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Necessity of Clinical Engineers to Improve Present Health Technology Management in Developing Countries

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Abstract

Developing countries such as Bangladesh, Nepal, Bhutan, Indonesia and so many could not introduce clinical engineering professional (CEP) in health technology management (HTM) science. As a result, they could not establish the safe health technology management. Conversely, CEP has been introduced by developed countries in HTM for about last 35 years long and thereby established a safe health care system. We noticed the continual problem in the health care management system. To overcome this continual problem, we think that clinical engineering professional is very much necessary to proper implementation of health technology management in developing countries in order to ensure the safe health care system. CEP will train to HTM personnel and a safe health care management will be established in developing countries. The modern medical technology will be involved by the proper practice of HTM and CEP. This pioneer professional will keep the whole HTM with good functional condition. Therefore, we conclude that introducing of CEP is badly necessary to improve the existing unhealthy HTM as well as health care system of the developing countries.HTM personnel will understand the necessity of CEP as well as health care planners. This paper will guide to the existing personnel of HTM and help them to understand the importance roles of CEP. Among these counties, the health care technology management system seems to very problematic. Continually, it is observing that the health care technology management performance is twisting with the increase of sophisticated medical devices. Authors firmly believe that an excellent benefit can be obtained by introducing skilled clinical engineers in the health services of developing countries as Bangladesh.

Keywords: low case clinical engineers, developing country, health services, health technology management, medical equipment management

1. Introduction

1.1 Background of the Study

With the rapid growth of medical technology, developed countries (e.g. America, Canada, Japan, Germany) and so many others have been producing clinical engineering professional (CEP) for their hospitals with a vision to ensure the safe and cost effective health care management in their countries about past 35 years. They have upheld the standard health care technology management system (HTM) by employing educated and skilled clinical engineers within their health care organizations. As a result, they have successfully established clinical engineering department (CED) in each level of hospitals and thus they have ensured a standard, safe and cost effective management of their health care assets (Frost & Reich, 2009). Since 1990s, developing countries such as Malaysia, India, South Africa, Jordan and so many others have understood the necessity of skilled clinical engineers for the safe and cost effective health care management. They also have introduced clinical engineering professionalism in their health care management system and thus have improved significantly the health care system in their respective countries (Frize, Cao, & Roy, 2005). It is unfortunate that other developing and underdeveloped countries such as Bangladesh, Nepal, Bhutan, Myanmar, Indonesia and so forth could not

understand the necessity of skilled clinical engineers for the improvement of health care system. This may be due to the lack of awareness and/or less attention is given to the management of healthcare technology. As the result, the health care delivery in these countries could not reach a standard acceptable level (Hossain, Ahmad, & Yusuf, 2014). The authors believe the current condition of the health services in these countries need to be enhanced by the introduction of clinical engineering professionals. We have identified the shortfall in healthcare technology management due to the absence of skilled clinical engineers and biomedical engineering scientists in developing countries as a National Health Service problem.

Developing countries such Bangladesh has been continuing the health care technology management through conventional short trained graduate electrical and mechanical engineers since more than 35 years long (Azad & Sultana, 2014). Ministry of Health and Family Welfare, Government of the People's Republic of Bangladesh have been developed a plan to repair and maintenance of medical equipments and medical devices of public hospitals and accordingly, Government of Bangladesh established an organization and it is named as National-Electro-Medical Equipment Maintenance Workshop & Training Center at Dhaka, Bangladesh since 1983 with 12 graduate engineers, 12 diploma engineers and 36 general technicians but their conceptual ideas are quite incorrect. Because the standard ratio of graduate engineers, diploma engineers and technicians are 1:2:4 (Germani & Hossain, 2013; Hossain, Ahmad, & Yusuf, 2014). Besides, with the increment of medical equipments and health care facilities about 72 diploma engineers and 36 technicians again recruited by the government in 18 greater) districts in 1987. This plan was too incorrect because the ratio of diploma engineer and technicians are found 2:1 instated of 1:2. In spite of increased health care management parameters, engineers and technicians were not recruited furthermore up to date by the government and in opposition most of the engineers and technicians have gone to retirement due to the age limit (Nieto, 1999).

The current performances of conventional electrical and mechanical engineers significantly have been decreased with rapid increased of medical technology The existing conventional electrical and mechanical engineers could not coverage medical technology due rapid growth health care technology. The skilled and knowledge of present engineers in health care system is found about 16% with reference of skilled clinical engineers. (Hossain, Rashid, Islam, & Ahmad, 2015). Considering the reality of present health care management in developing countries like Bangladesh, we are describing the necessity of clinical engineers for the improvement of the health care technology management. In this study, we reflect the data of existing condition of health care technology management through conventional engineers and as well as through skilled clinical engineers. The objective of the study is versatile but key objectives are as follows;

- To make a comparison of performance of health care technology between conventional engineers and skilled clinical engineers
- To encourage the health providers about the benefit from skilled clinical engineers in health care system of developing countries such as Bangladesh
- Health stakeholders understand the necessity of skilled clinical engineers for health care technology.
- The importance link between health care technology and safe health care system.

There is a core relation among skilled clinical engineers, health care technology management and health care system. In the modern medical technology, health care system has been using lots of sophisticated costly medical devices to ensure the diagnosis results and treatments of patients. But a safe and cost effective health care system is very important for patients. Nevertheless, demand of the patients could be met-up without proper management of health care technology management and on the contrary skilled clinical engineers are the actual core manager to manage the health care technology management (Mutia, Kihiu, & Margana, 2012). So, at a glance, it can be concluded that skilled clinical engineers are the key personnel to ensure the qualitative health care system.

We have found that the health care technology in developed and developing countries in globe will be varied on country contexts. Example; most of the developed countries have been manufacturing medical devices since past 35 years and thus they understood the necessity of skilled clinical engineers for the better practice of health care technology (Bauld, 1991). Whereas developing countries such as Bangladesh is fully different from the developed countries and that's why we need to write justification about the necessity of skilled clinical engineers for the better health care technology management system (HTM) in developing countries as Bangladesh. In global skilled CEs are well recognized and as well as this professionals are improving with rapid growth of health care technology (Hummel, Rossum, Varkerke, &, Rakhorst, 2000). The identified problem is very importance for the following reasons:

- Skilled clinical engineers are the most key components of health care technology management and equally

important such as medical doctors and other medical staffs of the health care system

- Health care system is health based health care system could not be run without CE professionals
- Skilled clinical engineers are the key managers of health care management team in hospitals
- Without skilled clinical engineers health care system is unsafe and costly.

Over all skilled clinical engineers are very important to keep safe and cost effective health care system through proper practice of health care management and it is found that the health care system performance declined in a low standard due absence of skilled clinical engineers. From several studies, it can be noted that lots of costly medical equipment & medical devices are being used by developing countries like Bangladesh in the globe (Hossain, Ahmad, Islam, & Rashid, 2012; Sloan, Mathew, & Liberatore, 2003). These equipments and devices are being maintained by the conventional trained graduate engineer in mechanical and electrical (Hossain, M.A., Ahmad, M., Islam, M.R., & Yusuf, M.S., 2014). Therefore, the life cycle of the medical equipment & devices could not be sustained in a standard level (Azad, 2014). Population, hospitals and medical equipment/devices are comparatively more in Bangladesh than other developing countries (e.g. Pakistan, Myanmar, Bhutan, Nepal and so forth). For the convenient of the research, we select Bangladesh as a case study.

We have identified the shortfall in healthcare technology management due to the absence of skilled clinical engineers and biomedical engineering scientists in developing countries as a National Health Service problem. Considering the reality of present health care management in developing countries such as in Bangladesh, we are describing the necessity of CEP to introduce for the improvement of the existing inferior health care services in Bangladesh. Our novel proposal will be helpful to understand the need of skilled clinical engineers in hospitals for the improvement of health care services. It can be used to understand the performance difference of skilled clinical engineers and conventionally trained electrical and mechanical engineers.

This study will also explore the benefit of having skilled clinical engineers and hence assist the health care management policy makers and health service managers to introduce this important technical professional in the health services. Our hope is that a safe and cost effective health care management system will be established in the developing countries as Bangladesh which is presently lacking. In many countries, the health care technology management system seems to be very problematic (WHO bulletin, 2014). Continually, it has been observed that the health care technology management performance could not cope with the introduction and increase of sophisticated medical devices (Liberatore & Nydick, 2015). The authors seriously believe that excellent benefit could be obtained by the introduction of skilled clinical engineers in the health services of developing countries such as in Bangladesh through their excellent practice for a safe and cost effective health care management.

1.2 Description of Relevant Study

The details description was given in subsections 1.2.1 to 1.2.4.

1.2.1 Definition Clinical Engineers

ACCE defines that “A Clinical Engineer is a professional who supports and advances patient care applying engineering and managerial skills to healthcare technology (Gwee & Dyro, 2004). A professional who brings health care facilities a level of education, experience, and accomplishment which will enable him to responsibly, effectively, and safety manage and interface with medical devices, instruments, and systems and the user thereof during patient care (Kuru & Karinca, 2015).Clinical Engineer is a professional who supports and advances patient care by applying engineering and managerial skills to healthcare technology. The department of Clinical Engineering plays an important role beginning from procurement process and facilitates effective management of medical devices, which are especially used in health care facilities. Additionally, clinical engineering department increases life cycle of medical devices, optimizes spare parts and the cost of technical service of medical devices in order to improve the quality of health.

1.2.2 Relation among HCS, HTM, LCMME & CEP

There is coherent relation among health care system, health technology management, life cycle management of medical equipment and CEP (Heesbeen, Eisma, & Hamel, 2012). Figure 1 represents their relation. HCS depends on HTM of a country. But with the rapid growth of medical technology, it is the most important to maintain the life cycle of medical devices through skill clinical engineers and hence clinical engineering is denoted as a foundation of healthcare system. The components of LCMME are shown in Figure 2.

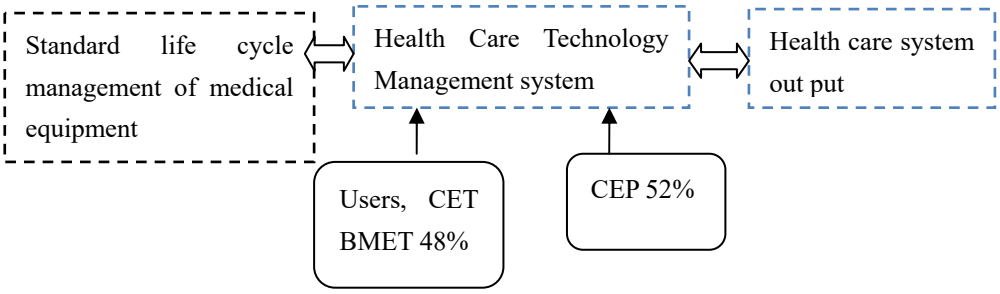

Figure 1. A coherent relation among HCS, HTM, LCMME & CEP

As the CEP is not being introduced by the Government of developing countries likes Bangladesh and that's why HCS of this country is being fluctuated (Mon-Son-Hing, O'Connor, Coyle, Berquist, & McAlister, 2000).

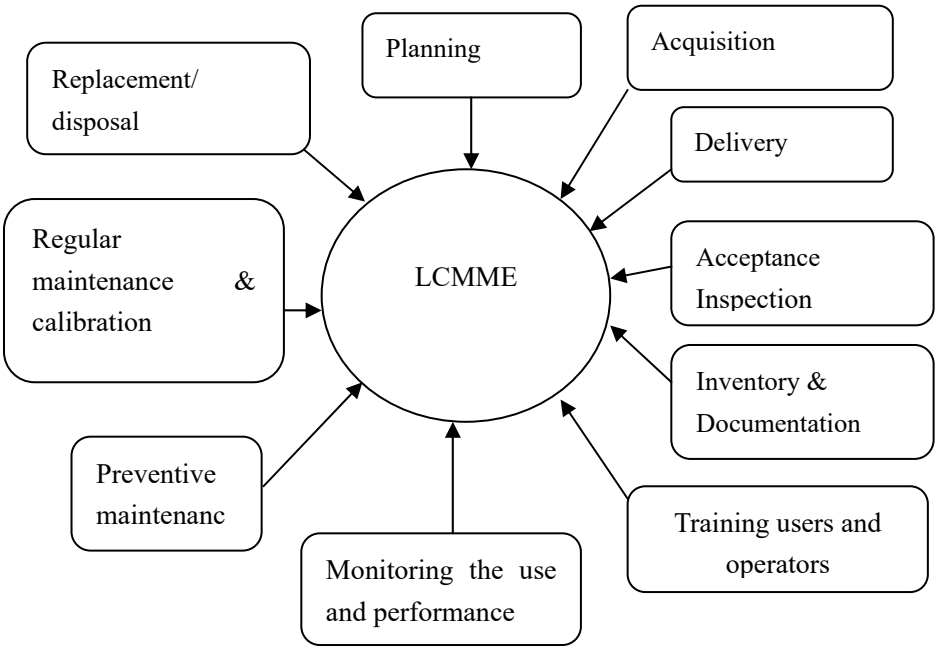

Figure 2. Typical life cycle management of medical equipment

1.2.3 Perquisite Knowledge and Responsibilities of Clinical Engineering Professional in Hospitals

- Knowledge of human anatomy, physiology, electronics, and electro-mechanical, medical equipment operation, troubleshooting, and safety in healthcare facilities
- Develop technical configuration of equipment as clinical needs and knowledge on computer associated software and hardware
- Design and develop installation place and control the hospital environment in 223avour of equipment
- Managerial skilled to manage the biomedical equipment technician
- Analytical skills to determine the cause of equipment malfunctioning /or failure
- Practical skills to repair and perform preventive maintenance of electromechanical equipment
- Ability to write reports and make clear presentations on technical and operational issues
- Interpersonal skills to work effectively with clinical staffs, vendors and fellow engineers

In addition, clinical engineers should play an important role for HTM. As example, clinical engineering department increases the life cycle of medical devices, optimizes spare parts and technical services, costs of

medical devices in order to improve the quality of health care. Hospital in-house clinical engineering department (HIHCED) plays an important role in clinical practices such as cardiac operations, dialysis room, Operation Theater, intensive care unit, as well as in the education of medical doctors and nurses on the use of medical equipment (Sloan, Mathew, & Liberator, 2003; Hossain, Rashid, Islam, & Ahmad, 2015).

1.2.4 State of Art of Hypotheses and Correspondence to Research Design

In order to find out any necessity, it is prerequisite to find out the past and present data analysis about related system and we overview the existing condition of health care technology management system (HTM) and health care system. The performance existing short term trained conventional electrical and mechanical engineers of developing countries as Bangladesh is found poor. Then we compare the results of exciting CTEPs, HTM and with standard systems of CEs, HCTM and HCS. According to results health care providers understand the importance roles of skilled clinical engineers for health care technology as well as for health care system. Finally we recommended the causes of necessity to introduce skilled clinical engineers instead of CTEs for improvement of existing health care technology management for developing countries in the world such as Bangladesh.

2. Method

Literatures review results guide us to understand that the necessity of skilled clinical engineers introduced in the health care technology to ensure safe and cost effective health care system in developed countries. We observe that they follow different logics for introducing the skilled clinical engineers of HTM. The prescribed logics of developed countries regarding the necessity to introduce CEP is seemed well but we assume that there are some basic difference between developed and developing countries of necessity to introduced CEP in HTM to improve the health care system. Because, they introduce CEP in HTM fundamentally but developing countries like Bangladesh, it is very difficult to make understand to the health care system providers. Therefore, our approach will differ with respect to developed countries due to country contexts.

2.1. Sample Map of Methodology of the Study

- Performance difference between CEP & CTEP
- Present performance of HCTM in developing countries as Bangladesh through CTEP
- Performance of HCTM in developed countries through CEP
- Performance of HCM with CEP and without CEP
- Summarize the results on three bullets said in above
- Logic issue to recommendation of CEP introduction in HCTM for safe and cost effective HCM in developing countries such as Bangladesh

In this regard, we approach a block diagram and which is shown in Figure 3.

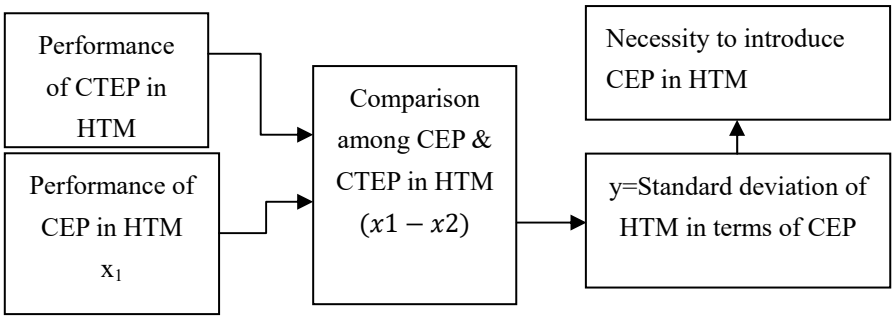

Figure 3. Research design diagram

2.2 Sample Data Collection and Data Analysis

2.2.1. Performance evaluation between CEP and CTEP

In subsection, we compare two professionals based on educational background and skilled. We reviewed literatures and consider country contexts. Accordingly we distribute the score point. The measuring indicators and score points are shown in Table 1. Here we consider 10 different score points to evaluate of two professionals such as CEPs and CTEPs.

Table 1. Performance evaluation between CEP and CTEP based on education and skilled

Standard key course curriculum of CEP	Standard credit score point of CEP	Standard course and skill scores of CEP and CTEP	
		CEP (score point obtain)	CTEP(score point obtain)
Basic Human Anatomy & Physiology	10	Complied (10)	No(0)
Medical Equipment Management	10	Complied (10)	No(0)
Biomedical Signal	10	Complied (10)	No(0)
Biomedical Image processing	10	Complied (10)	No(0)
Biomedical Sensor	10	Complied (10)	No(0)
Bioelectricity	10	Complied (10)	No(0)
Biomedical Instrumentation	10	Complied (10)	No(0)
Hospital Management	10	Complied (10)	No(0)
Prerequisite knowledge on Hospital environment	10	Complied (10)	No(0)
Knowledge on health care technology Management	10	Complied (10)	No(0)
Patient safety and risk management	10	Complied (10)	No(0)
Basic Electronics	10	Complied (6)	Complied (10)
Basic electricity	10	Complied (6)	Complied (10)
PC based computerized skill	10	Complied (10)	Complied (6)
Total score point	140	132	26
Score scale consider	100	Score obtained by CEP 94.28	Score obtained by CTEP 18.57%

The scores are evaluated in Table 1, based on educational background and skill of CEP and CTEP. Hence result is plotted in Figure 4 as percentage.

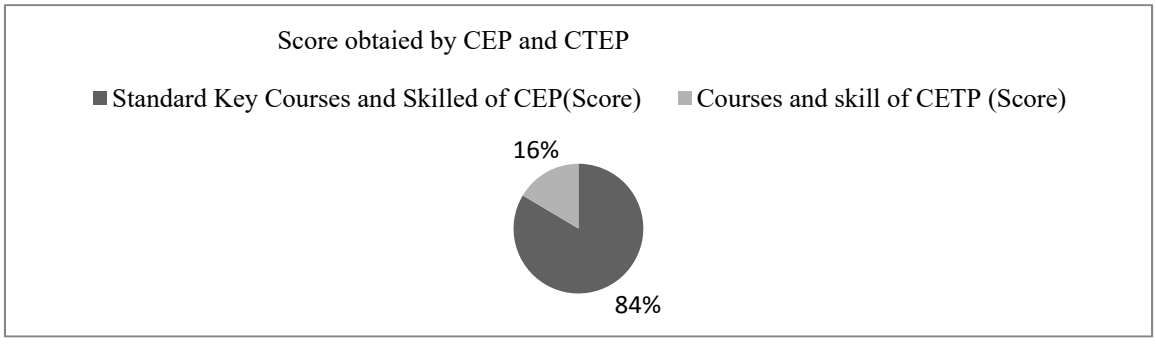

Figure 4. Performance evaluation result between CEP and CTEP based on education and skilled CEP.

From Table1 and Figure 4, we find that CTEP is compiled only 16% course curriculum of CEP. Whereas CEP is 84% is educated and skilled of design course curriculum of standard CEP.

2.2.2 Performance requires from CEP in the health care technology management system for the standard safe and cost effective health care technology management.

According to literature review results, we find that ten key components for the standard healthcare technology

management should be maintained by the health care technology management personnel to ensure standard health care system/ health care management/ health care services. The ten components of HTM are such equipment planning, technology assessment, budgeting, procurement, incoming inspection & acceptance, installation & commissioning, skilled development, operation & safety, maintenance and decommissioning/disposal. More than 15 key medical professionals are involved in standard health care technology management system (HTM). According to the literature review, publications, it is found that the enrolment of CEPs are near about 52% of HTM and remaining 48% are being maintained by the other health technology management system personnel such as clinical doctors, clinical nurses, medical technologists, biochemist, microbiologist, cardiographers, Laboratory technicians, clinical engineering technologists, biomedical technicians and so many (Hossain, Rashid, Islam, & Ahmad, 2015).

HTM should be involved 52% from CEP to maintain the standard HCS and remaining 48% to be maintained by the other medical health care personnel. To fulfill 52% HTM of clinical engineers should have 84% educational background and skilled on life cycle of medical equipment management but we have found that present conventionally short trained electrical engineer/mechanical engineers are 16% efficient instead of 84% of CEP. To find out the present involvement of CTEP with respect to CEP in HTM of developing countries as Bangladesh, We use the following formula.

$$y = \frac{x1}{x2} \times e \tag{1}$$

Whereas, x1= (Existing educational qualification and skilled of CTEP =16%. x2= Standard educational qualification and skilled of CEP=84%, e= Standard require participation of CEP in the HTM=52% out of 100% HTM, y= Present involvement of CTEP with respect to CEP in the HTM. By inserting the said values, we have found the result of y= 9.90%≈ 10%. . Therefore, HTM practice of developing countries such as Bangladesh 10% from CTEP out of 52%. The deviated value of HTM of developing countries from CEP = {Performance from (CEP-CTEP)} = 42%.

2.2.3 An interaction of skilled clinical engineers, HCTM , HCM & Relation with clinical engineering professional and other health care professional

There is sensitive relation between clinical engineer and patient medication. The ultimate goal of healthcare system is to ensure safe treatment/medication for the patients. However, for proper medication, medicines are required to apply on human body on patients. The micro definition of medicine is external appliance of drugs, equipment therapy and behavior therapy through which a patient will be cured (Hummel, Rossum, Varkerke, & Rakhorst, 2000). However, before applying any medicine, accurate results of diagnosis of diseases are very important prerequisite. Clinical engineers will ensure diagnostic result and patient treatment through equipment by applying his engineering knowledge in advance patient care (Dolan, 2000).

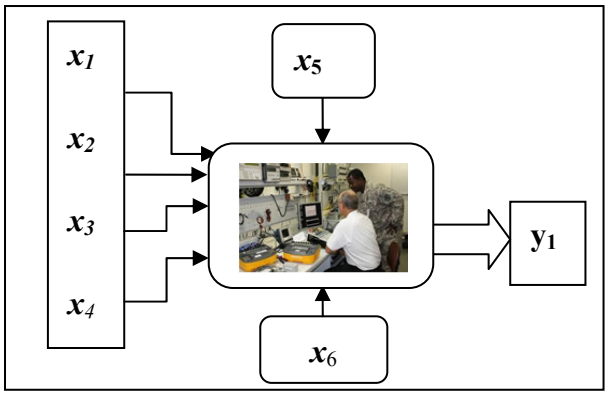

Figure 5. Diagnostic results of patients from equipment

Mathematically, the effect and contribution of CEP in the medication field the following equation can be used for analyzing the medication of patients in terms of some important parameters.

$$Patient\ Medications = \sum_{i=1}^{4} y_i \tag{2}$$

Where, y_1 = Diagnostic Results; y_2 = Drug; y_3 = therapy from instrument; y_4=behavior therapy.

Diagnostic result from medical equipment: (i) Measuring & recording equipment were used to find out abnormality of physical organs of human body such as, ECG, EEG, medical ultrasound, automated analyzers, medical microscope medical X-ray, CT scanner, MRI etc. (ii) Healing through instrument is grouped as therapeutic equipment such as, physiotherapy, cobalt-60, pacemakers, linear accelerator, intensive care ventilator, surgical diathermy, medical suction machine, medical nebulizer, and so many. The situation is illustrated in Figure 5. The method for correct diagnostic result interface of medical measuring equipment with clinical engineering professionals is given by the following proposed expression.

$$y_1 = \sum_{i=1}^{6} x_i \quad (3)$$

Where, x_1= stable power source, x_2 = equipment calibration, x_3 = regular maintenance, x_4 operator's skill, x_5 = room temperature control & humidity control, x_6 = clinical setting. In Eq. (2), y1 is diagnostic result of a patient and y_1 is the sum of six parameters. These six parameters are prerequisite to get the correct result from diagnostic equipment which is shown in Figure 5. Therefore; it is reasonably found that all six parameters are integrated with skilled clinical engineers.

2.2.4 Current Status of Clinical Engineers in the Health Care Technology Management System of Bangladesh

From the present data and record of government of Bangladesh, there is no qualified clinical engineer in the health care system in Bangladesh government. Only 13 numbers of CTEP have been working in the health services since 1983. With the rapid increase of medical devices, government of Bangladesh did not recruit engineers in health sector furthermore. From the result of contextual work (WHO bulletin. 2014), we find that the number of CEPs is depended on some factors which are stated in blow:

- Number of medical devices
- Number of health facilities
- Amount of capital investment for medical equipments
- Number of health care technology personnel

We find that all mentioned parameters are increased more than threefold but engineers are not increased any more. At present a very few graduate engineers are working in health services of Bangladesh Government against 13 numbers of sanction posts. Information is represented in Table 2 to apprehend the past and present situation about health care engineering status in health services of Bangladesh Government.

Table 2. Scenario of CTEP in the health care technology management for the past 30 years (Hossain, Rashid, Islam, & Ahmad, 2015: Frize, Cao, & Roy, 2005)

Year	Number of Medical devices	Required corresponding CEP	CTEP statues/ employed/ posted
1985-1990	8000	40	13
1990-1995	12000	60	12
1995-2000	20000	100	8
2000-2005	30000	150	6
2005-2010	36000	180	4
2010-2013	48000	240	4
2014-2015	60000	300	1

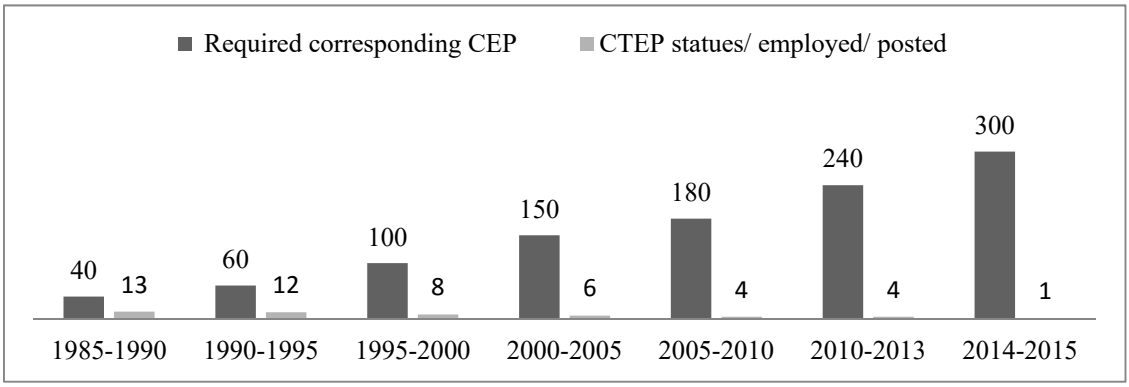

Figure 6. Scenario required CEPs versus appointed CTEPs in health care technology management for the past 30 years of Bangladesh Government

From existing data analysis, we find that the Government of Bangladesh created the 13 numbers of posts for CTEP but from 1995-2015 most of posts were vacant. Not only that, health planners could not consider engineers for HTM to maintain HCS (Germani & Hossain, 2013). From Figure 6, we have found that HTM of Bangladesh was incorrect from begging. Presently HTM situation is going to be eliminated with respect to increase of medical equipment. The present situation is treated as chronic problems for the health services of Bangladesh. Considering the country contexts and other health care management facilities, about 350 numbers of clinical engineer should be recruited by the health sector of Bangladesh Government. However, to understand the involvement of CEP in HTM is required to calculate. For the calculation CEP input in HTM, we use the following formula,

$$y = \frac{n1}{n2} \times 52\% \tag{3}$$

Whereas, y = Present in performance of HTM from CEP views, n1= number of existing CEP =2 and no other engineers in HTM in the public health sector of Bangladesh government, n2= required number of CEP=350. From equation, we have found the value of y =0.295. Therefore, present performance of CEP in HTM of Bangladesh government HTM = 0.30% only out of 52%.

3. Results

3.1 Staffing & Data Collection Procedures

Our goal of the study is to assess the necessity to introduce of CEP to improve accessible health care technology management system (HTM) in the health care management for developing countries. With this aim, we have collected collect data, information and other relevant documentation from different sources. In this connection we take the help of national and international biomedical consultants for the past 8 years. We also engage near about 50 numbers of students from polytechnic colleges in Bangladesh and all trainee students were in electro medical engineering trade (diploma engineering final year student). Besides, we (have gathered information) take information from local vendors of medical equipment manufacturers and suppliers of developed countries and we have been conducting training of health care technology personnel such as MT, Users, Nurses, technicians, Diploma engineers and trainee students from Polytechnic colleges of Bangladesh too. Data has collected in reference of standard godliness. Raw data is processed by a group of engineers, medical doctors and other medical professionals.

3.2 Statistics and Data Analysis

In introductory section, the importance roles of CEP for the standard practice of HTM are described briefly. From section 2 and its subsections we find that the performance difference of CEP and CTEP is 68% with reference of educational back ground and skilled. Average performance and intelligence of CEP for the HTM is 42% better than CETP out of 52%. Without CEP, it is not possible to provide medication to the patients. We calculated the requirement of CEPs to improve present inferior HTM of Bangladesh. To meet up the 52% HTM from CEPs a minimum 350 numbers of CEs will be required. Nevertheless, presently HTM of Bangladesh Government has only one CEP and no other CTEP is present in HTM (Hossain, Rashid, Islam, & Ahmad, 2015). The existing involvement of CEP in HTM is 0.148% only from clinical engineering point of view in Bangladesh.

Table 3. Scenario of HTM practice of CEP in the health care technology management of Bangladesh for the past 30 years with respect to standard

Year	Number of Medical devices	Required CEP(M)	CTEP statues/ employed/ posted(N)	HTM practice=(N/M)×52%
1985-1990	8000	40	13	16.9
1990-1995	12000	60	12	10.4
1995-2000	20000	100	8	4.16
2000-2005	30000	150	6	2.08
2005-2010	36000	180	4	1.15555556
2010-2013	48000	240	4	0.86666667
2014-2015	60000	300	1	0.17333333

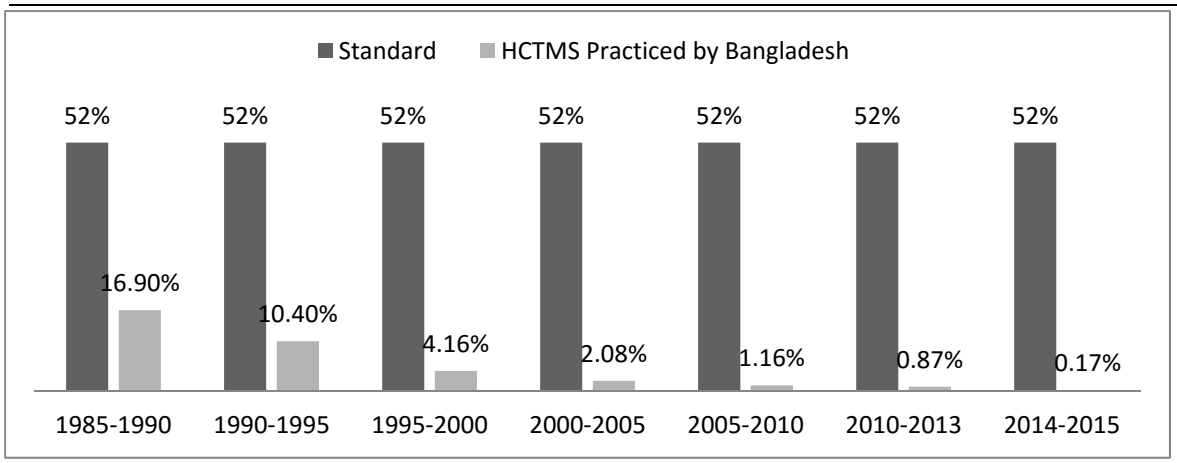

Figure 7. Present involvement of CEP with respect to standard involvement of CEP in HCTM Bangladesh for HCS

Health care management of a country depends on the skilled clinical engineers. From the analytical result, it is logically gauged that the present performance of healthcare technology system of healthcare system of Bangladesh Government is very negligible. Because, HTM of Bangladesh is divided into two parts such as, HTM = {(CEP+ (end-users of medical devices+ BMET)}. HTM cycle indicates that HTM of (end-users of medical devices+ BMETs) is directly proportional to CEP. Therefore, we can conclude that HTM performance is very trifling in the healthcare system of Bangladesh government. In this study, we see that the existing healthcare technology management share of CEP of government of Bangladesh is only 0.17% out of 52% which is shown in Table 3. A terrible condition is presented by the national news frequently due to negligible performance of HTM in the health services of Bangladesh Government (Germnai, & Hossain, 2013; Barbuda. & Islam, 2010). From the results and discussion we proclaim that this situation is not developed in a day and this gap are being carried over by health planers since past near about 30 years. As the records, we investigate the past situations of HCTM and its data and information are shown graphically in Figure 7. Finally, research results prove that without CEP, HCTM of health services for any country could not be sustained

3.3 Ancillary Analyses

There is no In-house clinical engineering department in any hospitals of Bangladesh. Not only that any in-house engineering department is not being developed by the health planners due to lack of their awareness and less attention. In this concerns lots of consultants from different development agencies and partners to improve the HTM practice in the HCM but we observed their reports. In their submitting reports we find that only they have mentioned biomedical engineers are important for HCM but they did not explain causes. Moreover, we seemed that they did not provide any sufficient information regarding CEP or CED. We are informing that two public engineering universities such as Bangladesh University of Engineering & Technology (BUET) and Khulna University of Engineering & Technology (KUET) have been started the under graduate course on biomedical engineering in 2015-16 session. Clinical engineers, clinical engineering technologists and biomedical equipment technicians are the key personnel of clinical engineering department but there is not public or private institute or training center in Bangladesh.

3.4 Summary of Results

To get the results of research, we have used three subsections such as 3.1, 3.2 and 3.3. The following results are evidenced in this section.

- Importance of CEP for HTM is totally unknown to the health care system of Bangladesh Government due to lack of awareness and less attention.
- Table 3 and Figure 7 are showing that HTM of Bangladesh is introduced by CTEP with inadequate number with respect to number of medical devices.
- We can ensure that health care technology management practice from conventionally engineers were incorrect method.
- From Figure 7 and Table 5, it is seen that conventional graduate engineers were being recruited by government were inadequate numbers for the past 30 years. The involvement CEP for standard HTM from 1985 to 2015 is found 16.90% to 0.17% which is fluctuating. Nevertheless CEP involvement in HTM should be constant for the standard health care system of any country.
- Health care management system personnel and health care planners did not give deep attention to make a liner relation among the health care technology management system personnel of Bangladesh Government for the standard health care management.
- From the data of Directorate General Health Services of Bangladesh Government, It found that health facilities and other health care personnel and co-medical personnel were increased linearly. Whereas, number of conventional engineers are decreased as well as conventional technicians decreased.
- Presently only one biomedical engineer, 6 number of diploma engineers and 36 number of general technicians are involved in the HTM centrally. Besides, about 72 conventional diploma engineers and technicians are working in the 18 greater districts of Bangladesh instead of 350 CPEs, 700 CTEs and 1400 BMETs.
- During training we find that most of diploma engineers and technicians of government health care system are aged and bearing backdated analogue technology. Average age of all technical person about 54 years and they could not catch up modern medical technology
- According to data and literatures review we conclude that HTM practice from the engineer is found 0.17% only out of 52% from CEP. In this research we see that involvement of CEP in HTM in developing countries such as Myanmar, Nepal, Bhutan and so forth are inferior condition and comparatively we find CEP participation in HTM of Bangladesh is very terrible

4. Discussions & Conclusions

From the data analysis and review results, we have found that the standard HTM from CEP input is that average about 52% of HTM is maintained by CEPs for ensuring the health care system of any country. Whereas developing countries such as Bangladesh the CEP practice is 0.17% only present in HTM. Nevertheless, about 0.17% HTM is achieved by the existing HCS of Bangladesh Government from CEP. HTM of developing countries could not improve due some reasons which are mentioned in below;

- No research center is yet opened by the health care system planers and due to lack of awareness of health planers CEP is not produce and introduce in the HTM for standard health care system in developing countries like as Bangladesh.
- Conventionally trained electrical and mechanical engineers are claimed themselves as biomedical / clinical engineers and as the result, medical professionals and health planers are not getting real messages about CEP.
- Besides, medical equipment manufactures and vendors have given authorization to the local agents without proper judgment. We think that present 0.17% HTM input from CEP is very negligible for HCS of Bangladesh Government.
- It is very urgent requirement to convey the message towards healthcare stakeholders.
- In this regards, Ministry of Health & Family Welfare, Government of Bangladesh, arrange national and international seminars/conferences/workshops.
- Skilled clinical engineers can be hired in seminar /conference/workshop as keynote speakers from abroad.
- It is crying need to ensure the participation of health care managers from each level of public hospitals,

CTEPs, private hospitals, international development partners and agencies in the seminars/conferences/workshops.

- The said program can be conducted by the GOB fund/development fund/donor's fund.
- After understand the necessity of CEP for HCS about 350 numbers of CEP will be needed to recruit by Government of Bangladesh.
- However, practically, it is not possible to get and recruited 350 numbers of CEP in Bangladesh at a time.
- It is recommended to recruit at least 100 graduate engineers from different trade such electrical, electronics, mechanical, computer and chemical, medical physicists as apprentice.
- One-year national diploma certificate course on clinical engineering can be designed by skilled CEs/BMEs for the apprentice engineers by training center of NEMEMW & TC under the Ministry of Health and Family Welfare and Private health care technology Organizations like as Malaysia.
- This standard training center will be affiliated with Public Engineering Universities and hospitals to train them and within short time CEP can produce and introduce.
- In this concern, a project can be initiated or launched by Ministry of Health & Family Welfare, Government of Bangladesh as soon as possible.
- After one year, the HTM from CEP will be improved about 17% out of 52%.It means that 17% HTM practice from CEP will be merged into health care system/ health services of Bangladesh Government and then they will trained other health care technology personnel of health care system.
- From results, we find that 48% HTM practice is owned by other health care personnel. Health care technology personnel are linearly related with CEP. Therefore, with the increase of 17% HTM from CEP, rationally 16% HTM will be increased automatically by other health care personnel as the Excellency and skilled CEs
- Subject to implement the our recommendations, we firmly believe that within 2 years the HTM practice will be improved 33% through creation of CEP in developing countries such as Bangladesh. Consecutively HTM will be improved with the improvement of CEP.
- We firmly recommend that no other alternative to improve the existing HTM without producing and introducing CEP in developing countries. Nevertheless, the concept on CEP is very new and its important roles for HCS are unknown to the healthcare system personnel too. Therefore, to make them understand, recommendations are being specified here by us and we firmly believe that HCTM will be improved subject to produce and introduce CEPs in developing countries like Bangladesh
- We firmly believe that the present terrible condition of health care management of Bangladesh will be improved subject to implement of recommendations and in this connection; we will appreciate to the publishers to publish the paper in wide range in globe.

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Appendix A

Abbreviations/ nomenclatures

BMET: Biomedical Equipment Technician

CE: Clinical Engineer

CEP: Clinical Engineering Professional

CTEP: Conventional Trained Engineering Professional

CMSD: Central Medical Store Depot

DEMEW: District Electro-Medical Workshop

DGHS GOB: Government of Bangladesh

Directorate General of Heath Services

HTM: Health Care Technology Management System

HTM: Health Technology Management

HCM: Health Care Management

HCS: Health Care System or Health Care Services

MoH & FW: Ministry of Health & Family Welfare

NEMEMW & TC: National Electro-Medical Equipment Maintenance Workshop & Training Center

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