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Health Engineering in the Future

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1. INTRODUCTION

Facilities and equipment technology of secondary or differen - tiated health care (hospitals, advanced laboratories, medical research institutions, etc) and primary health care (health centres, polyclinics, public health laboratories, etc) are inte - grated under the huge umbrella of HEALTH ENGINEERING which also deals with water, sewage and air pollution as well as the engineering of food, habitat, as far as health is concerned. Although its scope is immense, the main concern of this paper regards hospitals basically.

Modulation, versatility, technology, efficiency and quality are the principal aspects that hospital technicians take into consideration, today and especially in the near future, in the area of hospital engineering. It is evident that there are another

very important aspects in other areas of health such as medicine and nursing, administration and law. Some aspects even interest several areas, either vocationally or openly, having so significant interfaces that they need the convergence of knowledge from experts belonging to different areas.

It is not enough to say in the abstract, for example, that the hospital of the future will be a different hospital as today, where patients transit more then stay and where there will be more demand for better quality. In fact it will be necessary to situate that hospital in time and space since future alone is to vague: 20 years? 100 years? Where? In Europe? In Central Africa? Quality of what?

Following the usual fluctuations of the hospital evolution, now it can be seen that some European countries are returning again to small hospitals, very common 30 and 40 years ago, in opposition to a notorious concept of the seventies, well acclaimed in most countries of Europe, recommending that the dimension for a general hospital of the district type be around 400 beds (500 in the UK, 300 to 400 in France and 400 in Portugal, for example).

Today some specialists augur that within 50 years there will be hospitalization only for a few types of delicate surgery, such as the transplant surgery, in the hospitals of the most technologically advanced countries, taking into consideration that most surgery will be ambulatory and patients will be treated at home and or at the hospital or day centres as ambulants. Obviously this concept have important implications. In fact it

deals with a multidisciplinary and complex problem! For example, in the year 2043, will there be again the familial cell or clan as before the Second World War? Or, do persons live alone? If the later hypothesis is true, where will be the necessary human resources to support most patients at home?

Nowadays, in some European countries as Portugal, France and Switzerland, some people ask themeselves whether it won't be preferable to let patients stay in hospitals as long as it is medically advisable, since the alternative would be to submit them to an "adventure" that may have serious consequences with the inherent legal proceedings.

The well spread idea that a hospital shall not have more than 500 beds in order to be humanized should not be considered "ipsissima verba" because the capacity of an university hospital, for example, is necessarily bigger because it must cover all hospital medical needs of its region and it shall teach all medical disciplines as can be seen in almost all university hospitals in Europe built since the sixties. The experiment based on the division of a university hospital into two or more smaller hospitals working complementarily together seems to have important inconveniencies both functionally and economically.

Of course, nowadays, paying attention to the increase of the ambulatory work, the big rotation of one hospital bed per year, the technological innovations and, yet, an adequate supplies and services policy, the "ideal" non-teaching hospital may have a capacity of 300 to 400 beds. However, it shall be very well equipped and must offer good comfort and security. Then it will

get an high degree of humanization if the personnel, all personnel, treats patients as human beings.

It is evident that this "ideal" hospital will be very dear. Since engineers and architects are realists, they know that in this matter idealism is good for nothing. Therefore, engineers and architects must face the painful dilemma of quality and cost. They are challenged to help find the way to an appropiate solution since the ideal solution is unobtainable in practical terms. This creativity and ingeniousness make beautiful their work.

2. MODULATION

Today it can still be noted a significative trend for modulation in health facilities as the following examples show :

- A modulated 300 mm general grid, or M30, is widely used, namely, in Europe.
- In some European countries as the UK and in other belonging to the British Commonwealth, there is a large use of a basic 15x15 meter or 16x16 meter square module in hospitals; it is the basis of the Nucleus method, strongly supported by some British architects, where the modules are implanted perpendicularly to a main circulation axis (the "main road"), originating a network of modules with primary and secondary as well as orthogonal and parallel circulations regarding the "main road".

- A macro-modulation based on nursing units for hospitalization has been used since many years ago due to functional and economic reasons; usually there are four exceptions to that rule (pediatrics, infecto-contagious diseases, burns and intensive care units) in general central hospitals and two exceptions only (pediatrics and I.C.U.) in general district hospitals.
- An Operating theatre bloc can be modulated using operating suite modules (e.g., the D.H.S.S. type).
- Large Out-patients and Imaging departments can be partially modulated also.

The main characteristic of modulation in some cases is an easiness for expansion of facilities as it happens in the Nucleus process referred above. Another characteristic is the possibility of industrialization of a module either totally or partially and, consequently, a more favourable cost.

Lately it seems that there is again some interest for the de - centralization of clinical disciplines into small autonomous buildings in a hospital. This idea, the "pavillion" concept, have had some vogue 60-70 years ago. However, it was put aside because its economical and functional (in general) disadvantages were bigger than the specific functional advantages.

In the areas of engineering and architecture modulation is in itself an act creativity! Therefore it may be said that it doesn't freeze or harm progress.

3. VERSATILITY

Having in mind the permanent change, modification and diversity of clinical methods and hospital concepts which take place at a very accelerated pace lately and imply either to bring in to existence new services, units and sectors either to increase, reduce or eliminate those existing already, it is more and more necessary that facilities can be easily adapted to new objectives, different functions and new equipment.

Some reasons are responsible for those changes as, for example, alterations of morbility, ageing, medical progress, technological innovations and new clinical and administrative ideas.

Hospital facilities must allow quick and with ease functional updating. Even deep conceptual alterations shall be made without difficulty in order to cause minimal trouble to the normal work in a hospital. Ease adaptability is a very important aspect to be kept in mind by those who design hospitals.

Versatility of the hospital facilities shall be accompanied with high flexibility of the engineering services which shall adapt easily to new situations such as the change or the functional alteration of facilities and to the enormous diversity of general equipment and medical devices as far as function and manufacturing charateristics are concerned.

The issue of centralization and decentralization exerts a strong influence upon the degree of versatility especially because the concepts are in mutation permanently. More and more

the centralizations and decentralizations foreseen in the original programme of a hospital are subjected to alterations due to functional reasons which will have great implications either in a large scale (e.g., the Out-patients and the Emergency departments or the Operating theatre bloc)or in small or restricted scale (e.g., imaging or signal examinations).

Technological innovations can alter or change concepts of centralization or decentralization that were established without knowing of then.

Engineering services decentralizations is an issue with a strong component of engineering, important architectural and administrative components and a relatively weak medical component. However, as far as medical devices are concerned,the clinical component is very important.

In principle and as a general rule it may be said that the principal advantages of a hospital centralization are the economy in human and material resources and the increase of efficiency due to a more intensive utilization of those resources; and the major advantages of a decentralization is a bigger functional flexibility which is essential in research and some clinical specialized studies.

The trend for the next future indicates that centralizations shall prevail in small and less differentiated hospitals; and that there will be an increase of decentralizations, at least partially, in big and differentiated hospitals such as the university hospitals.

4. TECHNOLOGY

In the last decades the technological evolution in hospitals has progressed rather quickly and the trend today is to increase its velocity due principally to equipment, especially the medical devices and, in a smaller proportion, to the engineering services.

The digitalization and some automation made their appearances in hospitals lately: the trend, as time goes by, is for a generalized digitalization, a big automation and a strong robotorization. In fact, the most painful or dangerous work will be performed by robots in the future.

Today a large research in biomedical engineering is taking place in some countries, namely, the European Community, the USA and Japan. Soon that research will be translated into technological innovations that will have important implications in diagnoses, therapies, the prevention and the rehabilitation, improving the health care.

Some areas of biomedical engineering research engaging a good deal of engineers, clinicians, physicists, biologists and other professionals are biomagnetism, biosensors, telemedicine, advanced informatics in medicine and rehabilitation of vision, hearing and motricity.

Within the vast framework of the European Community Biomedical and Health Research Programme, biomedical technology is one of four sub-areas of one (Development of coordinated research on

prevention, care and health systems) of four areas. Some examples of research themes deal with studies on biomaterials, artificial organs, microsensors, biosensors, stimulators and on medical and health applications of information science and technology; the development of coherent systems including biomedical devices ("lato sensu") for prevention, diagnoses, therapies, rehabilitation and accident prevention, especially in the elderly and handicapped; multidisciplinary studies to compare new biomedical devices with existing ones; and methodological studies on efficacy and effectiveness of biomedical devices.

A few examples of current projects of the European Community biomedical technology:

a) Laser-Doppler flowmetry for microcirculation monitoring (Dr. Moller, Germany)

b) Restoration of muscle activity through functional electrical stimulation and associated technology (Prof. Pedotti, Italy)

c) Electrical impedance tomography (Dr. Barber, UK)

d) Positron emission tomography of cellular regeneration and degeneration (Dr. Comar, Belgium)

e) Ocular fluorometry - new methods and instrumentation for non-invasive diagnosis by ocular fluorescence measurement (Dr. Leite, Portugal)

Also, nowadays, there is extensive research in some areas of engineering generally speaking such as informatics which in a few years will be translated into progress, namely, to support personnel tasks in order that they will be more simplified, quicker,

less painful and safer.

Hospital engineers and architects must be watching carefully what is going on because extensive high technology may bring with it a danger - the dehumanization - into health facilities, especially into hospitals that are more differentiated. That danger is increasingly bigger because the technological resources augment more and more both quantitatively and in complexity in such a way that a hospital within 30 years or less may be compared to a huge health machine. Today there are already a few syndromes related, for example, to the I.C.U. and the Operating theatre that frighten more sensitive patients and, as far as medical devices are concerned, the positron émission tomography , the magnetic resonance and the computerized tomography in a smaller scale.

5. EFFICIENCY

Efficiency in hospitals is also a rather interesting, complex and difficult problem! In most cases there are two main aspects do deal with: the human component and costs, both having many variables and some rather subjective.

The human condition of a patient shall be a permanent concern of those who work on health. Consequently it should be accepted "in limine" that the known rule of the liberal economy (bigger quantity with better quality and less cost) must not be applied to patients' health care. The main reason is that in health the principal objective is always to give good health to all people

and the "material" to work with is man. A hospital is not a factory that manufactures shirts or a firm that produces services. The first priority in a hospital is good quality of care and the other two factors (quantity and cost) shall be considered also but without harming the first objective ever.

For example, the patient average stay in hospitals is a controversial issue. Everywhere the number of days has been strongly reduced and sometimes drastically. In several hospitals in Portugal it was reduced to one third in 25 years! In France it decreased from 18 to 9 days in a decade (1973-1983). Now some people are alarmed with the low current values which they find too diminutive and eventually harmful to patients since many are sent home not totally recovered, for economic reasons and eventually in order that some hospital indices are improved also! It is obvious that this decrease can not go on forever because the limit would be zero!

To improve the efficiency in hospitals? Yes, but within advisable limits because s patient is a human being and not a merchandise. This is an important aspect that engineers and architects can not forget since they design, build and maintain hospitals. The respect for a patient's human condition should be as a star guiding their work always.

It is evident that to face the reality means to meet difficulties because the reality in a capitalistic world subjected to a liberal economy is something hard to live with even in areas so socially important as health. Since health expenses are climbing always, even rich countries press for more efficiency in

order to survive. Nowadays some are thinking to privatize hospitals as a way to improve efficiency and reduce expenses.

A good deal of people may be shocked having in mind that health is a precious asset so valuable that it won't be advisable to put a value on it; therefore, it should be out of all efficiency reasonning. However, it seems that it is necessary to find a value because the cycle is more and more demanding better quality and security and, for that, better facilities and equipment are needed as well as more personnel that cost more and so costs are climbing. On the other hand it must not be forgotten an aggravating factor. The elderly are growing fast and significatively in number ...

In this difficult issue the role of engineers and architects is to find the best technical solutions at reasonable costs. Good common sense plays an importante role in order to achieve that desideratum.

6. QUALITY

Quality is for sure the noblest aspect of the hospital function since patients will trust it when the quality of its health care is good.

Quality implies security as well as comfort because a hospital without them can not have quality. Degrees or levels of quality shall be applied to comfort only since good security, according necessarily to available parameters, is required always for

all types of hospitals.

The evolution of the levels of comfort has been favourable to patients and personnel alike. Some aspects of comfort considered as normal today would have been regarded as luxury some decades ago...

It is obvious that comfort has some limits as, for example,the impossibility to have a hospital next to each door where a person becomes ill or to offer all clinical disciplines and medical devices in all small hospitals.

It may be said that security has accompamied the technological evolution positively but there is still a lot of work to do,namely, in what regards biocontamination and safety in some medical devices (lasers, etc).

The European Community is very concerned with the quality surveillance of medical devices so that some E.C. Directives contain already(and others coming out soon will include) special regulations to ensure its execution in the 12 countries of the Community.

As time goes by it is necessary to attend to new aspects of security which were unknown or even not considered before as informatics "hacking" and the theft of information in hospitals; other aspects became more relevant such as the protection against endogenous and exogenous electromagnetic fields due to the great sensitivity of some new medical devices.

In an increasing degree the progress in general and the ever increasing demands from people are requiring more security and better comfort. As a consequence, hospital administrations request more from engineers and architects who, in turn, ammeliorate the levels of security and comfort so establishing a cycle of demands that is translated into progress that benefits patients and personnel.

Periodical testing and calibration of hospital equipment, especially medical devices, will guarantee better levels of reliability of results and security or, in another words, better quality.

Although preventive technical maintenance is a crucial factor in order to get security in hospitals, the truth is that it is not practiced routinely in many hospitals of the world nowadays. Nevertheless it should be enforced so that hospitals could get: appropriate and unbroken supply of engineering services; adequate and continous work of the equipment (consequently, better efficiency); less degradation of facilities; and better environmental well-being. To get that it is necessary to create an attitude for quality persuading all personnel that it will be good both to patients and to themselves.

Quality in a hospital has many components: some more general and others more specific, some full of complexity and others very simple. However, a patient is essentially interested in the quality of medical care delivered to him. The roles of Engineering and Architecture are very important indeed because they deal with the facilities and equipment that are necessary to hospi-

talize, to make diagnoses and therapies and to rehabilitate patients, caring that they feel well physically and psychically. Also they provide a good environment as well as the equipment and engineering services needed to help personnel to accomplish well their tasks. They provide for a good work in the huge material and human complex system that a hospital is.