

Improving Health Care and Patient Safety at the ICU by Using Innovative Medical Devices and ICT Tools: Examples from Bangladesh

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Abstract—Innovative medical technologies offer more effective medical care, with less risk to patient and healthcare personnel. Medical technology and devices when properly used provide better data, precise monitoring and less invasive treatments and can be more targeted and often less costly. The Intensive Care Unit (ICU) equipped with patient monitoring, respiratory and cardiac support, pain management, emergency resuscitation and life support devices is particularly prone to medical errors for various reasons. Many people in the developing countries now wonder whether their visit to hospital might harm rather than help them. This is because; clinicians in the developing countries are required to maintain an increasing workload with limited resources and absence of well-functioning safety system. A team of experts from the medical, biomedical and clinical engineering in Sweden and Bangladesh have worked together to study the incidents, adverse events at the ICU in Bangladesh. The study included both public and private hospitals to provide a better understanding for physical structure, organization and practice in operating processes of care, and the occurrence of adverse outcomes the errors, risks and accidents related to medical devices at the ICU, and to develop a ICT based support system in order to reduce hazards and errors and thus improve the quality of performance, care and cost effectiveness at the ICU. Concrete recommendations and guidelines have been made for preparing appropriate ICT related tools and methods for improving the routine for use of medical devices, reporting and analyzing of the incidents at the ICU in order to reduce the number of undetected and unsolved incidents and thus improve the patient safety.

Keywords—Accidents reporting system, patient care and safety, safe medical devices.

I. INTRODUCTION

MEDICAL devices are intended to improve quality of diagnosis and treatment, increase health care efficiency, quality, safety and reduce cost. But, it may also introduce errors and adverse events due to several reasons, such as, inappropriate design, poor technology interface with patient or environment, inadequate planning and lack of training for proper use, maintenance and management. Patient safety can be achieved reducing the risk of adverse events related to exposure to medical care across a range of diagnoses or therapy. In the developing countries like, Bangladesh, there are frequent reports in the media about ICUs failure to manage the critically ill patients due to different sources of adverse

events. Many people now wonder whether their visit to hospital might harm rather than help them, and are demanding concerted action. Clinicians worldwide in general, and in the developing countries like, Bangladesh in particular, are required to maintain an increasing workload with limited resources. The ICU is particularly prone to medical errors because of the complexity of the devices, interdependence of the practitioners, and dependence on functioning of personnel and equipment. There are standards developed to help avoid preventable mishaps, or diminish the severity of their consequences, in ICUs worldwide [1], [2]. It is recommended that both the critical care physicians and the senior nurses should have appropriate specialist qualifications and experience, and be responsible for education, training and quality management. The sharing of patient data such as hospital admissions information, laboratory results, progress notes, and imaging data throughout any healthcare facility is essential for maintaining the accuracy and efficiency of clinical care. A seamless flow of information is especially vital within the ICU, where seconds always count [3]. Every year, thousands of ICU patients across Europe either die or stay sick for longer than necessary due to the lack of well organised information and control system. Many of these conditions can be now improved by integrating ICT applications [4], [5]. Studies have shown that ICT-supported systems can reduce errors in the prescription of specific high-risk drugs. Introduction of an automated dispensing system reduced the risk of medication errors, while electronic prescription improved the legibility and completeness of prescriptions [6], [7]. It is possible to use ICT systems to generate reminders, alerts, or other information. The use of ICT applications supporting work processes can free staff for clinical activities at the patients' bedsides and improve safety, productivity, health and savings.

II. OBJECTIVES

The aims of this work were to:

- 1) Identify the problems, accidents due to medical device errors at the ICU to understand the nature and severity of medical device errors and their root causes from a systems perspective.
- 2) Review the cause, frequency and outcome of severe events and the current systems of reporting of medical device errors and adverse events.
- 3) Evaluate the data obtained from different ICUs covering government hospitals and private hospitals in Bangladesh,

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and present the results at an International workshop to prepare guidelines for an efficient and cost-effective ICT based support system for improving patient safety at the ICU

- 4) Develop appropriate web-based ICT based support systems with policies, procedures and protocols for improving patient safety from a collaborative approach
- 5) Implement the ICT based safety support system at five ICU for evaluation and dissemination of the results.

III. METHODS

Although, the majority of the incidents at the ICU may have components of diagnosis, treatment, infection, and other equipment and human errors, it is important to recognize its complexities and dynamic environment and therefore, this study included, staff members, resources utilization, record keeping, information management and procedures, outcome indicators, teaching activities, research activities, drug supplies, equipment, opinions and attitudes of customers, appropriateness of policies and procedures and documentation system. The study included interviews with relevant persons to address the following aspects: What might go wrong? How often? How likely? How bad? How can matters be improved? How much? How much better?

A. Field Study at the ICUs at Government and Private Hospitals

- 1) Design features: if the ICU access is easy for diagnosis, monitoring and therapeutic facilities, adequate supply and distribution of oxygen and medical air, suction, electricity, lighting and air condition, emergency backup etc.
- 2) Staffing: if the ICU physicians and nurses have appropriate specialist qualifications and experience, and are responsible for education, training and quality management.
- 3) Services: if all the time service with access to appropriate specialist available, and if organ imaging and biochemical measurement facilities are available, and how regularly the equipment are serviced, calibrated, cleaned or sterilized and recalibrated.
- 4) Equipment: if equipment are available to provide oxygen therapy and ventilator support, and recording vital parameters and therapeutic interventions, and if the specially equipped trolleys for therapeutic interventions are immediately available for; intubation of the airways, invasive hemodynamic tests etc.
- 5) Monitoring systems: if facilities are reliable and adequate for continuous monitoring and display of electrocardiogram, directly measured pressure, body temperature, respiratory rate, oxygen saturation etc.
- 6) Records: if progress notes for clinical assessment of the patient is regular and systematic with comments on status and trends in all vital signs and variables.
- 7) Drugs: if designated pharmacist is reliable for supply, stocks, use and checking and administration protocols.

- 8) Infection control: if infection risk is taken into consideration when initiating or reviewing any intervention.
- 9) Education: if time and resources are allocated for introductory and continuing education of all ICU staff, and if satisfactory attendance and performance at the courses are ensured.
- 10) Protocols and policies: if procedures for common ICU activities for availability, correct calibration and function, of all necessary equipment are checked in advance, and if the operators are appropriately experienced and supervised and if competent assistance is available to practice.

The study included five hospitals in Dhaka; two private, one semi-private, one public and one semi-public. Of the five hospitals visited, four is located in central Dhaka and one is located in Savar (outside of Dhaka). The hospitals included in the study are:

- 1) Gonoshasthaya Kendra Hospital (GK) [Private]
- 2) SQUARE Hospital [Private]
- 3) Bangladesh Institute of Rehabilitation for Diabetic Endocrine and Metabolic Diseases (BIRDEM) Hospital [Semi Private]
- 4) Dhaka Medical College (DMC) Hospital [Public]
- 5) Bangabandhu Sheikh Mujib Medical University (BSMMU) [Semi Public]

A questionnaire was constructed with questions regarding different aspects of patient safety in operating theatres. The questions are divided into three groups; Physical aspects, Technical issues and management system. The data was collected through interviews with personnel at three different kinds of operating theatres at each hospital. A checklist was used to collect data on the physical aspects and the technical equipment in the operating rooms. The checklist was filled out by observing the operating room and asking additional questions to find out if the room and the medical equipment were up to standard. At each hospital three operating rooms of different types were checked, 15 operating rooms in total

B. Seminars and Workshops to Present Results from the Field Study

Seminars were held at GK Medical University, Bangladesh University of Engineering and Technology in Dhaka, and with the rural health workers in Magura, Bangladesh, where the results from the field study were discussed, so that all participants have increased understanding to support the development of a new system to improve quality, safety, productivity and savings. The seminars shared the perspectives of various stakeholders, and provided examples of potential solutions. Following are some of the topics addressed:

- 1) Medical errors are costly in terms of health outcomes, direct healthcare costs, lost productivity, and erosion of public confidence in the healthcare system.
- 2) Medical Error Reporting systems- Encouraging communication about errors in order to learn from events

and holding providers accountable for improving patient safety.

- 3) Medical errors specific to ambulatory care settings with focus on improving patient follow up, emphasizing teamwork.
- 4) Application of ICT based support systems for patient safety improvement.

C. Recommendations for Improvements

- 1) Reduce the probability of harm to a patient;
- 2) Increase favourable outcomes for patients' safety.
- 3) Prepare explicit computerised decision support tools for clinical decision-making and can lead different clinicians to the same set of diagnostic or therapeutic instructions.

IV. RESULTS

The study showed that a combination of various factors such as understaffing, overcrowding, lack of proper functioning equipment, poor hygiene and sanitation, limited financing resources, contribute to unsafe patient care, and this agrees well with WHO findings from other developing countries.

Physical aspects: The temperature control was not up to the standard in most of the hospitals. Four out of five hospitals controlled the temperature by controlling the air conditioner. Eleven people in total said that they didn't know the room temperature and many of the remaining people gave the temperature the AC was set on. Only one private hospital had standard ventilation system, a positive pressure and humidity control in the ORs. The public hospitals all needed improvement or did not have enough equipment, at one of the public hospitals the washing areas were very unclean. None of the washing areas had a timer to make sure the surgeons scrubbed long enough. There were no automatic door closers at any of the hospitals, but many of the hospitals had doors that could be closed without using the hands. Out of 14 ORs in total there was a phone in 6 and an intercom in 8. There were no emergency bells or computers in any of the ORs visited.

Technological equipment: The OR tables were up to standard at all hospitals except in one OR at a public hospital. That table was out of order and the height could not be adjusted. There were basic resuscitation equipment at half of the ORs in the private hospitals and at none of the public hospitals. Sometimes the autoclave broke down because of electricity problems. The staff at the other public hospital experienced a problem with the autoclave in another building and because of this it took a long time to autoclave the equipment and they did not always have enough instruments. Four people in public hospitals thought that the operating lights are not good enough for safe surgery.

Management: 82% of the physicians, nurses and technicians in the study could identify deficiencies in patient safety at their hospital. The reporting system of both human errors and failure of the equipment is not up to date. The limitation of surgical equipment is delaying the operations and the delay is often related to the sterilization. Compared to the amount of patients the number of surgical instruments, autoclaves and

employees are too low. Absence of right blood group is also a factor in the delay. Because of the poor temperature control and the long surgeries, patients are sometimes put in hypothermia. The bed sheets are not always changed between patients and the personnel is questioning the cleaning process of the patients before operation.

Education and training: Both physicians and chiefs at the public hospitals complained about the nurse's poor education. The nurses did not think that the education lived up to the reality in the hospital. The nurses had to perform tasks that were out of their experience and it was often related to equipment as defibrillator, laparoscopy and anesthesia equipment. 27% of all the interviewed physicians said that they sometimes had to perform tasks that were out of their experience; all of them were working in a public hospital. The attitude to training was sometimes poor among the physicians.

Communication and information: The chiefs' image of communication between personnel was that everyone understood each other well and no improvement was needed. Only one chief thought that the communication needed upgrading. At the public hospitals, a clear majority of both nurses and physicians thought that the nurse's deficient education led to poor communication. In order to make sure that the right patient was on the operation table all hospitals asked for name and looked at the patient's symptom. Only one of the hospitals had a patient computer system and tags on the patient's wrist, the hospital was private. However, there are many reports from the patients and families which inform that; miscommunication has delayed in diagnosis, treatment and discharges.

Policies: All of the physicians in the study were vaccinated from hepatitis B, but only 67% of the nurses. At one public hospital a chief told us that everyone was vaccinated from hepatitis B, but one of the nurses claimed that she did not have that vaccination. There was no specific protocol at any hospital concerning how to clean the operating room. All hospitals stated that they had protocols regarding hand washing and most of them a preoperative and postoperative checklist, but the actual use and the form of the protocols varied and no exact data were collected.

Reporting: Two of the five hospitals said that they had a standard reporting system regarding both human errors and the failure of the equipment. The reporting of human errors were 82% for the physicians and 90% for the nurses, but most of the reporting were done by telling a senior colleague and not by making a written report to the hospital chief. Only 18% of the physicians and 16% of the nurses confirmed that they reported to someone in the hospital leading and no one described an actual process of a reporting system.

Infection control: At many of the visited OTs the washing station was in poor condition. It is not a change that would require a lot of money to make sure that the washing stations have all the essential equipment. Also a simple thing like keeping the washing stations clean and presentable can make a difference. At the hospitals where the autoclave equipment is far from the OTs it is a possibility for the instruments to be contaminated before they reach the OR. The autoclave needs

to be as close to the OR as possible to make sure that the patient can't get infected by the instruments.

Basic equipment: The emergency OTs was not prioritized at any of the hospitals, resulting in lacking of equipment and personnel and not ready for surgery thus patients might not get the treatment needed in time. Resuscitation equipment was missing from all of the ORs visited. In a warm country like Bangladesh it is extra important to be able to adjust temperature, humidity and air pressure of the room. This, in combination with the room temperature might be the reason there is a problem with patients going into hypothermia at one of the hospitals.

Maintenance: A lot of the people interviewed did not seem to know what calibration means, this implicate that it is not done. A confounding factor was that in many of the hospitals nurses were responsible for the equipment with limited understanding for it.

In most cases the checking of the equipment takes place when a problem arises and often due to absence of technically skilled staff equipment remained inactive until service person from the supplier can come to fix. This repair process is faster at the private hospitals whereas, at the public hospital, it may take a long time for various reasons, including costs and conflicts of interests.

V. DISCUSSIONS

It was found that many patients suffer every year due to preventable harm in health care especially in the rural areas and it is now believed that safety will be improved if patients are placed at the centre of care and are included as full partners. The patients education can improve their potential to help with the diagnosis, deciding about appropriate treatment, choosing and experienced and safe provider, improve their capacity to administer treatment and in identifying adverse events and also to take appropriate action.

Care providers need to have better understanding about how human factors can be used to reduce adverse events and errors by identifying how and why systems break down and how and why human beings miscommunicate. It is important to provide better designed systems and processes, provide backup when humans fail, improving communication, replacing or redesigning equipment that lead to error.

A data collection system to accurately measure baseline performance and future improvements needs to be developed. Effective strategies to change clinician behaviour at the ICU needs to be prepared that can ensure that performance is conducted on right patient, at right site, applying right procedure, with proper communication and also report errors. A template for future clinicians, researchers, and policy makers as they extend, and improve the safety aspects at the ICU is now under development. Use of ICT in Healthcare delivers new capabilities for safe and cost-effective health care services addressing the following questions:

- Was the patient's safety protected?
- Was care timely and not delayed or denied?
- Were the diagnosis and treatments provided consistent with scientific evidence and best professional practice?

- Was the care patient centered?
- Were services provided efficiently?
- Was the care provided equitable?

The work enabled to increase visibility of the ICT related activities for better safety at the hospitals in developing countries and expected impact would be; effective intensive care with reduced risk, fewer people in accident, enhanced efficiencies in the health sector. Further work needs to be done to make significant contribution to achieve quality care, and support developing countries in the promotion and deployment of ICT for better access to health information, delivery of safe medical knowledge and communication for the benefit of the patients.

VI. CONCLUSIONS

The physical structure, organization and practice have been investigated at operating theatres in Bangladesh and the main problems are lack of understanding for systems approach. Lack of reporting of errors due to blame culture, lack of on the job training, further education and proper communication due to understaffing and overcrowding with patients and workload, and poor facility for maintenance of equipment due to shortage of well trained technicians contribute of unsafe patient care. A real system for reporting has to be developed in order for the information to reach all people concerned. Education of nurses has to be more fundamental and there should be a possibility to empower all staff to be involved. The communication, collaboration and partnership between the personnel as well as with patients and families can help improve patient safety. It is important to involve patients and families in the work more effectively than ever before and ensure senior leaders understand problems and back staff to make effective changes. Technically skilled personnel should be present at all hospitals to maintain and calibrate the equipment. The best solution would be to have a biomedical department at all hospitals that would both save time and unnecessary expenses for repairs. Some of these changes need funding, but such changes in the long run can reduce harm and suffering of patients and their families, save more money. Safe care is cost effective, and avoidable harm is in itself really expensive.

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