United States and other developed countries. In both the United States and Brazil, however, clinical engineers have concluded that they should set a goal to eventually achieving comprehensive technology management responsibilities (Blackwell, 1989; ECRI, 1989; Wang, 1990). In Brazil and in some other developing countries, it is possible to occasionally observe fairly dramatic advances as well as retreats over short periods of time. In the more developed countries, growth tends to be steadier and slower and the gains tend to be lasting.

CONCLUSIONS

Clinical engineering is clearly beginning to gain ground in Brazil as a new, independent profession capable of solving many difficult and costly problems for the healthcare system. The general economic situation and socio-cultural prejudices will prevent steady or quick growth. Significant advances will be interspersed with setbacks, creating a ragged curve whose long-term average has a positive gradient. Fortunately, there seem to be enough hard-working clinical engineers and BMETs willing to accept the challenges, overcome difficulties, and prove that self-reliant ideas can and will work.

Clinical engineering is clearly beginning to gain ground in Brazil.

The creation of the **Brazilian Association of Hospital Engineering and Maintenance** three years ago marked an important step toward the promotion of CE in that country and will help to congregate all current workers in their efforts to overcome the traditional cultural bias against maintenance and to establish themselves as a new breed of professionals in healthcare.

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