Medical Technology - Impact on Patient Safety

Khalil Rizk
MPH, MHA, CPHQ, CPHRM
JCI Consultant,Chief of Quality
Important & Risk Management,
Alameda Healthcare

Introduction

The introduction of many forms of technology into the hospital environment is not a choice anymore. The way we conduct our business and deliver care to patients is continuously changing with the introduction of computerized information systems and other clinical decision support systems. With the ever increasing reliance on technology, the legitimate question to be asked is: What happens to patient safety during this entire technological invasion?

In this article, I will try to identify the various technological systems that are commonly used in hospitals, discuss how they are introduced, and evaluate their impact on patient safety.

Application of Advanced Technology Systems in Hospitals

Hospital staff uses technology in many ways to improve the efficiency and timeliness of patient care. Following are the most common applications used in hospitals:

• **Electronic medical record** (EMR) which makes health information available to authorized healthcare providers throughout the continuum of care. This technology replaces the paper-based medical record that limits access to one user in one location at a time. A lot has been written about the uses of EMR and it was made clear that its advantages have exceeded the drawbacks.

• **Computerized physician order entry (CPOE) system** allows physicians to order medications for their patients online by using pre-formatted computer screens provided by advanced applications. These medication modules have been prepared by individuals from different backgrounds in a multidisciplinary approach including physicians, pharmacists, nurses, IT professionals and others. CPOE systems provide the prescriber with a wide range of information that has been collected about the patient during the care process such as patient weight, allergies, interactions, laboratory results and can provide alerts for drug interactions and therapeutic duplication, thus reducing the reliance on the human memory.

• **Bar-coding systems** can be used to correctly and consistently identify and track individuals (staff, patients and newborns) andother resources (medical supplies, medications, blood components, medical devices and equipment, etc.). The use of bar-coding in hospitals continues to gain acceptability and is being introduced in more and more situations within the hospital environment. Medication bar-coding systems can help identify hospital staff, types of medications and match them to the correct patients. This helps promote effective medication administration and inventory control. Along the same lines, a more advanced technology is being used to track the movement of individuals and resources throughout the hospital such as the radio-frequency identification devices (RFID).

• **Intravenous medication infusion (IV) pumps** can control how quickly a medication is administered. The latest infusion pump technology includes the ability to compare the dose of a medication programmed by a nurse into the computer with a predetermined appropriate value. If the programmed dose exceeds the limit of the predetermined value, the computer will alert the user.

It is our responsibility as healthcare planners and officials to ensure that technology is properly designed to help us meet our ultimate objectives of providing safe and appropriate patient care. We have to ensure that the newly introduced systems are designed and tested to suit and support the professionals who use them. This is what we call human factors engineering.

Human Factors Engineering in Healthcare

According to The Joint Commission and the Agency of Healthcare Research and Quality (AHRQ) defines human factors engineering (HFE) as the *"discipline that takes into account human strengths and limitations in the design of interactive systems that involve people, tools and technology, and work environments to ensure safety, effectiveness, and ease of use"*. (1, 2)

The role of the human factors engineer is to match the capabilities of new technology with the demands of the task in order to achieve the desired outcome in a safe manner. This role becomes increasingly difficult in a complex environment like the hospital. It is a collection of data and principles about human characteristics, capabilities, and limitations in relation to machines, jobs, and environments. As a process, it refers to the design of machines, machine systems, work methods, and environments to take into account the safety, comfort, and efficiency of operators. So human factors engineering focuses on how systems work in actual practice and attempts to design systems that optimize safety and minimize the risk of error in complex environments. The process of weaving technology into healthcare has to take the following factors into account: (3)

• *Usability testing* - Human factors engineers test new systems and equipment under real-world conditions as much as possible, in order to identify potential problems and unintended consequences of new technology. By doing so, human factors engineers identify and eliminate situations where hospital staff bypass standard operating procedures (work-around) and introduce system controls to streamline the work processes. A good example- One health care facility employed usability testing to help redesign the medication layout in code cart drawers to improve medication retrieval time from 3 min. to 1 min. 8 sec.

• *Forcing functions* - Designers of medical equipment introduce some constraints to make it difficult or even impossible, to complete a task without meeting some built-in controls. This is called "error-proofing". Well designed computerized medication systems would not complete a medication order unless allergy information and patient weight are entered. Another forcing function is the use of special luer-lock syringes and indwelling lines that have to be matched before fluid can be infused. Also, well-designed infusion pumps prevent free flow when the unit is turned off or fails or even when the shutter is not tightly closed.

• *Standardization and simplification* - Standardizing some types of medical equipment (e.g., infusion pumps and defibrillators) across the hospital will help reduce human errors, simplify staff training and ultimately improve safety. Devices that have not been standardized, or that work and look differently, increase the likelihood of operator errors. Similarly, efforts should be made jointly by designers and users to render the use of medical technology simpler and user-friendly.

The use of human factors principles in the design of medical technology still has a long way to go before we can achieve considerable control of safety problems in hospitals. One of the advantages of technology is that it can enhance human performance to the extent that the human plus technology is more powerful than either one alone. Good machines can question the actions of operators, offer advice, and examine a range of alternative possibilities that humans cannot possibly remember. However, technology can also create new demands on operators. For example, a new piece of equipment may provide more precise measurements, but also demand better precision from the operator for the equipment to work properly.

Medical equipment and devices should be designed using human factors principles to account for the human-machine interface. Our responsibilities as users include:
• Redesign devices to default to a safe mode
• Reduce the difficulties of using multiple devices simultaneously
• Minimize the variety of equipment models purchased
• Implement clear procedures for checking devices prior to their use

• Orient and train new staff on proper use of medical technology

• Encourage users to report malfunctioning equipment (4)

Why do Errors Continue to Happen?

Considerable efforts have been exerted by healthcare groups during the last decade to make the use of technology safer. Statistical trends show that the magnitude of medical errors and near misses are on the declining slope. It is true that we are on the right track but we are not there yet. Modern medicine is becoming increasingly dependent of the use of technology and that is not particularly bad as long as we use the technology with utmost care. Dr. Robert Wachter in his book *"The Digital Doctor- Hope, Hype, and Harm at the Dawn of Medicine's Computer Age"* argues that the hasty introduction of computerized hospital information system made the busy health care workers rely on equipment to carry out life-saving interventions, with the underlying assumption that technology will improve outcomes. (5)

In his book, Dr. Wachter shares his observations on an unfortunate incident where a life-threatening medication overdose ordered by a doctor, filled by the pharmacy, and administered by the nurse. The incident was attributed to a both design limitation and improper utilization of a CPOE system. The physician who ordered the medication knew how much he needed and attempted to order it. But a poorly designed CPOE interface made it far too easy to make a big mistake. The system did not display the vital information nor it produced the necessary alerts to draw the users' attention to a fatal mistake that was about to take place.

The Agency for Healthcare Research for Quality analyzed a total of 889 medication errors encountered in different hospitals using CPOE. This analysis found that more than half of the recorded incidents were associated with computerized provider order entry.

The unintended consequences associated with health information technologies for medication management clearly indicate that computers and medication management systems alone do not solve problems associated with medical errors. We have to continue to introduce system improvements to reduce risks of such incidents and avoid unnecessary e-iatrogenesis (patient harm caused at least in part by the application of health information technology). (6)

Final Word

The use of technology in health care is not going away. On the contrary we are expected see more and more applications that are intended to make our work easier, safer and more efficient. Computers can often perform complex tasks more accurately and reliably than humans. On the face value, technology may be seen as the solution to many problems. Through the use of technology-such as the computer and the Internet-we have been able to improve the speed of communication and transfer data across the continuum of care. However, technology has its limitations, when not designed appropriately, tested realistically, or used consistently, technology can actually cause more harm than it prevents.It is our responsibility to make sure that the use of technology is appropriate and implemented in an integrated fashion taking in consideration the human factorsand how the users will interact with the technology. (7)

References

1. John W. Gosbee, & Laura Lin Gosbee: Using Human Factors Engineering to Improve Patient Safety: Problem Solving on the Front Line, Joint Commission Resources, 2nd edition, 2010
2. Agency for Healthcare Research and Quality, Human Factors Engineering-Patient Safety Primer, https://psnet.ahrq.gov/primers/primer/20/human-factors-engineering, updated in July 2016
3. Alphonse Chapanis & William Holstein, Bioengineering, Encyclopedia Britannica https://www.britannica.com/topic/human-factors-engineering,
4. Institute of Medicine (US) Committee on Quality of Health Care in America; Editors: Linda T. Kohn, Janet M. Corrigan, and Molla S. Donaldson, To Err is Human-Building a Safer Health System, Washington (DC): National Academies Press (US); 2000.
5. Robert Wachter, The Digital Doctor-Hope, Hype, and Harm at the Dawn of Medicine's Computer Age, Columbus, Ohio: McGraw-Hill Education; 2015.
6. Lawes Grissinger, Medication errors attributed to health information technology, Agency for Healthcare Research and Quality, Patient Safety Network, https://psnet.ahrq.gov/ M. PA-PSRS Patient Saf Advis. March 2017;14:1-8.
7. Jane Englebright, Realizing the Promise of Improved Patient Safety through Health Information Technology, NPSF Professional Learning Series, 2011