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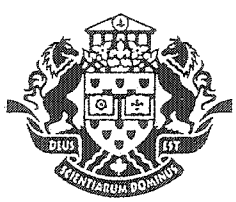

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ABSTRACT

This study was to evaluate the development level of Clinical Engineering Departments (CEDs) in hospitals in developing countries. The method of data collection was a survey done by structured questionnaire sent by Email and Listserv. In total, 61 responses (9% response rate) were grouped into two regions: Latin America (27 from Venezuela, Mexico, Brazil) and Asia (34 from India, Bangladesh, P.R. China, Indonesia, Saudi Arabia, South Africa); The responses from those developing countries were compared with those from developed countries acquired in previous studies done by Frize and Glouhova. In this study, results indicate that CEDs that responded to the survey from developing countries have similar organizational structure as developed countries, but there are differences in personnel educational levels, responsibilities, and resources. We also identified differences in the level of development of CEDs in respondents from Asia and those from Latin America. The latter were more advanced overall than those in Asia, but CEDs in both regions need to improve their level of development. Future research should focus on collecting more data from CEDs of developing countries, and expand the quantitative analysis that will be possible with a larger sample.

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CONTRIBUTIONS

This study was the first to apply CED effectiveness model (Dr. Frize's) to developing country study. We carried out the international CED survey completely through electronic approach, not paper-based, and found the factors that would improve the performance of CEDs in developing countries in terms of level of responsibility, education and resources. We also identified different levels of progress in different regions: the respondents in Latin America were more advanced in the development of their CEDs than those in Asia.

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Nomenclature

CED	Clinical Engineering Department
CE	Clinical Engineer
HDI	United Nations Human Development Index
IFMBE	International Federation for Medical and Biological Engineering
DCE	Division for Clinical Engineering of IFMBE
ACCE	American College of Clinical Engineering
BMET	BioMedical Equipment Technician
EEC	European Economic Community

CHAPTER 1. INTRODUCTION

No matter what your age, gender, race, religion is, or financial status, healthcare is important to you. In any country, healthcare is one issue on the minds of citizens and government officials. Different countries may have adopted different systems to deal with their public health, but the success of any healthcare system depends on the willingness and ability of governments to fund it. However, most developing countries cannot afford to spend more than 0.5-1.5% of their GNP (Gross National Product) on healthcare, in contrast with 5-14% in developed countries. [1] As a result, public healthcare systems in those countries are not able to effectively deliver healthcare services and products to the people who need them. [2]

Hospitals as one of commonest and most efficient ways are delivering healthcare services to patients. Doctors and nurses in hospitals deliver the service to patients face to face, and medical and clinical facilities are involved in the process. At all levels, successful patient outcomes are increasingly dependent on those facilities and medical equipment technology, which is a basic part of healthcare technology. And the clinical engineering department (CED) is regarded as an organization that applies and manages medical equipment technology. CEDs will insure that broken equipment is promptly repaired, test new

equipment to make sure that it can be used, consult purchasing equipment plans to hospital administrators, give an introduction on how to manipulate instruments, even research and develop new medical devices for patients. Clinical engineers (CEs) are the professionals to perform the clinical engineering functions in hospitals.

Clinical doctors, nurses and technologists know that suitable, properly running facilities provide a great deal help to their patients and themselves. Hospital administrators notice that an effective treatment for patients is indispensable and CEs or equivalent roles have to exist in the hospital organizations although sometimes there are no separate departments for them.

In 1985, in order to support the development of clinical engineering, the IFMBE (International Federation for Medical and Biological Engineering) constituted a specialized Division for Clinical Engineering (DCE). With clinical engineering rapidly developed in most industrialized countries, especially in North American and Western Europe, the ACCE (American College of Clinical Engineering, USA) launched a project named ACEW (Advanced Clinical Engineering Workshop) in 1991, which was mainly to assist developing countries to advance in their clinical engineering services. Since then, eleven ACEWs have been presented in the following locations: Beijing; Mexico City; Moscow; Santo Domingo, Dominican Republic; Vilnius, Lithuania; Cape Town, South Africa. [3].

With the development of clinical engineering, more research and studies on the field were set out. In 1988, to measure the effectiveness of CEDs in hospitals, an international survey on the actual activities of clinical engineering departments in some industrialized countries was created and sent by Dr. Frize. [4,5] 500 questionnaires were sent to North America (Canada and USA), three countries in former E.E.C. (France, UK, and Netherlands), and two Nordic countries (Sweden and Finland). About 116 responses were received finally. In 1991, Frize sent the survey to those countries again and received 59 responses. She said "compared with the study in 1988, there were minor variations between them". [6]

Eight years later (1999), a new worldwide CED survey was launched by the research group of Glouhova. [30] 1000 questionnaires were sent out to CEDs in North America (Canada and USA), Nordic countries (Norway, Sweden, Finland, Iceland and Denmark), Western Europe (Germany, Netherlands and UK), South Europe (Italy, Greece and Cyprus), Australia, and Latin America (Argentina, Brazil, Cuba and Mexico). Among them, only Brazil, Cuba and Mexico are developing countries according to HDI (see Appendix B), and the rest of countries are developed countries. In that survey, about 150 responses were received and just less than 10.6% came from developing countries in Latin America.

Recently, some studies in clinical engineering were taken, but they were limited within the NORDMEDTEK group, including Sweden, Finland, Norway, Denmark, and Iceland. [7] Additionally, a national survey was carried out to learn the CED's situation in Bulgaria. [8] From those studies, most subjects were developed countries, like North America, Nordic

countries, and Western Europe, where clinical engineering has developed at a higher level, but less information of CEDs were collected from developing countries. However, the overwhelming majority of the world population, 4.6 billion, is living in developing countries. They account for more than 67% of the population of the world. [9] The extent to their CEDs' development has great effect on the level of clinical engineering advance in the world.

1.1 Thesis motivation

The Frize and Glouhova studies assessed the level of functional involvement and effective performance of CEDs in developed countries. But no one has performed, to date, a similar study in developing countries. The situation is expected to be different in developing countries as discussed in some of the published articles on this topic [6-8] However no detailed study like the ones mentioned above have been done in these countries. This was the main motivation behind this thesis work.

1.2 Thesis objectives

The objective was to use a similar approach as the one used for developed countries to assess the level of development of CEDs in developing countries. The results of this study would then be compared with those from developed countries. The factors that could improve the performance of CEDs in developing countries would be identified.

1.3 Thesis organization

In this thesis, Chapter 1 provides the introduction, motivation, and objectives of the research. Chapter 2 defines clinical engineering and its main role and functions, describes the health care system in developing countries, and the main issues faced by clinical engineering in developing countries. Chapter 3 describes the methodology of this research, such as sampling strategy, method of data collection, data preparation, and Spearman correlation test for data analysis. Chapter 4 provides the results of the qualitative data analysis and hospital profile, CED personnel structure, organization structure, responsibilities, resources, and level of equipment management involvement. The data are compared with the two previous studies in developed countries and also compares the current responses from two regions in the world (Asia and Latin America). However the results do not assume that they are typical of these regions,. They just represent the situation as reported by the respondents from these regions. Chapter 5 provides a discussion of the results and conclusion. Chapter 6 proposes some future work the appendix contains a sample of the survey, research ethic approval certificate, all developing country list, online survey code, data preparation and analysis code, and technical report for test a hypothesis using the data.

CHAPTER 2. BACKGROUD

2.1 The public health status of developing countries

In the study, we choose some developing countries as our focus for they are in really different situations from developed ones. Developing countries usually lack access to water resources and health facilities, and lack education of the people, and have low income and a high children death ratio. Those features of developing countries make them distinguished from developed countries.

Public health in a country is not only a function of healthcare systems, but also the condition of the infrastructure, such as roads, electricity, clean water, telephone lines. Without adequate infrastructure, the healthcare systems cannot operate effectively. [2] In developing world, both systems and infrastructure are inadequate due to a variety of causes.

2.1.1 Infrastructure of developing countries

Developing countries have great differences with developed countries with respect to their economy. Sometimes, the difference is beyond our imaginations. Bekele stated, "The world's three richest people together own assets that exceed the combined gross domestic

product of the 48 least developed countries." [10] The global wealth is extraordinarily unequally allocated.

Developing countries are characterized by poverty. The United Nations Human Development Index (HDI) is included in the human development report by United Nations (UN), and gives a list of development degree of countries in the world. The HDI was published in 2001 that included 162 countries in the world. [11] (See Appendix B) In the report, 48 countries were in the high development category, 78 in the middle, and 36 in the low. The 114 countries ranked lower than 48 are called developing countries. They are geographically concentrated on six regions: East Asia and Pacific, East Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa.

Because of unequal property distribution, lack of income, poor health, and high illiteracy rate, the gap in science and technology (S&T) between developed countries and developing countries is enlarged. For example, the television receivers per 1000 inhabitants (1997), the number in developed countries is from 350 to 1050, in contrast, the number in developing countries is 0-349. [12] It means that on the average each of a thousand people in the richest countries owns at least one TV, whereas, there is less than one TV per thousand persons in the poorest countries.

What distinguishes the poor from the rich is not only that they have fewer assets, but also that they are largely excluded from the creation and the benefits of scientific knowledge. [13] UNESCO (United Nations Educational Scientific Cultural Organization) uses some scientific indicators to measure the state of science and technology (S&T) in the world. They are related to research and experimental development (R&D) indicators, including the number of researchers and R&D technicians per million inhabitants, number of R&D technicians per researcher, R&D expenditure as percentage of GDP, and R&D expenditure per capita and per researcher in national currency.

Regions/ countries	GDP		Population		R&D expenditure (GERD)				R&D researchers			
	Billion PPP$	% world GDP	Million	% world Population	Billion PPP$	% world GERD	% GDP	GERD per inhabitant (PPP$)	Researchers (thousands)	Researchers % world Total	Researchers per million inhabitants	GERD per researcher (thousands PPP$)
WORLD	34 391,9	100,0	5 483,3	100,0	548,7	100,0	1,6	100	5 189,4	100,0	946	105,4
Developing countries	13 356,8	38,9	4 258,5	77,7	85,5	15,6	0,6	20	1 476,2	28,4	347	57,9
Developed countries	21 815,1	61,1	1 224,4	22,3	481,3	84,4	2,2	377	3 713,3	71,6	3 033	124,2

Source from UNSECO, "the State of Science and Technology in the World, 1996 -1997".

Table 1 Key indicators on world GDP, population and R&D expenditure and personnel, 1996/97.

Table 1 shows that, in 1996-97, 77.7% of the whole population possesses 38.9% wealth, and 0.6% of their GDP is used to R&D expenditure in the developing world. It is impossible to develop R&D without adequate funds. Compared to developed countries, 2.2% of the GDP was used as R&D expenditure to promote technology development that is originally at an advanced level. Table 1 shows that developing countries were not only lacked financial resources, but were also short of personnel resources. For every million

inhabitants in developing countries, they have 347 researchers, in contrast to, 3033 researchers in developed countries. It is almost 8 times more.

In some high-tech fields, such as Internet and telecommunication, there are still great distinctions between developed countries and developing countries. Nearly 90 percent of all Internet users are in industrialized countries, and users in the United States and Canada account for 57 percent of the total. In contrast, Internet users in Africa and the Middle East, together account for only 1 percent of the global Internet users. [14]

	Telephon e mainlines (per 1,000 people)			Personal computers (per 1,000 people)			Internet hosts (per 10,000 people)		
	1995	1998	1999	1995	1998	1999	1995	1998	1999
Latin America & Caribbean	91.4	119.2	130.1	19.5	32.0	37.7	1.2	7.7	14.8
East Asia and Pacific	15.7	41.1	82.0	1.9	6.5	17.0	..	0.3	2.4
Europe & Central Asia	124.7	164.6	213.3	4.3	18.2	39.3	..	2.3	15.5
Middle East & North Africa	37.8	58.0	87.5	..	12.6	25.4	..	0.1	0.4
Sub-Saharan Africa	9.5	10.8	..	..	..	8.4	..	0.8	2.3
South Asia	5.6	11.9	23.2	0.4	1.5	3.2	..	0.0	0.2
High income countries	..	738.9	1130.7	..	261.7	385.0	..	..	641.0*

*Original datum is 64.1 per 1,000 inhabitants; source from www.unido.org/en/doc/4484.

Source from "World Development Indicators database, 2001"and [14]

Table 2 technology and infrastructure in developing countries

From table 2, the wide gap between developed countries and developing countries in high-tech is obvious. The three technology indicators in table 2 are telephone mainlines per thousand people, computers per thousand people, and Internet hosts number per 10,000 people. They show that developed regions (High income countries) often have much more technology and infrastructure than developing regions.

Infrastructure problems exacerbate conditions of healthcare systems in those countries. Muddy roads and poor transportation networks impede the health care service's delivery; lack of phone lines and fax service makes health service's network not combinational. Without round-the-clock electricity, hospitals cannot function effectively, and operations cannot be performed and refrigerated vaccines will spoil, water cannot be purified, and raw sewage cannot be processed; without enough clean water, hospitals cannot function properly, and diseases can even be spread out. So, developing countries hardly benefit from the advanced technologies that happen in developed countries.

2.1.2 Healthcare technology system, with a focus on clinical engineering

In industrialized regions and metropolises of developing countries, clinical engineering departments and other healthcare technologies have appeared and developed. For example, BIRDEM (Bangladesh Institute of Research & Rehabilitation in Diabetic & Endocrine Metabolism) and ICDDRB (International Centre for Diarrhoeal Diseases Research in Bangladesh) have a well-organized in-house technical team to keep the equipment in good working condition, and most devices were running. [15] But those well-developed CEDs centralized in the small amount of cities; a great deal number of rural and countryside regions only have limited CEDs in hospitals.

To reinforce the clinical engineering expertise, many developing countries add clinical engineering program into their higher education system, and provide training for clinical engineers or equivalent, such as:

- There are five universities to provide education in Biomedical/Clinical Engineering field in Brazil, and limited opportunities to train abroad supplied by Ministry of Education. [29]
- A Master's Degree in Biomedical Engineering can be obtained at the Department of Biomedical Engineering in the Faculty of Health Science of the University Of Cape Town, South Africa. [16]
- In China, since 1977, 20 universities have been authorized to offer Bachelor's Degree in BME, and 40 Master's programs have been accredited to offer Master's Degree in BME, and 13 institutions have been accredited to offer Ph.D. in BME, and 2 post-doctoral training programs of BME have also been accredited (they are Zhejiang University and Xi`an Jiaotong University). [17]
- The Medical Electronics and Medical Equipment Management School in London provides a Postgraduate diploma for overseas students educated in medical equipment technical and management subjects. [18]

They also import equipment and technologies from developed countries, and invite foreign specialists to coordinate with policy decision-maken for healthcare services. The international societies have also donated hundreds of medical devices to developing countries. However, after decades of efforts of developing countries and international societies, they find that issues obviously exist in the field. The section 2.2 will list and discuss the five main issues on clinical engineering of developing countries.

2.2 Main issues concerning clinical engineering in developing countries

2.2.1 Lack of financial funding

Most developing countries cannot afford to spend more than 0.5-1.5% of their GNP (Gross National Product) on healthcare delivery, in contrast with 5-14% in developed countries. [1] Nevertheless, they have 67% world population. The money spent on every person in those countries is so little that those counties cannot afford to establish and maintain their healthcare technology system for clinical engineering, and they cannot afford to train personnel to design and manufacture high quality medical devices to meet their needs. Only 7% of the annual spending on medical equipment is made by developing countries. [1]

2.2.2 Relying on technology from developed countries

It is estimated that there are approximately 6000 generic types of medical devices in the world, with 750,000 different brands and models. However, most of them are designed and manufactured by developed countries. So, most medical equipment and technologies used in developing countries are imported from industrialized world, especially USA, Japan, and Western Europe.

Developing countries do not have enough abilities to purchase 'high price' equipment and the technology of developed countries is not appropriate for developing countries. The

reason for high price of equipment is that the equipment prices not only include the material cost of medical equipment, but also include high wages in the industrialized countries where that equipment are developed and manufactured. Although now more and more medical equipment manufactures are moved into developing countries, such as China, Malaysia, India, Mexico, (because of their cheaper labors), most of their productions still cost much higher than local productions and they cannot be directly sold in those countries' markets. Customers cannot purchase those productions like local productions; instead, they need import those productions after adding high tariff.

Sometimes those equipment running-costs are also high for developing countries. Disposable consumable parts like electrodes, special pastes, etc., which are "very cheap in manufacture countries, but are expensive in non-manufacture countries like developing countries". [19]

Another reason of high price of medical equipment is caused by inappropriate technologies to developing countries, for example, many extra functions, which cost high and are results of violent market competitions in developed countries. Those technologies and functions are not necessary to improve the basic clinic utility and just a reason to promote customers to buy the device. So Mridha said that, "the lack of attention paid by medical equipment designers and manufacturers to the unique characteristics of the clinical environment of the developing countries is partly responsible for this situation. " [20]

Equipment imported by developing countries often includes high technology. So, the advanced medical equipment also requires a high qualification and skilled technician team to support them. This must become another large challenge to developing countries.

Donations from developed countries are another essential way for developing countries to get medical equipment, besides purchases. But studies for the assessment of operation status of equipment donated to some developing countries stated that "Gifts of both state-of-the-art and obsolete equipment without service manuals or manuals in a foreign language do not always have the positive effect envisioned by the donating group". [21] The followings are some examples from developing countries:

- A used diagnostic ultrasound was donated to a hospital. The machine cost more than thousands dollars to transport to Bangladesh, but when it arrived, it was found that it was out of order. Additionally, the machine was an old model, and rather complicated to operate, and there was no technician being able to operate it. Moreover, a more modern and easy-to-operate diagnostic ultrasound was available at the hospital at that time. [20]
- In Bangladesh, a tissue processor that could process hundreds of samples at one time had rarely been used because the hospital only processes a few cases per week. [15]
- In Bangladesh, a colposcope was left unused for three years because no operator manual was available. [15]

2.2.3 Poor maintenance of medical equipment

Studies have indicated that about 40-60% of the medical equipment in most developing countries is non-functional due to inadequate maintenance services. [22] Some studies even showed that 80% of equipment remains idle. [23] Those developing countries find themselves flooded with sophisticated medical equipment, but they can neither maintain nor repair. The reasons for those are considered to relate with a lack of user's manuals, trained staff, spare parts, and planned acquirement.

When the equipment arrives at hospitals, it needs qualified engineers and technicians to install it, inspect it, and test it. Some equipment is sitting in the storage or the hall of hospitals for several years because no one knows how to install it. If the equipment is installed normally, it needs to have qualified physicians or technicians to operation it and make it serving to patients. Some equipment is hardly used in the clinical departments or laboratory for years because no one knows how to operate it, or no one dares to use it without a team leader's permission. If the equipment runs normally, after several months or one year, the equipment would break down due to wear and tear. Meanwhile, hospital administrators realize that there is no qualified technical staff to repair them. Even though they have technicians who would like to repair them, those technicians would find that there are no manuals, or specification, or maintenance instruction to refer to. If technicians find problem parts in the equipment finally, they would be aware that there are no spare parts in their inventory and they cannot get the spare parts in a short period because the

equipment is not manufactured locally. They have to wait until the request of spare parts is approved by health service bureaucracy and who then send it to the supplier. The request may be delayed by clerical procedures for months. Contrasted with developed countries, like UK, the next day delivery for spare parts is common. [24]

2.2.4 Inadequate maintenance budgets

World Bank found that a disproportionately small part of public budgets was allocated to preventive care and routine equipment maintenance in public hospitals in Nigeria, Tanzania, Guinea-Bissau and Malawi, which are developing countries. [2] Inadequate maintenance budgets cause inadequate preventive and corrective maintenance that makes equipment fail frequently, and makes glitch equipment deteriorate to the point of disrepair, and reduces equipment lifetime, and extends equipment "down time". In many cases, improving maintenance, managing to extend operating life, and reducing equipment downtime would be more efficient and effective than buying new equipment. [24]

2.2.5 The absence of a "pervading technological culture" [25]

"Pervading technological culture" forms a supportive infrastructure (both visible and invisible) for clinical engineering activities. [25] In developing world, it often happened that the equipment was idle in a hospital that did not need, while another hospital was waiting to order the same type equipment from overseas; the severely shortage of trained

staff is still deteriorated by that some trained staff leave from hospitals to private sectors because of high salaries. These issues have arisen due to absent of an appropriate nation policy on clinical engineering field. [26] Therefore, realization and recognition to significance of clinical engineering should be noticed by the officers of National Ministry of Health. They need to be aware that well planned equipment purchase schema, continuous education of clinical engineering staffs and career structure of clinical engineering deserve to have their place in national health care policy. They are supposed to draw up national policies to uphold a good medical technology and management system. Roberts "A special Health Administrators for clinical engineering in developing countries are considered to contribute to the dilemma of medical equipment and technology." [24]

To solve the above five issues, experts suggested "local fabrication". [19,23,20,21,24,27] The approach is to provide local services and local training courses in Clinical Engineering field, especially in Medical Electronics and Medical Equipment Management. With more equipment being used in hospitals (Frize, p18), [28] clinical engineering is considered as a good approach to solve the higher repairing and maintaining expense in hospitals.

Furthermore, periodically updating training courses of clinical engineering or biomedical engineering are as important as new equipment and technology that will continue to invade developing countries. The expectation of training staff is not only to provide better maintenance, but also to develop and manufacture local medical equipment that is suitable

for local condition like weather, manufacture standard, and culture. It can also increase the spare parts localization and provide adequate user's manuals and instructions.

In hospital, the successful equipment maintenance and management depend to a great degree on whether or not clinical engineering department is integrated into the hospital organization, just like nursing, pharmacy. This study is expected to contribute to develop clinical engineering in some developing regions.

2.3 What is Clinical Engineering?

Clinical Engineering was first developed at George Washington University in 1967. Early years of clinical engineering activities started with clinically oriented research group that conducted research in hospitals with a strong technical orientation. [29] By the beginning of 1970s, specialized CEDs appeared in the larger hospitals. Their responsibilities were to repair and maintain simpler equipment like beds and wheelchairs, etc. Their responsibilities gradually increased to the whole management of medical equipment. As cost containment policies, in the 80s, led to more business-oriented, cost-justified approaches, CEs got involved in the pre-purchase consultation and evaluation of the technology that resulted in important savings for hospital budgets. In the 90s, CEDs moved their more missions to technology management, research and development, and technology assessment. [30]

DCE (Division for Clinical Engineering) of IFMBE define that *Clinical Engineering* is the safe and effective management of technology and the application of medical and biological engineering with the clinical environment, for the advancement of health care. [26] There are two typical ways to solve problems of medical equipment in hospitals. One is internal, in-house CED; the other is external service provided, as the third part service providers. In this study, the former is focused. An In-house CED of hospital plays a role in supporting and advancing patient care by applying engineering and management skills to healthcare technology, and CED staff has more understanding to the physical environment of their hospitals, the medical procedures of treatment for patients, and the abilities of clinical staff to operate facilities and equipment. These are the merits over the third-part service providers.

In general, the responsibilities and missions of a CED in a standard hospital are as follows:

1) In-house repairs

- Repairing or corrective maintenance to medical equipment including electronic, mechanical, optical devices used for diagnosis, monitoring, medical imaging, anesthetic, respiratory clinical laboratory, and computer systems. (Frize, p32) [28]
- In-door checking and servicing, contacting with manufactures or third parties companies.

2) Incoming inspections

- Acceptance inspections and testing of all new medical equipment when they are delivered and returned after externally repairing. (Frize, p32) [28]
- Corrective installation for equipment to meet safety standard.

- Setting equipment to meet users' requirement.

3) Preventive maintenance

- Ensuring equipment to keep the safety and efficacy, and making a plan to older equipment in order to obsolesce and replace it.
- Giving advice on technology and equipment and directing users on the spot.
- Modification of present facilities to meet new demands, and upgrading performance and safety.
- Taking of appropriate actions when receiving the hazard notice with regard to potentially defective equipment through the alert reporting systems. [26]

4) Education and training

- Training users on the safe and effective use of equipment and technologies. (Frize, p33) [28]

5) Consultation and evaluation for purchasing equipment

- Feasible analysis for equipment to perform the desired task and run in specified environment.
- Cost effectiveness analysis for purchase, installation, and running costs, performances.
- Evaluating reliability of product manufacturers, tenders/venders, follow-up service companies. (Frize, p33) [28]

6) Research and Development

- Conducting studies and research in design, development, advances in medical equipment and clinical instrumentation. (Frize, p33) [28]

- Development projects and recommending solutions on instrumentation needs and electrical-safety problems.
- Cooperation and support to medical researchers

7) Quality control activities

- The measurement of staff productivity, and "the assessment of the cost-effectiveness of services provided" (Frize, p33) [28]
- Quality control for services provided by CED
- Some administrative duties: budgets, staffing, planning, coordination with other departments, and continuous quality improvement programs. (Frize, p33) [28]

2.4 Personnel of CED

CEDs consists of clinical engineers, technicians, and clerical staff.

Clinical engineers (CEs): A definition by DCE is "a professional who supports and advances patient care by applying engineering and managerial skills to health care technology". [29] Plus, DCE requires the CE's qualification to be "at least a 4-year University course resulting in a Bachelor of Science or in Engineering and in addition a period of practical training". [29] In international survey of Glouhova group, they stated "In Europe, a very high percent of the CEDs employ engineers with PhD degrees, in North America the majority hold an MS. degree, while in Australia and Latin America the predominant degree is a BSc." [30] CE's expertise awareness directly influences to orientation of the CED's development.

Technicians: or equivalent. As for their qualification, although technicians have different classification on the occupation list in many countries, they usually have a two-year or more than two-year technical education after high school. "But in North America and Australia, there are technicians with BSc degrees and some in USA and West Europe even hold MSc degrees". [30]

Clerical staff: the administrative staffs in CEDs, at a ratio of one clerical staff to every eight or nine technical staff, which include engineers and technicians. [31]

In general, in a CED with three staff levels, the CE's activities of clinical engineering duties is user training, consulting, continuous research, and quality assurance. Technicians mostly perform in-house repairing, incoming inspecting, and prevective maintenance. The clerical staffs are mainly involved in task 7, the part of assisting in the administrative duties and documentation. (Frize, p34) [28]

2.5 Involved medical equipment classification

What does medical equipment refer to? Medical equipment includes all technological aids applied for medical purposes, from prevention – such as equipment for detection of breast tumors and fitness equipment measuring the heart rate – to equipment in hospitals and appliances used at home. Here, medical equipment includes all the equipment with which clinical engineering is involved; that is, equipment that clinical engineers and technicians

work with, maintain, and consult about. In Frize's book, the equipment is classified in the four categories of: medical clinical equipment, radiology equipment, clinical laboratory equipment, and anesthesiology equipment. (Frize, p67-70) [28]

In our study, the classification is revised due to expansion of clinical engineering responsibility and technology innovation. Medical equipment is now grouped into five groups. They are:

- Medical clinical equipment: e.g. monitoring and diagnostic instruments, dialysis equipment
- Laboratory equipment: e.g. calibrator, balance, blood gas analyzer
- Radiology/Imaging equipment: e.g. X-ray, CT, MRI
- Anesthetics ventilation equipment
- Computer/software systems for clinical and medical: e.g. telecommunication system for tele-diagnostic

With the worldwide high-tech advance, new categories come into the medical device family, such as tele-diagnostic, tele-surgery, decision-making support systems, etc. Therefore, we add the fifth category to the classification.

2.6 The model of CED effectiveness

A model to measure the effectiveness of hospitals' CEDs in Canada and some developed countries was purposed in Frize's thesis, *"Evaluating the effectiveness of clinical engineering departments in Canadian hospitals"*. It also gave the principle features of

CEDs in those countries, especially in Canada. The model is illustrated in figure 1. Her study established that the CED effectiveness (Outcomes) was affected by the organizational factors that reflect the organizational climate of CEDs in Canadian hospitals. The factors composing organizational climate are input-indicators of the system, and the CED effectiveness can be the output of the system. The CED effectiveness is measured by CED functions (or outcomes). That study in developed countries gave us better knowledge base on clinical engineering field, and that model will be employed in this study for developing countries. Additionally, making use of that model can allow us to compare studies and previous studies.

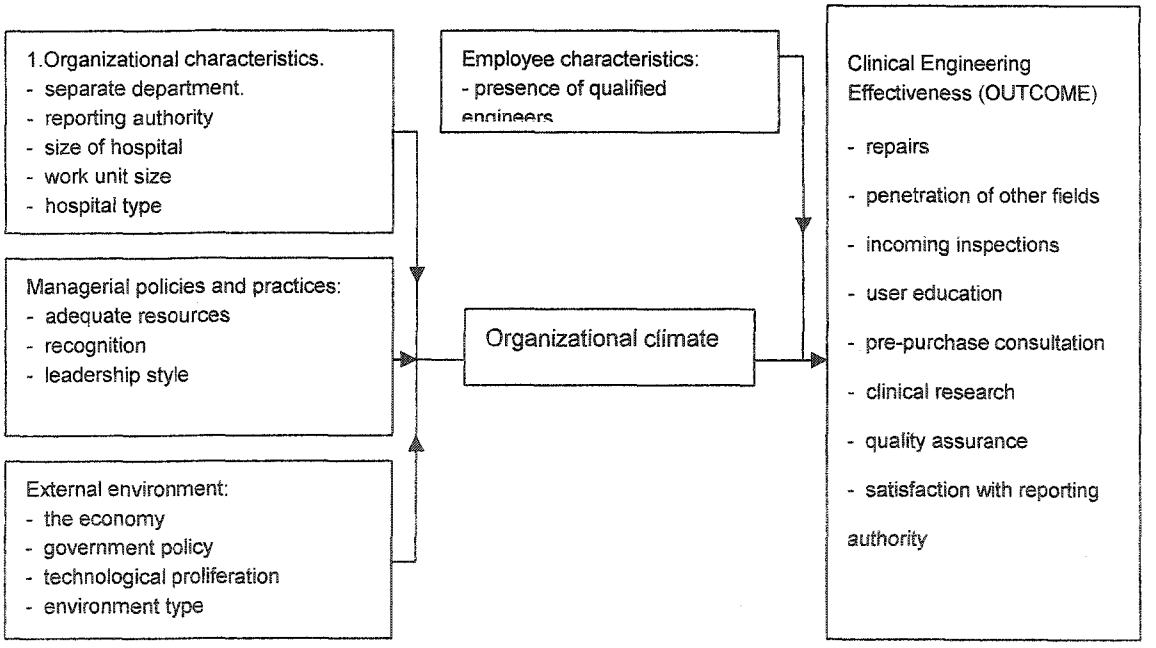


Figure 1 model of CED effectiveness (Frize, p63)[28]

In short, the current study aims to assess the development situation of CED in developing countries, including whether their hospitals have had clinical engineering departments, and what CEDs' functions, structure, personnel, and responsibilities are. This study could be the exploratory research and foundation to further study in clinical engineering development in developing countries.

CHAPTER 3. METHODOLGY

There are two methods to collect information: observation and interrogation. The observation method is an approach to gather information by seeing. The method is a huge challenge to be applied to a country-level, extensive research due to cost and time. So, the interrogation method, or survey, is selected. In fact, it is commonly used by both public and private organizations to collect information. In the U.S. Constitution, a survey for census is carried out every 10 years; the National Health Interview Survey has been carried out by Bureau of the Census for the Public Health Service since the late 1950s; the Bureau of the Census sends a survey for estimating the unemployment rates in certain region for a period. (Rao, p9-14) [32] Since every participant is asked the same questions in the survey, researchers are able to systematically compare the different types of responses people give. The systematic information is valuable to analysis and decision-making.

3.1. Data collection

3.1.1 Non-probabilistic sampling

The first step to data collection is to consider a sampling strategy that is going to determine how well a sample represents a population. The sampling strategy explains that what the

sample frame is, and how much the sample size is, and specific selection criterion and procedure.

Sampling strategies can be classified as either non-probabilistic or probabilistic. Probabilistic sampling is used when "the research focuses on a sample's representativeness or generalization." [32] The probabilistic sampling gives every individual in the population a chance to be selected. The sample selected is only a small percentage of the whole, and individuals are usually selected according to a random number table or a random number generator. By employing probabilistic sampling, researchers attempt to use the features of sampling to forecast the features of the whole population.

On the other hand, the non-probabilistic sampling is used when "the research focuses on how the sample or small collection of cases illuminates social life" or "clarify and deepen understanding of specific cases, events or actions." [42] The difference between probabilistic and non-probabilistic sampling is that the latter has a basic assumption about the nature of population under study, whereas, the former has a randomized selection process. The **basic assumption** is that "there is an even distribution of characteristics within the population." [33] The assumption makes researchers believe that any sample would be representative and results would be accurate. [33]

Non-probabilistic sampling means that a sample is selected not according to a random approach (e.g. random number table) but according to the experts' intuition, or self-

selection, or historical documentation, or long field experience in the area. [32] Because of this, it is not assured for every item to have a chance to be included. So it is impossible to estimate the probability of any item that could be included in a sample, the sampling variability, and reliability. Despite those shortcomings, non-probabilistic sampling "can be useful when descriptive comments about the sample itself are desired", and "some preliminary studies during the development stage of a survey", [33] and "often used in exploratory studies, e.g. for hypothesis generation". [34] The present study is an exploratory and preliminary study to assess development of CEDs in developing countries, which is rarely done by researchers before.

As a matter of fact, non-probabilistic sampling is widely used in survey research and studies. Fowler stated, "Although most governments generally are not funding survey research efforts designed to make estimates of population characteristics that are not based on probability sampling, almost all of the major public opinion polling groups, political polling groups, and market research organizations rely solely on non-probability sampling methods." [35] The Statistics Canada reports "we use probability sampling for most our surveys, but uses non-probability sampling for questionnaire testing and some preliminary studies during the development stage of a survey." [33]

The reason to choose non-probabilistic sampling strategy is as follows.

(1) Sampling Frame. There is not a complete sampling frame available for certain groups of the population, or as Fowler said "Users may not know the limits of the data (or

population) they are using."[35] In this survey, it is impossible to list all the CEDs in all developing countries. This means there is no complete sample frame that is precondition of probabilistic sampling, but in non-probabilistic sampling, it is not a handicap for study. In non-probabilistic sampling, a sample frame is produced by using the sampling strategy to select which sample should be included.

(2) Cost and Time. The choice of a sampling strategy rests in part on feasibility and costs. Non-probabilistic sampling costs less and is carried out more quickly than probabilistic sampling. [36] In the present survey, at a preliminary and exploratory stage of this field, it would not have been possible to choose a truly probabilistic sampling method, especially for mail survey as instrument. Non-probabilistic sampling is the only feasible method with the present cost and time constraints. This fact is going to be taken into account throughout this study and data analysis. Although cost and time is limited, obtaining more responses from sampling frame is hoped. So, CEDs in hospitals that have been known by international society, and clinical engineers who have contact with their colleagues in developed countries are been considered as priority participants of the survey.

(3) Exploratory study. A study was preformed by Frize (1988) to evaluate effectiveness of CEDs in hospitals in Canada and other developed countries. That study began this kind research in this field. Later, in 1999, Glouhova preformed another study to describe the situation of CEDs in the world. Both of them focused on the developed world. Now the subject of the present study focuses on CEDs in developing countries, and this study is to

discuss on their development. This study faces a new subject group and its attribution is exploratory.

Based on the above reasons, non-probabilistic sampling strategy is selected for this study. The main non-probabilistic sampling methods are listed below.

- convenience or haphazard sampling
- purposive or judgment sampling
- volunteer sampling
- quota sampling

Among them, purposive sampling is often used as a sampling approach in practice, as researchers usually approach sampling problems with a specific plan in mind. One or more specific predefined groups based on researchers' aims are defined at the beginning of study. For example, if you want to sample shoppers, you will go to a mall and stop various shoppers to ask them whether you could interview them. In a purposive sampling, a sample is taken based on certain judgment about overall population. The judgment is defined by a selection criterion by which researchers verify whether an individual meets for being in the sample. The criterion of the above example is that an individual is a shopper of that mall. The selection criterion of the present study is that an individual is a CED in a hospital in a developing country that is listed on developing country list (See Appendix B). The next step is to ask the individuals verified whether they agree to participate in the research. In this study, a consent form is designed to state a respondent's rights and duties, and if the

respondents agree to participate in this study, they can sign the consent form. The copy of the consent form is in Appendix A.

Purposive sampling can be very useful for situations where you need to reach a targeted sample quickly. So, one of its advantages is the reduced cost and time involved in acquiring the sample. On the other hand, sampling for proportionality is not the primary concern. Purposive sampling is subject to the researcher's biases that are a kind of sampling bias. So, **the underlying assumption** of this sampling method is that the researcher will select units that are characteristic of the population.

3.1.2 Sample size

How big a survey sample should be determines sampling error and confidence interval for sampling. *Sampling error* is the variation around the true value, stemming from the fact that by chance samples may differ from the population as a whole.[35] The table 3 is calculated to estimate the limits of the confidence by using standard error (describing sampling error) and sample size and proportion having a characteristic in a sample. Fowler said" how much confidence one can have that the characteristics of a sample accurately describe the population as a whole". [35] If one studies Table 3, it can been seen that precision increases rather steadily up to sample sizes of 150 to 200. After that point, there is a much more modest gain to increasing sample size. [35] For example, there are 50 cases in a sample; 20 say "they are married", and 30 say "they are not married". This yields a

sample estimate of 40% married; the table 3 reports a confidence interval near .14, and the estimate should be 40% ± 14. If a sample of about 100 cases produced an estimate that 20% were married, the table 5 says that we can be 95% sure that the true figure is 20% ± 8 percentage points (or 12% to 28%).

Table 3 Confidence Ranges for Variability Attributable to Sampling *

Sample size	*5/95*	*Percentage of Sample With Characteristic*			
		10/90	*20/80*	*30/70*	*50/50*
35	7	10	14	15	17
50	6	8	11	13	14
75	5	7	9	11	12
100	4	6	8	9	10
200	3	4	6	6	7
300	3	3	5	5	6
500	2	3	4	4	4
1000	1	2	3	3	3
1500	1	2	2	2	2

Note: Chances are 95 in 100 that the real population figure lies in the range defined by ± number indicated in table, given the percentage of sample reporting the characteristic and the number of sample cases on which the percentage is based.

* Source from "survey research method" by Fowler [35]. "This table describes variability attributable to sampling. Errors resulting from nonresponse or reporting errors are not reflected in this table. In addition, this table assumes a simple random sample. Estimates may be subject to more variability than this table indicates because of the sample design or the influence of interviewers on the answers they obtained; stratification might reduce the sampling errors below those indicated here." [35]

In this study, there are 61 valid respondents from developing countries. Although the amount of respondents is around at the level of sample size of 75 in table 3, it is still not enough to a quantitative analysis, such as testing hypothesis, since from table 3 we can be 95% sure that confidence ranges at 8-7% for 10%, 10% for 20%, 12% for 30%, 13% for 50%. But a technical report to trying to test hypothesis with those 61 respondents are discussed in Appendix D, and the null hypothesis is accepted finally.

3.1.3 Response rate

Response rate usually is reported as a percentage of a selected sample from which data were collected. Response rate has an effect on estimating response error and sampling method. If a low response rate is produced in a mail survey, the response error will appear, as a lot of data from sample frame are not been reflected in the mail survey. Fowler said, "in essence, non-probability samples are comparable to samples that result from very low response rates". [35]

In this study, the response rate is 8.6%, which is a low percentage. The reasons of this are discussed in the following data analysis section (4.1.3). For such low response rate, it is reasonable to apply non-probability sampling to this research. But in quantitative analysis, the results of this study are subject to response error. The response error and sampling error have influence on estimating preciseness of the results.

In addition, acceptance to false hypothesis could be produced by testing a small sample size. Weldon said "Small samples tend to suggest acceptance of false hypothesis, even when they are far from correct. For example, if the average age in grade eight is 13.0, and a sample of size 5 has a sample average of 13.0, this example would probably not reject the hypothesis that the average age is 14.0. The small sample does not produce a very precise estimate of a population average. "[36]

In the context of the following chapters, a qualitative analysis is preformed to compare data from some developing countries with those from some developed countries reported by Frize in her thesis and publications.

3.1.4 Methods of data collection: Survey

Surveys can be divided into two broad categories: the questionnaire and the interview. Questionnaires are usually self-administered and are often performed to create new information for resolving business or marketing information problems, especially on a large scale. In this study, a survey will be performed in some countries all over the world to collect new data from CED region. When most people think of questionnaires, they also think of the mail survey. But with the Internet technology spreading, Email has become another way to communicate, paralleled with mail, phone, fax, and face-to-face. Survey by Email has most advantages of mail and overcomes its flaw, long posting period. Sometimes, it is difficult to gain the exact mail address, but it is easy to get its email address. In this study, Email acts as a main approach to collect data.

The first step of this survey is to collect Email contact information of CEDs from Internet and documents. There are three ways of contact information to be gained.

1. Email addresses of CEDs and hospitals

Email addresses of CEDs and hospitals are from Morocco, India, Bangladesh, China (mainland), and South Africa. Totally, 339 email addresses are gained from five developing countries. They are Morocco (8), India (42), Bangladesh (23), China (145), and South Africa (124). The email addresses except from Morocco are mostly collected from the websites of hospitals and association. Some of them are generally the Email-boxes of hospital administrators' if there is no direct Email address of CEDs available on their websites, and then we ask them to forward the survey to their CEDs.

2. Listserv

Another way to contact is the listserv of biomedical/clinical engineering societies. We sent our clinical engineering survey request to the four listservs:

(1) Yahoo!Groups named Brazilian Clinical Engineering Group (327 members)

It is a cyber community of Clinical Engineers in Brazil to discuss clinical engineering techniques, information, research, and practice. This group can be reached by visiting http://www.engeclin.eng.br or Email to engeclinbr@yahoogrupos.com.br after subscription. The members of this group are CEs, BMETs, professional in clinical engineering, equipment manufactures and service venders, government officers in healthcare section, etc. in Brazil. Portuguese is mainly used to communicate in this group, but many members have the ability to read and write English because in this survey we communicate in English with them. In this survey, most of responses from Brazil are gained from this group.

(2) The Brazilian Society fro Biomedical Engineering (SBEB)

SBEB is one of the major biomedical/clinical engineering societies in Latin America, and also is an affiliated organization of IFMBE in Brazil region. By the end of 2002, SBEB has 275 members, distributed as 132 senior, 124 junior and 19 student members. SBEB has its own academic periodical every four months, named Brazilian Journal on Biomedical Engineering (Revista Brasileira de Engenharia Biomedica - RBEB). RBEB is published in Portuguese but each paper has an English abstract. Besides the traditional communication way, SBEB maintains an active listserv (SBEB-L@peb.ufrj.br) and a website (www.sbeb.org.br). Although SBEB is probably the largest biomedical engineering societies in South America, there are only two responses to be considered from SBEB. It is possibly because recently the electronic society has been redesigning.

(3) BIOMEDTALK-L

Biomedtalk-L is one of the most worldwide listservs on Biomedical Engineering and Clinical Engineering. The members of this group are BMETs and Clinical Engineers in hospitals, manufactures and third part vendors. Most members are in such developed countries as USA, Canada, but some members are in developing countries. This group can be reached by Email to Biomedtalk-L@Listserv.aol.com after subscription.

(4) INFRATECH

The INFRATECH listserv is an Internet discussion group for the exchange of information on health care infrastructure and technology for health services, and it is sponsored by

Health Facilities and Services Provision, Department of Organization of Health Services, World Health Organization (WHO/HQ-OSD) and Regional Advisor for Health Services Engineering and Maintenance, WHO Regional Office for the Americas/Pan American Health Organization (WHO-AMRO/PAHO), and coordinated by the American College of Clinical Engineering (ACCE). After subscription, the members of INFRATECH listserv can be reached by Email to INFRATECH@LISTSERV.PAHO.ORG.

3. Contact with field professionals

There are some differences in China and Mexico from the other nationals. As for China, besides the questionnaires by Emails, a questionnaire was sent to two colleagues who have a long and valuable experience in clinical medical field in China, and they delivered the questionnaire to the CEDs by person. 30 questionnaires were delivered and 18 responses were received. On the other hand, 145 questionnaires were sent by Email, and only one response was received.

In Mexico, experts in Clinical Engineering were requested to help this survey, and they are the delegates of IFMBE in Mexico region, and the Directors in charge of Clinical Engineering in Mexican Society of Biomedical Engineering (MEXICAN SOCIETY OF INGENIERIA BIOMEDICA – SOMIB). They forwarded our survey to CEDs in Mexico and made some translations between participants and us. Besides, the delegates of IFMBE in Brazil, Mexico, Columbia, South Africa, and China had been inquired if they had interests in forwarding our survey to CEDs in their regions.

3.1.5 Computer-Aided data collection: online survey

In this study, an online survey is supposed to be adopted to promote feedback from participants. The online survey is created to be a website, and participants can answer questions online just like paper-based questionnaires. When the survey is completely answered, the information will be stored in the server storage for further study. The information will be collected, like that in paper-based (by mail or email) and is analyzed statistically by SPSS. To some extent, online survey can assure the data quality because some illogical, dissociable data will not be allowed to store by programmed constraints. For example, all the workload percentages that are allocated to different activities are supposed to be added up to 100%. The constraint can be conformed by coding. But it is difficult to achieve it in a paper-based questionnaire. Another merit is instant and efficient. In fact, survey by Email is a substitute of survey by mail, and to some extent it is paper-based too. However, online survey can directly save data into database and process data according to designer's requests and even produce chart on demand. It is an automatic procedure of survey and data analysis. Of course, the precondition is that the participants have the ability to access the website through Internet. As the matter of fact, some developing countries hardly have access to Internet and email service.

Some attempt to set up an online survey on university servers have been tried, but the website of online survey we set up only can be visited within the Intranet of our university

and visitors outside university campus cannot reach the website due to some router configuration problems and a firewall that isolate inside of university campus from outside. But, for the cost and time required, the attempt is futile. The program of this online survey is available in Appendix C. It is written by C#, ASP.NET, Jscript, SPSS Syntax and SaxBasic, and will be running on WIN2000 or Windows XP (Pro) with .NET Framework and IIS6.

In the data analysis phase, the program is used for application program to input raw data into a database, and then transform the data into SPSS dataset.

3.1.6 Design questions

"Designing a question for a survey is designing a measure," [21] Good questionnaires maximize the relationship between answers and what the researcher is trying to measure [35] To design a reliable questionnaire, ensuring consistent meaning for all respondents is the first consideration to designers. If researchers want all respondents to be asked the exactly same questions, there are the following principles to be considered:

1) Providing adequate question wording

It is the first principle to gain a consistent data collection. For example, if a question is "the percentage of occupancy of your hospital", question words do not express the accurate meaning of questions and do not constitute a complete question. The question should be

described as "what is the average percentage of bed occupancy in the last year?" Sometimes optional wording is required to fit different respondent circumstances. Usually, optional wording is put in parentheses. For example, in question "6.4 Have you been performing quality assurance (or quality control) on your services?"

2) Providing well defined terms

It is a further consideration to ensure that questions mean the same thing to every respondent. For example, the question"1.4 What is the proportion of ICU (*intensive-care unit)* beds in your hospital?" The "ICU beds" in the question is a poorly defined term. Some people consider more nurses attending to be "intensive care". Others think that "ICU bed" has monitoring devices, such as electrocardiograph, respiration care monitor. and emergency services, and multidisciplinary care team. In order to avoid the differentiation, a definition of "ICU beds" is necessary. So, the question changes to "For our purposes, ICU (intensive-care unit) beds means intensive care for patients with acute, life-threatening illness or injury, accompanied with monitoring, emergence service and a multidisciplinary team. What is the proportion of ICU beds in your hospital?"

3) Collect comparable data from people who speak different languages

In this survey, the questionnaire needs to be translated into two languages from English. They are French for Morocco and Chinese for China. The other countries (Bangladesh, India, Brazil, Mexico, and South Africa) are given English version questionnaires. A list of

official languages in developing countries can be gotten in Appendix B. The list contains 114 developing countries ranked higher than 48 on the HDI (2001).

If different languages are involved in a survey, a process is inevasible that is a translator translates the original version into other languages, and then the answers in other languages are translated back to the original language. Therefore, the questions have to be expressed by simple words for improving the readability because it is easy to produce misunderstanding and errors during the processing.

3.1.7 Design responses of closed-end questions

The simplest way to give respondents the same perceptions to questions is to provide them with a list of acceptable answers. Such questions are called *closed-end* questions. [35] In this survey, most questions are asked in closed-end question form, for example,

" What is average percentage of bed occupancy in last year?

❑ <=50% ❑50.1-75% ❑ >=75%".

This survey also includes questions to assess a respondent's attitudes or opinions, such as, "Is this reporting arrangement satisfactory? ❑Yes ❑No". This two-sided or bipolar response format is widely known as a "*Likert Scale*" (Likert, 1932). An unwilling response such as "don't know" or "no opinion" is not designed for this survey, because an "I don't

know" response may entice 'lazy' participants to choose it without thinking or give participants a hint that does not flash in their brain.

The Likert scale can have a statement to present an issue, or a set of response categories to measure people's reaction, such as "strongly agree", "agree", "disagree", and "strongly disagree". When there is a middle response category between category continuum, the number of all categories is discussed by scientists. Although there is no standard rule about how many response categories should be used, between 4 and 7 categories are generally acceptable.[37] Using less than 4 response categories may cause loss of information; on the other hand, using more than 7 categories can exaggerate the decision-making abilities of respondents. [37]

Design an odd number or even number of response categories? In general, to keep participants neutral and non-committal, responses remain an even number, especially for the Likert scale responses. Providing an odd number of responses may lead to concentration on selecting the middle response category, such as overweight selections to "sometimes" in the responses of "always", "sometimes", "never". This cannot actually reflect participants' thoughts.

In this study, Frize's model is the basis for designing questionnaire. But some adjustments were made in our questionnaire to consider the differences between developing and developed countries. Examples are the number of hospital beds and the total replacement

value of equipment. Lower level response categories were added and the highest-level response categories were deleted. The number of questions has been reduced from 50 to 33, and the number of questionnaire pages reduces from 7 to 4. Some questions were omitted, and some new questions were added to our questionnaire. For example for new ones, "Is your department a member of an association?" and "Are operating manuals adequate?" The reason to add them into our questionnaire was that many experts think that they would be a factor affecting performance of CEDs. [15,38] The sample of this questionnaire and consent forms can be found in Appendix A.

3.2 Data preparation

In a questionnaire, there are four scales of data on which they are measured. They are:

- Nominal scale—it is used only for identification and it cannot be meaningfully ranked from smallest to largest.[39] For example: the country name that the survey comes from.
- Ordinal scale— variables whose values indicate only order or ranking are said to measured on an ordinal scale. [39] For example: "Preparation of specifications: ❑ Always ❑ Often ❑ Sometimes ❑ Never". Most data from this survey are ordinal scale as there is a great deal of closed-end questions discussed before.
- Interval scale— it is just like ratio scale except that it does not have an absolute zero. [39] The interval data are very rare, and are not used in our survey. Fahrenheit temperature is a good example.
- Ratio scale—if you record people's actual annual incomes, you are measuring income on a ratio scale. Data that can be measured on ratio scale are actual numbers, and are arithmetical. They are allowed to make ratio and distancing comparisons (Frize, p261). [28]

Four types of data scales result in four different ways of measurement in data analysis. Most data from surveys are quantitative or measurable data. They could be applied to statistic analysis, after being sorted, revised, screened for abnormal values, and standardized. The phase is carried out by SPSS. We will code variables from the questionnaire into SPSS 11.5 for windows XP. In this phase, data are prepared in the following steps:

- Deal with the missing values, check the data.
- Cut all data into small sections to simplify calculation.
- Regroup data according to analysis requirement.
- Compute some new variables to assist analysis.
- Transform data to the new values according to analysis requirement.
- Some codes of data preparing can be seen in Appendix C that is written in SPSS Syntax.

3.3 Data analysis

3.3.1 Spearman correlation test

A correlation test is to obtain the relevant relationship between variables. Because the test sampling is not random and it is unknown the distribution of data, non-parametric correlation tests are considered; the advantages are:

- Data tested can be free distribution. In general, they are ordinal.
- Data tested are rank-order.

- Easy to calculation.

The test is to verify the independence between two variables.

The correlation coefficient, which is calculated from correlation test, stands for the lineal strength of association between two variables. The value is between –1 and +1, and when the correlation coefficient is greater than 0, it is a positive correlation. It means that variable A is increasing while variable B increases. When correlation coefficient is less than 0, it is negative correlation. It means that variable A is decreasing while variable B increases. The absolute value of correlation coefficient represents the degree of correlation. The higher the correlation coefficient is, the stronger the degree of correlation is.

In general, there are mainly three methods to measure correlation.

- Pearson correlation: it measures the degree of linear correlation between two variables with normal distribution, and the variables are interval scale or ratio scale.
- Kendall's tau correlation: it measures the correlation degree of the ordering variables or rank variables. It is non-parametric correlation test on ordinal level. Kendall's can test a hypothesis. Kendall's tau-b is a measure of association for ordinal or ranked variables that take ties into account. Kendall's tau-c is a measure of association for any size table. [39]
- Spearman (rank) correlation: It is the non-parametric counterpart of Pearson Correlation. It is based on the ranks of the data and suitable for the order data that do not need to meet the normal distribution requirement. In this study, Spearman correlation test is selected to test the hypothesis.

Two commonly encountered correlation coefficients are the Pearson correlation coefficient and the Spearman correlation coefficient. The former is calculated using the actual data values (interval scale data) with a normal distribution. The latter, a nonparametric alternative to the Pearson correlation coefficient, replaces the actual values with ranks. [39]

Another test of independence between variables is Chi-Square (or cross-tabulate test) that is so often used in scientific research and studies, and regarded as the basic methods of measuring association. But it asks the data have to comfort to two preconditions:

- The expected value of each cell of the table cannot be less than 1.
- There are 20% cells where expected values are not less than 5.

In this study, the two preconditions cannot be fulfilled, so Chi-Square test is abandoned.

To apply Spearman test, there are two steps to take. The first step is to rank the sample data by increasing order or decreasing order. The second step is to apply the formula:

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

where r_s is called Spearman's correlation coefficient,

d is a difference between the ranks for a pair of sample data

n is the number of pairs of data.

If $n>30$, use the formulae $r_s = \frac{\pm Z}{\sqrt{n-1}}$, where Z corresponds to the significance level.

In the questionnaire, there is a great deal of data with order ranking. For example, for "Preparation of specifications" question, the question responses are: always, often, sometimes, never. Those range from a higher-level outcome to a lower level outcome. For "Yes/No" choice, "Yes" is ranked as a high level and "No" is ranked as a low level. In this manner, all data are ranked with a comfortable level, and the Spearman correlation studies are appropriate for the type of data measured.

Those calculations are coded by SPSS Syntax and run in SPSS, and then we gain statistically independent variables from variables assumed independent. Then the Spearman correlation coefficient and significant test are calculated between statistically independent variables and dependent variables. Finally the conclusion will be drawn whether to reject or accept the hypothesis.

CHAPTER 4. DATA ANALYSIS – QUALITATIVE

In the following chapters, the labels "Latin America" and "Asia" represent the responses received from these regions and do not assume that the results represent the entire population of CEDs in these regions or countries.

4.1 The samples

The survey was launched in June 2003 by means of a structured questionnaire. The questionnaire aimed to identify the structure, personnel, responsibilities, resources, and equipment management of CEDs in hospitals in developing countries. 699 questionnaires were sent to Morocco, India, Bangladesh, China, Indonesia, South Africa, Saudi Arabia, Brazil, Mexico, Venezuela, and Morocco by Email and Listserv. Table 4 shows the number of questionnaires sent and responses by country and region. The symbol '-' in the table means that there is no concrete number of questionnaires sent to the country. In that case, the responses came from Listserv. (See section 3.1.4)

Table 4 number of sent questionnaires and responses

		Number of sent questionnaires	*Number of responses*	*Response rate*	*Total for region*
Asia region	India	42	1	2.4%	34
	Bangladesh	23	2	8.7%	
	China	175	19	10.9%	
	Indonesia	-	1	n/a	
	South Africa	124	9	7.3%	
	Saudi Arabia	-	2	n/a	
Latin America region	Brazil	327	15	4.6%	27
	Mexico	-	11	n/a	
	Venezuela	-	1	n/a	
	Morocco	8	0	0	
	Total	699	61	8.7%	61

In total, 61 valid responses have been received and they were grouped by nation. They were from Bangladesh, Brazil, Mexico, Venezuela, Indonesia, Saudi Arabia, China, India and South Africa. One response was from Spain and one from USA, which are not developing countries, so, the responses are identified as invalid responses. Those 61 valid responses are also grouped by region, Latin America (Brazil, Mexico, and Venezuela) and Asia (Indonesia, Saudi Arabia, Bangladeshi, China, and India). South Africa is the only country in Africa that responds this survey, and is classified into Asia region group. Among all valid responses, 44.3% (27/61) of respondents come from Latin America region, and 55.7% (33/61) are from Asia region.

Comparatively, the survey by Frize received 116 responses for regional analysis from Canada (41), USA (37), EEC (20), and Nordic countries (18). Another survey by Glovuhova received 130 responses for regional analysis from North America (45), Nordic countries (18), West Europe (31), South Europe (13), Australia (8), Latin America (16).

4.1.1 Overview of Latin America group

Brazil: Brazil ranked NO. 69 in the Human Development Indicator (2001), belonging to Medium Human Development Country in developing countries (See Appendix B). CEDs appeared at the beginning of 1980s in some hospitals after Brazil imported large quantities of expensive and complex medical equipment in the early 1970s.[40] Although CEDs saved considerable money for hospital budgets, there are only 50-80 hospitals (about 10% of all hospitals with more than 150 beds) have their own CEDs until 1991. [40] Among them, a few CEDs managed to grow and improve to individual full-scale technology management units. For technical personnel in CEDs, all Brazilian departments in Glouhova's survey employed CEs, while some of them did not employ any technicians. [30] And CEDs still remained predominately male workplaces although 31% of CEDs employed more than one woman. [30] There are five universities to provide education in Biomedical/Clinical Engineering field, and limited opportunities to train abroad supplied by Ministry of Education. [29] The Brazilian Society for Biomedical Engineering (SBEB) is the main biomedical/clinical engineering associations in Brazil, and the Brazilian Association of Hospital Engineering and Maintenance (ABEHM) is another association for promoting clinical engineering department, especially at the beginning of CED development in Brazil.

It is interesting to note that, in the present survey, the responses from 'Rio de Janeiro' province all stated "our hospital is a customer of a private clinical engineering consulting. The contract was obtained by government bid. Our hospital pays about US$**** per month. In Rio de Janeiro, only private hospitals have their Clinical Engineering Departments." The 'US$****' was reported from US$5,000 to US$ 14,093. But in other provinces, such as Sao Paulo, Bahia, Rio Grande do Sul, there was no such response stating a similar situation. In Wang's paper, he said" in Brazil, the public hospitals are rarely responsive to the money-saving ideas", [40] and public hospitals are generally non-profit institutions that live with the money from the Government, insurance companies, and private patients. On the other hand, the private institutions cared more about their budgets because they were privately owned and managed as a business. They also played an important role in health care services in Brazil, and Machado said that private sectors took charge of 75% of all hospitals beds (501,660 beds) in 1985. [41]

Mexico: Mexico ranked NO. 51 in the Human Development Indicator (2001), belonging to Medium Human Development Country in developing countries (See Appendix B). Initially clinical engineering was done in national research institutions and some of the Public Health Care hospitals, and CED was commenced practically in 1977 in Mexico and by 1984 CED began at a private hospital founded by the Humana Corporation. [42] In Mexico, the public sectors covered about 69% of the Mexican people; private sectors covered only 5%; the rest was not over by anyone; [43] By 2002, there were only 60 CEDs

in this country, mainly in the private sectors, [43] and most of them tends to centralized resources at a small number of metropolises, such as Mexico City. [43]

In 1973, the Biomedical Engineering (BME) degree was founded in Mexico, [44] and by 1981 Clinical Engineering (CE) was formally established as a major of Bachelor Degree in Biomedical Engineering. [43] And CE had begun to be commenced practically before then. However, technical schools in Mexico did not offer a Biomedical Engineering Technician (BMET) course until the beginning of 1990s. [43] Before then, there was no BMET formally in CEDs of Mexican hospitals. So, all responsibilities of BMETs were performed by CEs, such as medical equipment repair or corrective maintenance. This was regarded as an obstacle for the development of true CE activities, and a reason for the inappropriate ratio of CEs and technicians in CEDs. [43] This issue also happened in Brazil, and was noticed by Glouhova's survey. She said "in all Latin America all departments employed CEs, while some of them do not employ any BMETs." [30] The Mexican Society of Biomedical Engineering (Sociedad Mexicana de Ingeniería Biomédica--SOMIB) is one of major clinical engineering associations in Mexico.

In the present survey, nine Mexican responses of CEDs from private hospitals that belong to the same private company performed the clinical engineering functions at the same level except for the number of personnel. They stated "we belong to the same company and the answers apply the same for each hospital, since we use the same operation standards. Only the number of personnel is not same."

4.1.2 Overview of Asia group

China: China ranked NO. 87 in the Human Development Indicator (2001), belonging to Medium Human Development Country in developing countries (See Appendix B). The present study focuses on the mainland of China, not Hong Kong or Taiwan, because they have much higher development level than mainland, for example, Hong Kong as a Special Administrative Region (SAR) of China ranked NO. 27 in HDI (2001). Biomedical Engineering in China was developed from electrophysiology and biomedical electronics lab around 1977, and establishment of clinical engineering had more relation with medical equipment and instrument technology. Zhou said "medical equipment maintenance is still the major work for the current CEDs, but the work model will be gradually changed to security testing, measurement, technology evaluation and risk management of equipment." [45] For personnel of CEDs in China, technical staff has a good education background. More than 40% of technical staff has Bachelor degree or postgraduate degree in general hospitals and even 80% in large general hospitals. [45]

In China, the first formal undergraduate program of Biomedical Engineering (BME) was established in 1977. At the moment, the State Commission of Education had an accreditation system of granting graduate and undergraduate degrees in BME. Since 1977, 20 universities have been authorized to offer Bachelor's Degree in BME, and 40 Master's programs have been accredited to offer Master's Degree in BME, and 13 institutions have

been accredited to offer Ph.D. in BME, and 2 post-doctoral training programs of BME have also been accredited (they are Zhejiang University and Xi`an Jiaotong University). There are two main clinical engineering associations in China, Chinese Society of Biomedical and Clinical Engineering and Chinese Medical Association Engineering Branch.

Bangladesh: Bangladesh ranked NO.132 in the Human Development Indicator (2001), belonging to Low Human Development Country in developing countries (See Appendix B). There were 13 clinical engineers working in hospitals in Dhaka, the capital, in 1993. [29] There was a 'Dhaka Health Database' to record all health care associations, universities, professional colleges, research institutes, teaching hospitals, major hospitals and health center, blood banks, and eye banks in Dhaka. International Centre for Diarrhoeal Disease Research, Bangladesh, (ICDDRB) Dhaka, and Bangladesh Institute of Research & Rehabilitation in Diabetic & Endocrine Metabolism (BIRDEM) has their own well-organized in-house CEDs in Dhaka. [15, 46] But, in 1995, there were still no university trainings and academic courses in the field of biomedical and clinical engineering in Bangladesh; instead, National Electromedical Repair Workshop and Institute of Scientific Instrumentation provided some valuable industry training in this field. [46]

4.1.3 Low response rate

The average response rate of this study is 8.7%, compared with 15% (150/1000) in Glouhova study, and almost 25% (116/500) in Frize study. The lower response rate could be explained by the following reasons:

1) Different study subject: developing countries versus developed countries. The study subject of Frize's study (1988) was North America (Canada and USA), three countries in former EC (France, UK, and Netherlands), and two Nordic countries (Sweden and Finland). Ten years later (1999), the study subject of Glouhova's group was North America (Canada and USA), Nordic countries (Norway, Sweden, Finland, Iceland and Denmark), West Europe (Germany, Netherlands and UK), South Europe (Italy, Greece and Cyprus), Australia, and Latin America (Argentina, Brazil, Cuba and Mexico). About 150 responses were received in Glouhova's survey. Among them, only Brazil, Cuba and Mexico are developing countries. The 16 responses (10.6%) of Latin America were not all from developing countries, since there was a transition-developed[1] country Argentina in the Latin America group. [30] So, the previous two studies mainly focused on CEDs in developed countries.

In the present study, the study subject is CEDs in some developing countries. During the period of data collection, the difficulties to reach the CEDs and make them agree to join this research were proved. There were 669 Email addresses related with CEDs in developing country hospitals listed in the sample frame. The questionnaires with consent forms had been sent to every Email address listed in the sample frame six times during two months. 101 out of 669 (15.1%) Emails were

[1] Transition-developed country means that the country is just transited from developing country to developed country.

returned as Email addresses were not correct, or mailbox had a problem to accept Email, or receivers stated not eligible for this research. 540/669 (80.7%) of all Email addresses did not have any response to the six requests.

Near the deadline to collect questionnaires, some long distance calls were made to some CEDs in China because of inadequate responses. Some calls reached the head of CEDs, and some reached the staff of CEDs. But all the calls were not successful in obtaining new responses. The excuses stated by those people were "we don't have time to do your survey", "we can't do it until we can get higher authority's permission", "we are not interested to join your research", "our supervisor is not here, you need to talk him about this", and so on. Due to the ineffective calls and the limit of cost and time, the plan to make more telephones in other countries was canceled.

During the data collection phase, we found that developing countries lack an interest in improving their CED's services and development, and they did not attempt to set up or join in strong organizations to keep their CEDs contacting with others in order to promote their development.

2) Different survey delivery method. The questionnaire by Frize (1988) was all sent by mail, and Glouhova's group sent 600 surveys by mail and 400 by Email. In the present study, most questionnaires (669/699) were sent by Email. Although Email

is faster than mail, Email could be lost as much as mail. It is normal for a person to have several Email addresses and some of them are obsolete. To some extent, mail is a more official communication way than Email, and Email is much more easily neglected and deleted. Receivers have more freedom to choose whether to answer it and when to reply to it because they can delete Emails without catching anyone attention and without any vestige. Compared with mail and Email, personal interview will get higher response rate, sometimes nearly 95%, but it is also the most expensive plan in all data collection approaches. [35] It was proven in this survey: 30 questionnaires were delivered by person in China and 18 responses were received, that is, 60% response rate was gotten. The suggestion, personal interview, is discussed in future work section.

4.2 The hospital profile of sample

4.2.1 Hospital type

A teaching hospital (or university-based) is usually an integral part of the Institute of Medicine, and staffed by faculty who are clinical doctors, are teachers of medical students, and are researchers in the medical field. A teaching hospital also serves as learning and practicing environment for medical students. Teaching hospitals usually have a great number of devices, equipment, and investments. Frize reported "teaching hospitals invest roughly six times as much annually in capital expenditures as non-teaching hospitals". [28]

In this study, hospital type is categorized to 'Teaching hospitals' and 'Non-teaching hospitals.'

In this survey, teaching hospitals predominate, with 34/61 (55.7%) in the respondent hospitals. Figure 2 shows that in this survey how many respondents from teaching hospitals and how many from non-teaching hospitals in Asia region and Latin America region. The survey by Frize showed "the proportions of respondents from teaching hospitals are: 65% in Canada, 50% in the US, 60% in EEC, 56% in the Nordic Countries". (Frize, p41) [28] It can be seen that the proportions of teaching hospitals in this survey are similar to Frize's, but Latin America region had a lower proportion of teaching hospitals than others.

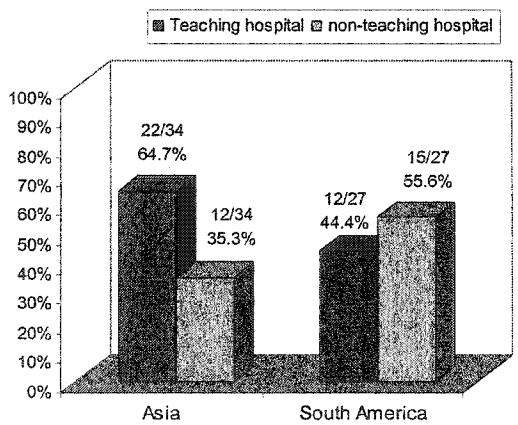


Figure 2 percentage of respondents from teaching and non-teaching hospitals per region

4.2.2 Hospital size

The range of hospital size in this survey was from 50 to 2000 beds. The hospital size was categorized into three groups, "small, medium, large", based on the number of hospital beds. Small hospitals have less than 250 and greater than 50 beds. Medium-sized hospitals have between 250 and 500 beds. Large hospitals have beds from 500 to 2000. Compared with Frize's survey, hospital size ranged from 100 beds to 2000 beds. There were three types of hospital size: small hospitals had less than 500 beds; medium-size hospitals had 501-1000 beds; large hospitals had more than 1000 beds. (Frize, p42) [28] Considering that hospitals in developing countries have fewer resources than those in developed countries, the criterion of hospital size for developed countries has been downsized. In this study, 26 respondents were from small hospitals, 15 from medium-sized hospitals, and 20 from large hospitals. Figure 3 shows the percentage of respondents from different hospital size in Asia and Latin America regions. It is noted that Latin America region has a higher proportion of small hospitals in this survey.

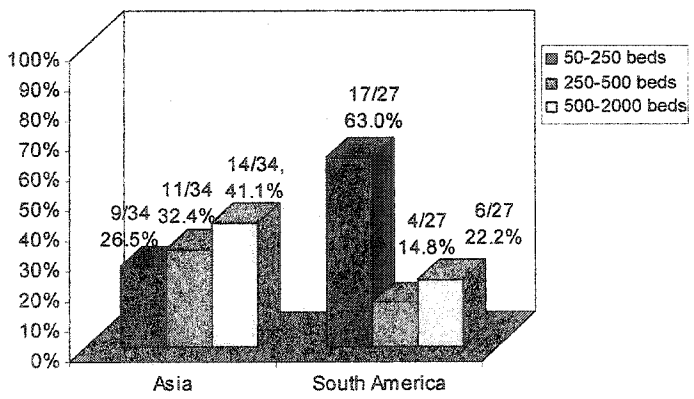


Figure 3 Percentage of respondents from different hospital size per region

4.2.3 Occupancy rate of beds

Most respondents stated that their bed occupancy rates were high in this survey. 39/61 (63.9%) respondents said they had more than 75% usage rate in ward beds. The rest of respondents have a rate between 50% and 75%, and no one claimed that the occupancy rate was below 50%. This infers that in this survey these hospitals where CEDs exist and choose to answer the questionnaires are relatively active units in their public health systems, and they are also units where science and technology are heavily utilized. A similar situation was reported from some developed country studies. For example, Frize reported that" occupancy rate was high everywhere: more than 75% occupancy was reported in more than 87% of the hospitals for all countries in our survey." (Frize, p42) [28]

4.2.4 Proportion of critical care beds

In general, critical care beds in hospitals are the area where various technologies are intensively and comprehensively used. In this survey, 22/61 (36.1%) of all hospitals have more than 10% critical care beds in all ward beds versus "36% of all hospitals" in Frize's survey. There is 16/34 (47%) of teaching hospitals and 6/27 (22%) of non-teaching hospitals having more than 10% critical care bed in this survey. Compared to Frize's, "56% of teaching hospitals and 40% of non-teaching hospitals have more than 10%" (Frize, p42) [28] So, it is assumed that teaching hospitals utilize more technologies for their patients

than non-teaching hospitals in the two surveys for some developing countries and developed countries.

In summary of hospital profile in this survey, like Frize's survey, more than half of subjects in this survey are from teaching hospitals. There are three types of 'hospital size', small, medium, and large. Compared to Frize's, the number of beds in each type is less. A high occupancy rate (>75%) of beds in most hospitals is represented in this survey, and teaching hospitals have a higher proportion of critical care beds in this survey.

4.3 CED personnel structure

In this survey, Question 3.0, 'personnel structure', collected some ratio scale data from respondents, including the number of CEs, technicians, clerical staff, and other staff in their department, and the educational backgrounds of their staff. (See Appendix A)

4.3.1 Staff ratios of CEs to Technicians and clerical staff to technical staff

Table 5 Comparison to ratios of CEs to technicians and clerical staff to technical staff by developing countries and developed countries.

		CEs to Technicians	*Clerical staff to technical staff*
Developing countries (2003)	Asia	1:0.7 (133:93)	1:5.7 (40:226)
	Latin America	1:2.0 (71:140)	1:8.1 (26:211)
Developed countries (1988)		1:3-5	1:8-10

In this survey, CEDs mainly consist of CEs, technicians, and clerical staff. The average number of CEs per CED is 4 (3.82), and 4 (3.34) for technicians, and 2 (1.08) for clerical staff. The ratio of CEs to technicians and the ratio of clerical staff to technical staff (CEs plus technicians) are calculated from those sum numbers. Table 5 shows the ratio of CEs to technicians and the ratio of clerical staff to technician staff for Asia region, Latin America region, and developed countries in Frize's survey.

In Frize's study, there was a "guideline proposed to developed countries (as Canada)" in which the ratios were 1:3-5 and 1:8-10 respectively. She anticipated that "The future mix of technical expertise was expected to move to a lower ratio of engineers to technicians, but definitely to one engineer per two or three technicians by the mid 1990's, perhaps even to the point of 1:1." (Frize, p165) [28] Besides, Borjon stated that "the ideal number of CEs for a second level hospital is two engineers companied with four technicians, or, one CE with four technician staff." [42] Obviously, in this survey, the ratios from Latin America region overlap these criteria, but ratios from Asia region are lower than the criteria, and there are more CEs than technicians in Asia.

However, some respondents reported that they did not have technicians or CEs in their CEDs. For example, in this survey, four CEDs from Asia region and two CEDs from Latin America region stated that there were only CEs without any technicians. Whereas, CEDs from Asia region stated that they only had technicians without any engineer in their departments. Those similar situations can be found in the book by Frize (Frize, p45) [28]

and in the study by Glouhova [30], which showed that "some CEDs in Latin American and in Europe do not employ any technicians, while in other regions there are no engineers." The present survey shows that all the CEDs in Latin America region employed CEs, but almost one third (10/34) of Asia respondents have not employed any CEs in their departments, and some of them employed only CEs without any technician. CEDs in Asia region employed more CEs than technicians in this survey. Therefore, CEDs in Latin America have more rational staff structure than those in Asia region in this survey.

4.3.2 The number of CEs in different hospital types and regions

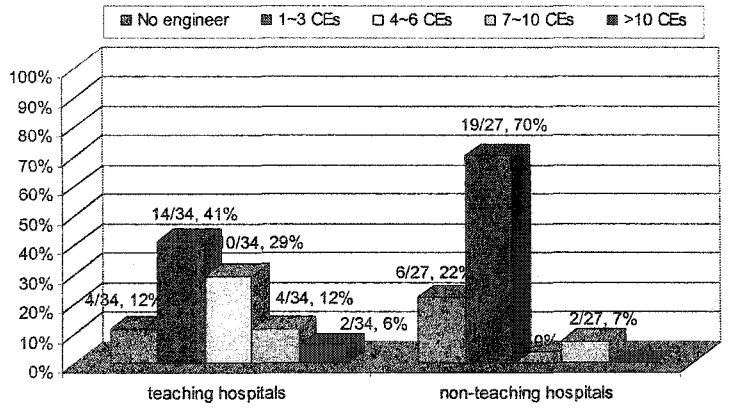


Figure 4 Percentage of respondents having the number of CEs in different hospital type

In this survey, teaching hospitals have 71.6% (379/529) of all CED staff, and 147/204 (72.1%) of all CEs. Figure 4 shows the distribution of CE number in teaching hospitals and non-teaching hospitals. In this survey, only two CEDs of teaching hospitals have more than 10 CEs, and one is in China, the other one in Saudi Arabia; most non-teaching hospitals

(19/27, 70%) have 1 to 3 engineers in their CEDs. So teaching hospitals in this survey employ more engineers than non-teaching hospitals

In this survey, CEDs in Asia region employ more CEs than those in Latin America region (the ratio of total CE number between two regions is 133:71, or the ratio of mean number of CE between two regions is 5.5:2.6) and CEDs in Latin America mainly have 1~3 engineers in their departments and around one-third of CEDs in Asia has no engineer. (See figure 5)

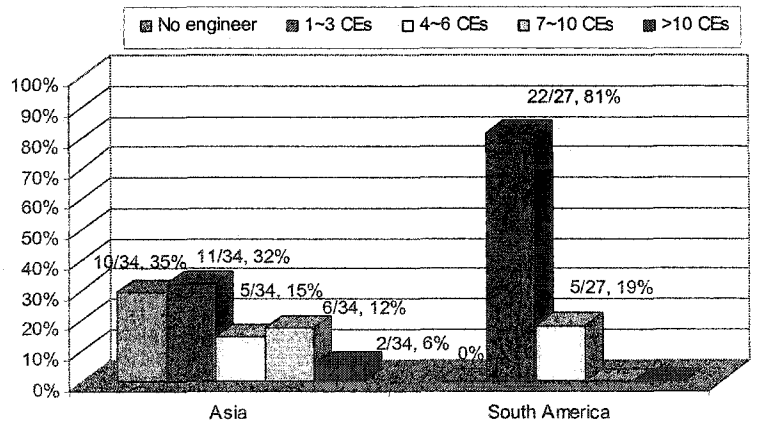


Figure 5 Percentage of respondents having the number of CEs per region

4.3.3 he highest educational background of CED staff

In this survey, 63.8% (30/47) of respondents said that their highest educational background of CEs was BSc. Degree; 12 respondents who account for 25.5% (12/47) have their highest degree, MSc. degree, and among them, 7 respondents from Brazil, 3 from Mexico, 1 from Bangladesh, and 1 from Saudi Arabia; three respondents said that their highest educational background was PhD. Degree and they were all from teaching hospitals and respectively

from Brazil, Saudi Arabia, and Venezuela. In total, there are 95.7% (45/47) of all respondents stating that the highest educational background of their CEs is a Bachelor's Degree or higher in this survey and the rest of respondents stated their highest educational background is 4-year technical school or lower, and they all came from China and South Africa. Actually they were not eligible for a CE, since we assume CEs are supposed to have four-year university education with BSc. according to the definition of Clinical Engineer by IFMBE. [29] Figure 6 shows that Asia region has more CEDs without an engineer than Latin America in this survey.

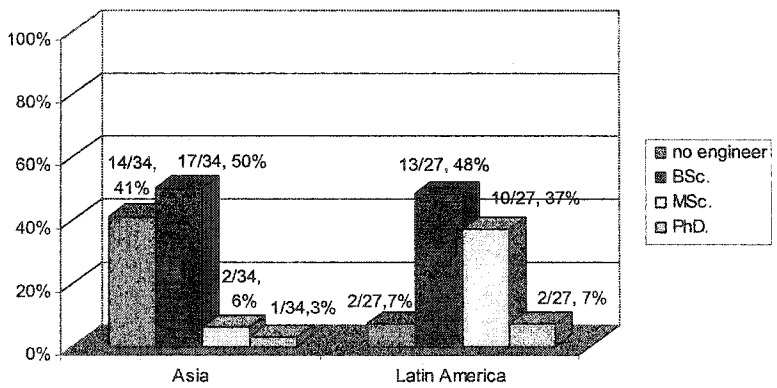


Figure 6 Percentage of respondents reporting the highest educational background per region

As for the educational background of technicians in this survey, the highest educational background of technicians appeared in Saudi Arabia: one technician owned a BSc. degree. The highest educational background of clerical staff in CED is BSc from China.

4.3.4 The educational extent of all CED staff

	Educational Extent	*Asia*	*Latin America*
CEs	PhD.	1/133	2/71
	MSc.	11/133 (8%)	12/71 (17%)
	BSc.	73/133 (55%)	49/71 (69%)
	under BSc.	35/133	0
	not available	13/133	8/71
Technicians	BSc.	9/93	0
	4-year technical school	10/93	27/140
	3-year technical school	34/93 (37%)	24/140 (17%)
	2-year technical school	8/93 (8%)	31/140 (22%)
	1-year technical school	1/93	11/140
	high school	16/93	26/140
	under high school	0	1/140
	not available	15/93	20/140
Clerical Staff	Bsc.	7/40	0
	4-year technical school	3/40	0
	3-year technical school	12/40	0
	2-year technical school	5/40	6/26
	hign school	2/40	7/26
	under high school	0	9/26
	not available	11/40	4/26

Table 6 The educational extent of CED staff by region

There are 529 persons in 61 CEDs reported by respondents in this survey, and 204 are CEs, and 233 are technicians, and 66 are clerical staff, and 26 are other staff in CEDs. From table 6, 72% (148/204) of CEs have university education with a BSc. degree or higher, and some of them (11%, 23/204) held a MSc. degree, and 3 of them had a PhD in this survey who were the tiny parts in Asia and Latin America region. (See table 6) In contrast to the previous two surveys for developed countries, "most regions, such as North American, Nordic countries, EEC, had CEs with a PhD. degree in their CEDs, and they have a fair proportion of CED staff", [28][30] and Frize reported "there were 62% clinical engineers

with MSc. or PhD. degree.."(Frize, p94, [28]) But in the present survey, there are only 13% (26/204) of CEs with MSc. or PhD. degree. So, the education levels of both developing country regions in this survey are lower than those in developed countries.

A look at the educational extent of CEs in table 6 shows that in this survey, CEs in Latin America region has higher proportions than those in Asia region at the BSc., MSc, PhD. levels; no CEs in Latin America has educational extent under BSc Degree, but Asia has. So, CEs in Latin America have higher educational extent than Asia in this survey.

Among 233 technicians in this survey, two-thirds (67%, 155/233) of them reported have studied in technical school after high school in this survey. Table 6 shows that CED's technicians with 3-year technical school education account for the largest proportion in Asia region, versus, 2-year technical school for Latin America region. Compared with Frize's survey (1988) in developed countries, the largest portion was 65% for a two-year technical school diploma. In the international survey (1999) by Glouhova's group, the largest portion reported was 41% four-year technical school diploma. It is interesting to note that a lower education is represented in this survey for technicians in Asia and Latin America, and Latin America is worse. Meanwhile, there was no technician holding a Master's degree in this survey. However, Frize and Glouhova reported that some technicians had a BSc. Degree, even a MSc. degree in USA and West Europe in their surveys. [28] [30]

As for the education level of clerical staff, a trend can be seen in table 6 that the clerical staff in Asia region has higher educational background than that in Latin America region in this survey. Mentioned before, the ratio of clerical staff to technical staff (CEs plus technicians) is 1:6 for Asia and 1:8 for Latin America. The ratios are acceptable for a normal CED personnel structure. But, there are 15 Latin respondents stating that their CEs had to undertake administration tasks daily and they stated a proportion of workload for this activity from 15% to 68%. Moreover, these 15 respondents are all from Latin America region. It is presumed that the clerical staff with the lower educational background and inadequate number in Latin America has not completely been competent to their clerical and administrative work.

In table 6, there are some "not available" parts that indicate the following situations:

I. Respondents state the number of staff, but not giving their education levels;

II. Respondents state the number of staff and state an unidentified education level, for example, a respondent from Bangladesh stated having one CE, but his education level is a diploma. Another example is that a respondent filled 'trained technicians' in the technician education level.

III. Respondents leave a blank table in the personnel structure question.

The "not available" parts account for 21/204 (10%) in CEs staff, 35/233 (15%) in technicians, 15/66 (23%) in clerical staff in this survey. It is worth to notice that all the proportions of 'not available' are keeping at the relatively high level of missing values in

this survey. The situation accords with the low response rate of this survey and the difficulties to collect data from those countries. The respondents in developing countries did not show more interest in learning their CED status and did not pay enough attention to attempting to improve their clinical engineering status.

4.3.5 Other staff in CED

There are 10 out of 61 respondents stating that they have other staff in their departments. The other staff includes physicists, students, secretaries, and training staff. Among them, the amount of students is the most. Their educational background ranges from BSc. to under high school.

4.3.6 Belonging to associations and Staff training

45/61 (74%) of all respondents are not a member of an association of clinical engineering or biomedical engineering society. One respondent from Bangladesh stated that his CED is a member of "Institute of Engineers Bangladesh (IEB)", which is the largest engineer societies in Bangladesh, with 16,223 members; [47] Another respondent from Brazil stated being a member of "Sociedade Brasileira de Engenharia Biomédica (SBEB)"; one respondent from Mexico stated his department is a member of SOMIB; three Chinese respondents stated they were members of 'Chinese Society of Biomedical and Clinical Engineering'; one from Saudi Arabia is the member of 'Ar-Riyardh Biomedical

Engineering Club—ARBEC'; six from South Africa are members of 'the Clinical Engineering Association of South Africa--CEASA'. CEASA is a national clinical engineering association, and has nine branches throughout the South Africa. It also has a website for communication and there are 124 members in the member list on the website. They are professionals, experts, national councilors, manufacturers, venders and students. CEASA is a particular society for the field of Biomedical and Clinical Engineering and its former name was South African Association for Clinical Engineering (SAACE).

As for staff training, around 51% (31/61) of respondents stated that they were trained in 'combination of on the job and a special biomedical center', and 39% (24/61) got training on the job, and two respondents said 'in special training centers of their hospitals'. Another two respondents who selected 'other, specify' said that their trainings were provided by equipment manufacturers and dealers.

In Summary, CEDs in developing countries of this survey basically consist of CEs, technicians, and clerical staff, the same as those in developed countries. In this survey, Latin America region has more rational staff ratio than Asia region; Asia employ more CEs than Latin America, even the number of CEs exceeds the number of technicians, but the education level of CEs in Asia is lower than Latin America, and 26% (35/133) of them do not have a BSc. or higher while there is nothing in Latin America; moreover, although CEs in Latin America has higher education than Asia, technicians and clerical staff in Latin America do not have better education than Asia. To some extent, their education levels are

lower than Asia. So, CEs in Latin America need to perform some duties of technicians and clerical staff in this survey.

On the whole of CED staff in this survey, the largest size of CED staff is from Saudi Arabia, and it has 42 employees. It also has the largest CE team, 24 CEs. The highest educational background of CEs and technicians are PhD (from Saudi Arabia, Brazil, Venezuela) and BSc. (from Saudi Arabia) respectively. Most (72%) CEs in this survey at least have a BSc, and 67% of technicians went to technical school. However, their education levels are both lower than developed countries. Like western countries, teaching hospitals in this survey have more personnel, such as the presence of CE, the number of CEs and CED staff than non-teaching hospitals.

4.4 Description of CED structure

4.4.1 Separate unit

"Does the CED exist as a separate unit in the hospital?" is a major indicator to measure the CED's effectiveness in Frize's developed countries' study. (Frize, p93) [28] In this study, 50/60 (82%) of respondents stated that they existed as a separate unit, and most them (47/50, 94%) were also satisfied with their present reporting authority. On the other hand, 10/61 (18%) of respondents stated that they were in non-separate departments, and 6/10 of them stated not liking their reporting arrangement. In Frize's survey (1988), "17% of

respondents are in non-separate CEDs in Canada, 15% in E.E.C, 6% in US, 17% in Nordic Countries". (Frize, p29)[28] In this survey, the proportion of existence as a non-separate unit is similar to Frize's.

In this survey, respondents in non-separate departments said they were a part of departments as follows: "Administration", "Plant/Maintenance Department", "Equipment department", "pharmaceutics and equipment department", "Engineering service department", "Technical support department", "General engineering department" and "Electronic Department".

4.4.2 Reporting authority

Hospital organizational structure usually reflects the position of various departments in a hospital. The positions are related with the functions of departments. But the structure is not fixed and static, and it changes as department functions change. We notice that when clinical engineering services began to emerge in hospitals, "the general engineering plant department of hospital took responsibility for the early clinical engineering service. " (Frize, p161) [28] When clinical engineering began to develop, larger hospitals began to form separate, specialized, in-house departments to meet increasing needs of equipment repair and maintenance, and hospital administrators were more likely to govern CEDs directly or have them report to senior administrators of hospitals (Frize, p86) [28], because

the CEDs not only supervised hospital equipment maintenance, but also began to be involved in purchasing medical equipment and negotiating service contracts.

In this study, 'reporting authority' is categorized into four classes that are the same as Frize's classification.

- Senior administrators
- Medical directors
- Plant / maintenance directors
- Other directors.

The survey results show that 31/61 (51%) of all respondents reported to senior administrators in their hospitals, and 15/61 (25%) to plant / maintenance directors, 8/61 (13%) to other higher authorities, and 7/61 (12%) to medical directors. In contrast, in developed countries' data, the order of 'reporting authorities' is 'Senior Administrators', 'medical directors', 'plant directors' and 'other managers', from the most desirable to the least desirable according to respondents. (Frize, p86) [28] Like CEDs in developed countries, CEDs mostly report to senior administrators in this survey. Moreover, most (28/31, 90%) respondents reporting to senior administrators are satisfied with their reporting authorities. Similarly, in Frize's book, a high rate (95%) of satisfaction of reporting to senior administrators was reported in her survey for industrialized countries. (Frize, p92) [28]

Those who select 'other directors' pointed out that they

- report to 'Associate Director of Lab Sciences' in Bangladesh

- report to 'University Technology Research Institute' in Brazil
- report to 'Biomedical engineering director' in Mexico
- report to 'Senior Manager of Technical Support' in Indonesia
- report to 'Equipment and logistics department' in China
- report to 'Associate Director of Engineering Service', 'Nursing Manager', 'Technical Manager' in South Africa
- report to 'General Superintendent' in India.

It is interesting to note that they are all (8/8) satisfied with their reporting authorities.

4.5 CED Responsibilities

4.5.1 Number of devices and their replacement value

Frize said that the number of devices and the amount of equipment replacement value represented the extent of technology acquisition in hospitals. (Frize, p17) [28] In the present survey, about half of respondents said they had 500~2000 devices to manage and the amount of equipment value was greater than 10 Million US dollars.

Table 7 and table 8 are the comparisons between Frize's survey and the present survey in the percentage of respondents with more than 2000 devices and more than 6 million US dollars of equipment value in more than 500 beds hospitals. Frize (1988) stated "the trend for hospitals (>500 beds) where they managed more than 2000 devices valued at more than

6 million US dollars is fairly widespread in Canada, US., E.E.C., and the Nordic Countries" (Frize, p19-21) [28] It is easy to see that that trend is not appropriate to the present survey, and respondents in the present survey take charge of less devices and value than those in Frize's survey under the same condition. Although the average equipment value is about 10 million US dollars that greater than 6 million US dollars in Frize's survey, the level of the number of equipment is still low. It can be probably explained by that developing countries have the small amount of equipment and the price of the equipment is expensive for them, which has been illustrated in many publications.

	Percentage of respondents with more than 500 beds and more than 2000 devices
Developed country survey (1988)[1]	68%
Developing country survey (2003)[2]	15% (9/61)

Note: 1. Frize's survey for developed countries.
2. The present survey for developing countries.

Table 7 Comparison of the percentage of respondents with more than 500 beds and more than 2000 devices to manage between two surveys

	Percentage of respondents with more than 500 beds and more than $6 million US dollar devices
Developed country survey (1988)[1]	68%
Developing country survey (2003)[2]	26% (16/61)

Note: 1. Frize's survey for developed countries.
2. The present survey for developing countries.

Table 8 Comparison of the percentage of respondents with more than 500 beds and more than $6 million US dollar devices to manage between two surveys

The following is another example as a contrast: Glouhova (1999) said "in the majority medium-sized hospitals (500-1000 beds) in North America and Nordic countries, as well as in the large hospitals (>1000 beds) in all regions, CEDs supported more than 4000 devices

representing more than $20 million (US) of equipment value.", and "more than half of large hospital in North America, Nordic countries and West Europe supported equipment valued at more than $40 million (US)". [30] So, a bigger gap of device number and value can be found between the present survey for developing countries and Glouhova's developed country survey.

Like developed countries, CEDs in teaching hospitals supervise more devices than non-teaching hospitals in this survey: 41% (14/34) of CEDs in teaching hospitals manage more than 2000 devices, versus, 7% (2/27) in non-teaching hospitals. Most CEDs (70%, 19/27) in non-teaching hospitals supervise '500-2000' devices, while in the same proportion (71%, 27/34) of CEDs in teaching hospitals, there are half (14/27) of them supporting more than 2000 devices.

4.5.2 Workload percentage of CEs and technicians

In this survey, respondents were asked to estimate the percentage of workload that engineers and technicians spent on each activity of clinical engineering, and this question is another source of ratio scale data in this survey. Table 9 shows the percentage of respondents and the average value of workload percentage of CEs and technicians. It can be seen that repairs, incoming inspections, preventive maintenance, user training, pre-purchase consulting are performed by most CEDs in this survey, but research activity are not; CEs perform more workload percentage in user training, pre-purchase consulting, and

research than technicians, while technicians perform more workload in repairs, incoming inspections and preventive maintenance than CEs. Glouhova reported the similar situation in her survey of 1999: "pre-purchase consultation, educational and training, research and development are mainly performed by the engineers, while preventive and corrective maintenance are predominantly responsibility of BMETs." [30]

Table 9 of percentage of respondents doing the work and the mean value of its workload percentage for CEs and technicians

	workload % of CEs		*Workload % of Technicians*	
	% of respondents doing the work	*Mean (%)*	*% of respondents doing the work*	*Mean (%)*
Repair	46/49, 94	41	43/43, 100	51
incoming inspection	44/49, 90	10	40/43, 93	13
preventive maintenance	46/49, 94	14	41/43, 95	21
user training	46/49, 94	9	36/43, 84	8
pre-purchase consulting	46/49, 94	13	27/43, 63	6
Research	27/49, 55	11	12/43, 28	7

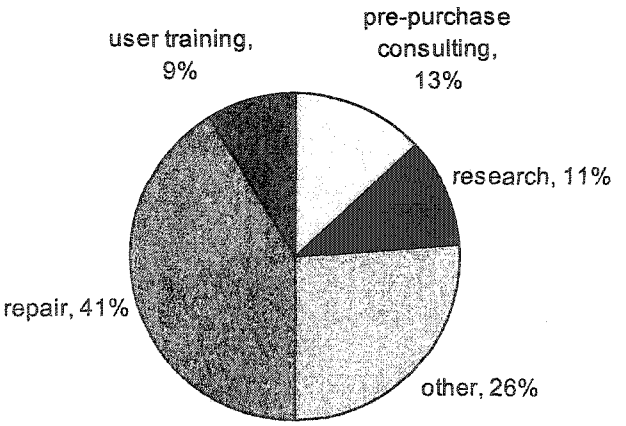


Figure 7 Activity mix for CEs in clinical engineering functions

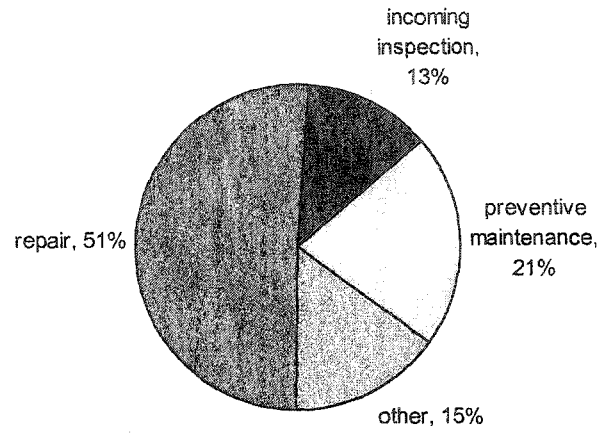


Figure 8 Activity mix for technicians in clinical engineering functions

Figure 7 shows the average level of CEs' activities in this survey, compared with that in Frize's survey, the biggest difference for CE's activities is that CE in developed countries spent their 40% workload on consultation, while CE in developing countries spent the same workload on repair. Their consultation activities only account for 13% in their workload in this survey.

Figure 8 shows the average level of technician's activities in CEDs in this survey. There are no big differences between this survey and Frize's. Only technicians in this survey spent more workload in repair (51% versus 40%) and incoming inspections (21% versus 5%), and less workload in prevent maintenance (21% versus 30%).

Table 10 and table 11 are the similar tables for Asia region and Latin America region. It is noted that CEs in Asia region take their more workload (53>50) in repair work than technicians in this survey. It is probably because CEDs in Asia hire more CEs than technicians and so CEs have to do some technician's work. This kind situation does not happen in Latin America region and developed countries studied by Frize and Glouhova.

Table 10 percentages of respondents doing the work and the mean value of its workload percentage for CEs and technicians in Asia region

	workload % of CEs		*Workload % of Technicians*	
	% of respondents doing the work	*Mean (%)*	*% of respondents doing the work*	*Mean(%)*
Repair	22/22, 100	53	19/19, 100	50
incoming inspection	19/22, 86	9	16/19, 84	16
preventive maintenance	21/22, 95	16	17/19, 89	25
user training	20/22, 91	8	14/19, 74	8
pre-purchase consulting	20/22, 91	10	11/19, 58	6
Research	12/22, 55	6	6/19, 32	5

Table 11 percentages of respondents doing the work and the mean value of its workload percentage for CEs and technicians in Latin America region

	workload % of CEs		*Workload % of Technicians*	
	% of respondents doing the work	*Mean (%)*	*% of respondents doing the work*	*Mean(%)*
Repair	24/27, 100	31	24/24, 100	52
incoming inspection	25/27, 93	11	24/24, 100	11
preventive maintenance	25/27, 93	12	24/24, 100	18
user training	26/27, 96	11	22/24, 92	7
pre-purchase consulting	26/27, 96	15	16/24, 67	5
Research	15/27, 56	16	6/24, 25	8

In this survey, it is interesting to note that some respondents reporting that CEs in their department spent some work time on 'other tasks', such as, "bio-safety",

"administrative/management/clerical tasks", "collaboration project", "souring spares/services tracing suppliers" and "moving devices". Among them, "administrative/management/clerical tasks" is most often claimed by respondents, and the workload percentage of the task is from 15% to 68% and the respondents usually from Latin America. In contrast, Glouhova said "CEDs reported their other tasks were government activities, project management, administration, consultation, parts sourcing etc." in her survey (1999). [30]

4.5.3 Pre-purchase consultation

Table 12 percentages of respondents performing the task

Pre-purchase consultation	*% of respondents performing the task*
Preparation of specifications	61/61, 100
Analysis of tenders	57/61, 93
Recommendation on final choice	57/61, 93
Getting devices before users	58/61, 95
Discussion on service contracts	58/61, 95

In this survey, five tasks on the table 12 are subcategories of pre-purchase consultation activity. Table 12 gives that "how much percent of respondents perform these 5 tasks." Question 4.5 also asked respondents to give frequency ranks to those five tasks performed by their CEDs. The frequency ranks are identified to "Always", "Often", "Sometimes", and "Never". In this survey, more than half of respondents performed 'preparation of specifications', 'analysis of tenders', 'getting devices before users', 'discussion on service contract' at the "Always" frequency. Only 'Recommendation on final choice' was

performed at "Often" frequency by about one-third respondents. Table 11 shows that in this survey, most respondents preformed all the five tasks in pre-purchase consultation and the pre-purchase consultation was well performed in the five aspects in this survey.

4.5.4 The level of performance to clinical engineering functions

In this survey, respondents were asked to estimate the percentage of each function of clinical engineering performed by their departments, such as "75% repair work in medical equipment has been done by our department." After data collection, the percentages are classified into three groups: >25%, 25%~75%, >75%.

For Asia region, 16/34 (47%) of respondents claimed more than 75% level of repair medical equipment, versus, 6/27 (22%) in Latin America. This confirms that CEs and technicians spent their more work and time on repairing than Latin America. (See 4.5.2) So, they gain the higher executive level in repairing medical equipment in this survey.

For Latin American, they presented the higher level (>75%) in inspecting medical equipment, preventively maintaining medical equipment, training, and pre-purchasing consultation than Asia region. The comparisons of percentages of them are 19/27 (70%) versus 18/34 (53%); 16/27 (59%) versus 9/34 (27%); 14/27 (52%) versus 13/34 (38%); 14/27 (52%) versus 12/34 (35%).

For the level of research and development in medical equipment, both regions have the similar performance level: 7/34 (20%) of Asia respondents and 7/27 (25%) of Latin American respondents performed more than 10% research activities.

From the level of clinical engineering functions performed by CEDs, the activity range of CED can be seen. There are more than 75% (42/56) respondents stating that they repaired, incoming inspected, and consulted before purchasing for medical equipment, radiological/imaging equipment, laboratory equipment, and anesthetic ventilation equipment; there are also more than 75%(42/56) respondents stating that they performed preventive maintenance and training users in medical equipment and anesthetic ventilation equipment. As for the other activities in clinical engineering functions, such as, preventive maintenance and training in radiological/imaging equipment and laboratory equipment, were reported by less than 70% of respondents. Especially for research activity, only 10%~40% (6/56~22/56) of respondents reported that activity.

4.6 CED Resources

4.6.1 Adequate staffing

In this survey, 21/61 of respondents said that they had enough staffing in their departments, while 40/61 (66%) said that they need more staff. Compared with Frize's survey, there

were 63% of Canadian respondents who perceived not having enough personnel and 80% in E.E.C., 72% in Nordic countries, 40% in US". (Frize, p48) [28]

In the present survey, 16/61 (26%) of respondents saying need more CEs, 29/61 (48%) need more technicians, 18/61 (30%) need more clerical staff, 3/61 (5%) need more 'other staff', such as "senior CE". As for the Asia region, 12/34 (35%) need more CEs, 15/34 (44%) need more technicians, 13/34 (38%) need more clerical staff; for Latin America region, 4/27(15%) need CEs, 17/27(63%) need technicians, 5/27(19%) need clerical staff. Compared with Frize's survey, there were "39% of respondents need more CEs, 53% need more technicians, and 38% need additional clerical support" (Frize, p48) [28] A perception was also reported by Glouhova. She said "most of the departments in all regions have inadequate staffing levels, and the call for technicians is very high in all regions surveyed and higher than the need for CEs." [30] It is interesting to note that the need for technicians is also higher than other staff in the current survey, especially in Latin America region; and the higher needs also happened in the previous surveys for developed countries; and most respondents thought they were lack of personnel resources in the three surveys.

4.6.2 Spare parts

In this survey, Question 5.1 asked respondents to state the value of their spare parts, as a percentage of the replacement value of equipment supported by their departments, and Question 5.6 asked if their spare parts were adequate. Table 13 shows the proportions of

respondents in different spare part value who stated whether their spare parts were adequate or not. It is clear that over half (35/55) of respondents were at the minimal spare part value level; 27/55 (49%) stated this level was not adequate; at the next level, 0.5 to 1%, there were 14/55 of respondents, and 11/55 of them stated their spare parts were not adequate; at the highest level, more than 1%, there were 5/55 of respondents who stated not adequate. A trend seems to be seen that the higher spare part value level, the less respondents felt their spare parts were not adequate. Compared with Frize's survey and Glouhova's survey, "a consensus seems to be reached that when a level of spare parts reached the point at 1% of the equipment value supported, more respondents felt adequate in spare parts." (Frize, p162) [28] [30] In the current survey, the consensus cannot be seen because the proportions of 'adequate' kept a low level at all spare part value levels.

Table 13 Percentage of respondents reporting spare parts were either 'adequate' or 'not adequate' in each category of spare part value*

*Spare part value (%)**	*Adequate*	*Not adequate*	*Total*
Less than 0.5%	3/55, 6%	27/55, 49%	32/55, 55%
0.5 to 1%	3/55, 6%	11/55, 20%	14/55, 26%
More than 1%	6/55, 11%	5/55, 9%	11/55, 20%
Total	12/55, 23%	43/55, 78%	55/55

* spare part value means a percentage of spare part value to replacement value of equipment supported by CEDs.

In this survey, Question 5.6 also asked respondents who stated not to have enough spare parts to judge whether the shortage had effect on the down time of equipment. 31/40 (78%) of respondents who reported not to have enough spare parts stated the shortage of parts had effect on equipment's down time, and 9/40 (22%) said that there is no effect. So, in this

survey, most (45/61, 74%) respondents reported to have inadequate status in spare parts, and 51% (31/61) of them thought the shortage influenced in equipment's down time.

4.6.3 Test equipment/devices

Like spare parts, test equipment value, in this survey, was asked to estimate as a percentage of replacement value of equipment under CED supervision in Question 5.2, and Question 5.7 asked respondents to judge whether the test equipment is adequate. Table 14 shows that the percentages of respondents reporting either 'adequate' or 'not adequate' in each test equipment value level. Like spare parts, there were a few respondents (14/58, 24%) who were satisfied with the number of test equipment they had. Most of them (44/58, 76%) stated they did not have enough test equipment to assis their work. Moreover, the results are not like those obtained by Frize and Glouhova. They stated, "a level of test equipment, which amounts to at least 1% of the equipment value supported, seems to be adequate for the majority of respondents." (Frize, p162) [28] [30] But in this survey, most of respondents presented that they do not have adequate test equipment.

Table 14 Percentage of respondents reporting test equipment was either 'adequate' or 'not adequate' in each category of test equipment value*

*Test equipment value (%)**	*Adequate*	*Not adequate*	*Total*
Less than 0.5%	5/58, 9%	34/58, 59%	39/58, 67%
0.5 to 1%	5/58, 9%	3/58, 5%	8/58, 14%
More than 1%	4/58, 7%	7/58, 12%	11/58, 19%
Total	14/58, 24%	44/58, 76%	58/58

* test equipment value means a percentage of spare part value to replacement value of equipment supported by CEDs.

4.6.4 Space allocation

Like spare parts and test equipment, space allocations per person, in Question 5.3, were asked respondents to estimate the area of CED allocated in square meter. And Question 5.8 asked respondents to judge whether the space was adequate. Table 15 shows that the situation in Asia region and table 16 is the situation in Latin America in this survey. It is interesting to see that when the space level reached the point of 15 square meters per person, 51% (17/33) of respondents in Asia began to satisfy their space allocation level. But in Latin American region, there is still no such point to make most respondents of that region satisfied, since there is a high proportion (19/27, 70%) of 'Inadequate'. Compared with results from. Frize, "20 square meters per person was the minimum standard that departments should try to obtain." (Frize, p164) [28] And results from Glouhova, showed that "a space allocation of at least 20 square meters per person is considered necessary for CEDs worldwide. In Nordic countries, 72% of respondents reported more than 20 square meters; 60% in Australia." [30] It is clear that the minimum standard of CED's space in Asia region, 15 square meters per person, is lower than the minimum level of the developed countries. It is worthy to note most (49/61, 80%) of respondents in present survey had less than 20 square meter space per person for their department, and it means that they are below the minimum standard of space in developed country surveyed. This low level situation in space area was also reported by Glouhova's survey. She said, "in Latin America 94% had less than 15 square meters and the majority was not satisfied with it."

[30] 'Latin America' in Glouhova's survey was consisted of some developing countries, such as Brazil, Cuba and Mexico.

Table 15 Percentage of respondents reporting test equipment was either 'adequate' or 'not adequate' in each category of test equipment value* for Asia region

Space Allocations(per person)	*Adequate*	*Not adequate*	*Total*
Less than 15 M^2	1/33, 3%	11/33, 33%	12/33, 36%
15 to 20 M^2	10/33, 30%	3/33, 9%	13/33, 39%
More than 20 M^2	7/33, 21%	1/33, 3%	8/33, 24%
Total	18/33, 55%	15/33, 45%	33/33

* test equipment value means a percentage of spare part value to replacement value of equipment supported by CEDs.

Table 16 Percentage of respondents reporting test equipment was either 'adequate' or 'not adequate' in each category of test equipment value* for Latin America region

Space Allocations(per person)	*Adequate*	*Not adequate*	*Total*
Less than 15 M^2	3/27, 11%	14/27, 52%	17/27, 63%
15 to 20 M^2	3/27, 11%	4/27, 15%	7/27, 26%
More than 20 M^2	2/27, 7%	1/27, 4%	8/27, 11%
Total	8/27, 30%	19/27, 70%	27/27

* test equipment value means a percentage of spare part value to replacement value of equipment supported by CEDs.

4.6.5 Adequate manuals

In this survey, Question 5.9 asked respondents whether the operating manuals were adequate. The reason for asking the question is that some articles think shortage of operating manuals is related to effectiveness of CED performance, especially in repairs and preventive maintenance. [15,48] There were 30% (18/61) of respondents thinking they did not have enough operating manuals and the reasons of it are: "many devices did not accompany with operating and maintenance manuals", "we need technical manuals or

electric circuit diagrams", "service manuals needed in some cases", 'we need manuals in Chinese language'.

In this survey, compared with Latin America region, Asia region has a higher need to manuals: 14/34 (41%) of respondents of Asia region though there were no enough manuals, versus, 4/27 (15%) in Latin America.

4.7 CED equipment management

4.7.1 Computerized system for equipment/inventory management

In this survey, Question 6.1 asked respondents which kind MIS system was used for equipment management in their department. 7/61 (12%) of respondents said that they have not had computerized system and instead they managed equipment information by hand; 24/61 (39%) had general software (systems) to store and manage their equipment and inventory, such as Microsoft Excel; 30/61 (49%) had a special computerized system (or MIS) for their equipment and inventory, but those special software systems were developed by various companies, organizations and individuals, and there was no an uniform management information system (MIS) for technical service department--CED in this survey.

As for Asia region, all respondents who managed their equipment information by hand are from this region, that is, all the CEDs from Latin America had a computerized system for equipment management, whereas, 79% (27/34) in Asia region. Moreover, over half (7/12) of CEDs in Latin America which have special computerized management systems developed the MISs by themselves, So, Latin America has more advanced technology applied to equipment management than Asia region in this survey.

4.7.1 Computers and Internet

In this survey, 60/61 (98%) of respondents stated they had at least one computer in their departments, and the average number of computers per CED is 4. The computers were used for 'word processing', 'equipment inventory', 'parts inventory', 'maintenance reports', 'budgeting', and 'equipment statistics'. Respondents also reported other tasks for computer, such as 'bio-safety control and management' 'ISO 9001 procedures', 'service order', 'automated PM test', and 'equipment testing'. Meanwhile, 'testing' is reported four times by respondents in this survey.

42/61 (69%) of respondents in this survey stated that they could always access Internet from their departments. The high proportion of using Internet is probably because that the present survey is mainly sent and collected through Internet, so respondents' ability to access Internet is the precondition to join this survey. But there are still 13/61 (21%) of respondents saying that they never can online from their department. 5/61 (10%) said that

they could online sometimes, and they explained it with "our department is in a local area networking (LAN) that cannot go through Internet", 'we use telephone line to connect with Internet, but we cannot tie up the phone line all the day because the phone line is the only line in our department to contact with outside', and 'supervisor permission needed'.

As for Latin America in this survey, 26/27 (96%) of respondents claimed that they could always online, compared with Asia region; there was 16/34 (47%). Moreover, all 13 respondents who can never online are in Asia region. So, Latin America has more high-tech resources than Asia region.

4.7.2 Quality assurance and Productivity index

'Quality assurance' activity is to control and improve the quality of services provided by CED and 'Productivity index' is used for a measure of staff performance in CEDs. In this survey, 9/34 (27%) of respondents admitted not having started 'quality assurance' programs yet in Asia region and 6/27 (22%) in Latin America, and table 16 shows the comparison the percentage of respondents who said not having quality assurance and productivity index between the three surveys. It can be seen that respondents of Asia and Latin America in this survey had a similar percentage in 'not having quality assurance' with Canada, Nordic countries in 1988; and Asia region has a better performance in productivity index than Latin America and other regions. The reason for this is presumed that those developing countries have high population density than others, and there is more

intensive competition to have jobs. The measure of staff productivity and work quality is an efficient way to determinate who has more significances and contributions to the jobs and organizations, and who should be promoted, laid off and fired. Additionally, an example in China could give some explanations to this situation: although there is no official standard of 'productivity index' for CED staff in China, this activity is a necessary condition for classify hospitals into a higher category, such as 3A, 3B. The relative standard accreditation on productivity index of a 3A hospital is:

- Give weight value for each task of work
- Give a numerical comment on staff work. [49]

It also can be seen from table 18 that the percentages of 'quality assurance' in USA are relatively lower than others. Frize explained, "quality assurance activity is a mandatory requirement for North American hospitals through the JCAH (Joint Commission for the Accreditation of Hospitals) and CCHA (Canadian Council on Hospital Accreditation)." (Frize, p49) [28]

	No quality assurance activity			*No productivity index*		
	1988[1]	*1999*[2]	*2003*[3]	*1988*[1]	*1999*[2]	*2003*[3]
USA	17%	30%	-	28%	44%	-
Canada	28%	30%	-	60%	44%	-
Nordic countries	29%	30%	-	94%	56%	-
Western Europe	40%	39%	-	75%	26%	-
Latin America	-	38%	22%	-	43%	63%
Asia region	-	-	27%	-	-	18%

Note: 1. source from. Frize survey for developed countries (1988)(Frize, p50) [28].
2. source from Glouhova survey for the world (1999) [30].
3. source from the present survey for developing countries (2003).

Table 17 Comparison in the percentage of respondents saying not having 'quality assurance' and 'productivity index' in their departments between three surveys

4.7.3 Recognition

This survey asked respondents to judge whether their department functions and services were well recognized in their hospitals. 20/45 (44%) of respondents claimed they were well recognized in their institutions, compared with 38% in Canada, 44% in Nordic countries, 54% in USA, and 70% in EEC by Frize's survey;[5] another comparison is from Glouhova: more than 80% in all regions. [30] It is clear to see that the departments in the present survey were not well-recognized and accepted as much as those in developed countries.

CHAPTER 5. CONCLUSION

5.1 Results from the present survey

In this survey, 61 respondents from some developing countries are grouped into two regions, Asia (34) and Latin America (27). Respondents in Asia region chiefly came from teaching hospitals with more beds, and most respondents in Latin America from non-teaching hospitals with less ward beds. In this survey, CEDs in Latin America have more appropriate ratio of CEs and technicians (1:2) than those in Asia region, but they hire less engineers than Asia, and some CEDs in Asia employ more CEs than technicians; engineers in Latin America have higher educational background than Asia, but there is opposite situation in technicians and clerical staff; CEs in Latin America need do some administrative work to assist clerical staff; In Asia region, CEs perform more repair activity than technicians, compared, the duty activities of CEs and technician in Latin America are more appropriate; in Asia region, the level of medical equipment repair is performed higher than Latin America, but Latin America perform incoming inspection, preventive maintenance, and pre-purchase consultation higher than Asia, and the level of research activity is done similarly between them; In Asia, a minimum standard of space allocation is 15 square meters per person, which can make most respondents satisfied; Latin America has more specialized computerized management systems for equipment and inventory, and

more chances to access Internet than Asia; more CEDs in Asia have carried out productivity index activity in their departments.

In this survey, teaching hospitals, like western countries, have more normal beds and ICU beds than non-teaching hospitals and they are also the intensive technology utilized units; teaching hospitals hire more CEs than non-teaching hospitals; CEDs in teaching hospitals supervise more devices than those in non-teaching hospitals.

Most CEs in this survey have a BSc, and 67% of technicians went to technical school. However, their average education levels are both lower than developed countries. The levels of device number and equipment replacement value are lower than those developed countries. CEs in this survey perform a great deal repair activity while, instead, CEs in those developed countries perform pre-purchase consultation. Over half respondents in this survey think they are not well recognized in their institutes, but in developed countries, most departments felt that they were well recognized. Most respondents said not satisfied with the resources they had, and said to need more staff, spare parts, test devices, space, and manuals, but in developed countries, most were satisfied with them.

The following features are similar to developed countries in the previous studies. Most respondents in this survey received training from training centers and on the job. Most CEDs in this survey are separate units in hospital organizations and most of respondents reporting to 'Senior Administrators' are satisfied the mechanisms. Most respondents

perform repair, inspection, maintenance, training, and consultation in medical equipment, radiological/imaging equipment, laboratory equipment and anesthetic ventilation equipment. But research activity in those kinds of equipment is relatively few. CEs in this survey perform more user training, pre-purchase consultation, and research than technicians, while technicians perform more repair, incoming inspection, and preventive maintenance. Most respondents have at least one computer and have begun quality assurance and productivity index activities in their department.

5.2 Recommendations

Since most of respondents from Latin America were from Brazil (15) and Mexico (11), the following recommendations would perhaps be more applicable to these two countries:

- Increase technician education level to more than 3-year technical school.
- Employ more clerical staff and increase their education level to some postsecondary.
- Increase the number of clinical engineers with an MSc. or a PhD.
- Increase the availability of test equipment, spare parts, staff, and space allocation.
- CEDs should perform productivity measurements on a yearly basis.

Recommendations for countries in Asia, especially for China (19/34):

- Employ qualified clinical engineers (with a BSc as a minimum requirement and some with an MSc..

- Improve the personnel ratio of clinical engineers to technicians.
- Increase the availability of test equipment, spare parts, staff, and manuals.
- Improve the equipment management process overall to be able to deal with more sophisticated equipment.

Recommendations applicable to all respondents: To improve staff education levels, define clinical engineers' responsibilities, improve department resources, and the number and value of devices supported by CEDs.

CHAPTER 6. FUTURE WORK

A major difficulty was in reaching and encouraging CED staff to participate in this research. (See 3.1.4 and 4.1.3) With a low response rate, enough data cannot be gained to do quantitative analysis and test hypothesis. In the future work, collecting more data from CEDs in developing countries is one of tasks. Researchers should attempt to do personal interviews and field research. Email, telephone interview, and personal interview were tried in this study. Comparably, personal interviews received the best results.

Professional associations were very helpful for this study. We found and contacted the CED staff in a country through its local professional associations. Probably, it is not easy to build up a database for all clinical engineers and technicians in developing countries, but it is relatively easier to establish a database to all professional associations in those countries.

When adequate data are obtained, further research can be carried out, such as testing the hypothesis from Frize's thesis (See Appendix D), and classifying data into groups by cluster analysis.

Appendix A: SAMPLE OF QUESTIONNAIRE, CONSENT FORM, APPROVAL CERTIFICATE

University of Ottawa

International Survey of clinical engineering departments--2003

The survey should be answered by members of Clinical Engineering department in your hospital. The survey faces the unit of CE department. The data obtained in the survey are always kept strictly confidential according to the consent form. Please return this survey by Email or mail or fax. The return Email address is xcao016@uottawa.ca, and mail address is Dr. Monique Frize, SITE, University of Ottawa,161 Louis Pasteur, P.O. Box 450, Stn A, Ottawa, Ontario, Canada, K1N 6N5; fax number is 1-613-562-5175.

Hospital/Organization name: _____ Email (optional):_____

Street: _____City: _____Province: _____

Country: _____Postal Code: _____

Please check ☑ the most appropriate answer.

1.1 Your hospital type is:

❑ University based/Teaching hospital

❑ Non-teaching hospital

1.2 How many beds in your hospital:

❑ <50 ❑ 50-250 ❑ 250-500 ❑ 500-2000 ❑ >=2000

What is average percentage of occupancy of beds in the last year:

❑ <50% ❑ 50-75% ❑ >= 75%

For our purposes, *ICU (intensive-care unit) beds* means intensive care for patients with acute, life-threatening illness or injury, accompanied with monitoring, emergence service and a multidisciplinary team. What is the proportion of ICU beds in your hospital?

❑ < 5% ❑ 5-10% ❑ 10-20% ❑ >=20%

Clinical Engineering Department (CED) profile

- **Structure**

2.1 Does your CED exist as a separate unit? ❑ Yes ❑ No

If No, which department is it part of? _____

2.2 Whom does your CED report to?

❑ Senior Administrator (or equivalence)

❑ Medical director (or chief of medical staff)

❑ Plant/maintenance director

❑ Others, specify: _____

2.3 Are you satisfied with reporting arrangement? ❑ Yes ❑No

- **Personnel**

3.0 Please fill in employee number and **highest** qualification (highest degree).

Personnel	No.	University			Technical school (after the high school)				High school	Under high school
		PhD	MSc	BSc	4 years	3 years	2 years	1 year		
Engineers										
Technicians										
Clerical staff										
Other										

3.1 Is your department a member of an association? ❑ Yes, its name_____ ❑ No

3.2 Was your staff trained:

❑ On the job ❑ In a special training center geared for hospital work

❑ Combination of on the job and special biomedical center

❑ Other, specify: _____

- **Responsibilities**

4.1 How many devices are serviced by your CED?

❑ <500 ❑ 500-2000 ❑ >=2000

4.2 Estimate replacement value of that equipment (in Million of U.S. Dollars):

❑ <1 ❑ 1-5 ❑ 5-10 ❑ >=10

4.3 Please estimate what percentage (%) of work time of **Engineers** and **Technicians** are spent on each of these tasks. TOTAL 100% PLEASE.

1. in-house repair..... _____%_____%
2. incoming inspection..... _____%_____%
3. preventive maintenance..... _____%_____%
4. user education/training..... _____%_____%
5. pre-purchase consultation..... _____%_____%
6. research and development.... _____%_____%
7. other (specify):_____..... _____%_____%

TOTAL 100% 100%

4.4 Please fill in the percentage of workload done by CED..

Table 1 Levels of Clinical Engineering Service

	A	B	C	D	E	F
	Medical equipment	Radiological /Imaging equipment	Laboratory equipment	Anesthetic Ventilation equipment	Computer /software	Infrastructure (electrical/mechanical/civil,etc.)
1. Repair (in-house)						
2.Incoming inspection						

3.Preventive maintenance						
4.User education training (safe use)						
5.Pre-purchase consultation						
6.Research and development						
7. Other						

NOTE: In each cell, fill in the percentage of the workload done by CED, for example ,fill in 75% in the first cell. It means 75% medical equipment to be repaired by CED.

4.5 When new equipment is purchased, you are consulted before the purchase for:

Preparation of specifications:

❑ Always ❑ Often ❑ Sometimes ❑ Never

Analysis of tenders (or venders):

❑ Always ❑ Often ❑ Sometimes ❑ Never

Recommendation on the final choice:

❑ Always ❑ Often ❑ Sometimes ❑ Never

When the equipment arrives at the hospital, it is sent to CED before the user gets it:

❑ Always ❑ Often ❑ Sometimes ❑ Never

Service contracts are negotiated by or in collaboration with your department:

❑ Always ❑ Often ❑ Sometimes ❑ Never

- **Resources**

5.1 *Spare parts* are the backup parts of equipment in your inventory. Estimate:

$$percentage = \frac{value\ of\ spare\ parts}{replacement\ value\ of\ equipment\ inventory\ under\ CED\ management} \times 100\%$$

❑ <0.5% ❑ 0.5-1.0% ❑ 1.0-1.5% ❑ 1.5-2.0% ❑ >=2.0%

5.2 Test equipment or devices you have, Estimate:

$$percentage = \frac{value\ of\ test\ equipment}{replacement\ value\ of\ equipment\ inventory\ under\ CED\ management} \times 100\%$$

❑ <0.5% ❑ 0.5-1.0% ❑ 1.0-1.5% ❑ 1.5-2.0%, ❑ >=2.0%

5.3 *Space* refers to how large your CED is occupied in area, and includes area of (inventory) storage. Estimate the space per person:

❑ <15M^2 ❑ 15-20M^2 ❑ 20-25M^2 ❑ >=25M^2

5.4 The total operation budget of your CED would be (as a percentage of the total equipment inventory):

❑ <1% ❑ 1-2% ❑ 2-3% ❑ 3-4%

❑ 4-5% ❑ >=5%

5.5 Is the number of your personnel adequate? ❑ Yes ❑ No

If No, then state additional personnel required: (specify a number)

❑ Engineers_____ ❑ Technicians_____ ❑ Clerical staff_____

❑ Other, specify_____

5.6 *Spare parts* is defined as before (5.1)

In you opinion, is the parts inventory adequate? ❑ Yes ❑ No

If No, do you think a shortage of parts is related to the average down time of equipment? ❑ Yes

❑ No

5.7 Is the number of test equipment adequate? ❑ Yes ❑ No

5.8 *Space* is defined as before (5.3). Is the space is adequate? ❑ Yes ❑ No

5.9 Are operating manuals adequate? ❑ Yes ❑ No, If No, specify:_____

- **Equipment management**

6.1 Do you have a computerized system for equipment or inventory management?

❑ No: management by hand

❑ Yes: management by a general software (e.g. Microsoft EXCEL)

❑ Yes: management by special software, detail: _____

6.2 How many computers does your department have? _____

Your department uses them for: ❑ word processing

(select all items applicable) ❑ equipment inventory

❑ parts inventory

❑ maintenance reports

❑ budgeting

❑ equipment statistics

❑ other, specify: _____

6.3 Can you access Internet in your department?

❑ Always ❑ Never ❑ Sometimes, explain: _____

6.4 Have you been performing quality assurance (or quality control) on your services?

❑ Not yet ❑ have just started ❑ have done so for a year or two

❑ have done so for more than two years

6.5 Do you use a productivity index in your department to measure your staff performance?

❑ Not yet ❑ have just started ❑ have done so for a year or two

❑ have done so for more than two years

• Additional comment (on clinical engineering/on your department/ on this survey). You can use a blank page.

Thank you most sincerely for your helps.

Consent form

Name of researcher(s): Xinyuan Cao Name of supervisor: DR. Monique Frize

Institution, Faculty, Department: The faculty of Administration, Systems Science Program

Telephone number: 1-(613)-234-2256

E-mail address: xcao016@uottawa.ca

I (or department),_____, agree to participate in the research conducted by *Xinyuan Cao, Master's Thesis* of the Department of *Systems Science, the faculty of Administration* at the University of Ottawa. The project is under the supervision of *Dr. Monique Frize*. The purpose of the research is *to assess the development level of clinical engineering departments in developing countries.*

My participation will consist essentially of attending *one time and 1 hour* session during which *to answer the questions on questionnaires*. The session has been scheduled for *one hour*. I will also be asked to *fill out the questionnaire.* I understand that the contents will be used only for *research objective* and that my confidentiality will be respected. *The questionnaire is anonymous, and any name of participants will not be shown up on the paper.*

I am free to withdraw from the project at any time, before or during the process, refuse to participate and refuse to answer questions.

I have received assurance from the researchers that the information I will share will remain strictly confidential. Anonymity will be assured in the following manner. *On questionnaires, participants are* ***not*** *asked to write their name; if participants give their name, the names will not be omitted.*

Any information about my rights as a research participant may be addressed to **Protocol Officer for Ethics in Research, 550 Cumberland Street, Room 160, (613) 562-5387 or** ethics@uottawa.ca .

There are two copies of the consent form, one of which I may keep.

If I have any questions about the conduct of the research project, I may contact the researcher or her supervisor

Dr. Monique Frize
Phone: (613) 562-5800 ext 6065
School of Information Technology and Engineering, University of Ottawa
Fax.: (613) 562-5175
E-mail: FRIZE@SITE.UOTTAWA.CA

Researcher's signature: (*Signature*) Date: (*Date*)

Research Subject's signature: (*Signature*) Date: (*Date*)

HEALTH SCIENCES AND SCIENCE RESEARCH ETHICS BOARD

CERTIFICATE OF ETHICAL APPROVAL

This is to certify that the University of Ottawa Health Sciences and Science Research Ethics Board has examined the application for ethical approval for the research project **The assessment of clinical engineering departments in developing countries (File H 04-03-03)** submitted by Xinyuan Cao, supervised by Monique Frize. The Board found that this research project met appropriate ethical standards as outlined in the Tri-Council Policy Statement and in the Procedures of the University of Ottawa Research Ethics Boards, and accordingly gave it a Category 1a (approval). This certification is valid for one year from the date indicated below.

May 16th, 2003

Andrée Bertrand — Date

Protocol Officer for Ethics in Research,

For the Chairperson of the Health

Sciences and Science REB

Daniel Lagarec

Appendix B: HUMAN DEVELOPMENT REPORT 2001

1. HUMAN DEVELOPMENT INDEX: the HDI measures a country's achievements in terms of life expectancy, educational attainment and adjusted real income

HDI rank			
High human development	Medium human development		Low human development
1 Norway	49 Trinidad and Tobago	88 Jordan	127 Pakistan
2 Australia	50 Latvia	89 Tunisia	128 Togo
3 Canada	51 Mexico	90 Iran, Islamic Rep. of	129 Nepal
4 Sweden	52 Panama	91 Cape Verde	130 Bhutan
5 Belgium	53 Belarus	92 Kyrgyzstan	131 Lao People's Dem. Rep.
6 United States	54 Belize	93 Guyana	132 Bangladesh
7 Iceland	55 Russian Federation	94 South Africa	133 Yemen
8 Netherlands	56 Malaysia	95 El Salvador	134 Haiti
9 Japan	57 Bulgaria	96 Samoa (Western)	135 Madagascar
10 Finland	58 Romania	97 Syrian Arab Republic	136 Nigeria
11 Switzerland	59 Libyan Arab Jamahiriya	98 Moldova, Rep. of	137 Djibouti
12 Luxembourg	60 Macedonia, TFYR	99 Uzbekistan	138 Sudan
13 France	61 Venezuela	100 Algeria	139 Mauritania
14 United Kingdom	62 Columbia	101 Viet Nam	140 Tanzania, U. Rep. of
15 Denmark	63 Mauritius	102 Indonesia	141 Uganda
16 Austria	64 Suriname	103 Tajikistan	142 Congo, Dem. Rep. of the
17 Germany	65 Lebanon	104 Bolivia	143 Zambia
18 Ireland	66 Thailand	105 Egypt	144 Côte d'Ivoire
19 New Zealand	67 Fiji	106 Nicaragua	145 Senegal
20 Italy	68 Saudi Arabia	107 Honduras	146 Angola
21 Spain	69 Brazil	108 Guatemala	147 Benin
22 Israel	70 Philippines	109 Gabon	148 Eritrea
23 Greece	71 Oman	110 Equatorial Guinea	149 Gambia
24 Hong Kong, China (SAR)	72 Armenia	111 Namibia	150 Guinea
25 Cyprus	73 Peru	112 Morocco	151 Malawi
26 Singapore	74 Ukraine	113 Swaziland	152 Rwanda
27 Korea, Rep. of	75 Kazakhstan	114 Botswana	153 Mali
28 Portugal	76 Georgia	115 India	154 Central African Republic
29 Slovenia	77 Maldives	116 Mongolia	155 Chad
30 Malta	78 Jamaica	117 Zimbabwe	156 Guinea-Bissau
31 Barbados	79 Azerbaijan	118 Myanmar	157 Mozambique
32 Brunei Darussalam	80 Paraguay	119 Ghana	158 Ethiopia
33 Czech Republic	81 Sri Lanka	120 Lesotho	159 Burkina Faso
34 Argentina	82 Turkey	121 Cambodia	160 Burundi
35 Slovakia	83 Turkmenistan	122 Papua New Guinea	161 Niger
36 Hungary	84 Ecuador	123 Kenya	162 Sierra Leone
37 Uruguay	85 Albania	124 Comoros	
38 Poland	86 Dominican Republic	125 Cameroon	
39 Chile	87 China	126 Congo	
40 Bahrain			
41 Costa Rica			
42 Bahamas			
43 Kuwait			
44 Estonia			
45 United Arab Emirates			
46 Croatia			
47 Lithuania			
48 Qatar			

2. THE OFFICIAL LANGUAGE(S) OF DEVELOPING COUNTRIES

Country Name	Official language(s)	Country Name	Official language(s)
49 Trinidad and Tobago	English	106 Nicaragua	Spanish
50 Latvia	Lettish	107 Honduras	Spanish
51 Mexico	Spanish	108 Guatemala	Spanish
52 Panama	Spanish	109 Gabon	French
53 Belarus	Belarusian, Russian	110 Equatorial Guinea	Spanish
54 Belize	English	111 Namibia	English
55 Russian Federation	Russian	112 Morocco	Arabic
56 Malaysia	Bahasa Malaysia	113 Swaziland	English and siSwati
57 Bulgaria	Bulgarian	114 Botswana	English, Setswana (national)
58 Romania	Romanian	115 India	Hindi and English
59 Libyan Arab Jamahiriya	Arabic	116 Mongolia	Khalkha Mongolian
60 Macedonia, TFYR	Macedonian	117 Zimbabwe	English, Shona, Ndebele
61 Venezuela	Spanish	118 Myanmar	Myanmar
62 Colombia	Spanish	119 Ghana	English
63 Mauritius	English, French	120 Lesotho	Sesotho, English
64 Suriname	Dutch	121 Cambodia	Khmer
65 Lebanon	Arabic	122 Papua New Guinea	Spanish
66 Thailand	Thai	123 Kenya	KiSwahili, English
67 Fiji	English, Fijian, Hindi	124 Comoros	Arabic, French
68 Saudi Arabia	Arabic	125 Cameroon	French, English
69 Brazil	Portuguese	126 Congo	French
70 Philippines	Filipino (based on Tagalog)	127 Pakistan	Urdu (native), English
71 Oman	Arabic	128 Togo	French
72 Armenia	Armenian	129 Nepal	Nepali
73 Peru	Spanish	130 Bhutan	Dzongkha
74 Ukraine	Ukrainian	131 Lao People's Dem. Rep.	Lao ,English***
75 Kazakhstan	Kazakh	132 Bangladesh	Arabic
76 Georgia	Georgian	133 Yemen	Arabic
77 Maldives	Dhivehi (Maldivian)	134 Haiti	Creole, French
78 Jamaica	English	135 Madagascar	Malagasy, French
79 Azerbaijan	Azeri (Turkic)	136 Nigeria	English
80 Paraguay	Guaraní, Spanish	137 Djibouti	French/Arabic (Somali/Afar)
81 Sri Lanka	Sinhala, Tamil and English	138 Sudan	Arabic
82 Turkey	Turkish	139 Mauritania	Arabic
83 Turkmenistan	Turkmen	140 Tanzania, U. Rep. of	KiSwahili, English
84 Ecuador	Spanish	141 Uganda	English
85 Albania	Tosk Albanian	142 Congo, Dem. Rep. of the	French
86 Dominican Republic	Spanish	143 Zambia	English
87 China	Chinese	144 Côte d'Ivoire	French
88 Jordan	Arabic	145 Senegal	French
89 Tunisia	Arabic	146 Angola	Portuguese
90 Iran, Islamic Rep. of	Farsi (Persian)	147 Benin	French
91 Cape Verde	Portuguese, Creole(native)	148 Eritrea	Tigrinya, Arabic, English*
92 Kyrgyzstan	Kyrgyz, Russian	149 Gambia	English
93 Guyana	English	150 Guinea	French
94 South Africa **	Afrikaans, English, Ndebele	151 Malawi	English, Chichewa
95 El Salvador	Spanish	152 Rwanda	Kinyarwanda, French, English
96 Samoa (Western)	Samoan	153 Mali	French
97 Syrian Arab Republic	Arabic	154 Central African Republic	French
98 Moldova, Rep. of	Moldovan	155 Chad	French and Arabic
99 Uzbekistan	Uzbek	156 Guinea-Bissau	Portuguese
100 Algeria	Arabic, Tamazight	157 Mozambique	Portuguese
101 Viet Nam	Vietnamese	158 Ethiopia	Amharic
102 Indonesia	Bahasa Indonesia	159 Burkina Faso	French
103 Tajikistan	Tajik (Farsi)	160 Burundi	Kirundi , French
104 Bolivia	Spanish	161 Niger	French
105 Egypt	Arabic	162 Sierra Leone	English

*English is not the official language, but is working in the countries.
** Sesotho, Northern Sotho, SiSwati, Tsonga, Tswana, Venda, Xhosa, and Zulu are also the official language.
*** English is the business language of the Lao government. Source from: www.worldinformation.com

Appendix C: CODE OF THE ONLINE SURVEY AND DATA DICTIONARY

1. CODES OF ONLINE SURVEY

2. DATA DICTIONARY OF SURVEY

```
 1: using System;
 2: using System.Collections;
 3: using System.ComponentModel;
 4: using System.Data;
 5: using System.Drawing;
 6: using System.Web;
 7: using System.Web.SessionState;
 8: using System.Web.UI;
 9: using System.Web.UI.WebControls;
10: using System.Web.UI.HtmlControls;
11: using System.IO;
12:
13: namespace Web
14: {
15:   /// <summary>
16:   /// Summary description for index.
17:   /// </summary>
18:   public class index : System.Web.UI.Page
19:   {
20:     protected System.Web.UI.WebControls.HyperLink HyperLink2;
21:     protected System.Web.UI.WebControls.HyperLink HyperLink1;
22:     protected System.Web.UI.WebControls.HyperLink HyperLink3;
23:     protected System.Web.UI.WebControls.HyperLink HyperLink4;
24:     protected System.Web.UI.WebControls.Label Label2;
25:     protected System.Web.UI.WebControls.LinkButton LinkButton1;
26:     protected System.Web.UI.WebControls.LinkButton LinkButton2;
27:     protected System.Web.UI.WebControls.LinkButton LinkButton3;
28:     protected System.Web.UI.WebControls.Label Label1;
29:
30:     private void Page_Load(object sender, System.EventArgs e)
31:     {
32:     }
33:
34:     #region Web Form Designer generated code
35:     override protected void OnInit(EventArgs e)
36:     {
37:
38:       InitializeComponent();
39:       base.OnInit(e);
40:     }
41:
42:     /// <summary>
43:     /// Required method for Designer support - do not modify
44:     /// the contents of this method with the code editor.
45:     /// </summary>
46:     private void InitializeComponent()
47:     {
48:       this.LinkButton1.Click += new System.EventHandler(this.LinkButton1_Click);
49:       this.LinkButton2.Click += new System.EventHandler(this.LinkButton2_Click);
50:       this.LinkButton3.Click += new System.EventHandler(this.LinkButton3_Click);
51:       this.Load += new System.EventHandler(this.Page_Load);
52:
53:     }
54:     #endregion
55:
56:     private void LinkButton1_Click(object sender, System.EventArgs e)
57:     {
58:       //string root="C:\temp";
59:       //string filepath="c:\\";
60:       FileInfo file= new FileInfo("c:\\survey_en.exe");
61:       if (file.Exists)
```

```
62:         {
63:           string length=file.Length.ToString();
64:           Response.Clear();
65:           Response.ContentType="application/octet-stream";
66:           Response.AddHeader("Content-Disposition", "attachment; filename=survey_en.e
    xe");
67:           Response.AddHeader("Content-Length", length);
68:           //Response.Flush();
69:           Response.WriteFile(file.FullName);
70:           Response.End();
71:         }
72:         else
73:            Response.Redirect("SysError.aspx");
74:
75:
76:
77:     }
78:
79:     private void LinkButton2_Click(object sender, System.EventArgs e)
80:     {
81:       FileInfo file= new FileInfo("c:\\survey_cn.exe");
82:       if (file.Exists)
83:       {
84:         string length=file.Length.ToString();
85:         Response.Clear();
86:         Response.ContentType="application/octet-stream";
87:         Response.AddHeader("Content-Disposition", "attachment; filename=survey_cn.e
    xe");
88:         Response.AddHeader("Content-Length", length);
89:         //Response.Flush();
90:         Response.WriteFile(file.FullName);
91:         Response.End();
92:       }
93:       else
94:         Response.Redirect("SysError.aspx");
95:
96:     }
97:
98:     private void LinkButton3_Click(object sender, System.EventArgs e)
99:     {
100:      FileInfo file= new FileInfo("c:\\survey_fr.exe");
101:      if (file.Exists)
102:      {
103:        string length=file.Length.ToString();
104:        Response.Clear();
105:        Response.ContentType="application/octet-stream";
106:        Response.AddHeader("Content-Disposition", "attachment; filename=survey_fr.e
    xe");
107:        Response.AddHeader("Content-Length", length);
108:        //Response.Flush();
109:        Response.WriteFile(file.FullName);
110:        Response.End();
111:      }
112:      else
113:        Response.Redirect("SysError.aspx");
114:
115:    }
116:  }
117: }
```

```
1:          using System;
2: using System.Collections;
3: using System.ComponentModel;
4: using System.Data;
5: using System.Drawing;
6: using System.Web;
7: using System.Web.SessionState;
8: using System.Web.UI;
9: using System.Web.UI.WebControls;
10: using System.Web.UI.HtmlControls;
11: using System.IO;
12:
13: namespace Web
14: {
15:   /// <summary>
16:   /// Summary description for WebForm1.
17:   /// </summary>
18:   public class WebForm1 : System.Web.UI.Page
19:   {
20:     private string[] q=new string[67];
21:     private string[,] q44=new string[7,6];
22:     private string id, hosp_name, street, city, prov, country, email, memo;
23:     protected System.Web.UI.WebControls.RadioButtonList q12_rbl;
24:     protected System.Web.UI.WebControls.RadioButtonList q13_rbl;
25:     protected System.Web.UI.WebControls.RadioButtonList q14_rbl;
26:     protected System.Web.UI.WebControls.RadioButtonList q22_rbl;
27:     protected System.Web.UI.WebControls.RadioButtonList q23_rbl;
28:     protected System.Web.UI.WebControls.RadioButtonList q31_rbl;
29:     protected System.Web.UI.WebControls.TextBox q31_tb;
30:     protected System.Web.UI.WebControls.TextBox q22_tb;
31:     protected System.Web.UI.WebControls.RadioButtonList q41_rbl;
32:     protected System.Web.UI.WebControls.RadioButtonList q42_rbl;
33:     protected System.Web.UI.WebControls.TextBox q43_tb2;
34:     protected System.Web.UI.WebControls.TextBox q43_tb3;
35:     protected System.Web.UI.WebControls.TextBox q43_tb4;
36:     protected System.Web.UI.WebControls.TextBox q43_tb5;
37:     protected System.Web.UI.WebControls.TextBox q43_tb1;
38:     protected System.Web.UI.WebControls.TextBox q43_tb8;
39:     protected System.Web.UI.WebControls.TextBox q43_tb9;
40:     protected System.Web.UI.WebControls.TextBox q43_tb10;
41:     protected System.Web.UI.WebControls.TextBox q43_tb11;
42:     protected System.Web.UI.WebControls.TextBox q43_tb12;
43:     protected System.Web.UI.WebControls.TextBox q43_tb6;
44:     protected System.Web.UI.WebControls.TextBox q43_tb13;
45:     protected System.Web.UI.WebControls.TextBox q43_tb14;
46:     protected System.Web.UI.WebControls.TextBox q43_tb7;
47:     protected System.Web.UI.WebControls.RadioButtonList q51_rbl;
48:     protected System.Web.UI.WebControls.RadioButtonList q52_rbl;
49:     protected System.Web.UI.WebControls.RadioButtonList q53_rbl;
50:     protected System.Web.UI.WebControls.RadioButtonList q54_rbl;
51:     protected System.Web.UI.WebControls.RadioButtonList q55_rbl;
52:     protected System.Web.UI.WebControls.TextBox q55_tb1;
53:     protected System.Web.UI.WebControls.TextBox q55_tb2;
54:     protected System.Web.UI.WebControls.TextBox q55_tb3;
55:     protected System.Web.UI.WebControls.TextBox q55_tb4;
56:     protected System.Web.UI.WebControls.RadioButtonList q56_rbl;
57:     protected System.Web.UI.WebControls.RadioButtonList q56_rbl2;
58:     protected System.Web.UI.WebControls.RadioButtonList q57_rbl;
59:     protected System.Web.UI.WebControls.RadioButtonList q58_rbl;
60:     protected System.Web.UI.WebControls.RadioButtonList q59_rbl;
61:     protected System.Web.UI.WebControls.RadioButtonList q61_rbl;
```

```
62:     protected System.Web.UI.WebControls.TextBox q61_tb;
63:     protected System.Web.UI.WebControls.TextBox q62_tb;
64:     protected System.Web.UI.WebControls.TextBox q63_tb;
65:     protected System.Web.UI.WebControls.RadioButtonList q64_rbl;
66:     protected System.Web.UI.WebControls.RadioButtonList q65_rbl;
67:     protected System.Web.UI.WebControls.RadioButtonList q11_rbl;
68:     protected System.Web.UI.WebControls.TextBox q30_tb1;
69:     protected System.Web.UI.WebControls.DropDownList q30_ddl1;
70:     protected System.Web.UI.WebControls.TextBox q30_tb2;
71:     protected System.Web.UI.WebControls.TextBox q30_tb3;
72:     protected System.Web.UI.WebControls.DropDownList q30_ddl3;
73:     protected System.Web.UI.WebControls.TextBox q30_tb4;
74:     protected System.Web.UI.WebControls.DropDownList q30_ddl4;
75:     protected System.Web.UI.WebControls.TextBox q43_tb15;
76:     protected System.Web.UI.WebControls.TextBox q59_tb;
77:     protected System.Web.UI.WebControls.DropDownList q30_ddl2;
78:     protected System.Web.UI.WebControls.TextBox q21_tb;
79:     protected System.Web.UI.WebControls.CheckBoxList q62_chbl;
80:     protected System.Web.UI.WebControls.RadioButtonList q63_rbl;
81:     protected System.Web.UI.WebControls.TextBox q44_tb11;
82:     protected System.Web.UI.WebControls.TextBox q44_tb12;
83:     protected System.Web.UI.WebControls.TextBox q44_tb13;
84:     protected System.Web.UI.WebControls.TextBox q44_tb14;
85:     protected System.Web.UI.WebControls.TextBox q44_tb15;
86:     protected System.Web.UI.WebControls.TextBox q44_tb16;
87:     protected System.Web.UI.WebControls.TextBox q44_tb21;
88:     protected System.Web.UI.WebControls.TextBox q44_tb22;
89:     protected System.Web.UI.WebControls.TextBox q44_tb23;
90:     protected System.Web.UI.WebControls.TextBox q44_tb24;
91:     protected System.Web.UI.WebControls.TextBox q44_tb25;
92:     protected System.Web.UI.WebControls.TextBox q44_tb26;
93:     protected System.Web.UI.WebControls.TextBox q44_tb36;
94:     protected System.Web.UI.WebControls.TextBox q44_tb31;
95:     protected System.Web.UI.WebControls.TextBox q44_tb32;
96:     protected System.Web.UI.WebControls.TextBox q44_tb33;
97:     protected System.Web.UI.WebControls.TextBox q44_tb34;
98:     protected System.Web.UI.WebControls.TextBox q44_tb35;
99:     protected System.Web.UI.WebControls.TextBox q44_tb41;
100:    protected System.Web.UI.WebControls.TextBox q44_tb42;
101:    protected System.Web.UI.WebControls.TextBox q44_tb43;
102:    protected System.Web.UI.WebControls.TextBox q44_tb44;
103:    protected System.Web.UI.WebControls.TextBox q44_tb45;
104:    protected System.Web.UI.WebControls.TextBox q44_tb46;
105:    protected System.Web.UI.WebControls.TextBox q44_tb51;
106:    protected System.Web.UI.WebControls.TextBox q44_tb52;
107:    protected System.Web.UI.WebControls.TextBox q44_tb53;
108:    protected System.Web.UI.WebControls.TextBox q44_tb54;
109:    protected System.Web.UI.WebControls.TextBox q44_tb55;
110:    protected System.Web.UI.WebControls.TextBox q44_tb56;
111:    protected System.Web.UI.WebControls.TextBox q44_tb61;
112:    protected System.Web.UI.WebControls.TextBox q44_tb62;
113:    protected System.Web.UI.WebControls.TextBox q44_tb63;
114:    protected System.Web.UI.WebControls.TextBox q44_tb64;
115:    protected System.Web.UI.WebControls.TextBox q44_tb65;
116:    protected System.Web.UI.WebControls.TextBox q44_tb71;
117:    protected System.Web.UI.WebControls.TextBox q44_tb72;
118:    protected System.Web.UI.WebControls.TextBox q44_tb73;
119:    protected System.Web.UI.WebControls.TextBox q44_tb74;
120:    protected System.Web.UI.WebControls.TextBox q44_tb75;
121:    protected System.Web.UI.WebControls.TextBox q44_tb66;
122:    protected System.Web.UI.WebControls.TextBox q44_tb76;
```

```
123:     protected System.Web.UI.WebControls.RadioButtonList q21_rbl;
124:     protected System.Web.UI.WebControls.Label q31_lbl;
125:     protected System.Web.UI.WebControls.RequiredFieldValidator q11_v;
126:     protected System.Web.UI.WebControls.RequiredFieldValidator q12_v;
127:     protected System.Web.UI.WebControls.RequiredFieldValidator q13_v;
128:     protected System.Web.UI.WebControls.RequiredFieldValidator q14_v;
129:     protected System.Web.UI.WebControls.RequiredFieldValidator q21_v;
130:     protected System.Web.UI.WebControls.RequiredFieldValidator q22_v;
131:     protected System.Web.UI.WebControls.RequiredFieldValidator q23_v;
132:     protected System.Web.UI.WebControls.RequiredFieldValidator q31_v;
133:     protected System.Web.UI.WebControls.RequiredFieldValidator q32_v;
134:     protected System.Web.UI.WebControls.RequiredFieldValidator q41_v;
135:     protected System.Web.UI.WebControls.RequiredFieldValidator q42_v;
136:     protected System.Web.UI.WebControls.RequiredFieldValidator q51_v;
137:     protected System.Web.UI.WebControls.RequiredFieldValidator q52_v;
138:     protected System.Web.UI.WebControls.RequiredFieldValidator q53_v;
139:     protected System.Web.UI.WebControls.RequiredFieldValidator q56_v;
140:     protected System.Web.UI.WebControls.RequiredFieldValidator q55_v;
141:     protected System.Web.UI.WebControls.RequiredFieldValidator q54_v;
142:     protected System.Web.UI.WebControls.RequiredFieldValidator q57_v;
143:     protected System.Web.UI.WebControls.RequiredFieldValidator q58_v;
144:     protected System.Web.UI.WebControls.RequiredFieldValidator q59_v;
145:     protected System.Web.UI.WebControls.RequiredFieldValidator q61_v;
146:     protected System.Web.UI.WebControls.RequiredFieldValidator q63_v;
147:     protected System.Web.UI.WebControls.RequiredFieldValidator q64_v;
148:     protected System.Web.UI.WebControls.RequiredFieldValidator q65_v;
149:     protected System.Web.UI.WebControls.Button Button1;
150:     protected System.Web.UI.WebControls.Button Button2;
151:     protected System.Web.UI.WebControls.ValidationSummary ValidationSummary1;
152:     protected System.Web.UI.WebControls.TextBox hosp_name_tb;
153:     protected System.Web.UI.WebControls.RequiredFieldValidator hpN_v;
154:     protected System.Web.UI.WebControls.TextBox street_tb;
155:     protected System.Web.UI.WebControls.RequiredFieldValidator st_v;
156:     protected System.Web.UI.WebControls.TextBox city_tb;
157:     protected System.Web.UI.WebControls.RequiredFieldValidator cty_v;
158:     protected System.Web.UI.WebControls.TextBox prov_tb;
159:     protected System.Web.UI.WebControls.DropDownList country_ddl;
160:     protected System.Web.UI.WebControls.TextBox email_tb;
161:     protected System.Web.UI.WebControls.TextBox q32_tb;
162:     protected System.Web.UI.WebControls.RadioButtonList q32_rbl;
163:     protected System.Web.UI.WebControls.TextBox memo_tb;
164:     protected System.Web.UI.WebControls.RequiredFieldValidator q62tb_v;
165:     protected System.Web.UI.WebControls.CompareValidator q62_v_int;
166:     protected System.Web.UI.WebControls.CompareValidator q30_v1_int;
167:     protected System.Web.UI.WebControls.CompareValidator q30_v2_int;
168:     protected System.Web.UI.WebControls.CompareValidator q30_v3_int;
169:     protected System.Web.UI.WebControls.CompareValidator q30_v4_int;
170:     protected System.Web.UI.WebControls.CompareValidator q55_v1_int;
171:     protected System.Web.UI.WebControls.CompareValidator q55_v2_int;
172:     protected System.Web.UI.WebControls.CompareValidator q55_v3_int;
173:     protected System.Web.UI.WebControls.CompareValidator hosp_v_str;
174:     protected System.Web.UI.WebControls.CompareValidator city_v_str;
175:     protected System.Web.UI.WebControls.CompareValidator street_v_str;
176:     protected System.Web.UI.WebControls.RequiredFieldValidator q45_v;
177:     protected System.Web.UI.WebControls.RadioButtonList q45_rbl;
178:     protected System.Web.UI.WebControls.RequiredFieldValidator q46_v;
179:     protected System.Web.UI.WebControls.RadioButtonList q46_rbl;
180:     protected System.Web.UI.WebControls.RequiredFieldValidator q47_v;
181:     protected System.Web.UI.WebControls.RadioButtonList q47_rbl;
182:     protected System.Web.UI.WebControls.RequiredFieldValidator q48_v;
183:     protected System.Web.UI.WebControls.RadioButtonList q48_rbl;
```

```
184:     protected System.Web.UI.WebControls.RequiredFieldValidator q49_v;
185:     protected System.Web.UI.WebControls.RadioButtonList q49_rbl;
186:     protected System.Web.UI.WebControls.CompareValidator q43_v1_int;
187:     protected System.Web.UI.WebControls.CompareValidator q43_v2_int;
188:     protected System.Web.UI.WebControls.CompareValidator q43_v3_int;
189:     protected System.Web.UI.WebControls.CompareValidator q43_v4_int;
190:     protected System.Web.UI.WebControls.CompareValidator q43_v5_int;
191:     protected System.Web.UI.WebControls.CompareValidator q43_v6_int;
192:     protected System.Web.UI.WebControls.CompareValidator q43_v7_int;
193:     protected System.Web.UI.WebControls.CompareValidator q43_v8_int;
194:     protected System.Web.UI.WebControls.CompareValidator q43_v9_int;
195:     protected System.Web.UI.WebControls.CompareValidator q43_v10_int;
196:     protected System.Web.UI.WebControls.CompareValidator q43_v11_int;
197:     protected System.Web.UI.WebControls.CompareValidator q43_v12_int;
198:     protected System.Web.UI.WebControls.CompareValidator q43_v13_int;
199:     protected System.Web.UI.WebControls.CompareValidator q43_v14_int;
200:     protected System.Web.UI.WebControls.CompareValidator q44_v11_int;
201:     protected System.Web.UI.WebControls.CompareValidator q44_v12_int;
202:     protected System.Web.UI.WebControls.CompareValidator q44_v13_int;
203:     protected System.Web.UI.WebControls.CompareValidator q44_v14_int;
204:     protected System.Web.UI.WebControls.CompareValidator q44_v15_int;
205:     protected System.Web.UI.WebControls.CompareValidator q44_v16_int;
206:     protected System.Web.UI.WebControls.CompareValidator q44_v21_int;
207:     protected System.Web.UI.WebControls.CompareValidator q44_v22_int;
208:     protected System.Web.UI.WebControls.CompareValidator q44_v23_int;
209:     protected System.Web.UI.WebControls.CompareValidator q44_v24_int;
210:     protected System.Web.UI.WebControls.CompareValidator q44_v25_int;
211:     protected System.Web.UI.WebControls.CompareValidator q44_v26_int;
212:     protected System.Web.UI.WebControls.CompareValidator q44_v31_int;
213:     protected System.Web.UI.WebControls.CompareValidator q44_v32_int;
214:     protected System.Web.UI.WebControls.CompareValidator q44_v33_int;
215:     protected System.Web.UI.WebControls.CompareValidator q44_v34_int;
216:     protected System.Web.UI.WebControls.CompareValidator q44_v35_int;
217:     protected System.Web.UI.WebControls.CompareValidator q44_v36_int;
218:     protected System.Web.UI.WebControls.CompareValidator q44_v41_int;
219:     protected System.Web.UI.WebControls.CompareValidator q44_v42_int;
220:     protected System.Web.UI.WebControls.CompareValidator q44_v43_int;
221:     protected System.Web.UI.WebControls.CompareValidator q44_v44_int;
222:     protected System.Web.UI.WebControls.CompareValidator q44_v45_int;
223:     protected System.Web.UI.WebControls.CompareValidator q44_v46_int;
224:     protected System.Web.UI.WebControls.CompareValidator q44_v51_int;
225:     protected System.Web.UI.WebControls.CompareValidator q44_v52_int;
226:     protected System.Web.UI.WebControls.CompareValidator q44_v53_int;
227:     protected System.Web.UI.WebControls.CompareValidator q44_v54_int;
228:     protected System.Web.UI.WebControls.CompareValidator q44_v55_int;
229:     protected System.Web.UI.WebControls.CompareValidator q44_v56_int;
230:     protected System.Web.UI.WebControls.CompareValidator q44_v61_int;
231:     protected System.Web.UI.WebControls.CompareValidator q44_v62_int;
232:     protected System.Web.UI.WebControls.CompareValidator q44_v63_int;
233:     protected System.Web.UI.WebControls.CompareValidator q44_v64_int;
234:     protected System.Web.UI.WebControls.CompareValidator q44_v65_int;
235:     protected System.Web.UI.WebControls.CompareValidator q44_v66_int;
236:     protected System.Web.UI.WebControls.CompareValidator q44_v71_int;
237:     protected System.Web.UI.WebControls.CompareValidator q44_v72_int;
238:     protected System.Web.UI.WebControls.CompareValidator q44_v73_int;
239:     protected System.Web.UI.WebControls.CompareValidator q44_v74_int;
240:     protected System.Web.UI.WebControls.CompareValidator q44_v75_int;
241:     protected System.Web.UI.WebControls.CompareValidator q44_v76_int;
242:     protected System.Web.UI.WebControls.Button Button3;
243:     protected System.Web.UI.WebControls.HyperLink HyperLink1;
244:     private int count=0;
```

```
245:
246:     private void Page_Load(object sender, System.EventArgs e)
247:     {
248:       if (!IsPostBack)
249:       {
250:
251:         for (int i=0;i<q.Length ;i++)
252:         {
253:           q[i]="";
254:         }
255:         //string[][] q44;
256:         for (int i=0;i<7;i++)
257:         {
258:           for (int j=1; j<6 ; j++)
259:             q44[i,j]="";
260:         }
261:
262:
263:       }
264:
265:       // Put user code to initialize the page here
266:     }
267:
268:     #region Web Form Designer generated code
269:     override protected void OnInit(EventArgs e)
270:     {
271:       //
272:       // CODEGEN: This call is required by the ASP.NET Web Form Designer.
273:       //
274:       InitializeComponent();
275:       base.OnInit(e);
276:     }
277:
278:     /// <summary>
279:     /// Required method for Designer support - do not modify
280:     /// the contents of this method with the code editor.
281:     /// </summary>
282:     private void InitializeComponent()
283:     {
284:       this.Button1.Click += new System.EventHandler(this.Button1_Click);
285:       this.Button3.Click += new System.EventHandler(this.Button3_Click);
286:       this.Button2.Click += new System.EventHandler(this.Button2_Click);
287:       this.Load += new System.EventHandler(this.Page_Load);
288:
289:     }
290:     #endregion
291:
292:
293:
294:     private void Button1_Click(object sender, System.EventArgs e)
295:     {
296:       if (Page.IsValid)
297:       {
298:         string strLine;
299:         string[] strArray;
300:         char[] charArray=new char[]{','};
301:         string hospStreet, hospStreet_tb;
302:
303:         try
304:         {
305:           if (File.Exists("c:\\hospital.txt")&&(File.Exists("c:\\data.txt")))
```

```
306:            {
307:              //TextBox1.Text="hd";
308:              FileStream h_file=new FileStream("c:\\hospital.txt", FileMode.Open);
309:              StreamReader h_sr= new StreamReader(h_file);
310:              strLine=h_sr.ReadLine();
311:              while (strLine!=null)
312:              {
313:                strArray=strLine.Split(charArray);
314:                hospStreet=strArray[1].Trim()+strArray[2].Trim();
315:                hospStreet_tb=hosp_name_tb.Text+street_tb.Text;
316:                if (hospStreet!=hospStreet_tb)
317:                  count=count+1;
318:                else
319:                {
320:                  //go to error page?
321:                  h_file.Close();
322:                  Response.Redirect("hospError.aspx");
323:                }
324:                strLine=h_sr.ReadLine();
325:              }
326:              h_sr.Close();
327:              h_file.Close();
328:
329:              if (count==0)
330:                id=generate_id(0);
331:
332:              id=generate_id(count);
333:              write_hospital();
334:              write_data();
335:              Response.Redirect("thanks.aspx");
336:
337:            }
338:            else
339:            {
340:              if ((!File.Exists("c:\\hospital.txt"))&&(!File.Exists("c:\\data.txt")))
341:              {
342:                FileStream h_file=new FileStream("c:\\hospital.txt", FileMode.CreateN
    ew);
343:                FileStream d_file=new FileStream("c:\\data.txt", FileMode.CreateNew);
344:                id=generate_id(0);
345:                h_file.Close ();
346:                d_file.Close ();
347:                write_hospital();
348:                write_data();
349:                Response.Redirect("thanks.aspx");
350:              }
351:              else
352:              {
353:                //go to error page,say system is down.
354:                Response.Redirect("SysError.aspx");
355:              }
356:
357:            }
358:          }
359:          catch (IOException e2)
360:          {
361:            //whether has file open, if so, close it.
362:            string err1=e2.ToString();
363:            //go to error page.
364:            Response.Redirect("SysError.aspx");
365:            return;
```

```
306:            {
307:              //TextBox1.Text="hd";
308:              FileStream h_file=new FileStream("c:\\hospital.txt", FileMode.Open);
309:              StreamReader h_sr= new StreamReader(h_file);
310:              strLine=h_sr.ReadLine();
311:              while (strLine!=null)
312:              {
313:                strArray=strLine.Split(charArray);
314:                hospStreet=strArray[1].Trim()+strArray[2].Trim();
315:                hospStreet_tb=hosp_name_tb.Text+street_tb.Text;
316:                if (hospStreet!=hospStreet_tb)
317:                  count=count+1;
318:                else
319:                {
320:                  //go to error page?
321:                  h_file.Close();
322:                  Response.Redirect("hospError.aspx");
323:                }
324:                strLine=h_sr.ReadLine();
325:              }
326:              h_sr.Close();
327:              h_file.Close();
328:
329:              if (count==0)
330:                id=generate_id(0);
331:
332:              id=generate_id(count);
333:              write_hospital();
334:              write_data();
335:              Response.Redirect("thanks.aspx");
336:
337:            }
338:            else
339:            {
340:              if ((!File.Exists("c:\\hospital.txt"))&&(!File.Exists("c:\\data.txt")))
341:              {
342:                FileStream h_file=new FileStream("c:\\hospital.txt", FileMode.CreateN
    ew);
343:                FileStream d_file=new FileStream("c:\\data.txt", FileMode.CreateNew);
344:                id=generate_id(0);
345:                h_file.Close ();
346:                d_file.Close ();
347:                write_hospital();
348:                write_data();
349:                Response.Redirect("thanks.aspx");
350:              }
351:              else
352:              {
353:                //go to error page,say system is down.
354:                Response.Redirect("SysError.aspx");
355:              }
356:
357:            }
358:          }
359:          catch (IOException e2)
360:          {
361:            //whether has file open, if so, close it.
362:            string err1=e2.ToString();
363:            //go to error page.
364:            Response.Redirect("SysError.aspx");
365:            return;
```

```
366:          }
367:
368:        }
369:
370:
371:      }
372:      private void write_hospital()
373:      {
374:        hosp_name=hosp_name_tb.Text;
375:        street=street_tb.Text;
376:        city=city_tb.Text;
377:        prov=prov_tb.Text;
378:        country=country_ddl.SelectedIndex.ToString(); //SelectedItem.Value;
379:        email=email_tb.Text;
380:        memo=memo_tb.Text;
381:
382:        try
383:        {
384:          FileStream h_file_w=new FileStream("c:\\hospital.txt", FileMode.Append, Fil
    eAccess.Write);
385:          StreamWriter h_sw=new StreamWriter(h_file_w);
386:          h_sw.WriteLine(id+","+hosp_name+","+street+","+city+","+prov+","+country+",
    "+email+","+memo);
387:          //TextBox1.Text="ready hosp";
388:          h_sw.Close();
389:          h_file_w.Close ();
390:        }
391:        catch (IOException e)
392:        {
393:          string err3=e.ToString();
394:          //go to error page
395:          Response.Redirect("SysError.aspx");
396:          return;
397:        }
398:
399:      }
400:      private void write_data()
401:      {
402:        q[1]= q11_rbl.SelectedItem.Value ;
403:        q[2]= q12_rbl.SelectedItem.Value ;
404:        q[3]= q13_rbl.SelectedItem.Value ;
405:        q[4]= q14_rbl.SelectedItem.Value ;
406:        q[5]= q21_rbl.SelectedItem.Value ;
407:        q[7]= q22_rbl.SelectedItem.Value ;
408:        q[9]= q23_rbl.SelectedItem.Value ;
409:        if (q21_rbl.SelectedIndex==1)
410:          q[6]=q21_tb.Text;
411:        else
412:        {
413:          q[6]="";
414:          q21_tb.Text="";
415:        }
416:        if (q22_rbl.SelectedIndex==3)
417:          q[8]=q22_tb.Text;
418:        else
419:        {
420:          q[8]="";
421:          q22_tb.Text="";
422:        }
423:
424:
```

```
425:
426:
427:        q[10]=q30_tb1.Text.TrimStart('0');
428:        q[11]=q30_tb2.Text.TrimStart('0');
429:        q[12]=q30_tb3.Text.TrimStart('0');
430:        q[13]=q30_tb4.Text.TrimStart('0');
431:        q[14]=q30_ddl1.SelectedItem.Value;
432:        q[15]=q30_ddl2.SelectedItem.Value;
433:        q[16]=q30_ddl3.SelectedItem.Value;
434:        q[17]=q30_ddl4.SelectedItem.Value;
435:        q[18]=q31_rbl.SelectedItem.Value;
436:
437:        if (q31_rbl.SelectedIndex==0)
438:        {
439:          q[19]=q31_tb.Text;
440:        }
441:        else
442:          q[19]=q31_tb.Text="";
443:
444:        q[20]=q32_rbl.SelectedItem.Value;
445:        if (q32_rbl.SelectedIndex==3)
446:        {
447:          q[21]=q32_tb.Text;
448:        }
449:        else
450:          q[21]=q32_tb.Text="";
451:
452:
453:
454:        q[22]=q41_rbl.SelectedItem.Value;
455:        q[23]=q42_rbl.SelectedItem.Value;
456:        q[24]=q43_tb1.Text;
457:        q[25]=q43_tb2.Text;
458:        q[26]=q43_tb3.Text;
459:        q[27]=q43_tb4.Text;
460:        q[28]=q43_tb5.Text;
461:        q[29]=q43_tb6.Text;
462:        q[30]=q43_tb7.Text;
463:        q[31]=q43_tb8.Text;
464:        q[32]=q43_tb9.Text;
465:        q[33]=q43_tb10.Text;
466:        q[34]=q43_tb11.Text;
467:        q[35]=q43_tb12.Text;
468:        q[36]=q43_tb13.Text;
469:        q[37]=q43_tb14.Text;
470:
471:
472:        q[38]=q45_rbl.SelectedItem.Value;
473:        q[39]=q46_rbl.SelectedItem.Value;
474:        q[40]=q47_rbl.SelectedItem.Value;
475:        q[41]=q48_rbl.SelectedItem.Value;
476:        q[42]=q49_rbl.SelectedItem.Value;
477:        q[43]=q51_rbl.SelectedItem.Value;
478:        q[44]=q52_rbl.SelectedItem.Value;
479:        q[45]=q53_rbl.SelectedItem.Value;
480:        q[46]=q54_rbl.SelectedItem.Value;
481:        q[47]=q55_rbl.SelectedItem.Value;
482:
483:        if (q55_rbl.SelectedIndex==1)
484:        {
485:          q[48]=q55_tb1.Text;
```

```
486:          q[49]=q55_tb2.Text;
487:          q[50]=q55_tb3.Text;
488:          q[51]=q55_tb4.Text;
489:        }
490:        else
491:        {
492:          q[48]=q55_tb1.Text="";
493:          q[49]=q55_tb2.Text="";
494:          q[50]=q55_tb3.Text="";
495:          q[51]=q55_tb4.Text="";
496:        }
497:
498:        q[52]=q56_rbl.SelectedItem.Value;
499:        if (q56_rbl.SelectedIndex==1)
500:        {
501:          if (q56_rbl2.SelectedIndex > -1)
502:            q[53]=q56_rbl2.SelectedItem.Value;
503:          else
504:          {
505:            q[53]="";
506:
507:          }
508:        }
509:        else
510:          q[53]="";
511:
512:
513:        q[54]=q57_rbl.SelectedItem.Value;
514:        q[55]=q58_rbl.SelectedItem.Value;
515:        q[56]=q59_rbl.SelectedItem.Value;
516:
517:        if (q59_rbl.SelectedIndex==1)
518:        {
519:          q[57]=q59_tb.Text;
520:        }
521:        else
522:          q[57]=q59_tb.Text="";
523:
524:
525:        q[58]=q61_rbl.SelectedItem.Value;
526:
527:        if (q61_rbl.SelectedIndex==2)
528:        {
529:          q[59]=q61_tb.Text;
530:        }
531:        else
532:          q[59]=q61_tb.Text="";
533:
534:        q[60]=q62_tb.Text.TrimStart('0');
535:        if (q[60]=="")
536:          q[61]="";
537:        else
538:          q[61]=q62_chbl.Items.Count.ToString();
539:
540:
541:        q[62]=q63_rbl.SelectedItem.Value;
542:
543:        if (q63_rbl.SelectedIndex==2)
544:        {
545:          q[63]=q63_tb.Text;
546:        }
```

```
547:       else
548:         q[63]=q63_tb.Text="";
549:
550:       q[64]=q64_rbl.SelectedItem.Value;
551:       q[65]=q65_rbl.SelectedItem.Value;
552:
553:       q[0]=id;
554:       q[66]=country_ddl.SelectedIndex.ToString(); //.SelectedItem.Value;
555:
556:       q44[0,0]=q44_tb11.Text;
557:       q44[0,1]=q44_tb12.Text;
558:       q44[0,2]=q44_tb13.Text;
559:       q44[0,3]=q44_tb14.Text;
560:       q44[0,4]=q44_tb15.Text;
561:       q44[0,5]=q44_tb16.Text;
562:       q44[1,0]=q44_tb21.Text;
563:       q44[1,1]=q44_tb22.Text;
564:       q44[1,2]=q44_tb23.Text;
565:       q44[1,3]=q44_tb24.Text;
566:       q44[1,4]=q44_tb25.Text;
567:       q44[1,5]=q44_tb26.Text;
568:       q44[2,0]=q44_tb31.Text;
569:       q44[2,1]=q44_tb32.Text;
570:       q44[2,2]=q44_tb33.Text;
571:       q44[2,3]=q44_tb34.Text;
572:       q44[2,4]=q44_tb35.Text;
573:       q44[2,5]=q44_tb36.Text;
574:       q44[3,0]=q44_tb41.Text;
575:       q44[3,1]=q44_tb42.Text;
576:       q44[3,2]=q44_tb43.Text;
577:       q44[3,3]=q44_tb44.Text;
578:       q44[3,4]=q44_tb45.Text;
579:       q44[3,5]=q44_tb46.Text;
580:       q44[4,0]=q44_tb51.Text;
581:       q44[4,1]=q44_tb52.Text;
582:       q44[4,2]=q44_tb53.Text;
583:       q44[4,3]=q44_tb54.Text;
584:       q44[4,4]=q44_tb55.Text;
585:       q44[4,5]=q44_tb56.Text;
586:       q44[5,0]=q44_tb61.Text;
587:       q44[5,1]=q44_tb62.Text;
588:       q44[5,2]=q44_tb63.Text;
589:       q44[5,3]=q44_tb64.Text;
590:       q44[5,4]=q44_tb65.Text;
591:       q44[5,5]=q44_tb66.Text;
592:       q44[6,0]=q44_tb71.Text;
593:       q44[6,1]=q44_tb72.Text;
594:       q44[6,2]=q44_tb73.Text;
595:       q44[6,3]=q44_tb74.Text;
596:       q44[6,4]=q44_tb75.Text;
597:       q44[6,5]=q44_tb76.Text;
598:
599:
600:       try
601:       {
602:         FileStream aFile=new FileStream("c:\\data.txt", FileMode.Append, FileAccess
    .Write);
603:         StreamWriter sw=new StreamWriter(aFile);
604:         for (int i=0;i<67;i++)
605:           sw.Write(q[i]+",");
606:         //sw.Write(q[65]);
```

```
607:          for (int i=0; i<7; i++)
608:          {
609:            for (int j=0;j<6;j++)
610:            {
611:              if (i==6 && j==5)
612:              {
613:                sw.Write(q44[6,5]);
614:                sw.WriteLine();
615:              }
616:              else
617:                sw.Write(q44[i,j]+",");
618:            }
619:
620:          }
621:
622:          sw.Close();
623:          aFile.Close ();
624:        }
625:        catch (IOException e)
626:        {
627:          string err2=e.ToString();
628:          //go to error page
629:          Response.Redirect("SysError.aspx");
630:          return;
631:        }
632:      }
633:
634:
635:
636:      private void Button2_Click(object sender, System.EventArgs e)
637:      {
638:        spsswin.ApplicationClass objSpss= new spsswin.ApplicationClass();
639:        //spsswin.CS_ApplicationClass o=new spsswin.CS_ApplicationClass
640:
641:        objSpss.OpenSyntaxDoc("c:\\inputdata.sps").Run();
642:
643:
644:      }
645:
646:
647:      private void Button3_Click(object sender, System.EventArgs e)
648:      {
649:        hosp_name_tb.Text="";
650:        street_tb.Text="";
651:        prov_tb.Text="";
652:        city_tb.Text="";
653:        //country?
654:        email_tb.Text="";
655:        q11_rbl.ClearSelection();
656:        q12_rbl.ClearSelection();
657:        q13_rbl.ClearSelection();
658:        q14_rbl.ClearSelection();
659:        q21_rbl.ClearSelection();
660:        q21_tb.Text="";
661:        q22_rbl.ClearSelection();
662:        q23_rbl.ClearSelection();
663:        q30_tb1.Text="0";
664:        q30_tb2.Text="0";
665:        q30_tb3.Text="0";
666:        q30_tb4.Text="0";
667:        q30_ddl1.SelectedIndex=0;
```

```
668:        q30_ddl2.SelectedIndex=0;
669:        q30_ddl3.SelectedIndex=0;
670:        q30_ddl4.SelectedIndex=0;
671:              q31_rbl.ClearSelection();
672:        q31_tb.Text="";
673:        q32_rbl.ClearSelection();
674:        q32_tb.Text ="";
675:        q41_rbl.ClearSelection();
676:        q42_rbl.ClearSelection();
677:        q43_tb1.Text="";
678:        q43_tb2.Text="";
679:        q43_tb3.Text="";
680:        q43_tb4.Text="";
681:        q43_tb5.Text="";
682:        q43_tb6.Text="";
683:        q43_tb7.Text="";
684:        q43_tb8.Text="";
685:        q43_tb9.Text="";
686:        q43_tb10.Text="";
687:        q43_tb11.Text="";
688:        q43_tb12.Text="";
689:        q43_tb13.Text="";
690:        q43_tb14.Text="";
691:        q43_tb15.Text="";
692:        q45_rbl.ClearSelection();
693:        q46_rbl.ClearSelection();
694:        q47_rbl.ClearSelection();
695:        q48_rbl.ClearSelection();
696:        q49_rbl.ClearSelection();
697:        q51_rbl.ClearSelection();
698:        q52_rbl.ClearSelection();
699:        q53_rbl.ClearSelection();
700:        q54_rbl.ClearSelection();
701:        q55_rbl.ClearSelection();
702:        q55_tb1.Text="0";
703:        q55_tb2.Text="0";
704:        q55_tb3.Text="0";
705:        q55_tb4.Text="";
706:        q56_rbl.ClearSelection();
707:        q56_rbl2.ClearSelection();
708:        q57_rbl.ClearSelection();
709:        q58_rbl.ClearSelection();
710:        q59_rbl.ClearSelection();
711:        q59_tb.Text="";
712:              q61_rbl.ClearSelection();
713:        q61_tb.Text="";
714:        q62_tb.Text="0";
715:        q62_chbl.ClearSelection();
716:              q63_rbl.ClearSelection();
717:        q63_tb.Text="";
718:        q64_rbl.ClearSelection();
719:        q65_rbl.ClearSelection();
720:        q44_tb11.Text="";
721:        q44_tb12.Text="";
722:        q44_tb13.Text="";
723:        q44_tb14.Text="";
724:        q44_tb15.Text="";
725:        q44_tb16.Text="";
726:        q44_tb21.Text="";
727:        q44_tb22.Text="";
728:        q44_tb23.Text="";
```

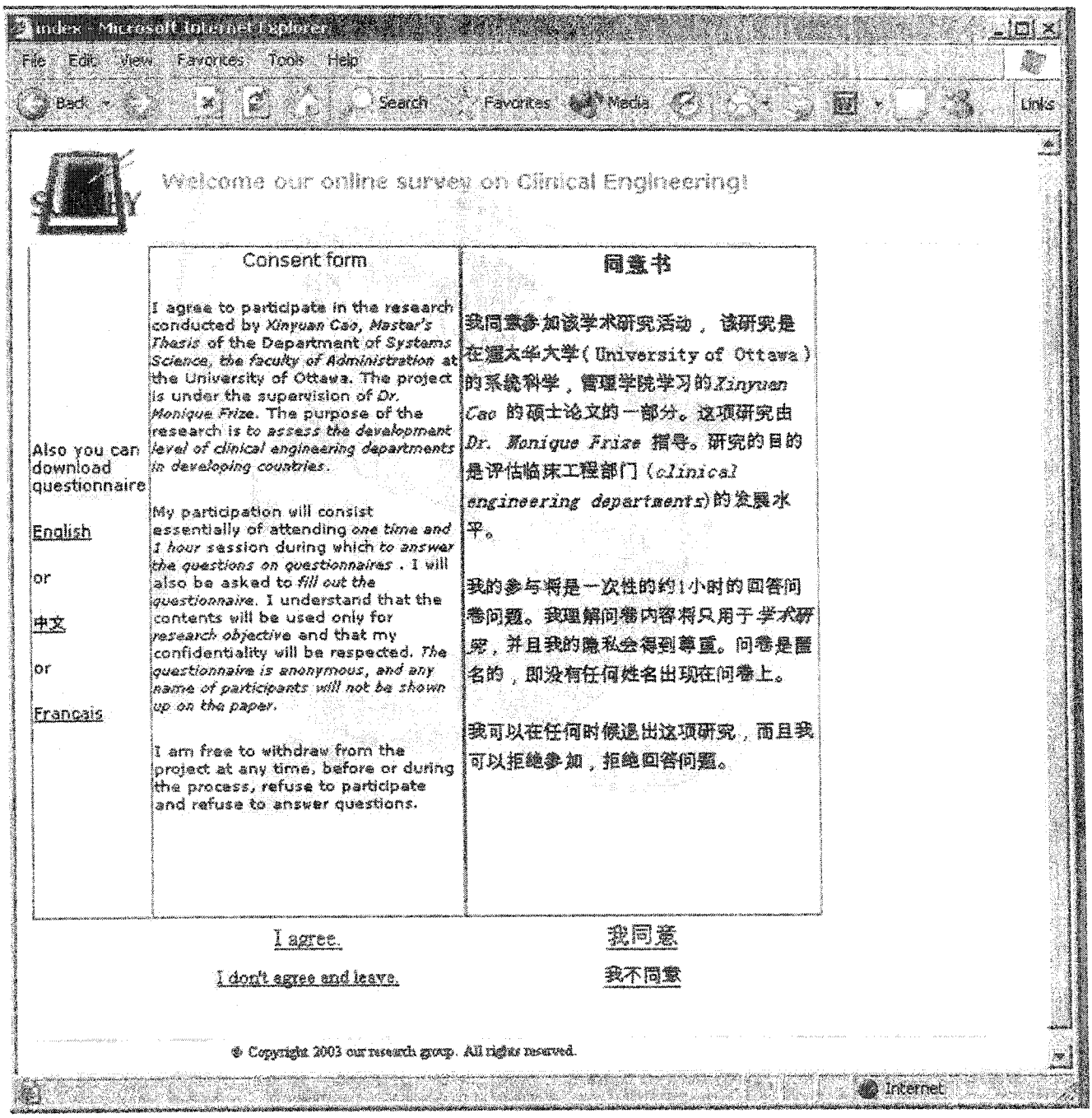
```
729:         q44_tb24.Text="";
730:         q44_tb25.Text="";
731:         q44_tb26.Text="";
732:         q44_tb31.Text="";
733:         q44_tb32.Text="";
734:         q44_tb33.Text="";
735:         q44_tb34.Text="";
736:         q44_tb35.Text="";
737:         q44_tb36.Text="";
738:         q44_tb41.Text="";
739:         q44_tb42.Text="";
740:         q44_tb43.Text="";
741:         q44_tb44.Text="";
742:         q44_tb45.Text="";
743:         q44_tb46.Text="";
744:         q44_tb51.Text="";
745:         q44_tb52.Text="";
746:         q44_tb53.Text="";
747:         q44_tb54.Text="";
748:         q44_tb55.Text="";
749:         q44_tb56.Text="";
750:         q44_tb61.Text="";
751:         q44_tb62.Text="";
752:         q44_tb63.Text="";
753:         q44_tb64.Text="";
754:         q44_tb65.Text="";
755:         q44_tb66.Text="";
756:         q44_tb71.Text="";
757:         q44_tb72.Text="";
758:         q44_tb73.Text="";
759:         q44_tb74.Text="";
760:         q44_tb75.Text="";
761:         q44_tb76.Text="";
762:       }
763:
764:
765:       private string generate_id (int nn)
766:       {
767:         string hosp_id;
768:         nn=nn+1;
769:         if (nn>0 & nn<=9)
770:         {
771:           hosp_id="H100"+Convert.ToString(nn);
772:         }
773:         else if (nn>9 & nn<=99)
774:         {
775:           hosp_id="H10"+Convert.ToString(nn);
776:         }
777:         else if (nn>99 & nn<=999)
778:         {
779:           hosp_id="H1"+Convert.ToString(nn);
780:         }
781:         else
782:         {
783:           hosp_id="H"+Convert.ToString(nn);
784:         }
785:         return hosp_id;
786:       }
787:
788:     }
789: }
```

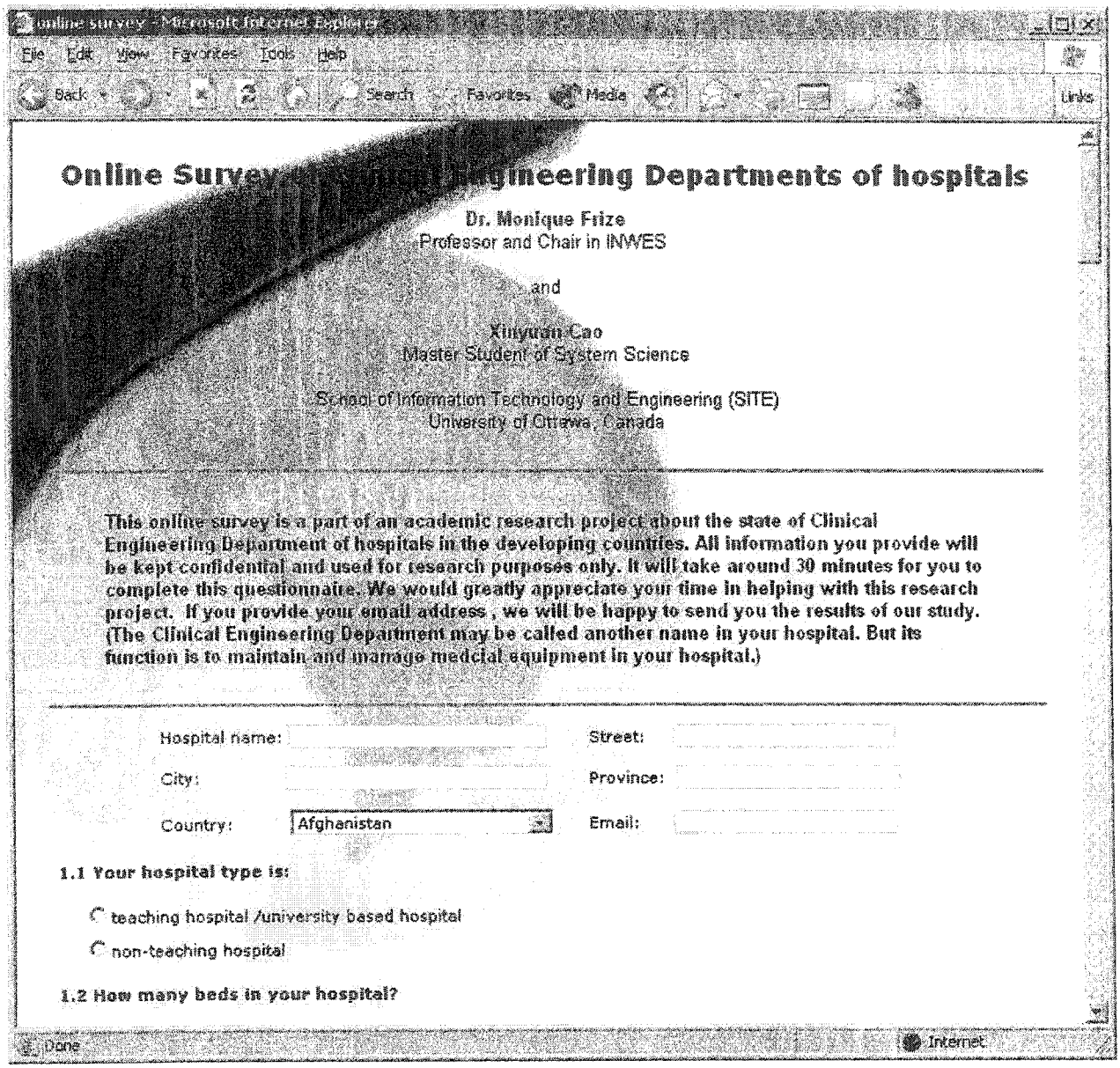
```
 1:          using System;
 2: using System.Collections;
 3: using System.ComponentModel;
 4: using System.Data;
 5: using System.Drawing;
 6: using System.Web;
 7: using System.Web.SessionState;
 8: using System.Web.UI;
 9: using System.Web.UI.WebControls;
10: using System.Web.UI.HtmlControls;
11:
12: namespace Web
13: {
14:   /// <summary>
15:   /// Summary description for fileError.
16:   /// </summary>
17:   public class fileError : System.Web.UI.Page
18:   {
19:     protected System.Web.UI.WebControls.Label Label2;
20:     protected System.Web.UI.WebControls.HyperLink HyperLink2;
21:     protected System.Web.UI.WebControls.HyperLink HyperLink1;
22:
23:     private void Page_Load(object sender, System.EventArgs e)
24:     {
25:       // Put user code to initialize the page here
26:     }
27:
28:     #region Web Form Designer generated code
29:     override protected void OnInit(EventArgs e)
30:     {
31:       //
32:       // CODEGEN: This call is required by the ASP.NET Web Form Designer.
33:       //
34:       InitializeComponent();
35:       base.OnInit(e);
36:     }
37:
38:     /// <summary>
39:     /// Required method for Designer support - do not modify
40:     /// the contents of this method with the code editor.
41:     /// </summary>
42:     private void InitializeComponent()
43:     {
44:       this.Load += new System.EventHandler(this.Page_Load);
45:
46:     }
47:     #endregion
48:   }
49: }
50:
```

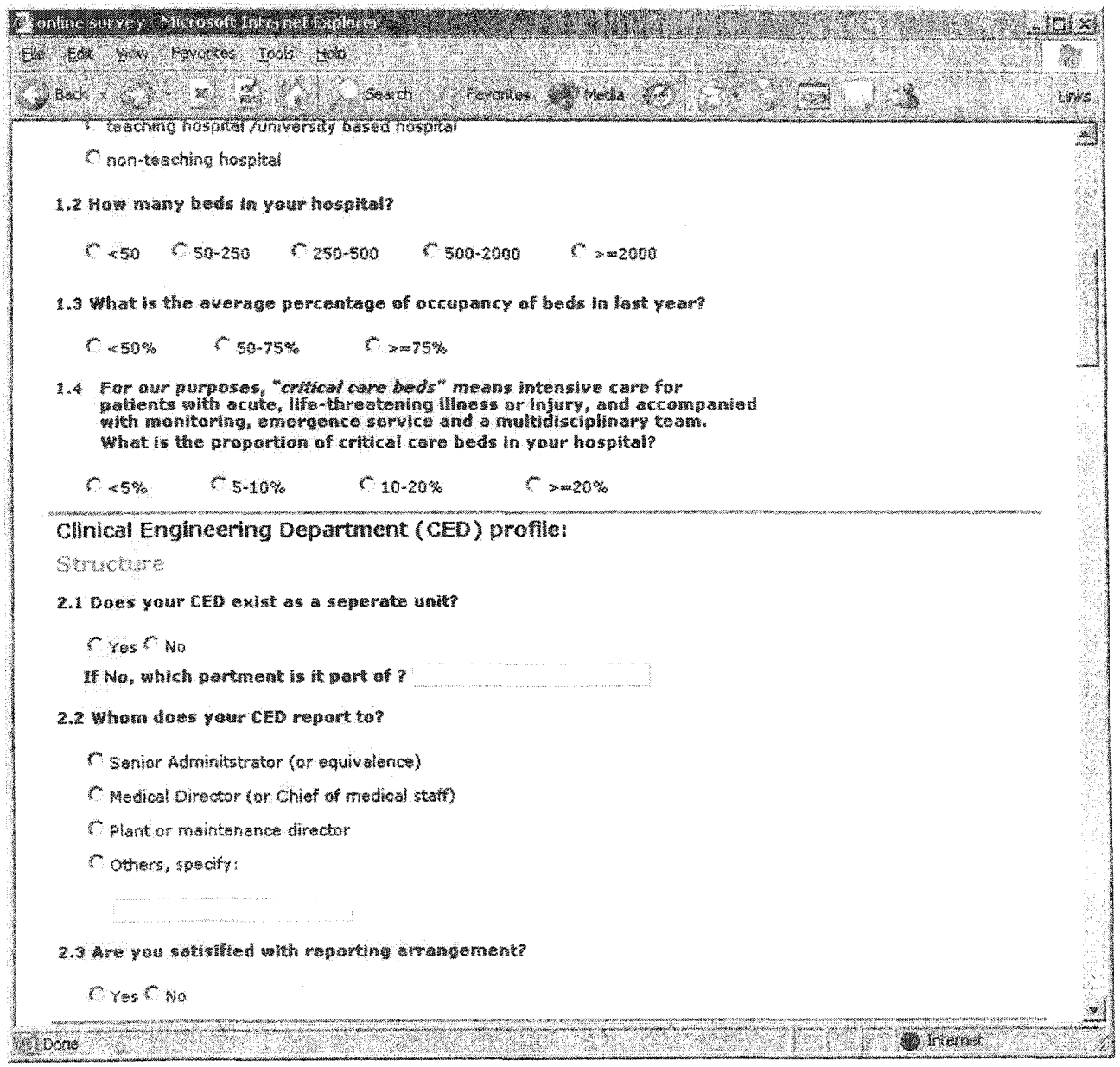
```
 1:                    using System;
 2: using System.Collections;
 3: using System.ComponentModel;
 4: using System.Data;
 5: using System.Drawing;
 6: using System.Web;
 7: using System.Web.SessionState;
 8: using System.Web.UI;
 9: using System.Web.UI.WebControls;
10: using System.Web.UI.HtmlControls;
11:
12: namespace Web
13: {
14:   /// <summary>
15:   /// Summary description for SysError.
16:   /// </summary>
17:   public class SysError : System.Web.UI.Page
18:   {
19:     protected System.Web.UI.WebControls.Label Label2;
20:     protected System.Web.UI.WebControls.HyperLink HyperLink3;
21:     protected System.Web.UI.WebControls.Button Button1;
22:     protected System.Web.UI.WebControls.Button Button2;
23:     protected System.Web.UI.WebControls.HyperLink HyperLink1;
24:
25:     private void Page_Load(object sender, System.EventArgs e)
26:     {
27:       }
28:
29:     #region Web Form Designer generated code
30:     override protected void OnInit(EventArgs e)
31:     {
32:       InitializeComponent();
33:       base.OnInit(e);
34:     }
35:
36:     /// <summary>
37:     /// Required method for Designer support - do not modify
38:     /// the contents of this method with the code editor.
39:     /// </summary>
40:     private void InitializeComponent()
41:     {
42:       this.Button1.Click += new System.EventHandler(this.Button1_Click);
43:       this.Button2.Click += new System.EventHandler(this.Button2_Click);
44:       this.Load += new System.EventHandler(this.Page_Load);
45:
46:     }
47:     #endregion
48:
49:     private void Button1_Click(object sender, System.EventArgs e)
50:     {
51:       Response.Write("<script>window.close();</script>");
52:     }
53:
54:     private void Button2_Click(object sender, System.EventArgs e)
55:     {
56:     Response.Write("<script>window.close();</script>");
57:     }
58:   }
59: }
```

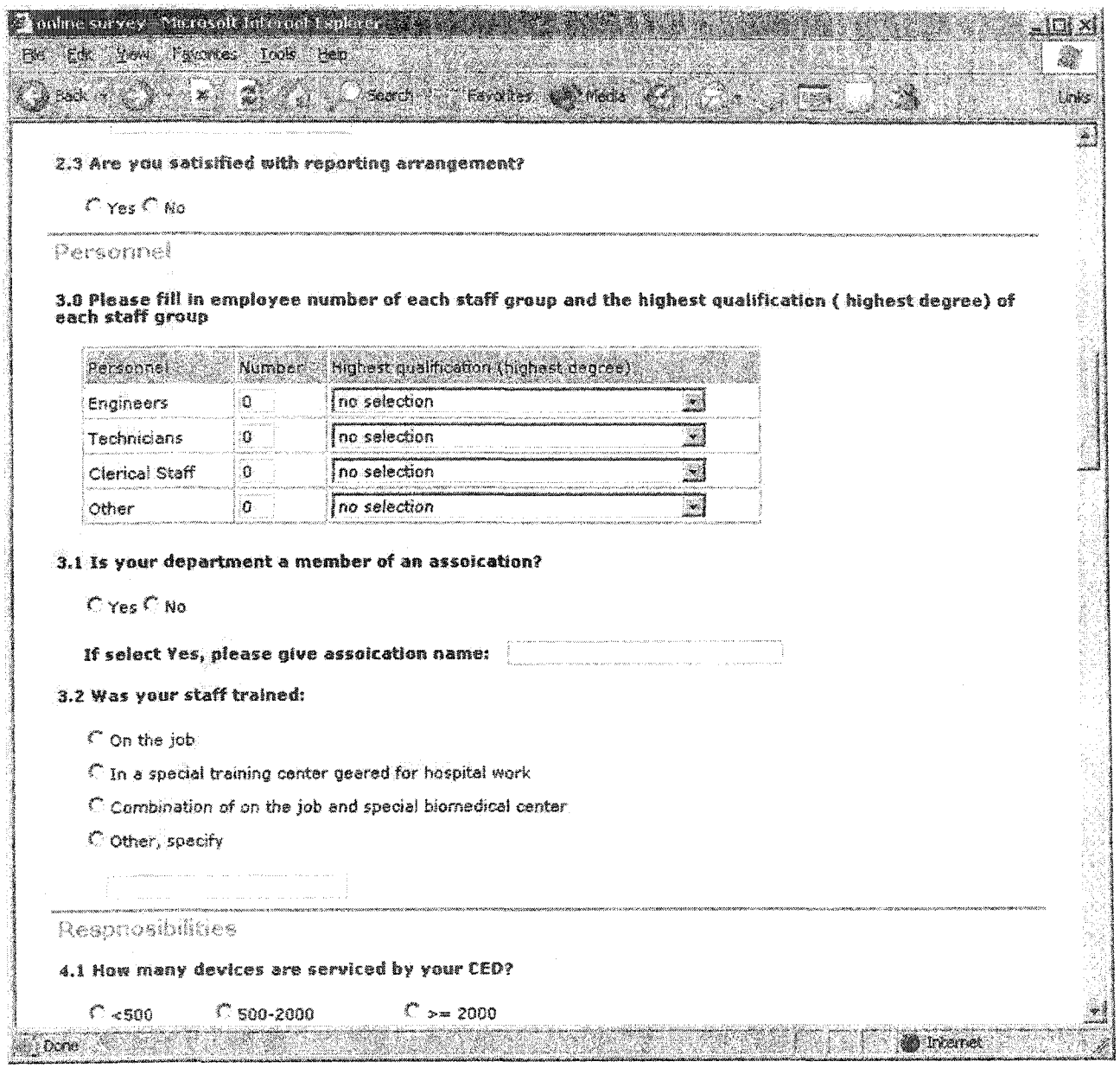
```
                                using System;
using System.Collections;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Web;
using System.Web.SessionState;
using System.Web.UI;
using System.Web.UI.WebControls;
using System.Web.UI.HtmlControls;

namespace Web
{
  /// <summary>
  /// Summary description for thanks.
  /// </summary>
  public class thanks : System.Web.UI.Page
  {
    protected System.Web.UI.WebControls.Button Button2;
    protected System.Web.UI.WebControls.Button Button1;
    protected System.Web.UI.WebControls.Label Label2;

    private void Page_Load(object sender, System.EventArgs e)
    {
      // Put user code to initialize the page here
    }

    #region Web Form Designer generated code
    override protected void OnInit(EventArgs e)
    {
      //
      // CODEGEN: This call is required by the ASP.NET Web Form Designer.
      //
      InitializeComponent();
      base.OnInit(e);
    }

    /// <summary>
    /// Required method for Designer support - do not modify
    /// the contents of this method with the code editor.
    /// </summary>
    private void InitializeComponent()
    {
      this.Button2.Click += new System.EventHandler(this.Button2_Click);
      this.Button1.Click += new System.EventHandler(this.Button1_Click);
      this.Load += new System.EventHandler(this.Page_Load);

    }
    #endregion

    private void Button1_Click(object sender, System.EventArgs e)
    {
      Response.Write("<script>window.close();</script>");
    }

    private void Button2_Click(object sender, System.EventArgs e)
    {
      Response.Write("<script>window.close();</script>");
    }
  }
}
```

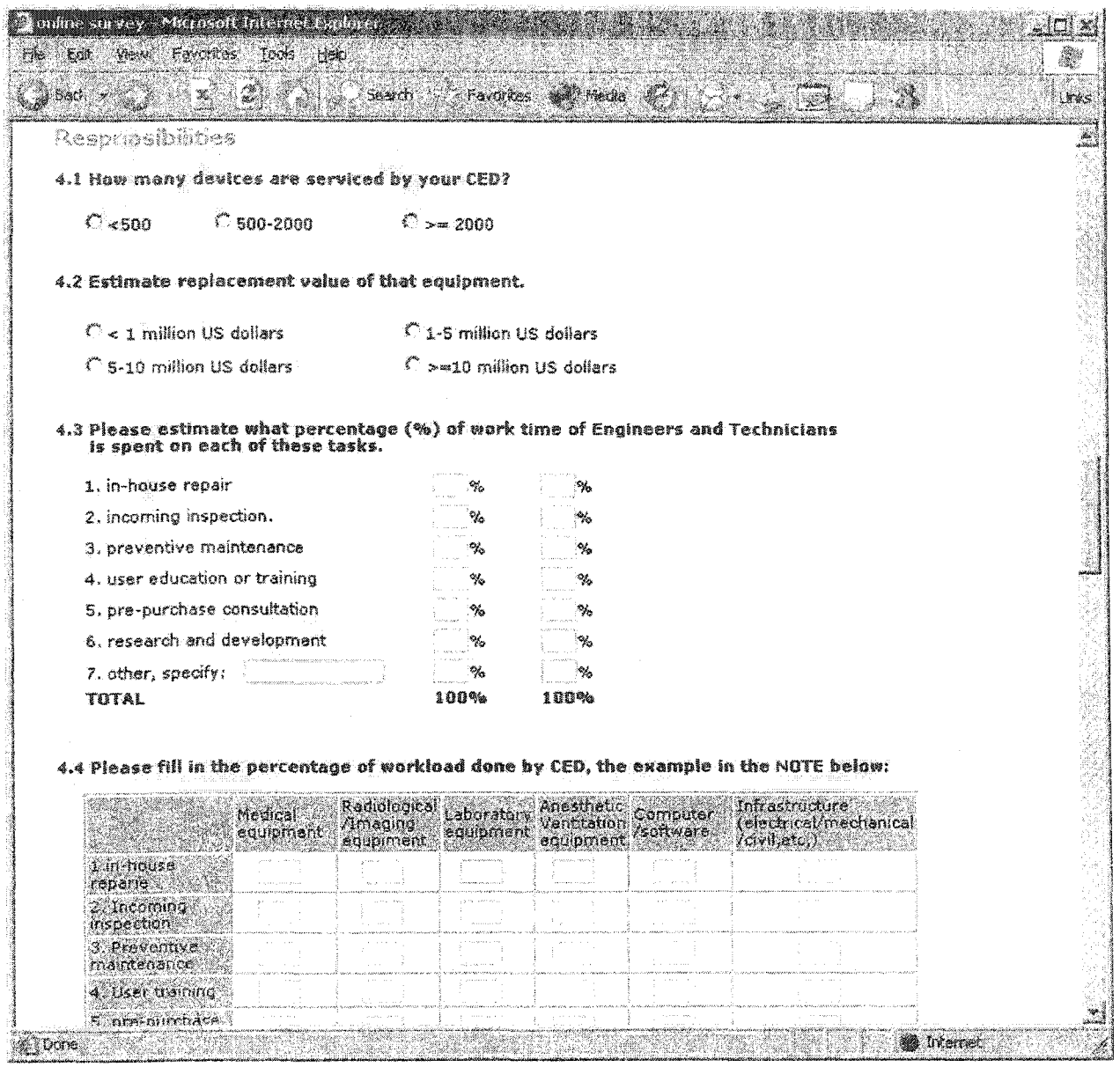
INTERFACES OF THE ONLINE SURVEY

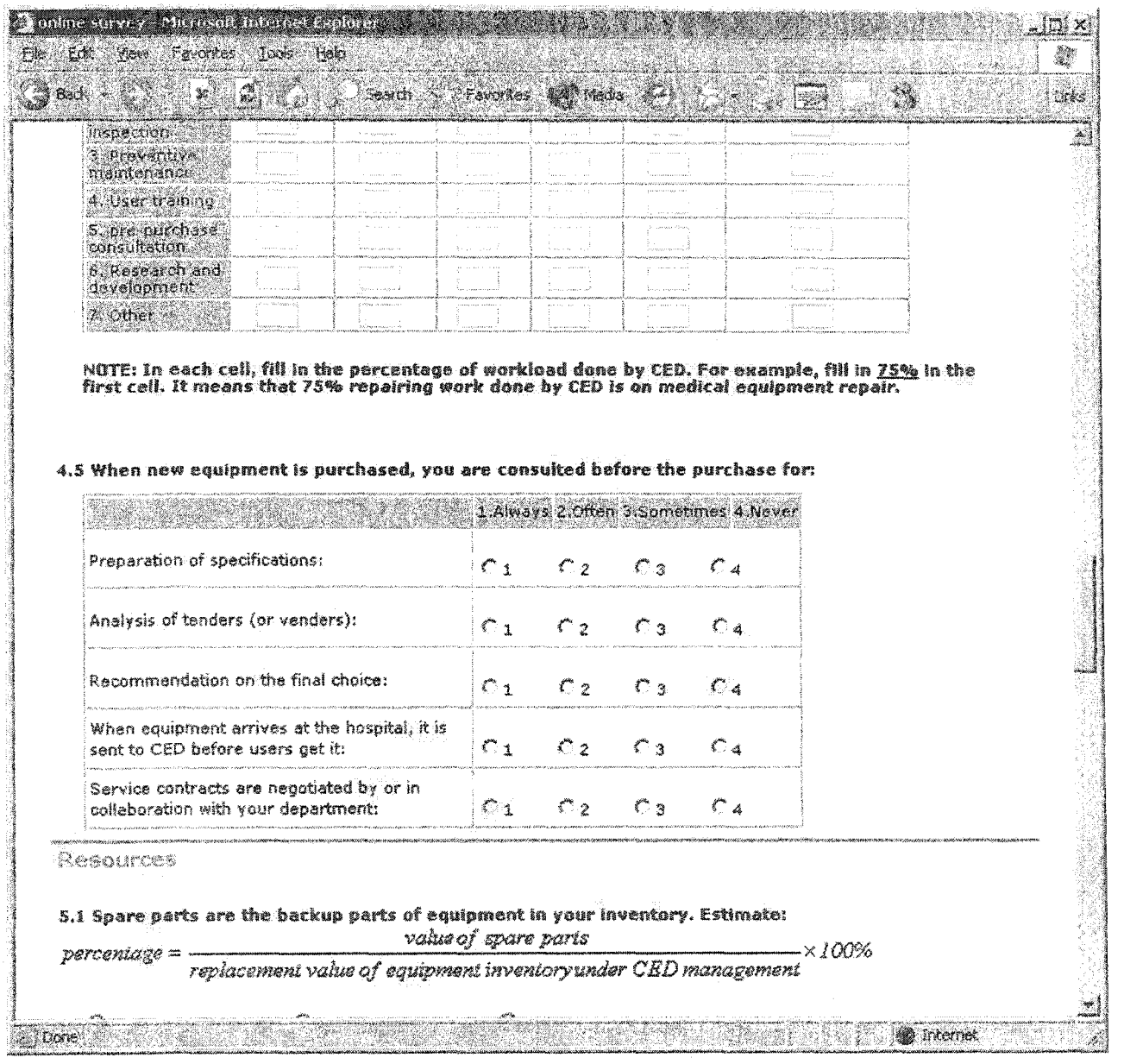












Inspection:						
3. Preventive maintenance:						
4. User training:						
5. pre-purchase consultation:						
6. Research and development:						
7. Other:						

NOTE: In each cell, fill in the percentage of workload done by CED. For example, fill in 75% in the first cell. It means that 75% repairing work done by CED is on medical equipment repair.

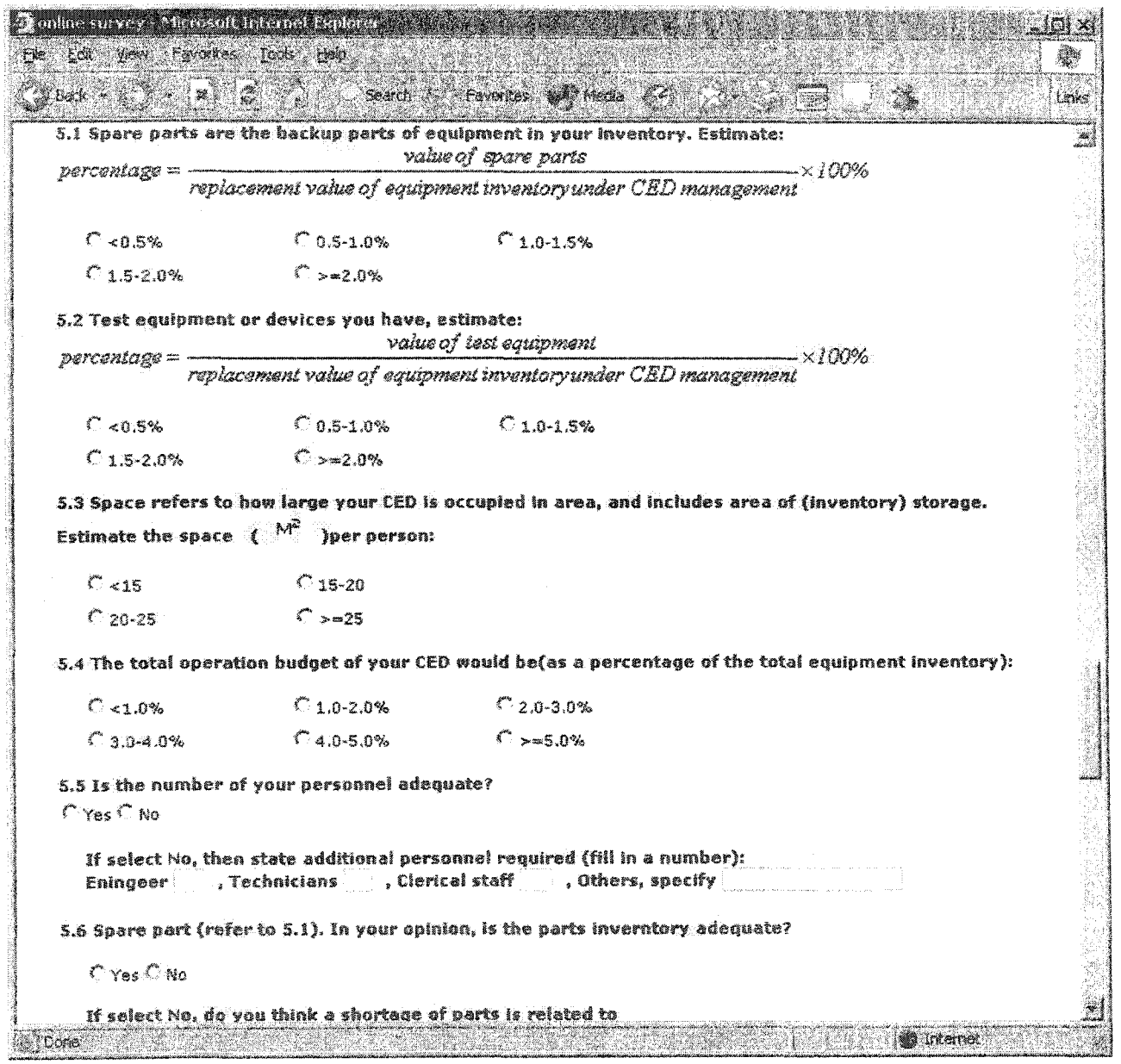
4.5 When new equipment is purchased, you are consulted before the purchase for:

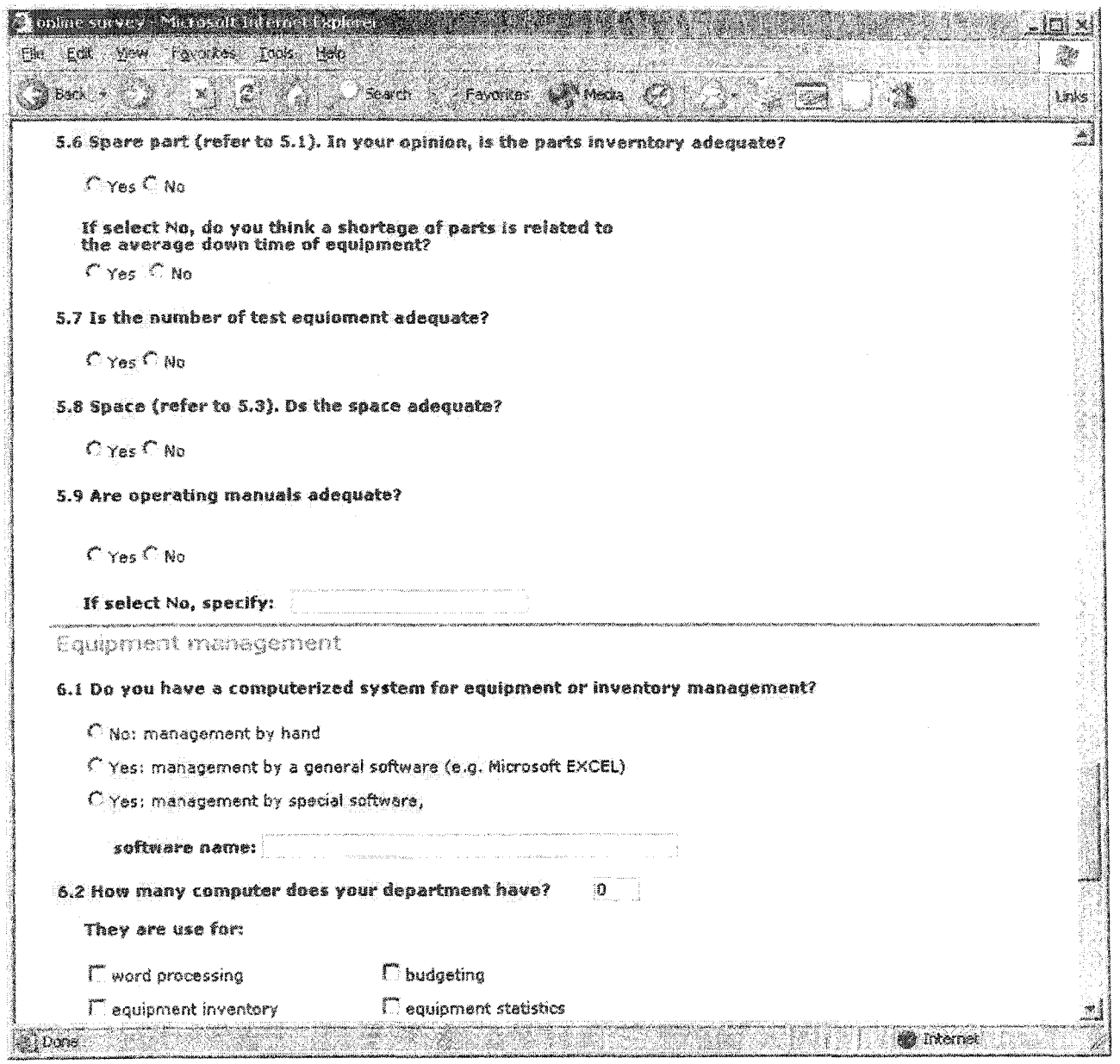
	1.Always	2.Often	3.Sometimes	4.Never
Preparation of specifications:	1	2	3	4
Analysis of tenders (or venders):	1	2	3	4
Recommendation on the final choice:	1	2	3	4
When equipment arrives at the hospital, it is sent to CED before users get it:	1	2	3	4
Service contracts are negotiated by or in collaboration with your department:	1	2	3	4

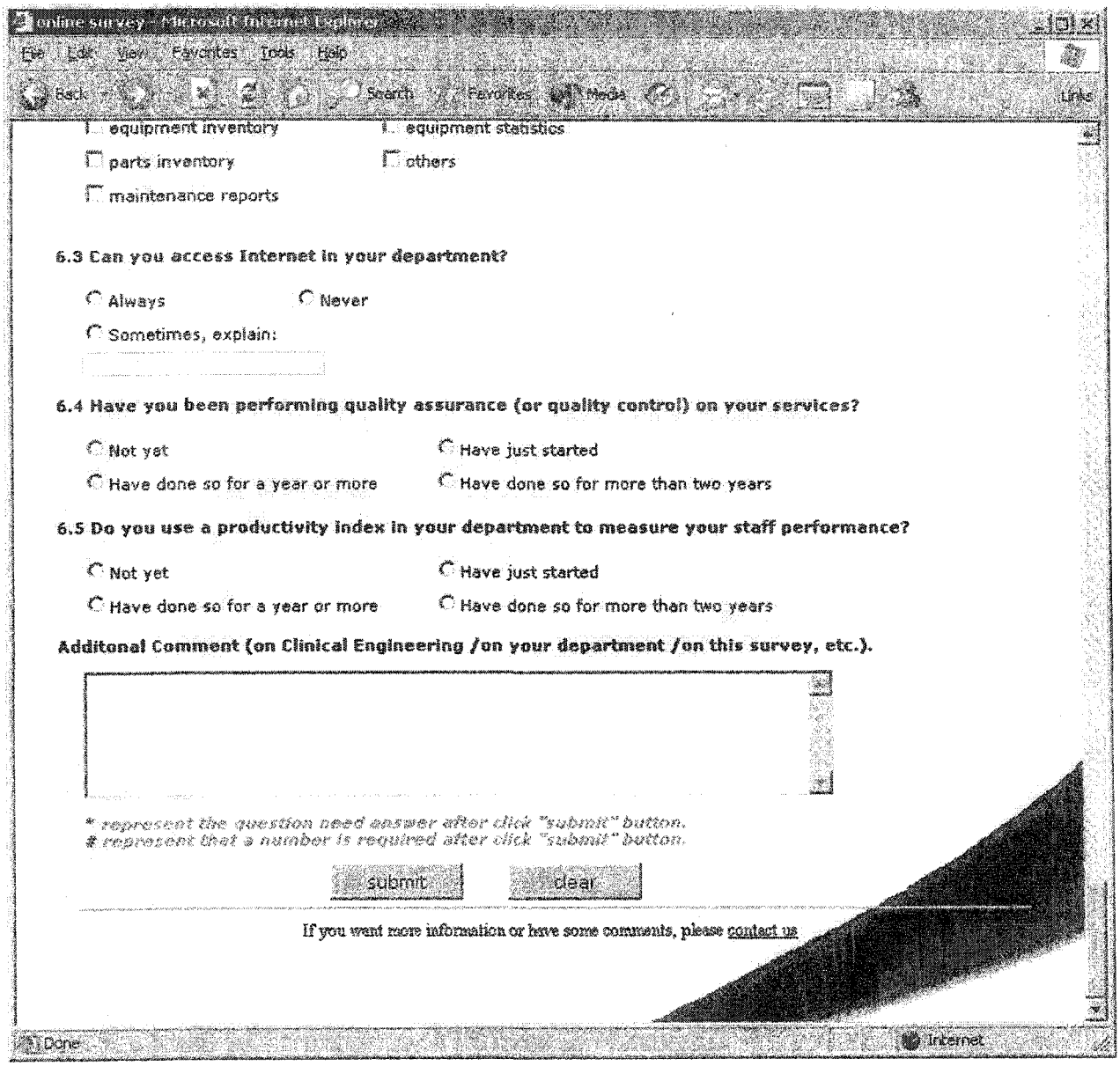
Resources

5.1 Spare parts are the backup parts of equipment in your inventory. Estimate:

$$perceniage = \frac{value\ of\ spare\ parts}{replacement\ value\ of\ equipment\ inventory\ under\ CED\ management} \times 100\%$$







```
 1: * SPSS PROGRAM FOR DATA PREPARING AND ANALYZE.
 2: * (1)INPUT RAW DATA TO SPSS DATASET (inputdata.sps).
 3:
 4: GET DATA  /TYPE = TXT
 5:  /FILE = 'C:\data.txt'
 6:  /DELCASE = LINE
 7:  /DELIMITERS = ","
 8:  /ARRANGEMENT = DELIMITED
 9:  /FIRSTCASE = 1
10:  /IMPORTCASE = ALL
11:  /VARIABLES =
12: v0 A5
13: v1 F1.0
14: v2 F1.0
15: v3 F1.0
16: v4 F1.0
17: v5 F1.0
18: v6 A20
19: v7 F1.0
20: v8 A20
21: v9 F1.0
22: v10 F2.0
23: v11 F2.0
24: v12 F2.0
25: v13 F2.0
26: v14 F1.0
27: v15 F1.0
28: v16 F1.0
29: v17 F1.0
30: v18 F1.0
31: v19 A20
32: v20 F1.0
33: v21 A20
34: v22 F1.0
35: v23 F1.0
36: v24 F2.0
37: v25 F2.0
38: v26 F2.0
39: v27 F2.0
40: v28 F2.0
41: v29 F2.0
42: v30 F2.0
43: v31 F2.0
44: v32 F2.0
45: v33 F2.0
46: v34 F2.0
47: v35 F2.0
48: v36 F2.0
49: v37 F2.0
50: v38 F1.0
51: v39 F1.0
52: v40 F1.0
53: v41 F1.0
54: v42 F1.0
55: v43 F1.0
56: v44 F1.0
57: v45 F1.0
58: v46 F1.0
59: v47 F1.0
60: v48 F2.0
61: v49 F2.0
```

```
 62: v50 F2.0
 63: v51 F2.0
 64: v52 F1.0
 65: v53 F1.0
 66: v54 F1.0
 67: v55 F1.0
 68: v56 F1.0
 69: v57 A20
 70: v58 F1.0
 71: v59 A20
 72: v60 F2.0
 73: v61 F1.0
 74: v62 F1.0
 75: v63 A20
 76: v64 F1.0
 77: v65 F1.0
 78: v66 F3.0
 79: v101 F3.0
 80: v102 F3.0
 81: v103 F3.0
 82: v104 F3.0
 83: v105 F3.0
 84: v106 F3.0
 85: v107 F3.0
 86: v108 F3.0
 87: v109 F3.0
 88: v110 F3.0
 89: v111 F3.0
 90: v112 F3.0
 91: v113 F3.0
 92: v114 F3.0
 93: v115 F3.0
 94: v116 F3.0
 95: v117 F3.0
 96: v118 F3.0
 97: v119 F3.0
 98: v120 F3.0
 99: v121 F3.0
100: v122 F3.0
101: v123 F3.0
102: v124 F3.0
103: v125 F3.0
104: v126 F3.0
105: v127 F3.0
106: v128 F3.0
107: v129 F3.0
108: v130 F3.0
109: v131 F3.0
110: v132 F3.0
111: v133 F3.0
112: v134 F3.0
113: v135 F3.0
114: v136 F3.0
115: v137 F3.0
116: v138 F3.0
117: v139 F3.0
118: v140 F3.0
119: v141 F3.0
120: v142 F3.0
121:  .
122: variable labels
```

```
123: v0 "No.of case"
124: /v1 "hospital type"
125: /v2 "beds"
126: /v3 "occupied beds%"
127: /v4 "critical beds%"
128: /v5 "sperate unit"
129: /v6 "part of"
130: /v7 "report to"
131: /v8 "report to others"
132: /v9 "reporting satisfy"
133: /v10 "N_engineer"
134: /v11 "N_technician"
135: /v12 "N_clerical"
136: /v13 "N_other"
137: /v14 "E_highDegree"
138: /v15 "T_highDegree"
139: /v16 "C_highDegree"
140: /v17 "O_highDegree"
141: /v18 "is association"
142: /v19 "association name"
143: /v20 "has training"
144: /v21 "training other"
145: /v22 "devices number"
146: /v23 "total equipment cost"
147: /v24 "E_repair"
148: /v25 "E_incoming inspection"
149: /v26 "E_preventive maintain"
150: /v27 "E_user training"
151: /v28 "E_pre-purchase consult"
152: /v29 "E_research"
153: /v30 "E_others"
154: /v31 "T_repair"
155: /v32 "T_incoming inspection"
156: /v33 "T_preventive maintain"
157: /v34 "T_user training"
158: /v35 "T_pre-purchase consult"
159: /v36 "T_research"
160: /v37 "T_others"
161: /v38 "preparation specification"
162: /v39 "tender analysis"
163: /v40 "recommend on final"
164: /v41 "get device before user"
165: /v42 "service contract"
166: /v43 "part_value"
167: /v44 "test_equipment_value"
168: /v45 "space per person"
169: /v46 "total budget"
170: /v47 "enough personnel"
171: /v48 "N_add_engineer"
172: /v49 "N_add_technician"
173: /v50 "N_add_clerical"
174: /v51 "N_add_other"
175: /v52 "enough parts"
176: /v53 "relate to down time"
177: /v54 "enough test device"
178: /v55 "enough space"
179: /v56 "enough manuals"
180: /v57 "reason lack of manuals"
181: /v58 "has a cmptr manage"
182: /v59 "special SW name"
183: /v60 "N_cmptr"
```

```
184: /v61 "cmptr use for"
185: /v62 "Internet"
186: /v63 "explain sometimes"
187: /v64 "has quailty assurance"
188: /v65 "productivity index"
189: /v66 "country code"
190: /v101 "repair medical"
191: /v102 "repair imaging"
192: /v103 "repair lab"
193: /v104 "repair anesthetic"
194: /v105 "repair computer"
195: /v106 "repair Infrastructure"
196: /v107 "inspection medical"
197: /v108 "inspection imaging"
198: /v109 "inspection lab"
199: /v110 "inspection anesthetic"
200: /v111 "inspection computer"
201: /v112 "inspection Infrastructure"
202: /v113 "maintain medical"
203: /v114 "maintain imaging"
204: /v115 "maintain lab"
205: /v116 "maintain anesthetic"
206: /v117 "maintain computer"
207: /v118 "maintain Infrastructure"
208: /v119 "training medical"
209: /v120 "training imaging"
210: /v121 "training lab"
211: /v122 "training anesthetic"
212: /v123 "training computer"
213: /v124 "training Infrastructure"
214: /v125 "prepurchase medical"
215: /v126 "prepurchase imaging"
216: /v127 "prepurchase lab"
217: /v128 "prepurchase anesthetic"
218: /v129 "prepurchase computer"
219: /v130 "prepurchase Infrastructure"
220: /v131 "research medical"
221: /v132 "research imaging"
222: /v133 "research lab"
223: /v134 "research anesthetic"
224: /v135 "research computer"
225: /v136 "research Infrastructure"
226: /v137 "other medical"
227: /v138 "other imaging"
228: /v139 "other lab"
229: /v140 "other anesthetic"
230: /v141 "other computer"
231: /v142 "other Infrastructure"
232: .
233: value labels
234: v1
235: 1 "teaching hospital"
236: 2 "non-teaching hospital"
237: /v2
238: 1 "<50"
239: 2 "50-250"
240: 3 "250-500"
241: 4 "500-2000"
242: 5 ">=2000"
243: 0 "NA"
244:
```

```
245: /v3
246: 1 "<50%"
247: 2 "50-75%"
248: 3 ">=75%"
249: 0 "NA"
250: /v4
251: 1 "<5%"
252: 2 "5-10%"
253: 3 "10-20%"
254: 4 ">=20%"
255: 0 "NA"
256: /v5 v9 v18 v47 v52 v53 v54 v55 v56
257: 1 "Yes"
258: 2 "No"
259: 0 "NA"
260: /v7
261: 1 "Senior Adimistrator"
262: 2 "Medical director"
263: 3 "Plant/maintenance director"
264: 9 "Other"
265: 0 "NA"
266: /v14 v15 v16 v17
267: 0 "NA"
268: 1 "Univeristy:PhD."
269: 2 "University:MSc."
270: 3 "University:BSc."
271: 4 "4-year technical school"
272: 5 "3-year technical school"
273: 6 "2-year technical school"
274: 7 "1-year technical school"
275: 8 "High School"
276: 9 "Under high school"
277: /v20
278: 1 "On the job"
279: 2 "In a special training center of hospital"
280: 3 "Combination of on the job and training center"
281: 9 "Other"
282: 0 "NA"
283: /v22
284: 1 "<500"
285: 2 "500-2000"
286: 3 ">=2000"
287: 0 "NA"
288: /v23
289: 1 "<1"
290: 2 "1-5"
291: 3 "5-10"
292: 4 ">=10"
293: 0 "NA"
294: /v38 v39 v40 v41 v42
295: 1 "Always"
296: 2 "Often"
297: 3 "Sometimes"
298: 4 "Never"
299: 0 "NA"
300: /v43 v44
301: 1 "<0.5%"
302: 2 "0.5-1.0%"
303: 3 "1.0_1.5%"
304: 4 "1.5-2.0%"
305: 5 ">=2.0"
```

```
306: 0 "NA"
307: /v45
308: 1 "<15"
309: 2 "15-20"
310: 3 "20-25"
311: 4 ">=25"
312: 0 "NA"
313: /v46
314: 1 "<1.0%"
315: 2 "1.0-2.0%"
316: 3 "2.0-3.0%"
317: 4 "3.0-4.0%"
318: 5 "4.0-5.0%"
319: 6 ">=5.0%"
320: 0 "NA"
321: /v58
322: 1 "No:management by hand"
323: 2 "Yes:management by a general software"
324: 3 "Yes:management by a special software"
325: 0 "NA"
326: /v62
327: 1 "Always"
328: 2 "Never"
329: 3 "Sometimes"
330: 0 "NA"
331: /v64 v65
332: 1 "Not yet"
333: 2 "have just started"
334: 3 "have done so for a year or two"
335: 4 "have done so for more than two years"
336: 0 "NA"
337: /v66
338: 17 "Bangladesh"
339: 29 "Brazil"
340: 45 "China"
341: 102 "India"
342: .
343:
344: variable level
345: v1 v2 v3 v4 v5 v7 v9 v14 v15 v16 v17 v18 v20 v22 v23 v38 v39 v40 v41 v42 v43 v44 v4
     5 v46 v47 v52 v53 v54 v55 v56 v58 v62 v64 v65 v66 (ORDINAL)
346: /v24 v25 v26 v27 v28 v29 v30 v31 v32 v33 v34 v35 v36 v37 v48 v49 v50 v51 v60 v101 v
     102 v103 v104 v105 v106 v107
347: v108 v109 v110 v111 v112 v113 v114 v115 v116 v117 v118 v119 v120 v121 v122 v123 v12
     4 v125 v126 v127 v128 v129
348: v130 v131 v132 v133 v134 v135 v136 v137 v138 v139 v140 v141 v142 (SCALE).
349:
350: missing value
351: v2 v3 v4 v5 v7 v9 v14 v15 v16 v17 v18 v20 v22 v23 v38 v39 v40 v41 v42 v43 v44 v45 v
     46 v47 v52 v53 v54 v55 v56 v58 v62 v64 v65 (0)
352: .
353:
354: CACHE.
355: EXECUTE.
356: ADD FILES FILE="c:\data5.sav" / FILE=*.
357: SAVE OUTFILE='C:\data5.sav'
358:   /COMPRESSED.
359: script 'c:\end.sbs'.
```

```
 1: 'CHECK SPSSOBJECT STATUS AND END IT (end.sbs)
 2: Sub Main
 3:   Dim objSpssApp As Object
 4:   Dim objDoc As ISpssDocuments
 5:   Dim objDataDoc As ISpssDataDoc
 6:   On Error Resume Next
 7:     Set objSpssApp = GetObject(, "Spss.Application")
 8:     If Err <> 0 Then       'If Spss not running, create a new one
 9:       Set objSpssApp = CreateObject("Spss.Application")
10:     End If
11:   'Set objSpssApp=CreateObject("spss.application")
12:   Set objDoc =objSpssApp.Documents
13:   Set objDataDoc=objDoc.GetDataDoc(0)
14:   objDataDoc.Visible=False
15:   'Set objDataDoc=Nothing
16:   'Set objDoc=Nothing
17:
18:   objSpssApp.Quit()
19:   'Set objSpssApp=Nothing
20: End Sub
21:
```

```
 1: *(2)SOME PROGRAMS FOR DATA PREPARAING.
 2:
 3: *group beds.
 4: RECODE v2 (2=1) (3=2) (4=3).
 5: EXECUTE .
 6:
 7: *create personnel.sav.
 8: GET FILE="d:\cao\61\61.sav"
 9: /KEEP v10 to v17 v1 v2 v66.
10: SAVE OUTFILE="d:\cao\61\personnel.sav".
11:
12: GET FILE="d:\cao\60\personnel.sav"
13: /KEEP ephd to cunder.
14: ADD FILES FILE="d:\cao\61\personnel.sav" / FILE=*.
15: SAVE OUTFILE="d:\cao\61\personnel.sav".
16:
17:
18:
19: *compute worksize(number of CE and Techs ).
20: COMPUTE worksize=v10+v11.
21: EXECUTE.
22:
23: *group worksize.
24: RECODE worksize (0 =0) (1=1) (2 thru 3 =2) (4 thru 6=3) (7 thru 10=4) (11 thru 15=5
    ) (16 thru 20=6) (21 thru 40=7) INTO gwsize.
25: EXECUTE.
26:
27: *group present of CE.
28: RECODE v14 (0=1) (1 thru 2=3) (3=2) (4 thru 9=1) into presentE.
29: EXECUTE.
30:
31: *compute total CED number.
32: COMPUTE totnmb=v10+v11+v12+v13.
33: EXECUTE.
34:
35: *create indepent.sav.
36: GET FILE="d:\cao\61\61.sav"
37: /KEEP v5 v7 v2 v1 v47 v67.
38: SAVE OUTFILE="d:\cao\61\indepent.sav".
39:
40: GET FILE="d:\cao\61\personnel.sav"
41: /KEEP gwsize presente.
42: ADD FILES FILE="d:\cao\61\indepent.sav" / FILE=*.
43: SAVE OUTFILE="d:\cao\61\indepent.sav".
44:
45: *renew 61.sav.
46: GET FILE="d:\cao\61\indepent.sav"
47: /KEEP presente gwsize.
48: ADD FILES FILE="d:\cao\61\61.sav" / FILE=*.
49: SAVE OUTFILE="d:\cao\61\61.sav".
50:
51: * group all data for .
52: RECODE
53:   v1  (1=2)  (2=1) INTO type.
54: *FORMATS type F1.0.
55: EXECUTE .
56:
57: RECODE
58: v5 v9 v47 v52 v54 v55 v56  (1=2) (2=1) INTO issperat isreport ghperson ghpart ghtes
    t ghspace ghmanual.
59: EXECUTE.
```

```
 60:
 61: RECODE
 62: v7 (1=4) (2=3) (3=2) (9=1) INTO reportto.
 63:
 64:
 65: RECODE
 66: v60 ( 0=0 ) ( 1=1 ) ( 2  thru 4=2 ) ( 5 thru 10=3 ) ( 11 thru 20=4 )  INTO  ncmpt.
 67:
 68: RECODE
 69: v62 (1=3) (2=2) (3=1) INTO internet.
 70: EXECUTE .
 71:
 72: *RECODE.
 73: *v67 (1 thru 2=1) (3 thru 4 =2).
 74: *EXECUTE .
 75:
 76: RECODE
 77: v66 (17=1)(29=2) (45=1)(106=1)(102=1)(103=1)(104=2)(107=2) (105=1) INTO groupc1.
 78: EXECUTE .
 79:
 80: RECODE
 81: v66 (17=1)(29=2) (45=1)(106=1)(102=1)(103=1)(104=2)(107=2) (105=2) INTO groupc2.
 82: EXECUTE .
 83:
 84: FORMATS  type size issperat isreport isasso ghperson ghpart ghtest ghspace ghmanual
      (F1.0).
 85: FORMATS ehigh thigh chigh ohigh training reportto(F1.0).
 86: FORMATS prepspec tender final getdevic contract ncmpt internet (F1.0).
 87:
 88:
 89: RECODE v10 (MISSING=SYSMIS) (0=0) (1 thru 2=1) (3 thru 6=2 ) (7 thru 10=3 ).
 90: RECODE v11 (MISSING=SYSMIS) (0=0) (1 thru 9=1) (10 thru 20=2 ) (21 thru 31=3).
 91: RECODE v12 (MISSING=SYSMIS) (0=0) (1 thru 2=1) (3 thru 4=2 ) (5 thru 6=3 ).
 92: RECODE v24 to v37 (MISSING=SYSMIS)  (0=0) (1 thru 25=1) (26 thru 74=2 ) (75 thru 10
     0=3 ).
 93: RECODE v101 to v130 (MISSING=SYSMIS) (0=0) (1 thru 25 = 1) (26 thru 74=2 ) (75 thru
      100=3 ).
 94: RECODE v131 to v136 (MISSING=SYSMIS) (0=0) (1 thru 5 = 1) (6 thru 10=2 ) (11 thru 2
     0=3 ) (21 thru 100=4).
 95: EXECUTE .
 96:
 97: * group quality control and productivity assess.
 98: RECODE v64 v65 (0=0) (1=1) (2=2) ( 3 thru 4 =2 ) INTO quality producti.
 99: EXECUTE.
100:
101: *group present of CE.
102: RECODE v14 (0=1) (1=4) (2=3) (3=2) (4 thru 9=1) into highestE.
103: EXECUTE.
```

List of variables on the working file

Name		Position
V0	No.of case Measurement Level: Nominal	1
V1	hospital type Measurement Level: Ordinal	2

Value	Label
1	teaching hospital
2	non-teaching hospital

V2	beds Measurement Level: Ordinal Missing Values: 0	3

Value		Label
0	M	NA
1		<50
2		50-250
3		250-500
4		500-2000
5		>=2000

V3	occupied beds% Measurement Level: Ordinal Missing Values: 0	4

Value		Label
0	M	NA
1		<50%
2		50-75%
3		>=75%

V4	critical beds% Measurement Level: Ordinal Missing Values: 0	5

Value		Label
0	M	NA
1		<5%
2		5-10%
3		10-20%
4		>=20%

V5	sperate unit Measurement Level: Ordinal Missing Values: 0	6

Value		Label
0	M	NA
1		Yes
2		No

V6 part of 7
Measurement Level: Nominal

V7 report to 10
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Senior Adimistrator
2		Medical director
3		Plant/maintenance director
9		Other

V8 report to others 11
Measurement Level: Nominal

V9 reporting satisfy 14
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Yes
2		No

V10 N_engineer 15
Measurement Level: Nominal

V11 N_technician 16
Measurement Level: Nominal

V12 N_clerical 17
Measurement Level: Nominal

V13 N_other 18
Measurement Level: Nominal

V14 E_highDegree 19
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Univeristy:PhD.
2		University:MSc.
3		University:BSc.
4		4-year technical school
5		3-year technical school
6		2-year technical school
7		1-year technical school
8		High School
9		Under high school

V15 T_highDegree 20
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Univeristy:PhD.
2		University:MSc.
3		University:BSc.
4		4-year technical school
5		3-year technical school
6		2-year technical school
7		1-year technical school
8		High School
9		Under high school

V16 C_highDegree 21
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Univeristy:PhD.
2		University:MSc.
3		University:BSc.
4		4-year technical school
5		3-year technical school
6		2-year technical school
7		1-year technical school
8		High School
9		Under high school

V17 O_highDegree 22
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Univeristy:PhD.
2		University:MSc.
3		University:BSc.
4		4-year technical school
5		3-year technical school
6		2-year technical school
7		1-year technical school
8		High School
9		Under high school

V18 is association 23
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Yes
2		No

V19 association name 24
Measurement Level: Nominal

V20 has training 27
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		On the job
2		In a special training center of hospital
3		Combination of on the job and training center
9		Other

V21 training other 28
Measurement Level: Nominal

V22 devices number 31
Measurement Level: Ordinal

Missing Values: 0

Value		Label
0	M	NA
1		<500
2		500-2000
3		>=2000

V23 total equipment cost 32
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		<1
2		1-5
3		5-10
4		>=10

V24 E_repair 33
Measurement Level: Scale
Missing Values: 0

V25 E_incoming inspection 34
Measurement Level: Scale
Missing Values: 0

V26 E_preventive maintain 35
Measurement Level: Scale
Missing Values: 0

V27 E_user training 36
Measurement Level: Scale
Missing Values: 0

V28 E_pre-purchase consult 37
Measurement Level: Scale
Missing Values: 0

V29 E_research 38
Measurement Level: Scale

Missing Values: 0

V30 E_others 39
Measurement Level: Scale
Missing Values: 0

V31 T_repair 40
Measurement Level: Scale
Missing Values: 0

V32 T_incoming inspection 41
Measurement Level: Scale
Missing Values: 0

V33 T_preventive maintain 42
Measurement Level: Scale
Missing Values: 0

V34 T_user training 43
Measurement Level: Scale

Missing Values: 0

V35 T_pre-purchase consult 44
Measurement Level: Scale
Missing Values: 0

V36 T_research 45
Measurement Level: Scale
Missing Values: 0

V37 T_others 46
Measurement Level: Scale
Missing Values: 0

V38 preparation specification 47
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Always
2		Often
3		Sometimes
4		Never

V39 tender analysis 48
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Always
2		Often
3		Sometimes
4		Never

V40 recommend on final 49

Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Always
2		Often
3		Sometimes
4		Never

V41 get device before user 50
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Always
2		Often
3		Sometimes
4		Never

V42 service contract 51
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Always
2		Often
3		Sometimes
4		Never

V43 part_value 52
Measurement Level: Ordinal

Missing Values: 0

Value		Label
0	M	NA
1		<0.5%
2		0.5-1.0%
3		1.0_1.5%
4		1.5-2.0%
5		>=2.0

V44 test_equipment_value 53
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		<0.5%
2		0.5-1.0%
3		1.0_1.5%
4		1.5-2.0%
5		>=2.0

V45 space per person 54
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		<15
2		15-20
3		20-25
4		>=25

V46 total budget 55
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		<1.0%
2		1.0-2.0%
3		2.0-3.0%
4		3.0-4.0%
5		4.0-5.0%
6		>=5.0%

V47 enough personnel 56
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Yes
2		No

V48 N_add_engineer 57
Measurement Level: Scale
Missing Values: 0

V49 N_add_technician 58
Measurement Level: Scale
Missing Values: 0

V50 N_add_clerical 59
Measurement Level: Scale
Missing Values: 0

V51 N_add_other 60
Measurement Level: Scale
Missing Values: 0

V52 enough parts 61
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA

```
                1     Yes
                2     No

V53             relate to down time                                    62
                Measurement Level: Ordinal
                Missing Values: 0

                Value     Label

                    0 M   NA
                    1     Yes
                    2     No

V54             enough test device                                     63
                Measurement Level: Ordinal
                Missing Values: 0

                Value     Label

                    0 M   NA
                    1     Yes
                    2     No

V55             enough space                                           64
                Measurement Level: Ordinal
                Missing Values: 0

                Value     Label

                    0 M   NA
                    1     Yes
                    2     No

V56             enough manuals                                         65
                Measurement Level: Ordinal
                Missing Values: 0

                Value     Label

                    0 M   NA
                    1     Yes
                    2     No

V57             reason lack of manuals                                 66
                Measurement Level: Nominal

V58             has a cmptr manage                                     69
                Measurement Level: Ordinal
                Missing Values: 0

                Value     Label

                    0 M   NA
                    1     No:management by hand
                    2     Yes:management by a general software
                    3     Yes:management by a special software

V59             special SW name                                        70
                Measurement Level: Nominal

V60             N_cmptr                                                73
```

Measurement Level: Scale
Missing Values: 0

V61 cmptr use for 74
Measurement Level: Nominal

V62 Internet 75
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Always
2		Never
3		Sometimes

V63 explain sometimes 76
Measurement Level: Nominal

V64 has quailty assurance 79
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Not yet
2		have just started
3		have done so for a year or two
4		have done so for more than two years

V65 productivity index 80
Measurement Level: Ordinal
Missing Values: 0

Value		Label
0	M	NA
1		Not yet
2		have just started
3		have done so for a year or two
4		have done so for more than two years

V66 country code 81
Measurement Level: Nominal

V101 repair medical 82
Measurement Level: Scale
Missing Values: 0

V102 repair imaging 83
Measurement Level: Scale
Missing Values: 0

V103 repair lab 84
Measurement Level: Scale
Missing Values: 0

V104	repair anesthetic Measurement Level: Scale Missing Values: 0	85
V105	repair computer Measurement Level: Scale Missing Values: 0	86
V106	repair Infrastructure Measurement Level: Scale Missing Values: 0	87
V107	inspection medical Measurement Level: Scale Missing Values: 0	88
V108	inspection imaging Measurement Level: Scale Missing Values: 0	89
V109	inspection lab Measurement Level: Scale Missing Values: 0	90
V110	inspection anesthetic Measurement Level: Scale Missing Values: 0	91
V111	inspection computer Measurement Level: Scale Missing Values: 0	92
V112	inspection Infrastructure Measurement Level: Scale Missing Values: 0	93
V113	maintain medical Measurement Level: Scale Missing Values: 0	94
V114	maintain imaging Measurement Level: Scale Missing Values: 0	95
V115	maintain lab Measurement Level: Scale Missing Values: 0	96
V116	maintain anesthetic Measurement Level: Scale Missing Values: 0	97
V117	maintain computer Measurement Level: Scale Missing Values: 0	98
V118	maintain Infrastructure Measurement Level: Scale Missing Values: 0	99

V119	training medical Measurement Level: Scale Missing Values: 0	100
V120	training imaging Measurement Level: Scale Missing Values: 0	101
V121	training lab Measurement Level: Scale Missing Values: 0	102
V122	training anesthetic Measurement Level: Scale Missing Values: 0	103
V123	training computer Measurement Level: Scale Missing Values: 0	104
V124	training Infrastructure Measurement Level: Scale Missing Values: 0	105
V125	prepurchase medical Measurement Level: Scale Missing Values: 0	106
V126	prepurchase imaging Measurement Level: Scale Missing Values: 0	107
V127	prepurchase lab Measurement Level: Scale Missing Values: 0	108
V128	prepurchase anesthetic Measurement Level: Scale Missing Values: 0	109
V129	prepurchase computer Measurement Level: Scale Missing Values: 0	110
V130	prepurchase Infrastructure Measurement Level: Scale Missing Values: 0	111
V131	research medical Measurement Level: Scale Missing Values: 0	112
V132	research imaging Measurement Level: Scale Missing Values: 0	113
V133	research lab Measurement Level: Scale Missing Values: 0	114

V134	research anesthetic Measurement Level: Scale Missing Values: 0	115
V135	research computer Measurement Level: Scale Missing Values: 0	116
V136	research Infrastructure Measurement Level: Scale Missing Values: 0	117
V137	other medical Measurement Level: Scale Missing Values: 0	118
V138	other imaging Measurement Level: Scale Missing Values: 0	119
V139	other lab Measurement Level: Scale Missing Values: 0	120
V140	other anesthetic Measurement Level: Scale Missing Values: 0	121
V141	other computer Measurement Level: Scale Missing Values: 0	122
V142	other Infrastructure Measurement Level: Scale Missing Values: 0	123

Appendix D: TECHNICAL REPORT

1. NULL HYPOTHESIS

The clinical engineering department model purposed by Frize for some developed countries can also be applied to clinical engineering department in developing countries to measure their level of development. The various levels would be defined as low, medium, and high.

2. TEST HYPOTHESES

2.1 The model, independent variables, and dependent variables

A model to measure the effectiveness of hospitals' CEDs in Canada and some developed countries was purposed in Frize's research study, *"Evaluating the effectiveness of clinical engineering departments in Canadian hospitals"*. It gave the principle features of CEDs in those countries, especially in Canada. The model is illustrated in figure 9. That study established that the degree of CED effectiveness (Outcomes) in Canadian hospitals was affected by the organizational factors that reflect the organizational climate of hospitals. The factors composing organizational climate are input-indicators of the system, and the degree of CED effectiveness can be the output of the system. The CED effectiveness is measured by CED functions (or outcomes). The study in developed countries gave us better knowledge base on clinical engineering field, and that model is employed in the present study of developing countries. Additionally, making use of that model can allow us to compare this study and the previous studies.

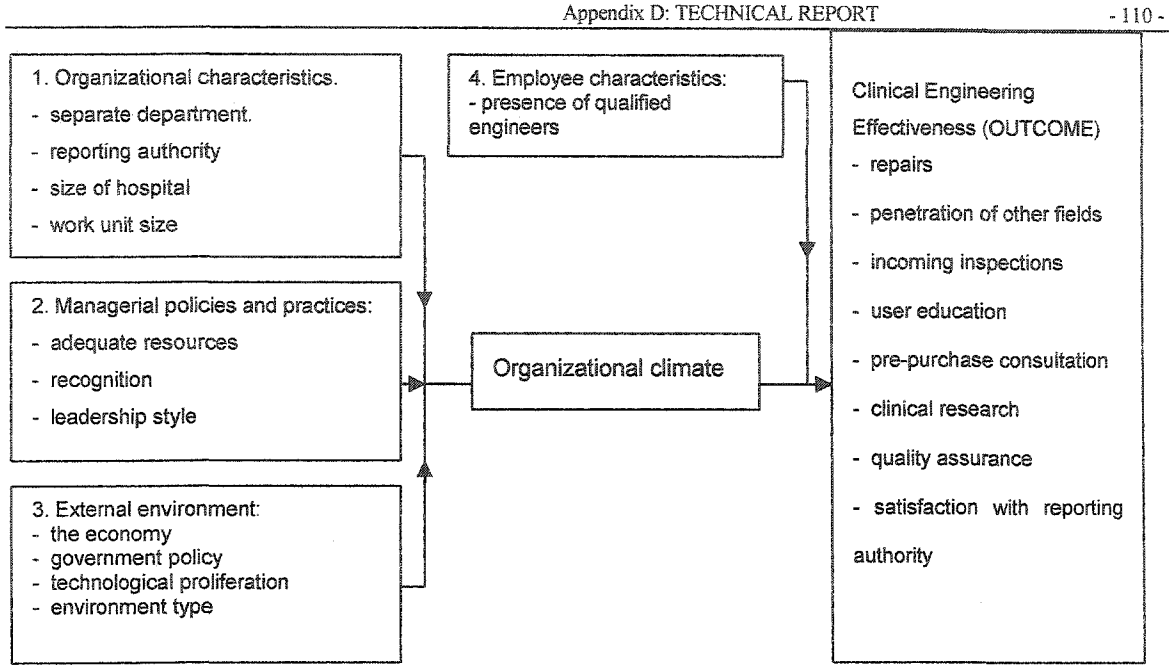


Figure 9 A model of CED effectiveness and Organizational Climate (Factors) affecting the outcome. [28]

In Frize's model, four concepts, "organizational characteristics", " managerial policies"," employee characteristics", and "external environment" were chosen and found to have consistent association with effectiveness.(Frize, p79) [28] These concepts were some abstract conceptual variables that affected a serial of outcomes of clinical engineering performance that were associated to CED effectiveness; these concepts represented the 'Organizational Climate' of the institution. Each of the four concepts has multiple indicators that give some measurements of relevant aspects of the concept. These indicators are listed in the boxes of figure 9, such as concept 'Organizational characteristics' is consisted of four indicators. They are 'reporting authority', 'size of hospital', 'work unit size', and 'hospital type'. "Of the four concepts, "external environment" is such a complex concept that it is not easily to measure by simply indicators. It could be analyzed qualitatively. "(Frize, p64) [28]

In this study, we need to clarify the definitions of "independent variable" and "dependent variable". When researchers begin a new study, they will define some variables to help them state their views or discover some facts. The variable the researcher wants to explain is called *dependent variable.* On the other hand, the other variables used in hypothesis are called *independent variable*s that "are used to examine whether they affect dependent variable". (Weisberg, p174)[50] In this model, CED effectiveness, or outcomes of the model, is the object that researchers want to explain, and it is measured by several indicators, such as the level of repair, incoming inspections, user education, pre-purchase consult, quality assurance, productivity of staff, and satisfaction with reporting authority, etc.. Those indicators are selected as dependent variables. On the other hand, the organizational climate was regarded as the factors affecting on the degree of CED effectiveness, which is also represented by four concepts, structure, managerial polices and practices, employee characteristics, and external environment. Each concept had its indicators (see the above paragraph), which were independent variables in the model. In this study, the similar dependent and independent variables were chosen as Frize's book, and they were also the basis for designing questionnaire.

2.2 Test the statistical independence between independent variables

The object of this test is to find the statistical independent variables from the variables assumed to be independent. A nonparametric correlation test is going to be used to measure the strength of the linear association between two variables. Nonparametric correlation test is suitable for ordinal data with a larger number of categories than would be appropriate for

cross-tabulation tables. (Frize, p262) [28] Being different from parametric test, this test does not need to assume a normal distribution, that is, the distribution of data is free.

Although the data from the questionnaire are varied (most data have in ordinal scale, the rest is ratio scale and nominal scale); they can be grouped and then become rank-order data. The methods of ranking have been discussed in methodology section of this study. (See section 3.3) The objective of ranking is to take Spearman correlation test between variables.

As discussed earlier, organizational climate is defined by a set of independent variables that are going to be examined by a Spearman correlation test. The following is the list of those independent variables. Among them, the variables, or indicators, with underline style are not chosen to be tested by a Spearman correlation test, as they do not have measurable questions in this study. So, eight indicators will be tested. The indicators of Organizational Climate:

A. Organizational structure:

1) Existence as a separate unit (1)
2) Reporting authority (2)
3) Hospital size (3)
4) Work-unit size (4)
5) Hospital type (5)

B. Managerial policies and practices:

6) Adequate resources (6)
7) Recognition (7)
8) Leadership style used by management (qualitative)

C. Employee characteristics:

9) Presence of qualified CE (8)

D. External environment: (qualitative)

It is necessary that the eight indicators, or variables, are explained before they are tested.

(1) Existence as a separate unit: Does the CED exist as a separate unit in the hospital organization?

(2) Reporting authority: Which department is the CED reporting to in the hospital? or who is CED's higher authority in the hospital?

(3) Hospital size: How many ward beds in the hospital?

(4) Work-unit size: How many technical staff in the CED? Technical staff includes CEs and technicians.

(5) Hospital type: Is the hospital teaching hospital or non-teaching hospital?

(6) Adequate resources: Do you think your CED staffing is adequate now?

(7) Recognition: How well the role and importance of the CED are recognized in your hospitals?

(8) Presence of CE: Is there a clinical engineer with at least BSc. degree in the CED?

By calculation, table 18 is the result of Spearman correlation coefficients and significance levels between the eight indicators. When significance level p is greater than 0.05, the two variables are statistically correlated, and when p is less than 0.05, the two variables are not correlated and they are considered statistically independent, which means that the independent variable can be treated as a separate and unique cause affecting the results.

The cells of table with shadow show the significant independence between the correspondingly row variables and column variables.

Table 18 Spearman correlation coefficient test for independent variables : the top number of cell is Spearman's coefficient, the bottom number is the significence level.

	IS SEPARATE	*REPORT AUTHORITY*	*HOSPITAL SIZE*	*HOSPITAL TYPE*	*ADEQUATE STAFFING*	*RECOGN -ITION*	*WORK-UNIT SIZE*	*PRESENCE OF CE*
IS SEPARATE		.277(*) .032	.234 .072	-.135 .304	.141 .284	.134 .387	.177 .177	.000 1.000
REPORT AUTHORITY	.277(*) .032		.193 .136	-.047 .719	.037 .778	-.192 .206	.071 .586	-.021 .874
HOSPITAL SIZE	.234 .072	.193 .136		.547(**) .000	-.183 .159	-.131 .392	.558(**) .000	.024 .856
HOSPITAL TYPE	-.135 .304	-.047 .719	.547(**) .000		.090 .491	.178 .243	-.324(*) .011	.020 .875
ADEQUATE STAFFING	.141 .284	.037 .778	-.183 .159	.090 .491		.177 .245	-.128 .324	.080 .539
RECOGNI-TION	.134 .387	-.192 .206	-.131 .392	.178 .243	.177 .245		-.102 .507	-.256 .089
WORK-UNIT SIZE	.177 .177	.071 .586	.558(**) .000	-.324(*) .011	-.128 .324	-.102 .507		.366(**) .004
PRESENCE OF CE	.000 1.000	-.021 .874	.024 .856	.020 .875	.080 .539	-.256 .089	.366(**) .004	

Note: 1. * Correlation is significant at the 0.05 level (2-tailed).
2. ** Correlation is significant at the 0.01 level (2-tailed).
3. Shadow means that the two variables are correlative in statistics.

From the calculations, it can be concluded that the originally selected independent variables to describe the organizational climate are not all statistically independent from each other. Five pairs of variables are correlated in statistics. They are:

1. 'existing as a separate unit' and 'report authority'
2. 'hospital size' and 'work-unit size'
3. 'hospital size' and 'hospital type'
4. 'work-unit size' and 'hospital type'
5. 'CE presence' and 'recognition'

In order to retain only real independent variables from the eight variables, some variables will be cut out and moved to the dependent variable group that represents the CEDs effectiveness as discussed before. In order that each variable in table 17 can be studied separately if it is statistically independent from the others, (Frzie, p83) [28] five statistically independent variables are selected to stand for more independent variable pairs. They are:

(1) Reporting authority
(2) Hospital type
(3) Adequate staffing
(4) Recognition
(5) Presence of CE

In Frize's study, there were four variables to be considered as independent variables that affected the outcome of the CED's effectiveness. They are:

- Reporting authority
- Hospital type
- Recognition
- Presence of qualified clinical engineers (it was added for an additional discussion, but it is not statistically independent from the three other variables). (Frize, p85) [28]

Among the above four variables, variable 'presence of CE' was analyzed by Frize even though it was not statistically independent from other variables in that study, because it had a significant impact on most of the dependant variables defining outcomes of the effectiveness.

Compared with the result obtained by Frize, apparently, the current study gain a similar statistically independent variables to the present study, although one study was carried out

in developed countries and the other one is in some developing countries. The results indicate that reporting authority, hospital type, recognition and presence of CEs exist as separate and unique causes in the CED effectiveness model, and for the developing countries, 'adequate staffing' become the new statistically independent cause. It is interesting to note that 'presence of CE' analyzed by Frize was not a statistically independent variable in developed country model, but it is a statistically independent variable in this developing country model.

2.3 Dependent variables—indicators of CED effectiveness

As mentioned before, dependent variables are the outcome of the model, and they are assured to be a measurement of CED effectiveness. The three independent indicators that were statistically correlated were moved into the dependent variable group. They are 'work-unit size', 'hospital size' and 'existence as a separate unit'. They combine with other dependent variables to form the 14-member dependent variable group. These are outcomes of the model. The following is the list of them:

(1) The level of in-house medical equipment repairs

(2) The level of incoming inspection performance

(3) The level of preventive maintenance performance

(4) The level of user training performance

(5) The level of pre-purchase consulting performance

(6) The level of research and development involved

(7) Existence as a separate unit

(8) Satisfaction with reporting authority

(9) The level of test equipment available

(10) The level of space available

(11) The level of CED staff training *

(12) Has a computerized management system *

(13) Adequate spare parts *

(14) Adequate operating manuals *

The variables with (*) do not appear in the dependent variable list of Frize. Instead, they were 'performing quality assurance audits',' performing productivity index', 'budget level', and 'involvement in budget preparation'. (Frize, p85) [28]

2.4 Correlation between organizational climate and CED effectiveness

The following process is to find which independent variables have an effect on outcomes of the model. Spearman correlation coefficients were calculated between five statistically independent variables and fourteen dependent variables labeled "outcomes" and their significance levels are listed in table 19. The results of significance level indicate that the five real independent variables are correlated with some outcomes in statistics. Next, an analysis was carried out according to each significantly independent variable.

Table 19 Spearman correlation test for five statistically independent variables and dependent variables and the number in cell is the significant level of two variables.

		REPORTING AUTHORITY	*HOSPITAL TYPE*	*ADEQUATE STAFFING*	*RECOG-NITION*	*PRESENCE OF CE*
1	Level of in-house repairs	.305	.311	.942	.083	.669
2	Level of incoming inspection	.286	.002	.700	.530	.033
3	Level of preventive maintenance	.759	.000	.046	.542	.062
4	The level of user training	.343	.005	.121	.708	.057
5	Level of pre-purchase consulting	.053	.001	.968	.528	.010
6	Level of research	.024	.079	.274	.018	.421
7	Existence as a separate unit	.018	.304	.284	.548	1.000
8	Satisfaction with reporting authority	.147	.250	.024	.042	.259
9	The level of test equipment available	.014	.044	.540	.161	.340
10	The level of space available	.155	.074	.692	.001	.758
11	The level of CED staff training	.000	.063	.319	.261	.761
12	Has a computerized management system	.087	.165	.294	.005	.026
13	Adequate spare parts	.006	.076	.000	.189	1.000
14	Adequate manuals	.904	.541	.324	.364	.047

Note: (1) Shadow means correlation is significant at less than 0.05 level (2-tailed).

2.4.1 Reporting authority

In this study, 'reporting authority' is categorized into four classes that are same as Frize's classification.

- Senior administrators
- Medical directors
- Plant / maintenance directors
- Other directors.

By Spearman's correlation computation, the statistically independent variable 'reporting authority' is correlated with five variables of outcomes in statistics (p=0.05). They are 'level of research', 'Existence as a separate unit', 'level of test equipment available', 'adequate spare parts', and 'level of staff training'. The followings are discussing their correlations one by one.

1. 'Reporting authority' and 'level of research'

Table 20 Cross-tabulation of the level of research by reporting authority

		Level of research		
		0	*1 to 10%*	*>10%*
Reporting authority	Senior Administrators	23/31, 74%	4/31, 13%	4/31, 13%
	Medical directors	6/7, 84%	1/7, 14%	
	Plant/maintenance directors	7/15, 46%	2/15, 13%	6/15, 27%
	Other directors	3/8, 38%	2/8, 25%	3/8, 38%

The table 20 tells us that the high level (>10%) of research and development activities appears in 13% of CEDs reporting to 'senior administrators', and 27% of CEDs reporting to 'plant/maintenance directors', and 38% of CEDs reporting to 'other directors', and none of 7 CEDs reporting to 'medical directors'. In Frize's study, 25% of CEDs reporting to 'senior administrators' and 40% of CEDs reporting to 'other directors' were at the same level of research. None of CEDs reporting 'plant directors' and 'medical directors' were at the level. (Frize, p91) [28]

The two studies, for developing and developed countries, obtained some overlapping conclusions: CEDs reporting to 'medical directors' do not perform high level of research and development (>10%) in this study and Frize's study; CEDs reporting to 'other directors' had the most proportion in performing the high level of research and development (>10%) in both studies. But CEDs reporting to 'senior administrators' and 'plant/maintenance directors' had the opposite situations in the two studies. So, reporting to 'Plant/Maintenance directors' is thought to a favor organizational structure for CED to perform high level of research activity in this survey.

2. 'Reporting authority' and 'Existence as a separate unit'

Table 21 Cross-tabulation of Existence as a separate unit by reporting authority

		Existence as a separate unit	
		Yes	*No*
Reporting authority	Senior Administrators	28/30, 93%	2/30, 7%
	Medical directors	6/7, 86%	1/7, 14%
	Plant/maintenance directors	11/15, 73%	4/15, 27%
	Other directors	5/8, 63%	3/8, 38%

Table 21 shows that 93% of respondents reporting to 'Senior Administrators' have separate CEDs in their hospitals, and the percentage decreases by the respondents reporting 'Medical directors', 'Plant/maintenance directors', and 'Other directors'. So, reporting to 'senior administrators' is helpful to make CEDs become a separate unit in this survey.

3. 'Reporting authority' and 'level of test equipment available'

Table 22 Cross-tabulation of level of test equipment available by reporting authority

		Level of test equipment available	
		*<1%**	*>=1%**
Reporting authority	Senior Administrators	27/30, 90%	3/30, 10%
	Medical directors	4/6, 67%	2/6, 33%
	Plant/maintenance directors	11/15, 73%	4/15, 27%
	Other directors	5/7, 71%	2/7, 29%

Note: * test equipment value means a percentage of spare part value to replacement value of total equipment supported by CEDs.

From table 22, it can be seen that 10% of respondents reporting to 'Senior Administrators' have test equipment value at the '>1%' level, while other reporting authorities have higher proportion at the level. So, less respondents reporting to 'senior administrators' do not have as much test equipment as other reporting authorities, like reporting to 'Plant/Maintenance directors'.

4. 'Reporting authority' and 'level of CED staff training'

The cross-tabulation of level of CED staff training and reporting mechanism shows that 39% (12/31) respondents reporting to 'senior administrator' have training in combination of on the job and at training centers and 58% (18/31) of them receive their training only on the job; compared with respondents reporting to 'plant/maintenance directors', there are 60% (9/15) trained in combination of on the job and at centers and 20% (3/15) on the job; as for reporting 'other directors', the higher proportion 88% (7/8) of respondents training in the combination appear. So, in this survey, reporting to 'Senior Administrators' does not help CED staff get better training.

5. 'Reporting authority' and 'Adequate spare parts'

In the cross-tabulation of adequate spare parts and reporting authority, 93% (28/30) of respondents reporting to 'Senior Administrators' said they did not have adequate spare parts, but for respondents who reported to 'Plant/maintenance directors', 53% (8/15) said 'not adequate' and the rest (47%, 7/15) said 'adequate'. So, respondents reporting to 'Senior Administrators' stated a higher proportion of having inadequate spare parts than those reporting authorities.

So, reporting to 'senior administrators' has better effect on CED's organizational structure (existence as a separate unit), but reporting to 'plant/maintenance directors' has better effect on CED's responsibilities (level of research) and CED's resources (level of test equipment available, adequate spare parts) and CED's personnel (level of staff training).

The results are somewhat opposite to Frize's. In her study, reporting to 'senior administrators' and 'medical directors' made the degree of CED's effectiveness higher and reporting to 'plant/maintenance directors' led to less effectiveness. But in the current study for developing countries, reporting to 'senior administrators' lead to less CED's effectiveness except for CED organizational structure, and reporting to 'plant/maintenance directors' cause more effectiveness except for CED organizational structure.

6.4.2 Hospital type

In this study, hospital type is categorized to

- Teaching hospitals
- Non-teaching hospitals.

From table 19, 'hospital type' is significantly correlated with 'level of incoming inspection', 'level of preventive maintenance', 'level of pre-purchase consulting', 'level of user training', and 'level of test equipment available'. The followings are discussing their correlations between statistically independent variables 'hospital type'.

1. 'Hospital type' and 'level of incoming inspection'

Table 23 Cross-tabulation of level of incoming inspection by hospital type

		level of incoming inspection		
		<25%	*25-75%*	*>75%*
Hospital type	Teaching	14/34, 41%	5/34, 15%	15/34, 44%
	Non-teaching	3/27, 11%	2/27, 7%	22/27, 82%

For the 'level of incoming inspection', table 23 shows that the proportions of CEDs who performed 75% or more of incoming inspection in teaching hospitals is 44% (15/34) but, versus, 82% (22/27) for non-teaching hospitals; at the '0~25%' level, there are 41% of

teaching hospitals and 11% of non-teaching hospitals. So, in this survey, most non-teaching hospitals perform the high level (>75%) of incoming inspection than teaching hospitals.

2. 'Hospital type' and 'level of preventive maintenance'

Table 24 Cross-tabulation of level of preventive maintenance by hospital type

		Level of preventive maintenance		
		<25%	*25-75%*	*>75%*
Hospital type	Teaching	16/34, 47%	11/34, 32%	7/34, 21%
	Non-teaching	4/27, 14%	5/27, 19%	18/27, 67%

Table 24 shows that, in this survey, a few (21%, 7/34) CEDs in teaching hospitals perform 75% preventive maintenance or more, and most of them (79%, 27/34) perform less than 75% of preventive maintenance in their hospitals. On the other hand, most CEDs (67%, 18/27) in non-teaching hospitals perform more than 75% level of preventive maintenance for medical equipment they supervise.

3. 'Hospital type' and 'level of user training'

Table 25 Cross-tabulation of level of user training by hospital type

		Level of user training		
		<25%	*25-75%*	*>75%*
Hospital type	Teaching	16/34, 47%	8/34, 24%	10/34, 29%
	Non-teaching	5/27, 18%	5/27, 18%	17/27, 63%

Table 25 is the cross-tabulation of the level of user training provided by CEDs and hospital type. It presents the similar relationship between 'incoming inspection' and 'preventive maintenance' with 'hospital type'. The lower percentage (29%, 10/34) of respondents from

teaching hospitals perform more than 75% level of user training, but there is a higher percentage (63%, 17/27) in non-teaching hospitals, and at the minimum level of user training performance, 0~25%, teaching hospitals account for a considerable proportion.

4. 'Hospital type' and 'level of pre-purchase consulting'

Table 26 Cross-tabulation of level of pre-purchase consulting by hospital type

		Level of pre-purchase consulting		
		<25%	*25-75%*	*>75%*
Hospital type	Teaching	15/34, 44%	11/34, 32%	8/34, 24%
	Non-teaching	5/27, 18%	4/27, 15%	18/27, 67%

Table 26 shows that the proportion of CEDs in teaching hospitals that perform 75% or more level of pre-purchase consultation is 24% (8/34) versus 67% (18/27) for non-teaching hospitals, and there are 44% (15/34) of CEDs in teaching hospitals performing less than 25% pre-purchase consultation, compared with 18% (5/27) of non-teaching hospitals at the level.

The correlation of 'level of pre-purchase consulting' and 'hospital type' is similar to that in before three tables, table 23, 24, 25. In this survey, less CEDs in teaching hospitals perform the high level (>75%) of CED's responsibilities ('incoming inspection', 'preventive maintenance', 'user training', and 'pre-purchase consulting') than non-teaching hospitals, although teaching hospitals have more ward beds and medical equipment and technical staff in CEDs than non-teaching hospital. (See section 4.5)

The explanation of it may be that teaching hospitals have a poor management system for medical equipment and CED staff. To some extent, the situation of teaching hospitals better reflects the national guidelines and policies for clinical engineering field, since they generally support by government, running not like private sectors. As McKie said, "the absence of a 'pervading technological culture', which a supportive infrastructure (both visible and invisible) for healthcare technology management activities, is one of issues developing countries are facing. " [25] In this survey, teaching hospitals had more infrastructure resources (e.g. devices) and personnel staff, but they utilized those resources not effectively enough. But for non-teaching hospitals in this survey, although they tend to be small private sectors and have fewer resources than teaching institutions, they perform the high level of CED's responsibilities. They are usually running like business and more care about the cost-effectiveness and profits of their enterprises because for existence of CEDs in their organization, their cost-effectiveness for medical equipment management has to be proved at first.

5. 'Hospital type' and 'level of test equipment available'

Table 27 Cross-tabulation of level of test equipment available by hospital type

		Level of test equipment available	
		*<1%**	*>1%**
Hospital type	Teaching	23/31, 74%	8/31, 26%
	Non-teaching	24/27, 18%	3/27, 11%

Note: * test equipment value means a percentage of test equipment value to replacement value of equipment supported by CEDs.

Table 27 shows that in this survey, more CEDs in teaching hospitals have more test equipment than those in non-teaching hospitals: 26% (8/31) of CEDs in teaching hospitals have the value of test equipment that accounts for more than 1% to the replacement value of total equipment, versus, 11% (3/27) in non-teaching hospitals. This consensus seems to be reached in the preceding discussion (See 4.2.2) that teaching hospitals have more resources, personnel, and technologies applied than non-teaching hospitals.

In summary, 'hospital type' has influence on CED's responsibilities ('level of in-house repair', 'level of incoming inspection', 'level of user training', 'level of preventive maintenance') and CED resources ('test equipment available'). But the way to influence those indicators is somewhat against that of Frize. She said "teaching hospitals in developed countries offered an organizational climate which is conductive to a higher degree of clinical engineering effectiveness than non-teaching institutions". In this study, CEDs in teaching hospitals have a lower level of performance in incoming inspection, preventive maintenance, user training, and pre-purchase consultation with more resources, personnel and technologies, whereas in non-teaching hospitals more CEDs perform them on a relatively higher level (>75%) with fewer resources. And in terms of organizational structure, personnel structure, and resources for CEDs, teaching hospitals have a better situation.

The reason for the contradictive situation of CEDs in teaching hospitals in developing countries is probably poor national guideline and policies for the clinical engineering field, poor recognition to clinical engineering functions, and poor experience in managing

healthcare technology and engineering in hospitals. Another reason for it is that CEDs in teaching hospitals administer more devices and staff than non-teaching hospitals. (See section 4.5.1) In this survey, most large-size hospitals are teaching hospital with more devices and staff and most non-teaching hospitals are small-size hospitals with less devices and staff. It happens that the larger number of devices, equipment, and staff, the more their management issues will be presented, whereas, the small amount of devices and staff are easy to manage and need less expertise management strategies.

2.4.3 Adequate staffing

The variable 'adequate staffing' is a new statistically independent variable compared to Frize's study. In this study, whether CEDs have adequate staffing becomes an independent condition to measure the effectiveness of CED performances. The variable 'adequate staffing' is categorized into

- Adequate staffing.
- Inadequate staffing.

From table 18, there are three variables having significant correlations with 'adequate staffing'. They are 'level of preventive maintenance', 'satisfaction with reporting authority', and 'adequate spare parts'.

1. 'adequate staffing' and 'level of preventive maintenance'

Table 28 Cross-tabulation of level of preventive maintenance by 'adequate staffing'

		Level of preventive maintenance		
		<25%	*25-75%*	*>75%*
Adequate staffing	Adequate	10/21, 47%	5/21, 24%	6/21, 29%
	Inadequate	10/40, 25%	11/40, 27%	19/40, 48%

In this survey, 29% (6/21) of respondents who thought they had enough staffing performed preventive maintenance at more than 75% level, versus, 48% (19/40) for respondents who stated 'inadequate staffing'. (See table 28)

2. 'adequate staffing' and 'satisfaction with reporting authority'

Table 29 Cross-tabulation of satisfaction with reporting authority by 'adequate staffing'

		Satisfaction with reporting authority	
		Yes	*No*
Adequate staffing	Adequate	21/21, 100%	0
	Inadequate	30/38, 79%	8/38, 21%

Table 29 shows, in the present survey, CEDs with 'adequate staffing' are satisfied with their reporting authorities, on the contrast, 21% (8/38) of CEDs with 'inadequate staffing' are not agreed with their reporting mechanisms. So, the attitude of 'adequate staffing' assures the satisfactions to reporting authority in this survey.

3. 'adequate staffing' and 'adequate spare parts'

Table 30 Cross-tabulation of adequate staffing authority by 'Is separate unit'

		Adequate spare parts	
		Adequate	*Inadequate*
Adequate staffing	Adequate	10/21, 48%	11/21, 52%
	Inadequate	3/37, 8%	34/37, 92%

In present survey, almost half (48%, 10/21) of respondents who stated adequate in personnel also thought that they had enough spare parts in their inventories. On the other hand, 92% (34/37) of respondents claiming not adequate in personnel also stated they did

not have enough spare parts. So in this survey, inadequate resources concentrated on some CEDs, which have both inadequate staffing and inadequate spare parts.

2.4.4 Recognition

In this survey, respondents were asked to assess the recognition degree. The question is "Do you agree the following statement? The statement is that your department's function has reached its full recognition in you hospital?". The answer choices concentrate on 'agree' and 'disagree'. So, the variable 'recognition' is classified into

- well recognized
- poor recognized

The variable, 'recognition', is to reflect the managerial policies and practices aspect of organization climate. The spearman correlation significance levels show 'recognition' and four variables, 'level of research', 'level of space available', 'satisfaction with reporting authority', and 'has a computerized management system' are statistically correlated. The followings are the detailed discussions between them.

1. 'Recognition' and 'level of medical equipment repairs'

Table 31 Cross-tabulate of level of in-house medical equipment repairs by recognition

		Level of in-house medical equipment repairs		
		<25%	*25-75%*	*>75%*
Recognition	Well recognized	2/20, 10%	7/20, 35%	11/20, 55%
	Poor recognized	6/25, 24%	12/25, 48%	7/25, 28%

From table 18, the correlation between 'recognition' and 'level of in-house repair' are not statistically significant at the 0.05 level. Their significance level (p=0.083) for the correlation is at the borderline of the 0.05 significance level. In Frize's study, significance

levels from 1.00 to 0.05 were regarded as borderline of the significance to be discussed. [28] So, their correlation is discussed in this survey as follows.

Table 31 shows that 55% (11/20) of respondents who stated to agreed that the functions of their CED were well recognized in their hospitals performed 75% or more level of in-house repairs, in contrast to 28% (7/25) of respondents who stated 'poor recognized' performed the same level of in-house repairs (>75%). In this survey, there were only 10% (2/20) respondents who were well recognized stating to perform less than 25% repairs. So, in this survey, more respondents who are well recognized perform the high level (>75%) of repair work for medical equipment.

2. 'Recognition' and 'level of research'

Table 32 Cross-tabulate of level of research by recognition

		Level of research	
		<10%	*>10%*
recognition	Well recognized	15/20, 75%	5/20, 25%
	Poor recognized	23/25, 92%	2/25, 8%

From table 32, a trend apparently appear that although most respondents performed less than 10% research, more respondents with being well recognized performed high level of research than those with not being well recognized: 25% (5/20) for respondents with being well recognized versus 8% (2/25) of respondents with not being well recognized at the level (>10%) of research in this survey.

3. 'Recognition' and 'satisfaction with reporting authority'

Table 33 Cross-tabulate of satisfaction with reporting authority by recognition

		Satisfaction with reporting authority	
		Yes	*No*
Recognition	Well recognized	18/18, 100%	0
	Poor recognized	22/25, 88%	3/25, 12%

From table 33, a situation can be seen that respondents with being well recognized also satisfied with their reporting authority in this survey, and a few respondents (3/25, 12%) with poor recognized stated not satisfying with their reporting mechanisms. So, 'well recognized' assures the satisfaction with reporting authorities in this survey.

4. 'Recognition' and 'level of space available'

Table 34 Cross-tabulate of level of level of space available by recognition

		Level of space available		
		<15M²	*15-20M²*	*>20M²*
Recognition	Well recognized	5/20, 25%	10/20, 50%	5/20, 25%
	Poor recognized	17/24, 70%	4/24, 17%	3/24, 13%

Table 34 tells us that most (75%, 15/20) of respondents with being well recognized reported they had more than 15 square meter area per person in their department, versus 30% (7/24) for respondents with poor recognized, and most (70%, 17/24) of respondents with not being well recognized stated having less than 15 square meters per person in this survey. Additionally, "15 square meters area per person" is also the minimum standard to make Asia respondents satisfied with their workspace area.

5. 'Recognition' and 'has a computerized management system'

Table 35 Cross-tabulate of has a computerized management system by recognition

		Has a computerized management system		
		Manage by hand	*Manage by a general software system*	*Manage by a special software system*
Recognition	Well recognized	2/20, 10%	5/20, 25%	13/20, 65%
	Poor recognized	3/25, 12%	16/25, 64%	6/25, 24%

A computerized management system is also called Management Information System (MIS) in other studies. Table 35 shows that 65% (13/20) of respondents with being well recognized stated that they had special computerized management systems or MISs for equipment and inventories, compared, 24% (6/25) in respondents with poor recognized. Most of respondents (16/25, 64%) with poor recognized had general software systems, such as MS EXCEL or ACCESS. So, in this study, more CEDs with being well recognized have more advanced technology management systems for their equipment and inventory than those with being poor recognized.

In summary, the variable 'reorganization' has effect on CED responsibility (repair medical equipment and research), CED resources (space available), CED organization structure (satisfaction with reporting authority), and CED's equipment management (has a computerized management system). More CEDs with being well recognized perform the higher level of repair and research in medical equipment and they have bigger space area and more advanced MISs to manage equipment information in this survey. The results are similar to the conclusions of Frize in her developed country study.

2.4.5 Presence of CE

The variable 'Presence of CE' refers to the highest educational background of clinical engineers present in a CED. In this survey, a qualified CE have to own Bachelor degree in Science or Engineering, or higher, which is accorded with the definition of CE by IFMBE and ACCE. The variable is categorized to

- No CEs
- Presence of CEs with BSc.
- Presence of CEs with MSc,or PhD.

The variable significantly correlated with four outcomes, which are 'level of incoming inspection', 'level of pre-purchase consultation', 'has a computerized management system', and 'adequate manuals'.

1. 'Presence of CE' and 'level of incoming inspection'

Table 36 Cross-tabulate of level of incoming inspection by Presence of CE

		Level of incoming inspection		
		0-25%	*26-74%*	*>=75%*
Presence of CE	No Ces	10/16, 56%	2/16, 13%	5/16, 31%
	CE with BSc.	5/30, 20%	2/30, 7%	23/30, 77%
	CE with MSc. or PhD.	3/15, 20%	3/15, 20%	9/15, 60%

Table 36 shows that most CEDs with higher than BSc. performed the high level (>75%) of incoming inspection for new medical equipment, in contrast to 31% (5/16) for CEDs with no CE presence at the level. So, in this survey, more respondents with CE presence perform the high level (>75%) of preventive maintenance than those with no CE presence.

2. 'Presence of CE' and 'level of pre-purchase consultation'

Table 37 Cross-tabulate of level of pre-purchase consultation by presence of CE

		Level of pre-purchase consultation		
		0-25%	*26%-74%*	*>=75%*
Presence of CE	No CEs	11/16, 69%	3/16, 19%	2/16, 13%
	CE with BSc.	6/30, 20%	6/30, 20%	18/30, 60%
	CE with MSc. or PhD.	3/15, 20%	6/15, 40%	6/15, 40%

Alike table 35, table 37 shows that most CEDs with qualified CE presence performed the high level (>75%) of pre-purchase consultation in this survey, but most of CEDs with no qualified CE presence performed less than 25% level of that duty. So, in this survey, qualified CE presence has a good effect on the level of pre-purchase consultation performance.

3. 'Presence of CE' and 'Has a computerized management system'

Table 38 Cross-tabulate of having a computerized management system by presence of CE

		Has a computerized management system		
		Manage by hand	*Manage by a general software system*	*Manage by a special software system*
Presence of CE	No CEs	5/16, 31%	5/16, 31%	6/16, 38%
	CE with BSc.	2/30, 7%	14/30, 47%	14/30, 47%
	CE with MSc. or PhD.	0	5/15, 33%	10/15, 67%

Table 38 shows that CEDs with CEs having MSc. and PhD. Degree have the highest percentage (67%, 10/15) to have special computerized management systems, or MISs for their equipment and inventories, while CEDs with no qualified CE have the highest percentage (31%, 5/16) to manage their equipment and inventory information by hand. So, in this survey, the higher educational background that CEs have, the more advanced technology management systems are used for equipment.

4. 'Presence of CE' and 'adequate manuals'

Table 39 Cross-tabulate of adequate manuals by presence of CE

		Adequate manuals	
		Yes	No
Presence of CE	No CEs	8/15, 53%	7/15, 47%
	CE with BSc.	21/30, 70%	9/30, 30%
	CE with MSc. or PhD.	13/15, 87%	2/15,13%

After creating the cross-tabulates between them, we see a clear result that the more high educational background of CEs in the respondent departments in this survey, the more respondents have adequate operating manuals: 53% (8/15) of respondents without CEs state that they have enough manuals; 70% (21/30) of respondents with CEs having BSc. stated that they had enough manuals; and the highest percentage, 87% (13/15) appears in the respondent group having CEs with MSc. or PhD..

So, 'Presence of CEs' has a positive effect on CED's responsibilities ('preventive maintenance', 'pre-purchase consultant') and CED's equipment management ('has a computerized management system') and CED's resources ('adequate manuals'). The result is like Frize's that attained in developed country study.

3. Summary

In this study, the model purposed by Frize for developed countries is adopted for the current study of some developing countries. In the model, the statistically independent variables, 'reporting authority', 'hospital type', 'adequate staffing', 'recognition', and 'presence of CE', have influences on the indicators (or variables) of effectiveness labeled as outcomes of the model, which is a similar conclusion with the one drawn by Frize in

developed country studies (1988) (Frize, p79)[28]. Although some statistically independent variables, such as 'hospital type', affect the CED effectiveness in the different way from that by Frize, all statistically independent variables are regarded as separate factors to affect the CED effectiveness in those developing countries in this survey. Through the statistical analysis, we draw this conclusion that the model of Frize is not only appropriate to study developed countries, but also suitable for analysis to developing countries. So, the null hypothesis is accepted. The model of Frize can be revised (see figure 10) for this developing country study.

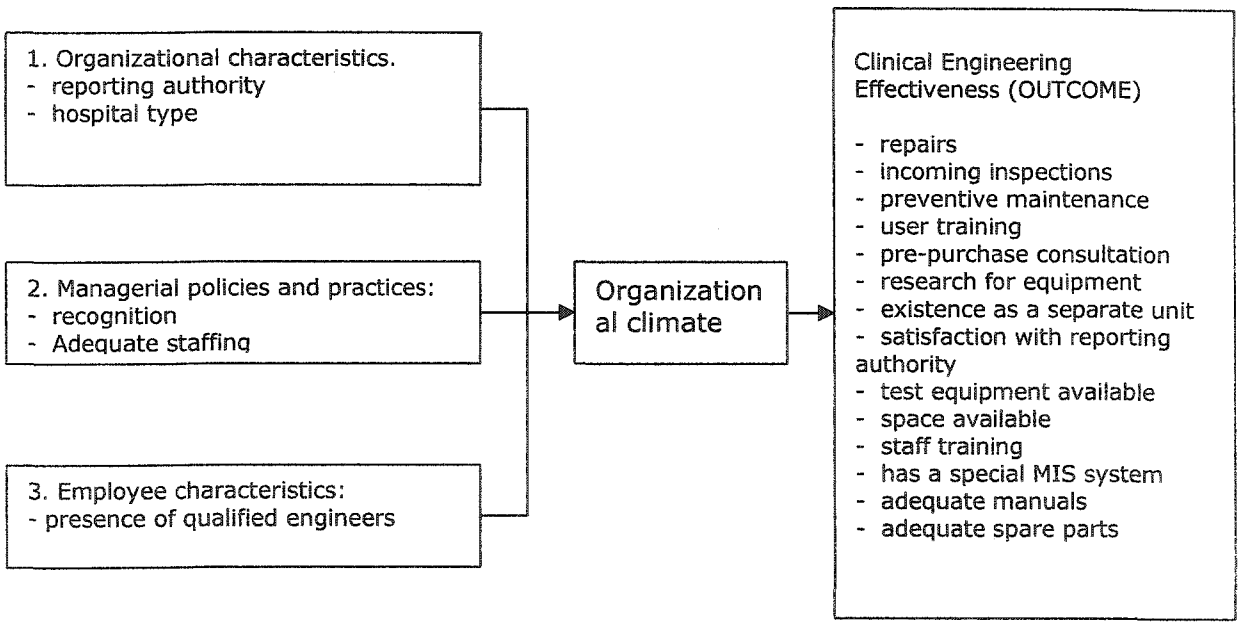


Figure 10 The revised model for CEDs in developing countries

The results of this study for some developing countries show that the degree of effectiveness is higher where CEDs report to 'plant/maintenance directors' and 'other directors' except for having a good organizational structure, vice versa for CEDs reporting to 'senior administrators'; CEDs who think they have adequate staffing have more resources and good organizational structure for clinical engineering development, but they

perform less clinical engineering responsibilities; Recognition of the role of CEDs by the hospitals is very helpful to get more effectiveness; Hiring qualified clinical engineers is also a positive factor to affect effectiveness; Teaching hospitals provide a better environment to CED development but they do not perform a high level of CED's responsibilities, whereas, non-teaching hospitals in this study perform a high level of CED's responsibilities though they have less resources, personnel, and technologies applied.

Appendix E: THE SCORING SYSTEM OF QUESTIONNAIRE ANSWERS

1. Table of scoring system for questionnaire answers

	Factors	Score
Q1.1	Non-teaching hospital Teaching hospital	1 2
Q1.2	50-250 beds 250-500 beds 500-2000 beds	1 2 3
Q1.3	<50% 50-75% >= 75%	1 2 3
Q1.4	< 5% 5-10% 10-20% =20%	1 2 3 4
Q2.1, Q2.3, Q3.1, Q5.5 Q5.6,Q5.7,Q5.8, Q5.9	No Yes	1 2
Q2.2	Senior Administrator (orequivalence) Medical director (or chief of medical staff) Plant/maintenance director Other s	4 3 2 1
Q3.0 CE number	0 1-2 3-6 7-10	0 1 2 3
Q3.0 technician number	0 1-9 10-20 21-31	0 1 2 3
Q3.0 Clerical staff number	0 1-2 3-4 5-6	0 1 2 3
Q3.0 Education	Under high school High school 1-year technical school 2-year technical school 3-year technical school 4-year technical school BSc. MSc. PhD.	1 2 3 4 5 6 7 8 9
Q3.2 training	On the job In a special training center geared for hospital work Combination of on the job and special biomedical center Other	1 2 3 4
Q4.1	<500 500-2000 >=2000	1 2 3
Q4.2	<1 1-5 5-10 >=10	1 2 3 4
Q4.3, Q4.4	0 1-24% 25-74% >75%	0 1 2 3
Q4.5	Never	1

	Sometimes Often Always	2 3 4
Q5.1, Q5.2	<0.5% 0.5-1.0% 1.0-1.5% 1.5-2.0% >=2.0%	1 2 3 4 5
Q5.3	<15M2 15-20M2 20-25M2 >=25M2	1 2 3 4
Q5.4	<1% 1-2% 2-3% 3-4% 4-5% >=5%	1 2 3 4 5 6
Q6.1	No: management by hand Yes: management by a general software Yes: management by special software, detail	1 2 3
Q6.2 Computer number	0 1 2-4 5-10 11-20	0 1 2 3 4
Q6.2 Computer usage	0 1-7	0 1
Q6.3	Never Sometimes Always	1 2 3
Q6.4, Q6.5	Not yet have just started have done so for a year or two have done so for more than two years	1 2 3 4

Note: missing values are assigned to '0'

2. Cluster Analysis

In this study, cluster analysis is used to classify the groups of development degree of CEDs in developing countries. In general, cluster analysis is to classify the sample. Bryan stated, "Cluster analysis is concerned with the identification of groups of similar objects." (Bryan, p13) [51]

Given a sample of n objects, each of which has a value for p variables, devise a scheme for classifying the objects into groups so that "similar" ones are in the same class. But the groups are unknown at the beginning of the analysis.

Many algorithms have been proposed for cluster analysis. Here our attention is restricted to one approach, hierarchic techniques. The method starts with the calculation of the distances of each individual to all other individuals. Groups are then formed by a process of agglomeration. Agglomerative hierarchic methods focus on the *"distance"* between individuals. Grouping means *"close"* together. There are various ways to define *" close"*. The simplest way is in terms of *"nearest neighbours"*. Another way is *"furthest neighbours"* with which two groups merge only if the most distant members of groups are close enough. (p131) [51]

How to measure the *"distance"*? The Euclidean distance is used to measure the distance between individual observations. The Euclidean distance between object i and j is

$$d_{ij} = \sqrt{\sum_{k=1}^{p} (x_{ik} - x_{jk})^2},$$

where, the data for a cluster analysis usually consist of the values of p variables $X_1, X_2 \ldots X_p$ for n objects.

x_{ik} is the value of variable X_k for individual i

x_{jk} is the value of the same variable for individual j.

The *"nearest neighbours"* algorithms mean $D_{pq} = \min d_{ij}$, where $x_i \in G_p, x_j \in G_q$.

The "*furthest neighbours*" algorithms mean $D_{pq} = \max d_{ij}$, where $x_i \in G_p, x_j \in G_q$.

The next step in the analysis is to calculate the Euclidean distances between all pairs of countries by using the above formula on the standardized data values. Finally, a dendrogram will be formed by the agglomerative, furthest neighbours (Euclidean distance), hierarchic process. The dendrogram shows the process of clustering data and result of clustering. The groups of CED development degree are obtained by furthest neighbours and Euclidean distance clustering.

3. Evaluation the development degree of CEDs

To classify the development degree of CEDs, *Scaling* is selected to make the questionnaire's answers quantitative, and produce scores to measure the development degree of CEDs. The term 'scaling' is applied to the procedures for attempting to determine quantitative measures of subjective abstract concepts. (p257) [52] Usually, a number is assigned to a property of objects in order to impart some characteristics of numbers to the properties in question. [52] In this study:

Objective of scaling is to measure the characteristics (development degree) of respondents. In this case, the emphasis is on measuring differences among the respondents.

Response Scales is classified as categorical (rating) and comparative (ranking). Categorical scales are used when respondents score some object without direct reference to other objects. [52] For example, the question in the questionnaire is "When new equipment is purchased, you are consulted for tender analysis before the purchase," and the four response categories are "Always", "Often", "Sometimes", "Never". Another example, question is "Are you satisfied with reporting authority?" and two response categories are "Yes", "No". Most responses of questions from the questionnaire are categorical.

Response methods: As discussed before, 'rating scales' is selected as the response scales in this study. *Graphic rating scale* is a common and simple form to use. The judge checks his responses or evaluation along a continuum. [52] For example, a question is "How well does

the employee get along with co-workers? (please check)", and the responses are "❑always gets along well ❑sometimes has trouble, ❑often has trouble, ❑always at odds with someone". [52] In our study, most of responses of questions are designed in this pattern, and those responses are also established as structured patterns which mean the order of responses to every question are gradually increasing or decreasing according to certain property of object. This feature makes scoring responses feasible. Here, an example is given to explain the method, the four responses and their corresponding score:

"Always"	4
"Often"	3
"Sometimes"	2
"Never"	1

According to this method, a scoring system (table) of our questionnaire lists the scores that respondents can obtain from each question. (See Appendix D)

Scale Construction technique: 'Arbitrary Scales' is selected to design the questionnaire. *Arbitrary Scales* means that collecting a number of items that researchers believe are unambiguous and appropriate to a given topic, and score each of them. The results may be studied in several ways. Totals may be by individual items, by company, by region depending on research objectives. [52] So, considering to our research objective, we calculate the totals by individual cases that range from 82 to 159. We divide the interval into three parts according to proportions 25%, 50%, 25% respectively. Then the first part is from 82 to 101, which accounts for '0-25%' of the whole interval. The second part is from 102 to 137, which accounts for '25%-75%' of the whole interval. The third part is from 138 to 159, which is the highest level of the interval, that is, it accounts for '75%-100%' of the

whole interval. The three parts stand for the low level, medium level, and high level of development degree of CEDs in some developing countries. All the answers of respondents are scored according to Scoring System table (Appendix E), and calculate their scores of development degree, and then they are classified into the three groups by the development degree scores according to the three intervals. Group-1 number is assigned to the front 16 respondents for identifying which group they belong to. (See table 40)

Group-2 number is gained by calculating Hierarchy Cluster Analysis using the same data source. Figure 11 shows the procedure of Group-2 clustering, and table 40 gives the score of development degree and Group-1 number and Group-2 number of each respondent. Compared with the members of Group-1 and Group-2, Group-2 members are a little bit different from Group-1 members. Although No. 4, No. 10, and No. 13 respondents are clustered in the same group, they are in a different group in Group-1 from Group-2. No.11 and No. 15 are also in a different group in Group-2 from Group-1. The rest of respondents are classified into the same group in Group-1 and Group-2.

Table 40 Score and Group-1 number and Group-2 number of each respondent

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
Score	82	144	132	99	123	150	146	115	120	86	133	145	92	139	131	159
Group-1	A	C	B	A	B	C	C	B	B	A	B	C	A	C	B	C
Group-2	A	C	B	B	B	C	C	B	B	B	C	C	B	C	C	C

Note: A means the respondent is in a low level of development degree of CEDs in some developing countries.
B means the respondent is in a medium level of development degree of CEDs in some developing countries.
C means the respondent is in the large level of development degree of CEDs in some developing countries.

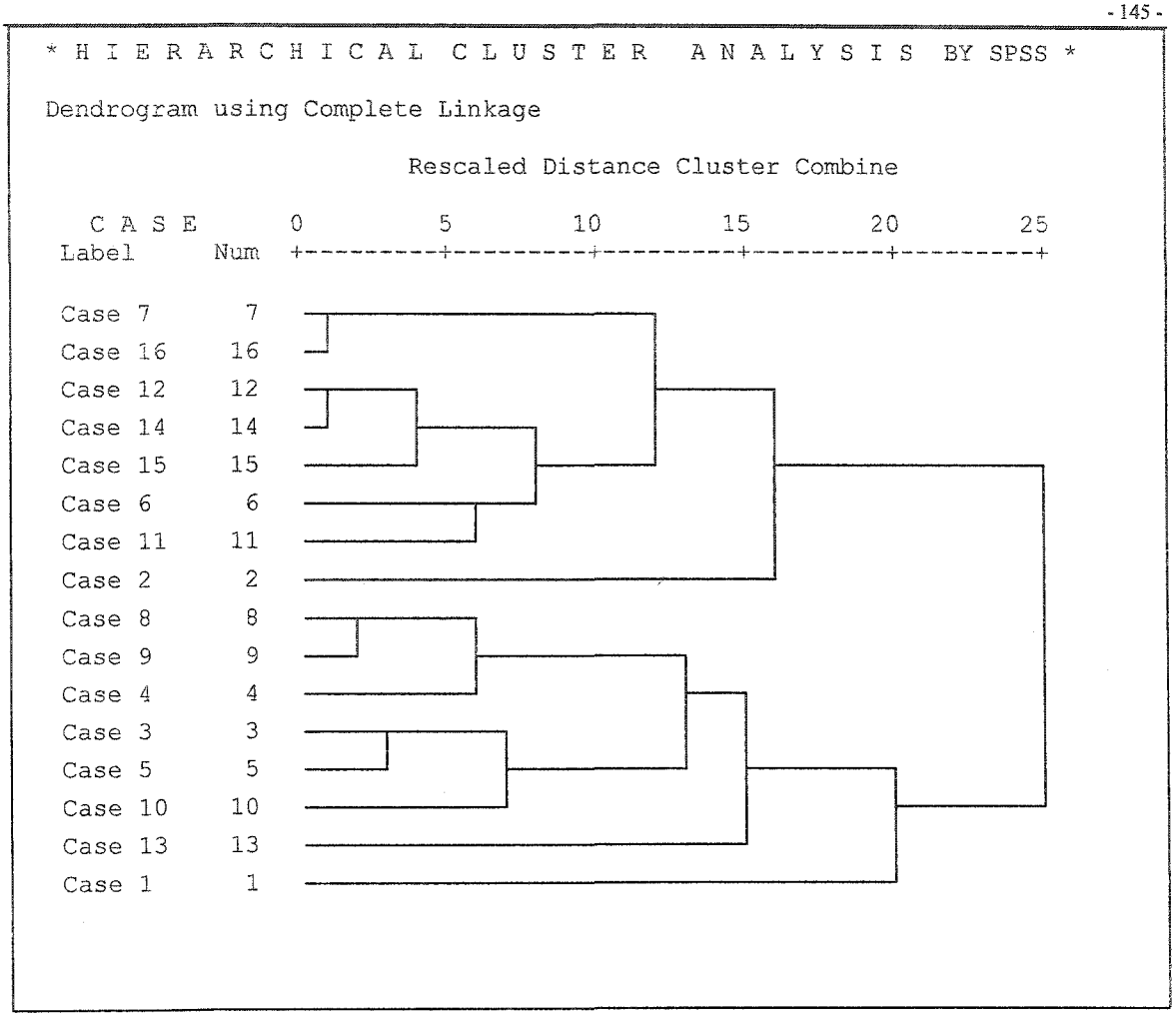


Figure 11 Dendrogram of Hierarchical Cluster Analysis for scoring data

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