Abstract—In Peruvian Health System, Clinical Engineering does not exist as a topic of intervention. 59% of biomedical equipment are officially classified as operational, however next to apply the correct classification methodology and include security issues, only 10% of the equipment are suitable for use in patients. The serious consequences for patients, is opposite to the results expected next to increased public investment in the health sector. Reversing this situation leads to structural changes at all levels of health organization as well as promote that the health staff: physicians, clinical engineers, administrative and technicians, build technology capacities to: implement systems, plans and programs, take adequate cost-effective decisions, recognize safety problems before they adversely affect patients, prevent adverse events related to medical devices, etc. Health Technopole CENGETS implements a linkage & leapfrogging strategy to incorporate and enhance the Healthcare Technology Management HTM and Clinical Engineering CE in Peruvian Health sector. A key component is the sustained multidisciplinary approach. Some results of the sustained innovative interaction developed are: creating HTM & CE Units in hospitals, Peruvian Ministry of Health and Social Security System are gradually including HTM & CE criteria in the norms and national programs, regional governments of Cusco and Trujillo start to plan pilot projects in HTM&CE, National Maternal & Perinatal Institute INMP incorporates HTM&CE in his policies, organization and management. The Peruvian HTM & CE model is effective and a relevant reference for development countries.


I.- INTRODUCTION

One particular global healthcare problem has been recognized for several decades but has not been fully addressed in a comprehensive and successful manner. This problem is the large amount of medical equipment - about 50%, according to the WHO - in developing countries that is not fully operational neither safety for patients or users. It is obvious that contribute to the development and strengthening of capacities to arrange for the management of technology of the health services and guarantee an adequate making decisions process are key factors, and without the correct type and quantity of functioning medical equipment, the provision of healthcare is severely compromised.

"In Peru, 59 % of biomedical equipment is in good conditions, 33% must be replaced and 8% must be repaired. Peru doesn't have a national regulation system neither an established calibration system for medical devices." [18]. There are many reasons for this situation, but they all revolve around the fact that healthcare providers do not have a planned, methodical and responsible approach for managing and maintaining healthcare technology. Generally in Peru, healthcare providers focus on clinical and administrative aspects ignoring healthcare technology management and clinical engineering aspects. Health Technopole CENGETS focuses in contributes to a safer environment for patients, more effective and available treatments and more efficient plans and programs in Peruvian Health Sector.

A Technopole is a conglomerate of capacities that connects the Research with emergent markets in order to solve specific social problematic and to promote the development of territories [8][9]. This is the case of the health sector in general, where it is required to investigate the high-priority requirements and to create, in an innovating way, a sustainable market for the Peruvian health sector, focused on resolving long-outstanding problems in Peruvian society – see Fig 1.
II.- STRATEGY AND METHODOLOGY

Health Technopole CENGETS facilitates sustainable innovation to promote structural change in the health sector, including upgrading human capital and human performance. The principal strategies are based on:

**Linkage Strategy:** Integration of capacities between the customers of health services, the government and relevant stakeholders of health sector. The strategic linkage model set objectives into two perspectives, activities and outcomes [1]. Health Technopole CENGETS is supported by a solid Institutional Network of international, national and local level entities, and is developed with the interaction of the Pan-American Health Organization PAHO of Lima and Washington.

**Leapfrog Strategy:** The goal is creating and promotes skills about Technology and Innovation using Training, Formation, Academic and Exchanging Programs [2]; see Fig 2. From the educational and training perspective, the intervention is in the macro and micro levels [3], see Fig 3. A key component is the multidisciplinary approach developed through Pilot Projects. Principal elements of the strategy are Organizational Development; Workforce Development; and Resource Allocation; Leadership and Partnership are key aspects for the success of the strategy. Health Technopole CENGET’s strategy is carried out through partnerships involving public and private sector stakeholders to support the impact of best-practices models implemented through Pilot Projects. Social and Technical aspects are both strongly considered due to the complexity of Peruvian Health Sector.

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**Fig. 2-a Health Technopole CENGETS’s Leapfrog Strategy: Developing Skills in Technology & Innovation through a Collaborative Frame**
<table>
<thead>
<tr>
<th>Types of Leapfrog Strategy</th>
<th>Contents in</th>
<th>Health Technopole CENGETS’s Application</th>
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</thead>
<tbody>
<tr>
<td>Leapfrog Development in Macro Level</td>
<td>Time</td>
<td>Using less time to obtain distinctive results appreciated by the government, academic and others local and international institutions;</td>
</tr>
<tr>
<td></td>
<td>Space</td>
<td>Developing collaborative projects in Peru; local &amp; regional areas as well as with other countries;</td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>Research &amp; Educational activities in line with best international practices; use of advanced educational contents;</td>
</tr>
<tr>
<td>Leapfrog Development in Micro Level</td>
<td>In the starting point of Teaching &amp; Training</td>
<td>Teaching and Training not at the actual developmental level, but at the level of potential development, namely, the Zone of Proximal Development (Vygotsky)¹;</td>
</tr>
<tr>
<td></td>
<td>In the growth level of individuals</td>
<td>Promote constant Leapfrogging over the actual developmental level of participants of Educational and Training Programs.</td>
</tr>
</tbody>
</table>

Fig.2-b Leapfrog Strategy: CENGETS PUCP’s application

**Projects & Problems Based Learning Methodology:** Ccollaborative learning model, organized by projects and problems based [6] is appropriate for Peruvian Health sector. Students from different specialties work in study teams choose and formulate problems and questions. The team investigates and analyses the selected problems, taking steps towards problem solving, while they make use of existing resources, methods and theories. Each group is assigned a supervisor. The supervisor helps, challenges, supervises, teaches, discusses with the students and assesses them. PUCP University provides laboratories. The group documents progress in a project report, which forms the basis for oral examination at the end of each semester. The work process has similarities to both research work and work of academics in public and private organizations, and therefore considered useful preparation for the candidate’s working life, with regard to the knowledge dimension as well as the development of collaborative and other general and transferable competences. Health Technopole CENGETS includes a Systemic Holistic approach applied to engineering education [7] considering the development of skills such as social communication.

### III.- RESULTS

Some topics related to Health Technopole CENGETS’s intervention are: Clinical Engineering, Healthcare Technology Management, Health Technology Assessment, Management of medical devices, Framework of Medical Devices Regulation, Technology Management, Qualification or training in Healthcare Technology, Management of Healthcare Quality, development of appropriate technology, promotion of a national industry for medical devices and promotion of companies in technological basic services for health sector. Following a brief description of results:

1. **HTM & CE Units in National Hospitals Program:** The vision is to provide an integrated organizational system to Peruvian hospitals, aimed to improving their ability to manage technology based in HTM & CE. With the support of PUCP, the Children’s Health National Institute INSN created the first Unit of Clinical Engineering in the country in 2000, which in a few months was disjointed from the original purpose. In 2004 and 2007, PUCP supported the creation of a HTM Unit in the National Hospital Cayetano Heredia in Lima, the experience was positive temporarily but it was disbanded for lack of a corporate policy decision. The project showed the unnecessary waste of economic resources in hospitals and therefore the economic viability of projects in CE. Further, in 2008 with the support of PUCP, the National Hospital Dos de Mayo established an HTM Unit, the original purposes were soon changed for the same reasons.

¹ The theory of “Zone of Proximal Development” (ZPD) put forward by Vygotsky in the 1930s has been widely applied all over the world. It contains the idea of Leapfrogging “the actual developmental level”, which refers to the results of children’s development cycles and the development level of psychological functions formed from them. ZPD refers to the level that children are reaching for - forming, maturing and developing it. Vygotsky proposed that teaching should be oriented to the children’s future instead of their past. Ref: Cao Changde, “The Significance of Leapfrog Education Development in China”, School of Education, Anqing Teachers College, China, 2008
above. Finally on 2009, the National Maternal Perinatal Institute INMP built the appropriate conditions and required by Health Technopole CENGETS to develop a HTM&CE Unit becoming one of the most relevant changes in the evolution of health organizations in Peru.

2. National and Regional resource, acknowledged by Health Ministry, PAHO/WHO, HTAI and other relevant international expert organizations: Health Technopole CENGETS PUCP, received the American College of Clinical Engineering ACCE & ORBIS International Award 2010, it was given to the organization demonstrating significant improvements in National Health Technology Management (HTM) structure/outcomes…[4].

3. HTM & CE On-Line Courses: On 2007, University of Vermont, USA and PUCP received Pan American Health and Education Foundation PAHEF’s support to design and implement the On-line Medical Equipment Technology: Basic Level and Advance Level Education Project. Before, in 2004 Global Development Learning Network GDLN World Bank - Content Development Fund supported the On-Line version of Health Technology Resources Management Diploma GeTS. 246 students were trained in total.

4. International Internships in Clinical Engineering: Technopole CENGETS coordinates with University of Vermont USA a collaborative program of internship for PUCP’s students, they receive an HTM&CE training program and work at American hospitals, next to the stage they return to work in Peruvian hospitals. 05 engineers were involved in this program.

5. Consulting to Health Sector: Health Technopole CENGETS is: a) a global liaison for collaboration with and a collaborator of Ministry of Health, Social Security hospitals, Andean Commission of Health, Chamber of Commerce of Lima and others; b) a member of Technical Committee to developing National Standards for Health Sector; it collaborates by reviewing the Peruvian version of IEC60601-1; c) a member of the National Committee for the creation of the Peruvian Agency of Healthcare Technology Assessment; d) as a requirement from Ministry of Health, Health Technopole CENGETS will develop a Best Practices HTM & CE Pilot Project at National Hospital Arzobispo Loayza; e) called by the Minister of Social Development will collaborate in 2 National Programs; g) responding to an invitation from the Presidency of the Health Commission of the Peruvian Congress, Health Technopole CENGETS will be on charge of include and develop the Technology issue in the contents of the National Health Law of Peru.

6. Maternal Perinatal Tele-Echography Project: Is a multi-institutional project, involves the University of Orleans and the University of Tours, France, and the University of Vermont and ORBIS International, USA it is also supported by the Embassy of France, Health Regional Direction of Cusco and the Ministry of Health.

7. Creation of Undergraduate Biomedical Engineering Program: at PUCP with the collaboration of the University of Vermont USA and the Latin American Counsel of Biomedical Engineering CORAL.


CONCLUSION

Technopole model usually applied to enhance industrial capacities is being efficient and appropriate to resolve complex social and technological problems in a developing country. CENGETS is doing distinctive initiatives improving the Quality in Health Sector of Peru by implementing a sustained strategy-mix: Linkage and Leapfrog Strategy applied to the Educational and Training Programs, supported by a Projects & Problems Based Learning Methodology. The model have resulted in distinctive results as: i) Development of Best Practices through Pilot Projects to create Integral Change (structure, planning, systems, equipments and others) at Peruvian health sector and ii) Promotion of the profession of Biomedical Engineering in Peru. Key components of the model are: Innovation, Technology, Management, Education, Interaction, Leadership, Multidisciplinary and international exchanges. The model have led to remarkable results and provide enough evidence for dissemination of a model focused on improve the Quality of Healthcare services and Development and Enhance Competitiveness in other similar countries.

REFERENCES


