Clinical Engineering Approach to Improve Healthcare Technology Management for Enhancing Healthcare Delivery System in Middle Income Countries

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Abstract- This paper discusses and presents implantation of healthcare technology management cycle (HTMC) to enhance the healthcare delivery system in the middle-income countries like Bangladesh, Bhutan, Nepal, Indonesia and Myanmar etc. With the rapid development and adoption of medical technology, the developed world has improved their care delivery system through large part structuring of healthcare delivery system that is based on establishing HTMC Organization like clinical engineering department for hospitals and Directorate of Healthcare Engineering Department at Central level. This contributed to assessment and implantation of appropriate healthcare technology since past 30 years. Countries like Malaysia, India, Jordan and South Africa etc. also have taken initiative to enhance HTMC in their respective countries by introducing clinical engineering department as well as medical regulation body under Public Healthcare Ministry since 2000. Whereas, economically unsteady middle-income countries like Bangladesh is not yet introduced any single clinical engineering department to practice or implement of HTMC. As a result, we have examined that the present state of healthcare delivery system of middle income countries without adequate HTMC have been facing significant problems. Some key problems are represented assist to understanding of the implement of HTM practice in healthcare delivery system to enhance healthcare delivery performance: Our findings: The medical equipment life cycle management in the middle-income countries like Bangladesh has been planned by the medical doctor dominated administration as well as traditional engineers and technicians. Moreover, the number of traditional engineers and technicians are very negligible with respect to number of medical devices. The existing system ratio is capable to maintain only 10% breakdown maintenance of medical devices in Bangladesh. We have discussed with present HTM personnel of this country through several national seminar and symposium and we did not find any HTM manger in healthcare delivery system, that able to explain the necessity of HTM and CE for enhancing the healthcare delivery system. We have examined that the risk factors from the medical equipment increased and it is continually present due to lack of clinical engineering skills in maintenance, calibration and clinical settings. Moreover, equipment with undiagnosed faulty error equipment has been providing unreliable diagnostic results, which is hampering patient care in terms of outcomes money and time. Unplanned maintenance increased the frequent breakdown of medical devices and which has been experienced inpatients during interventions at the surgical room. Due to chronic lack of maintenance desired life span of equipment could not be obtained. These factors seriously affected patient outcome services as well as drained our national economy. In this perspective, this very important issue presents problems that’s required to data collection and action. Our proposed research is investigating the present situations of HTM with and without clinical engineering department as well as healthcare engineering department in the central level. We collect data from healthcare organizations which are related to HTMC and healthcare delivery system. As it was established, healthcare delivery system comes under the spotlight of HTM as well as healthcare engineering department and hence, thus we submitted a complete proposal to enhance the HTM in middle income countries like Bangladesh. We focus deriving the benefits from introduction of clinical engineering department bringing healthcare stakeholders together to support the training of clinical engineers and establishment of clinical engineering department that can introduced in healthcare organization to practice effectively in the HTM field. We confidently believe that our proposal brings a good impact of healthcare management system in middle income countries like Bangladesh. Subject to the implementation of our proposal, the healthcare delivery performance will be safer and more cost effective. It concluded that clinical engineering department was
very necessary the introduce enhancement to the HTM practice in the middle-income countries like Bangladesh since 2008.

**Keywords**— clinical engineering, clinical engineering department, healthcare delivery system, healthcare technology, & life cycle of medical equipment.

I. INTRODUCTION

A. Background of the study: Over the years, traditional healthcare has increasingly become technology driven for the enchantment of quality of care. This is why; most of the countries in the world gave unending attention toward healthcare technology. From Literature review results, we have found some key notations regarding healthcare delivery system (HCDS) and healthcare technology management cycle (HTMC) [1-2]. Findings are presented in this section like as- (i) the aim of the healthcare system of developed world was to ensure safe and cost-effective patient care through the optimum utilization of healthcare technology, (ii) but application of healthcare technology became very much complex with rapid growth of medical technology. For the reasons developed world felt difficulties to solve the complex problems of the healthcare technology. After long debates, they produced and introduced clinical engineers to solve the complexity of the healthcare technology since 1991 [3-4]. Today’s healthcare technology is driven by clinical engineers in the developed and most of the developing countries (e.g. Malaysia, India, South and South Africa, etc.) [5-6]. For the safer and cost-effective use of the medical devices are being referring by medical technology, World Health Organization (WHO) and many developed countries have been structured the healthcare technology by nine important components or phases to enhance quality of patient care.

![Diagram of Healthcare Technology Management Cycle](image)

**Fig. 1. HTMC for HCDS for middle income countries like Bangladesh**

This structured is defined as healthcare technology management cycle and According to guidelines of WHO and our country contexts, we include one key phase of HTMC like engineering audit for accountability for safe use and cost-effective maintenance of medical equipment. Thus, we have presented a customize version of HTMC for the middle-income countries like Bangladesh and which represents in Fig. 1 [5, 7].

From Fig. 1 shows that each of the phases healthcare technology management cycle (HTMC) relates with special types of engineering educations and skills. We have seen the publication of ACCE and find the definition of clinical engineering [8]. Consecutively, many countries define and design the responsibilities of clinical engineers. All definitions and roles of clinical engineers completely comply with the requirements of HTMC [9]. Of course, biomedical engineering education is also for HTMC. But from definitions and roles, we have seen that clinical engineering is very much closer to the patient care than that of biomedical engineering education. When a biomedical engineer wishes to do job in the hospital then he or she should have skill on HTMC cycle. It means that a biomedical engineer can do the job in the healthcare organization after completion a comprehensive training course or accredited certified course [8-9]. In the recent years, ACCE, IFMBE and so many organizations/ institutions have been providing this accredited certificate to the biomedical engineers to build their carrier in clinical engineering professional (CEP) and thus they have been producing and introducing CEP in many countries to fulfill the healthcare requirements. Moreover, we have seen that most of the countries have giving the opportunity to other engineering disciplines (e.g. BS in EEE, ME, CSE, Physics, Chemistry, IPE and so on) as academically to build their carrier in clinical engineering [8]. However, clinical engineer and appropriate implementation of advanced health technology were integrated to enhance the patient care over the years and it was ethically established in many countries [6]. We have observed that excellent outcomes have been obtaining the healthcare organizations by the interactive roles of CEs and HTMC and continually. Moreover, we have seen that healthcare system of many countries reformed their healthcare system by healthcare engineering directorate (HCED) as well as clinical engineering department in the modern hospitals and thus they have enhanced their patient care [10].

Despite the further improvement of affiliation among CE and HTMC are yet needed to desire by the technical advanced countries and many developing countries, middle income countries like Bangladesh could not produce and introduce any CE in any level of healthcare delivery system for the safety use and cost-effective maintenance of medical devices. From the recent publication and configuration of healthcare regulatory authority, we have seen that many directorates have been included to reform healthcare delivery system in middle income countries like Bangladesh. But we do not find any notation of HCED and it’s seemed to be continually. Despite the rapid increment of medical devices...
for enhancing the healthcare delivery system, any clinical or any conventional engineers were not employed by the healthcare regulatory authority in Bangladesh, healthcare providers could not yet any develop any operation plan to produce and introduce CEP. We have observed that this unwanted situation was happened due to lack of awareness or less attention of the present healthcare planners. Besides, we have reviewed journals and health bulletins of Directorate General of Health services in Bangladesh but we do not find any article regarding healthcare technology assessment and importance roles of clinical engineering. The current status of HTMC in Bangladesh is found very much unpleasant. We are observing that a server unpleasant condition of HTMC is continuing due to absence of HCED and CED but healthcare provider organizations are yet becoming industrious to procure new medical devices without considering life cycle of medical devices and it is continually [11]. The present situation of medical devices of healthcare care system is shown in Fig.2.

![Fig. 2 Scenario of medical equipment in the public Hospital of Bangladesh (Source) [12]](image)

From discussions and statements, it has seen the patient care from medical devices in the public hospitals of Bangladesh was very unpleasant and it is continually. Here we have noted some sever problems regarding patient care in the public hospitals of Bangladesh. We show in as problem statements.

B. Problem statement

(i) The risk factors from the medical devices have increasing due to lack of calibration and preventive maintenance. Authors in [13] stated that ICU patients in this country has faced more than 65% risk from ICU Ventilators.

(ii) Breakdown rates of equipment are more than 50% and repairing procedure is very longer. As a result, admitted surgical patients stayed in the hospitals for long time [14]. Undesirable breakdown and longer breakdown time have been increased sufferings of poor patients and it is continually.

(iii) Most of outpatients are very poor and they become unavoidable to move toward lower class private clinics or hospitals but they lost their money only without any quality of care [15].

In this perspective, this very important issue presents problems that’s required to data collection and action.

II. METHODS AND MATERIALS

A. Aim/Goal of the research

The main aim of our study is to enhance healthcare delivery system in developing countries like Bangladesh by implementation of HTM practice. Our proposal enhances HTM practice by introducing CED and HCED. Thus, the enhancing HTM will ensure the safer and cost-effective healthcare delivery performance in this country which is presently found as very unpleasant.

B. Research Methodology

We consider the following steps:

- Measure the performance of HTM by present system and compare it with standard HTM by CED and HCED
- The difference will be needed to enhance
- The enhancing HTM will enhance the HCDS in middle income countries like Bangladesh
- Analyze the appropriate staffing for HCED & CED,
- Finally, we will command for establishing HCED for national level to regulate and monitoring activities and performance of CEDs.

C. Methodology of data collection

Data has been collected from eight hospitals of Bangladesh. We have been selected four public hospitals and four private hospitals in Bangladesh. Here G & P represent government hospital & private hospital respectively. G1/Dhaka Medical College Hospital (DMCH), G2/Shahed Shurawardy Medical College Hospital (SSMCH), G3/National Institute of Cardiovascular Diseases (NICVD), G4/National Institute of Neuroscience (NINS), P5/National Heart foundation, P6/Birdem, P7/Square Hospital, & P8/Apollo Hospital.

<table>
<thead>
<tr>
<th>Position</th>
<th>Hospital</th>
</tr>
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<tbody>
<tr>
<td>Head of ICU</td>
<td>G1 x G2 x G3 x G4 x P1 x P2 x P3 x P4</td>
</tr>
<tr>
<td>Physicians</td>
<td>x x x x x x x</td>
</tr>
<tr>
<td>Nurses</td>
<td>x x x x x x x</td>
</tr>
<tr>
<td>Technicians/Engineers</td>
<td>x x x x</td>
</tr>
</tbody>
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We have visited these eight hospitals for two months (10 January to 12 March 2017). OT, ICU and Emergency ward were included in this visit. The category of participants and hospitals are shown in Table 1.

Four problems have been addressed in the problems section. We have given deep attention toward the patient safety to minimize the risk factors from medical equipment in ICU as case study. The study collected information to identify the flowing indicators such as: (i) equipment failure, (ii) failure to see results of the test, (iii) errors in the performance of equipment operation, (iii) error in the
administrating treatment and (iv) delay in treatment due to equipment disorder, malfunction, system failure, inadequate monitoring or follow-up equipment performance. In addition, information on the influence of leadership, risk awareness and workplace condition was collected. Moreover, we evaluate the present performance of NEMEMEW & TC and DHGS on HTM and it will be compared with standard system. We use cell phone and audio recorder to record information. No in-house CED or any Engineering department was not found during visits in any government hospitals.

D. **Patient risk factors from ICU medical devices due to absence of clinical engineering department**

We take four data such as contamination of medical equipment, instant failure of ICU equipment, wrong data and human operating errors from medical equipment. From the public hospitals, we show the risk factor from ICU equipment and related with hospital in-house clinical engineering department. We collect data from four government hospitals and four private hospitals in Dhaka city of Bangladesh. We have found less risk factor from the ICU equipment in the private hospitals. The risk factors cum CED clinical engineering department support in the public hospitals are shown in Fig. 3.

Figure 3 shows that the rate of failure of ICU equipment is very high. Data shows that average failure case ≈ \( \frac{\text{Number of equipment failure}}{\text{Total number of equipment considered}} \times 100\% = 70.27\% \) (1) Period of data collection and data analysis, January 2017 to April.

E. **Healthcare Technology Performance in Bangladesh**

Referring to [12], the data is represented in Fig. 4. In [12], we have seen that the posts for CED and HCED are required more than existing. We represent the data of technical manpower for appropriate implementation of HTM practice in Fig. 9 to enhance the present unpleasant HCDS in Bangladesh. According to publication in [12], the data is represented in Fig. 5.

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\text{HTM performance for HCDS in Bangladesh =} \frac{\text{present number of staffs}}{\text{required number of staffs}} \times 100\% = \frac{143}{4200} \times 100\% = 3.40\%.
\]

III. **RESULTS AND DISCUSSIONS**

Health care technology practice depends on the clinical engineers, number of CEDs and Healthcare Engineering Directorate for regulation of medical devices. We have reviewed the data to determine the numbers of CEP for the standard practice of HTM in public healthcare system. 143 posts for NEMEMEW and DEMEW were created by the healthcare regulatory authority since 1984. Despite dissimilar quality and education of present s with respect to CED and HCED staffs, we consider them as CE, CET and BMET. Whereas, presently 143 posts are found for HTM in HCDS of Bangladesh. Therefore, the HTM practices in health care management in middle income countries like Bangladesh is very much poor. It seems that HTM practice for HCS from the contribution of CEPs is being denied by the health care planners for Bangladesh. Considering, the real situation of HTM practice for HCS, authors are firmly opinioned that HCS performance from the clinical engineering aspects are very much poor in Bangladesh. Bangladesh is functioning in a substandard and it will be more terrible. We therefore conclude that it is extremely necessary for Bangladesh to produce and introduce clinical engineering professional to improve the current health care system.

IV. **CONCLUSIONS**

From above data Tables and data analysis, we have found that the patient risk factors are very high from the medical equipment and most of medical equipment is not functioned. It means that quality of care from the clinical engineering aspects in the middle-income countries like Bangladesh. We
have seen that the patient care from medical equipment in the middle-income countries is found unsafe, unreliable and costly. These factors are deeply related with absence of maintenance, calibration, clinical settings of medical devices in the public hospitals in Bangladesh. But these three indicators are the phases of healthcare technology and life cycle of medical devices. We have seen that maintenance, calibration and clinical settings were designed during equipment planning and procurement and in procurement plan, installation, and commission, equipment incoming inspection, equipment acceptance, test run, skill development plan, inventory, documentation, maintenance such as annual/ framework/ comprehensive maintenance, safety operation procedure was planned by Healthcare Engineering Directorate as well as Clinical Engineering Department. But in our country, healthcare regulatory authority is yet not included this core department to regulate medical devices. From results and discussions, we have found that HTM of middle income countries like Bangladesh is very inferior due to the absence of clinical engineering professionals. As a result, health care management of developing countries like Bangladesh has been seriously affected. It is an urgent issue to produce and introduce clinical engineering professionals to improve the present horrible health care delivery system of middle income countries like Bangladesh. We completely believe that with the increase of clinical engineering professionals, the health care delivery system of middle income countries will considerably improve. Quality of care is the aim of the healthcare system. To ensure quality of care, it is very necessary to introduce CED in each level of public modern hospitals and HCED is very much needed to establish at national level to regulate medical devices, activities of CEDs as well as to make a good bridge with MUDs and other healthcare regulatory organizations under the public Ministry in Bangladesh.

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**REFERENCES**

8. ACCE Definition, WHO
12. Health Bulletin 2014. Published by DGHS, Dhaka, Bangladesh
13. WHO bulletin (2014). Life cycle of medical equipment management system. WHO Regional Office for Europe UN City Marnorvej, Copenhagen, DK-2100, and Denmark.

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