Technology and the Bedside Nurse
An Exploration and Review of Implications for Practice

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INTRODUCTION

Nursing has been successfully designing, organizing and guiding the patient’s experiences and expectations of health care technology since the late 1700s.1

…A true creator is necessity, which is the mother of our invention.
—Plato, an excerpt from The Republic, 369BC.

Disclosure Statement: K.H. Elgin is grant funded by Hewlett Packard Labs. Center for Quality and Clinical Effectiveness, Lucile Packard Children’s Hospital at Stanford, 700 Welch Road, Suite 225, Palo Alto, CA 94304, USA
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KEYWORDS
• Technology • High reliability • Quality of care • Patient safety • Patient care
• Patient experience • Big data

KEY POINTS
• Nursing has a well-established history of successfully deploying and integrating patient care technology.
• The accelerating pace of technological developments and devices in health care challenges nursing to balance the demands of learning new technology with maintaining the patient at the center of care.
• Health care–related technologies such as the electronic medical record have shown clear evidence that they are associated with improved nursing-sensitive patient outcomes.
• Nursing involvement is needed to develop new, nursing-focused patient care technology and optimize technology already in place.
• The role of the bedside nurse as advocate for patients is taking on new and uncharted dimensions in the age of technology.

http://dx.doi.org/10.1016/j.cnur.2015.02.001
nursing.theclinics.com
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Some of the initial technological wonders that nurses either developed or widely integrated into clinical practice include the measuring spoon, thermometer, flexible urinary catheter, hospital bed, and syringe. By including these and other devices in patient care, nurses acted as a catalyzing force in the early technological transformation of health care in the United States.

*Everything that can be invented, has been invented.*
—A quote from 1899 by Charles H. Duell, commissioner of the U.S. patent office.

Around the turn of the 20th century, the role of nursing in shaping medical technology became progressively more visible. As new technologies accumulated in hospitals and patient care areas, nurses were charged with mastering them. By the mid 1900s, the pace of technological development in the health sector had increased significantly, as had the development of formal nursing education programs and the number of hospitals in America.

*I think there is a worldwide market for maybe five computers.*
—A now famous quote made by IBM president Thomas J. Watson in 1943.

In 1991, a new and uncharted era of possibility for technology and human health emerged when the Human Genome Project began and the world wide web was launched. Since then, the fields of biotechnology, genetic medicine, and digital health data have grown with unimaginable speed, spread and application. As the Internet and the electronic medical record (EMR) expanded, patients gradually and increasingly gained access to their own information, as well as to treatment options surrounding impending health care decisions, symptoms, or medications. As a result, the way that patients, clinicians, and the health system as a whole connect to, process, and utilize information is evolving, as are the expectations of what technology can deliver.

*Any sufficiently designed technology is indistinguishable from magic.*
—A quote by Arthur C. Clark, one of the world’s best-selling authors of science fiction.

At 3 million licensed members, registered nurses comprise the largest professional group within the health care system. It follows that nurses, along with their patients, are the 2 groups impacted at the point of care by technology. The nursing literature demonstrates wide variation in how nurses perceive and receive the impact that technology has on their practice. Similarly variable is the description of nursing’s adjustment to the ever-increasing amount of technology in the patient care setting. Although there is less literature describing how nursing is influencing the technology that is driving massive change in the patient care environment, there is no doubt that technology has been, and remains, a driving force that is dynamically transforming the clinical and professional environment of nursing. Thus, a high-level discussion and summary of the advantages, disadvantages, and implications for practice around how technology is impacting nursing is appropriate, and is the focus of the remainder of this article. The following topics—high reliability theory, big data, patient experience, patient care, and advocacy—organize this broad discussion.
HIGH RELIABILITY THEORY, TECHNOLOGY, AND NURSING

High reliability theory is based on the belief that accidents can be prevented through thoughtful organizational design that integrates accountability for safety at all organizational levels.16 “High reliability organizations” (HROs) are those engaged in high-risk industries, such as aviation and nuclear power, which have developed standardized methods of practice to mitigate risk from human error. HROs incorporate an organizational commitment to safety with numerous system checks and balances, and strong organizational cultures for learning.17 Because mistakes can cause serious consequences, including death, HROs are not afforded the opportunity of trial-and-error learning and, instead, rely on standardized processes and the critical thinking of all employees (Box 1).

The Institute of Medicine (IOM) report “To Err is Human” signaled the formal acknowledgment of how dangerously flawed the American health system is, and was followed by a second IOM report, “The Quality Chasm,” which described how the American health care system could be redesigned to improve outcomes and decrease costs.18,19

We live in a society absolutely dependent on science and technology and yet have cleverly arranged things so that almost no one understands science and technology. That’s a clear prescription for disaster.
—A quote from Carl Sagan, American Astrologer.

One response to the IOM reports has been for health care to recognize that it must become an HRO. Although an argument can be made that health care should not be compared with manufacturing cars or operating nuclear power plants, the frequency and severity of harm caused by the United States health care system compels adaptation of the characteristics of successful HROs.

Recent deployments of key technologies in health care are advancing the transformation toward high reliability.20 The implementation of an EMR has been identified as a major tool for health care to become an HRO, and provides an excellent example of how technology can facilitate improvements in patient outcomes.21 Although some health care organizations voluntarily adopted at least parts of an electronic record, it was not until the American Recovery and Reinvestment Act of 2009 made it mandatory that all health care providers demonstrate “meaningful use” of EMRs to maintain their existing Medicaid and Medicare reimbursement levels that full implementation of EMRs became widespread (Fig. 1).22

Before the EMR, the record of patient care was compiled in a paper chart that consisted of disparate sections for each discipline to handwrite their notes. It has been widely known that paper medical records are among the main contributing factors to medical errors made every day in health care facilities.23 Recent literature has found

<table>
<thead>
<tr>
<th>Box 1 Characteristics of High Reliability Organizations</th>
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<tr>
<td>Preoccupation with failure prevention and evaluation</td>
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<td>Commitment to resilience and continuous improvement</td>
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<tr>
<td>Focus on operational systems failure rather than individual failure</td>
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<td>A strong culture of safety</td>
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that the presence of the EMR and other health information technology in the hospital setting has resulted in improved quality of nursing documentation.\textsuperscript{24,25} The EMR poses special challenges for nursing. The presence of the EMR and health information technology may cause several unintended consequences, such as over-dependence on technology and reduction in productivity while learning new technology. Additionally, end-users of an EMR may experience strong emotional responses as they struggle to adapt to new technology and disruptions in their workflow, especially those who lack computer skills.\textsuperscript{26,27} Further, legal issues can arise from EMR documentation in the form of templates that may contain factually incorrect information or data that are beyond the scope of the author yet is authenticated by that author.\textsuperscript{28} Privacy breaches are another grave concern in the age of the EMR, spanning from protected information left on an unattended computer screen to unauthorized access to medical records. Although technology can help nurses to provide safe care, it can also distract and consume valuable nurse/patient time. Nurses must learn to balance the benefits of new tools like the EMR with the impact on patients. Key to this balance is keeping the patient at the center of focus while using technology to strengthen the safety and quality of care provided.

\textbf{BIG DATA, TECHNOLOGY, AND NURSING}

In 2012, the IOM Committee on the Learning Health Care System released a report identifying the rising complexity of modern health care as 1 of 3 main areas that must be addressed to achieve better outcomes for patients. This report suggested that more effective use of health information technology is one approach to help manage the massive amount of patient data that are generated and stored, by guiding nurses and physicians in the decisions they make about patient care.\textsuperscript{29}

\begin{quote}
\emph{Getting information off the internet is like drinking from a fire hose.}\hfill —Mitchell Kapor, pioneer in the personal computing industry.
\end{quote}

Techniques developed to manage, analyze, and translate the vast and expanding amount of patient data elements, also known as ‘big data,’ that are stored in the

\begin{figure}
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\includegraphics[width=\textwidth]{fig1.png}
\caption{Adoption of electronic medical records, 2009 through 2013. (Adapted from Pronovost PJ, Berenholtz SM, Goeschel CA, et al. Creating High Reliability in Health Care Organizations. Health Serv Res 2006;41:1599–617.)}
\end{figure}
EMR will provide the foundation for much of the improvements in clinical practice and patient care that are yet to come.\textsuperscript{30}

Many professional groups and clinicians agree that maintaining an evidence-based practice is the correct approach to most effectively and optimally approach decisions in patient care.\textsuperscript{31,32} However, given the incredible volume of research and evidence that is generated each year and the time constraints facing clinicians, there are questions around the ability of health professionals to stay current with the literature or to access best practice information at the point of care to guide clinical practice.\textsuperscript{33}

Further, the literature has long described limitations in the human capacity to make factual or evidence-based decisions over time when faced with complexity, in the form of multiple or increasing options to choose from.\textsuperscript{34,35} It follows that the effective translation and application of the best practice, evidence, or guideline in health care presents a pressing challenge for clinicians and technology alike.

\begin{quote}
What is evidence-based nursing? An ongoing process by which evidence, nursing theory and the practitioners’ clinical expertise are critically evaluated and considered, in conjunction with patient involvement, to provide delivery of optimum nursing care for the individual.

\end{quote}

There is early evidence that suggests that technology can offer valuable solutions in identifying and managing gaps in clinical information via just-in-time access to electronic clinical guidelines, decision, and practice support tools that can be embedded in the EMR to guide practice.\textsuperscript{36,37} However, it is important to note that there is a large gap between what researchers and health systems believe electronic health technologies can do and what has been proven.\textsuperscript{38}

Although there may be questions around how to best apply new and developing virtual technology to evidence-based health care delivery, there is certainty that effective data management and analysis of the big data contained in EMRs will result in valuable information, and holds great potential to generate a new standard of evidence and source of knowledge. Recent actual and proposed developments in big data analytics within the EMR are increasingly making this possible.\textsuperscript{39,40}

\begin{quote}
The future of evidence-based care Healthcare accelerator Rock Health is predicting big advances for startups and healthcare providers using personalized, predictive analytic tools. The use of predictive analytics, essentially looking at historic data to predict future developments to directly intervene in patient care, will only increase as data multiplies, the report argues. In 2012, the healthcare system had stored roughly 500 petabytes of patient data, the equivalent of 10 billion four-drawer file cabinets full of information. By 2020, the healthcare system is projected to store 50 times as much information, 25,000 petabytes, meaning machine intelligence will be essential to complement human intelligence to make sense of it all.

\end{quote}

To date, large, multisite randomized controlled trials have not been a typical nursing pathway for generating primary data or knowledge. They are expensive, and there are frequent institutional barriers for nurses in their conduction. Translating the ‘big data’ in the EMR to knowledge represents a golden opportunity for nursing to work around
the institutional barriers encountered with randomized controlled trials, while still producing robust, highly powered results to inform clinical practice.41

A number of early approaches to tapping big data in the EMR are described in the literature, and have great potential to generate a new standard of evidence.42 Retrospective chart review and data mining have been revolutionized by trigger methodology and natural language processing software run through the EMR, which search for the quantitative or qualitative data that the user requests, respectively.43,44 These EMR data mining techniques were designed initially to identify patient safety events and trends, but are evolving along with EMR capabilities and big data to allow for expanded application, and represent yet another vehicle to connect nursing with the data needed to both explore and advance the quality of nursing care.

With EMR-based data mining in place, the bedside nurse can simply set the parameters she is interested in evaluating. For example, a nurse can request the data mining tool to search for any incidence of blood glucose less than 40 mg/dL in a newborn nursery over the past 30 days. A focused chart review takes place, with the disposition used to evaluate if a recently instituted neonatal feeding policy was effective at limiting hypoglycemia. Thus, the bedside nurse could mine and interpret these data at the point of care. These EMR data mining techniques are also an example of how technology can give bedside nurses comprehensive data from which they can advocate for patient and nursing needs that might otherwise be too resource intensive to identify or gather. The benefits of evidence-based cohort data, delivered when and how it is needed, at the fingertips of the nurse are obvious. The voice of the bedside nurse is critical in understanding what data need to be translated to actionable information, and how this information should be communicated in the patient care setting.45

**PATIENT EXPERIENCE, TECHNOLOGY, AND NURSING**

The patient experience is another primary force driving change in health care, with technology rapidly evolving to support the new model of the patient as the health care consumer. Smartphones, ubiquitous appendages in our world, allow patients instantaneous and unlimited access to an abundance of health-related information. Patients are presenting to nurses more informed and connected than ever before. Patients are using technology to research disease, treatment, and medications, as well as to connect with others who share health care experiences.46

Patients are able to “shop” hospitals, using transparent data like US News and World Report Top Hospital rankings or the Leapfrog Group’s letter grades, to choose their hospital. They can also access a hospital website to determine the services available to them as a patient. A patient may choose a hospital based on hospitality services, such as access to private rooms, on-demand food service, and email access to the care team. This all translates into a more informed and empowered patient population who presents to the nurse with preconceived expectations about the hospital stay and course of treatment.47

A major advantage that technology yields to the patient experience is the increased control a patient has over the clinical encounter. Technology can facilitate a number of empowering functions for the patient right from their hospital bed. Hospital television (TV) systems have evolved to be tools for learning, communication and comfort (Table 1). A patient may turn on the TV and be immediately directed to a video that outlines how they can partner with the health care team to achieve optimum outcomes. Often this includes informing patients of their rights, standards that should be fulfilled by health care staff during the care process, and who to contact if the standards are not met.
Technology that is used to support the patient experience can also have disadvantages. For example, many hospital systems have implemented immediate hand hygiene education for patients and families through their TV systems as part of the orientation to the hospital stay (Fig. 2; video link available at: http://www.cdc.gov/handhygiene/Patient_materials.html). The example of hand hygiene teaching through the TV system, although it is meant to empower the patient, can translate into a burden to some patients. Verbalizing concerns about lack of hand hygiene may be difficult, and the expectation that a patient will speak up may increase concern about the competency of the organization to provide safe care. Having the message come from the TV system rather than the traditional approach of the admitting nurse can establish a more depersonalized patient experience.

A depersonalized patient experience owing to integration of technology is increasingly becoming a concern. As technology becomes more integrated into the hospital

<table>
<thead>
<tr>
<th>Patient Experience</th>
<th>Health Education</th>
<th>Comfort Services</th>
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<tbody>
<tr>
<td>Access to health results (laboratory tests, diagnostic studies)</td>
<td>Admission orientation</td>
<td>On-demand movies and TV</td>
</tr>
<tr>
<td>Nurse call</td>
<td>Medication teaching</td>
<td>On-demand food services</td>
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<tr>
<td>Immediate feedback to department leaders</td>
<td>Diagnosis and treatment teaching</td>
<td>Games</td>
</tr>
<tr>
<td>Links to internal and external resources</td>
<td>Health promotion (smoking cessation, diet, and exercise)</td>
<td>Live broadcasts of activities (bingo, lecture series, etc.)</td>
</tr>
<tr>
<td>Virtual support groups</td>
<td>Discharge teaching with return demonstration and learning evaluation</td>
<td>Request housekeeping services</td>
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Table 1
Not just a TV anymore: examples of offerings from an interactive patient care platform

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Fig. 2. A CDC video used to educate patients and families upon admission to the hospital. (Courtesy of the Centers for Disease Control and Prevention.)
stay and bedside care, patients may feel less connected to their health care providers.  

> It’s so critically important to recognize that hospitals and the people there provide more than clinical care. The “value” that a nurse or a tech provides to a patient is more than just administering medications or taking vitals. Value is often taking a moment to talk and make a patient feel comfortable upon admission.  

—Mark Graban, Lean blog 2010.

Technologically enhanced discharge teaching provides an example. Traditionally, preparing a patient for discharge and caring for themselves at home was accomplished through one-on-one teaching with the bedside nurse. However, many hospitals have found that the content and efficacy of these sessions are nurse dependent, and poor discharge teaching and preparation can lead to unanticipated readmissions. Recently, some hospitals have shifted to standard video-based discharge teaching. This shift allows for flexibility for the patient to choose when they want to receive the teaching, because many are on demand, and allow patients and families to watch more than once if needed. This flexibility is an advantage. However, this approach eliminates the interpersonal communication between the patient and the nurse. Lost is the connection, the face-to-face interaction, and the expression of care and concern that can be so meaningful to a patient anxious to go home with a new condition or treatment regimen.

The implications of the influence of technology on the patient experience are profound. Technology can be used to improve the efficiency of the care experience and can empower, teach, and connect the patient to the health care team. Technology can also depersonalize the care experience, reducing the frequency and quality of interpersonal interactions with the care team. Nurses must adapt to this chasm through understanding the effect technology can have on the patient experience and focusing on continuing to build strong relationships with patients. Through this approach, nurses can harness the positive power technology can have on the patient experience without allowing for the depersonalization of the patient experience.

**PATIENT CARE, TECHNOLOGY, AND NURSING**  
The rise of technology is having significant impact for nurses at the bedside. Technology is integrated in almost every task a nurse performs during a shift, from monitoring patient vital signs and performing assessments, to administering medications and documenting care (Fig. 3). According to the Agency for Healthcare Research and Quality, there are more than 5000 types of medical devices in use by health care providers.

Technologic advances in health care are integrating human factor designs to help reduce human contributing errors during health care delivery. For example, intravenous medication administration pumps with smart technology can help to ensure a human error in programming does not result in a significant over-medication or under-medication of a dose to a patient. Bar code medication administration, which is used to verify patient and medication accuracy, can assist the nurse validates and adheres to the 5 rights of medication administration (Table 2). These technologies support the nurse to provide safe care in an increasingly complex clinical environment.

Technology can contribute to a reduction of time to build the nurse–patient relationship, and it can also erode critical thinking skills key to effective nursing practice. In an
effort to balance the tasks in a complex care environment, nurses may become reliant on the safeguarding technology. A nurse may stop checking armbands before administering a medication, believing the technology to be error proof. Reports of medication errors owing to malfunctioning technology are common, with something as simple as a low battery on a medication scanner contributing to wrong patient administration when the nurse did not verify the system was functioning. As technology becomes more advanced, and is integrated into all aspects of care nurses provide, nurses must adapt while maintaining and advancing the skills at the heart of nursing.

The human spirit must prevail over technology.
—Albert Einstein.

ADVOCACY, TECHNOLOGY, AND NURSING

In 2011, the theoretic physicist Michio Kaku reminded a health care audience that a single smart phone holds more computing power than all of NASA had when they sent Neil Armstrong to the moon in 1969. Kaku also explained Moore’s law, which (currently) assumes computing power will continue to double every 18–24 months. With the current and anticipated accelerating pace of change in technological capacity, it is difficult to imagine what the relationship between technology and nursing will be like in 20 or even 30 years. Similarly uncertain is conversation around the relationship between nurses as advocates for patients in the age of advanced technology.

The techniques have galloped ahead of the concepts. We have moved away from studying the complexity of the organism; from processes and organization to composition
A recent example demonstrating how disruptive technology has been to the traditional relationship between the patient, provider, and health system is best described by the lived experience of Salvatore Iaconesi. He is an artist and open-source engineer from Italy who was diagnosed with brain cancer at age 39. Iaconesi rejected the way he was approached as a “disease on legs” by the medical system, and opened his clinical data up to the world on a website he named “La Cura.”

When you have cancer you disappear. And you are replaced by someone/something else: a patient.
—A quote by Salvatore Iaconesi, as part of an interview posted in the McGill Reporter, 2014.

He invited anyone who could help him to find a cure to respond. He received more than 500,000 responses from around the world, weighed his options, applied many of the suggestions, and is now cancer free. None of what Salvatore Iaconesi chose for himself would have been possible 25 years ago, and yet today his is just one of countless examples of how technology is redesigning the experience of health care.

The role of the nurse advocate for a patient like Iaconesi is not difficult to imagine. He sought and found a way to be treated holistically, which falls comfortably into the nursing model. However, how will nurses advocate for their 13 year old patient who tested positive for an autosomal-dominant and fatal disease through direct to consumer marketing for genetic testing? What exactly will be the role of the nurse as advocate for her patient who wants genetic engineering to ensure the intellectual quotient, sex, or eye color of their child? Or for the new baby who is the first recipient of a 3-dimensional printed heart?

These examples of future possibilities are proposed based on current realities. Given Moore’s law, one must also consider the bulk of what is to come for technology and human health cannot even be imagined. Although bedside nurses cannot prepare for the unknown, they can and should be aware that patient care is now on a technological continuum that will likely be so changed as to be unrecognizable in 50 years. The nursing profession must begin to prepare itself now to move nimbly and rapidly forward with patients as their advocates, as technology continues the inexorable and often unpredictable transformation of the collective health care reality. For even

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<thead>
<tr>
<th>Technology</th>
<th>Purpose</th>
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<tr>
<td>EHR via computer</td>
<td>Review MAR for medications ordered</td>
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<tr>
<td>Automated dispensing system—medication</td>
<td>Access medication</td>
</tr>
<tr>
<td>Automated dispensing system—supplies</td>
<td>Access medication administration supplies</td>
</tr>
<tr>
<td>Computer</td>
<td>Review medication profile via electronic pharmacology database</td>
</tr>
<tr>
<td>Bar code scanner</td>
<td>Verify correct patient and medication</td>
</tr>
<tr>
<td>IV pump</td>
<td>Facilitate medication administration</td>
</tr>
<tr>
<td>EHR via computer</td>
<td>Document the medication administration and patient’s response to the medication</td>
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Abbreviations: EHR, electronic health record; IV, intravenous; MAR, medication administration record.
in the virtual age, patients are adrift without the nurse who will recognize that technology is providing solutions, but that the right questions still need to be asked.

*Computers are useless. They can only give you answers.*
—Pablo Picasso.

**SUMMARY**

Changing how information is communicated to nurses, and how nurses communicate information, is a deceptively simple sounding concept. The successful translation of this concept to action, through patient centered technological interventions, is critical to the success of a redesigned health care system. These changes, when weighed against the needs of patients and the demands of the health care system, seem inevitable. Nursing must prepare itself to guide and manage the changes in how health systems process, use and store patient data. Nurses must be involved in all steps of this redesign to ensure that the future course of technology in the patient care setting is guided by nurses, not for nurses.

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