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The promise of
big data

Improving patient safety and nursing practice

By Daniel Linnen, MS, RN-BC

AT SOME UNITS' monthly department meetings, managers review the latest quality outcomes on falls, pressure ulcers, catheter-associated urinary tract infections, and other measures. The information is provided in simple bar and line graphs, and some measures are compared against internal or external benchmarks in a "unit score card." The information is displayed in an overwhelming array of green and red arrows across a cross-tabulation grid. Making sense of the information presented can be difficult. Even though unit managers explain the highlights, nurses can't associate the information with any actual patients; the measures are retrospective and present only a static view of what happened in the past.

Although nurses use sophisticated electronic health records (EHRs) and spend hours each day documenting the care they planned and provided, most of this massive amount of documentation data isn't analyzed by medical centers' quality departments because the data are
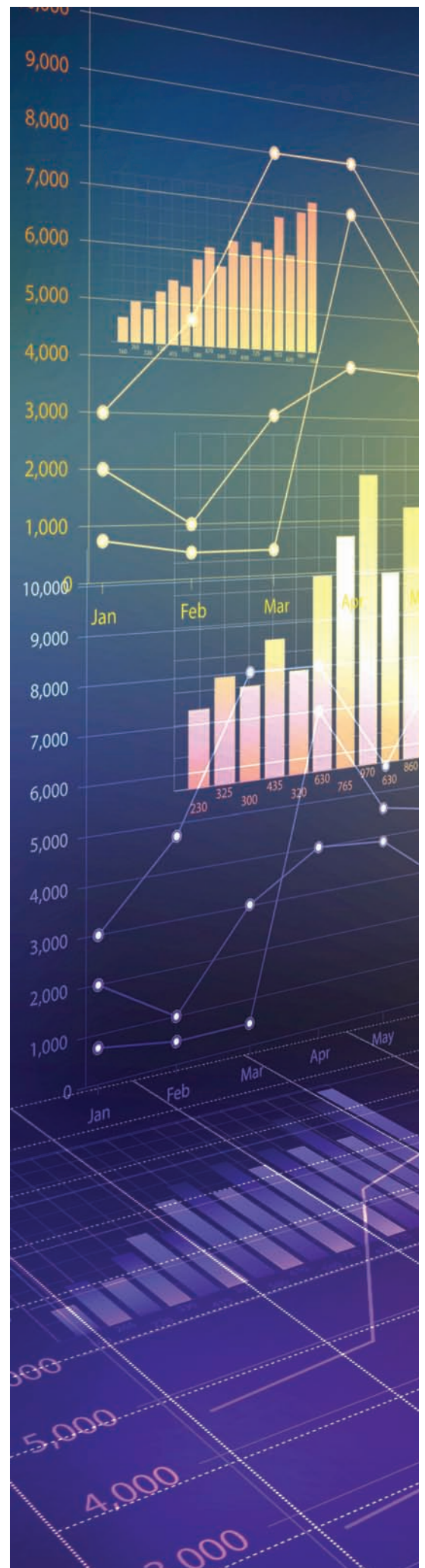
abstracted manually. In addition, the electronic reporting tools available in departments load so sluggishly that no one in the units are routinely using them.

This slow turnaround from data to information hinders a team's ability to turn this information into actual interventions for their patients. Even worse, it seems that the analytics presented focus mostly on what units have done wrong, not right, because most quality resources are used to analyze negative outcomes and areas where performance is below target.

Nurses may wonder: *What if our care outcomes data were available live, like a stock ticker, and our team could intervene to address issues while the patient was still on the unit? What if we could get actionable analytics at the speed of an Internet search? What if outcome analytics could pinpoint where we're doing well and why? And what if all this information were available on the unit 24/7 in a format that's easy to read and easy for nurses to incorporate into their practice?*

In fact, this is the future of healthcare data analytics, and it's enabled by a data technology often referred to as *big data*. This article outlines how big data can improve patient safety, care quality, and nursing practice.

The time is right
The rise of big data comes at an opportune time for healthcare. The combination of an aging population of baby boomers, shrinking federal reimbursements, and a shift to outcomes-based payments creates a challenging healthcare landscape. In response to the high cost of healthcare in the United States and the need to improve the effectiveness of care delivery, the Institute for Healthcare Improvement postulated the *Triple Aim* of healthcare:[1]
• Improve the patient experience.
• Improve health outcomes.
• Reduce the per capita cost of healthcare.

The Affordable Care Act initiated the National Quality Strategy, which builds on the Triple Aim. Administered by the Agency for Healthcare Research and Quality, the National Quality Strategy sets more nuanced strategic priorities, including patient engagement, support for healthy communities, and effective care coordination across settings.[2] Even though large amounts of health and nursing data are available today to support these strategies, efforts to use big data technologies on a large scale, as in banking, commerce, and web services, are far from complete in healthcare.[3]

Opportunities for advancement
Essentially, most health systems today are "data rich and information poor" in the absence of advanced data technologies used for data mining, aggregation, normalization, computation, and analytic output. (See *Coming to terms*.) Over the past few years, the focus in health information technology (HIT) has been on implementing EHRs as legal records with 80% overall adoption in the United States.[3] While this is an important foundational achievement, EHRs weren't intended for highly complex data analytics using intricate data integration techniques with databases such as staffing and medical devices. Such advanced big data methods have the potential to reveal new insights and make information more actionable, supporting the evolution from data to wisdom.[4]

Data are generated at ever-increasing speed and size: 90% of global data were created within the past 2 years.[5] As a means of transforming this massive amount of data into valuable information, big data technologies have become increasingly popular.

In its most basic definition, big data technologies are understood to be capable of the *Four Vs:* processing massive amounts of data (volume) from an integrated pool of multiple databases (variety) and ingesting and returning analytic computations at high speed (velocity) and with high precision (veracity).[6]

We've become accustomed to receiving nearly instant search results from Internet search engines. However, a similar real-time availability and consumption of analytics from historically unconnected healthcare data

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Coming to terms
• **Analytic output:** The final electronic information conveyed to a nurse after data are transformed through filtering, organization, mathematical computations, and statistical analysis. Output examples include basic reports and tables, or advanced interactive dashboards and clinical decision support alerts in the electronic health record.
• **Clinical analytics:** The application of analytic and statistical methods to convey meaningful information to clinical users. Examples include sepsis surveillance and readmission risk. This domain includes solution design and a user-centric view of the information workflow.
• **Computation:** A calculation or data transformation performed by a computer system with varying degrees of automation.
• **Data aggregation:** Collecting and storing data from various source systems in a common data warehouse for subsequent retrieval and analysis.
• **Data mining:** Finding useful information or patterns in large data sets.[27]
• **Data normalization:** The technical organization of data into tables in such a way that they can be related to other data tables.[28]
• **Electronic dashboards:** Visual analytic displays showing graphic representations of key nursing metrics.
• **Use case:** The story behind the information technology solution, or the clinical need for the solution. Also, the formal documentation of a series of steps performed by a nurse in a given information system to accomplish a task. Here it could be receiving information from a big data system and turning this information into a professional action.[29]

sources is an unprecedented prospect. These data provide new opportunities to convey information in more easily consumable formats; for example, in interactive electronic dashboards, as best-practice advisories (clinical decision support), or as a web-based service accessed on demand via smartphone or tablet by nurses and managers. Understanding and interacting with information in real-time promises to positively impact patient care as it occurs and improve the actionability of information presented.

In nursing, creating a big data "ecosystem" entails collecting numerous databases into a single data platform.[7] This may include data from the EHR, the nurse call system, bed exit alarms, code blue alarms, vital sign monitors, and wearable sensors. It may also include many other sources of data. (See *Collecting the data.*)

However, shifting to an integrated data environment is complicated.[4] Strategic planning at the federal level is ongoing in order to set the stage for deployment and use. In 2014, the federal Office of the National Coordinator (ONC) for Health Information Technology under the U.S. Department of Health and Human Services published a roadmap for an interoperable and secure data exchange network across health systems, which includes nursing data. (This will be discussed in a later section, The road ahead: Challenges and HIT policy.)

Valuable use cases for nursing
The practice of collecting data to measure clinical outcomes is certainly not new in nursing. In fact, data and information are the scientific underpinnings of nursing research, nursing practice, and health system enterprises, and they've been with our profession for a very long time.[2] Even the use of electronic registries capturing data from a large pool of health systems is well established. For example, the Collaborative Alliance for Nursing Outcomes was gathering nurse-sensitive outcome data as early as 1996, and the Na-

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Collecting the data

These are some of the databases that can be collected into a single data platform:
- EHR data
- nurse-sensitive indicators
- genomic data
- past adverse and sentinel events
- socioeconomic data
- financial and claims data
- social determinants of health
- air quality data
- staffing and workforce data
- data from other care encounters
- information from social media.

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tional Database of Nursing Quality Indicators has existed since 1998 with administration by Press Ganey since 2014.[8-10] What's different in the advent of big data in nursing and healthcare is the ability of data systems to ingest drastically larger and larger amounts of data, integrate a diverse set of data sources, and speed up the computational output.[4]

Health researchers have already begun to employ big data technologies for various clinical use cases. Most notably, early adopters have linked disease processes to genetics (precision medicine) to tailor medical interventions to individual patients and achieve optimal effectiveness from prescribed therapies.[11] As a result of the promise of big data in medicine, the National Institutes of Health launched the Precision Medicine Initiative in 2015 with the aim of building a massive research cohort of 1 million de-identified patient data sets.[12]

In addition, because federal reimbursement policies increasingly reward quality outcomes and high patient satisfaction, health systems have begun building multivariate predictive models that calculate a given patient's risk for various medical outcomes, such as hospital readmission and development of sepsis.[2]

Similarly, *precision nursing* is the ability to identify specific patients at risk for adverse nurse-sensitive care outcomes and to use big data and

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analytics tailored to nursing practice and specific patient characteristics.[13] The use of big data for precision nursing is still in its infancy.

The president of the American Nurses Association noted in 2015 that nurses need to be at the table to ensure that systems are designed to help nurses deliver top-quality patient care.[14] The promise of big data, then, is to fundamentally support the mission of nursing and to become an integral tool for patient safety and professional nursing practice.

Boosting patient safety
Arguably the most important application of advanced data technologies in nursing is its ability to support patient safety and quality of care. Showing the risk patients face during care encounters, the Institute of Medicine (IOM) landmark report *To Err Is Human* estimated that, conservatively, between 44,000 and 98,000 hospitalized patients died annually from an avoidable medical error in the United States (though the real number of deaths may be much higher).[15] In 2013, the number of deaths related to such errors was reexamined and revised to be as high as 400,000 and the number of serious harm events to be between 4 and 8 million.[16]

To fill in the gaps in process related to clinical communication, information exchange, and order entry, the implementation of HIT was first incentivized through the federal Health Information Technology for Economic and Clinical Health Act in 2009. Since then, its use has led to substantial improvements in quality and patient safety associated with such advances as better diagnostic and therapeutic decision support and built-in safeguards such as clinical alerts and reminders.[17]

By adding innovative big data technologies, clinical decision support for nurses will become more precise, more predictive, and more meaningful for many outcomes, including clinical deterioration; falls with injury; pressure ulcers; delirium; and healthcare-associated infections

from urinary catheters, central lines, or surgical sites. Nursing now has the opportunity to develop deeper insights into the effects of unit staffing, baccalaureate nursing education, or workplace environment ratings on nurse-sensitive care outcomes.

Finally, the way information is presented to nurses will shift to fast-loading, interactive data visualizations in a digital format embedded in the EHR or on smartphones, tablets, and electronic dashboards. Optimally deployed, this can dramatically improve nurses' experience with analytics and offer a deeper and richer understanding of patient risks and specific care needs along the continuum of care.

Improved professional practice

The generation and advancement of nursing knowledge and wisdom is a cornerstone of professional nursing practice in the 21st century. In accordance with the IOM's 2010 report, *The Future of Nursing*, professional nurses are called to assume leadership roles at the local, regional, state, and federal levels.[18] Efforts to make big data a reality in today's patient-care environments require nurses to participate in and guide the selection, design, development, and deployment of advanced data technologies.

Returning richer and more powerful information to frontline nurses and teams increases the sense of ownership of the care it reflects, mediating nurse empowerment and

Advanced big data methods could potentially reveal new insights and make information more actionable.

autonomy. As part of the learning healthcare system, patients, clinicians, and researchers can generate new insights out of massive amounts of data.[19] Advanced analytics not only collect and store data entered during patient-care encounters, but they also process the vast amounts of data in a way that empowers nurses and other healthcare team members to positively impact the care of

their patients.[4] This can take place through the guided use of clinical analytics, continuous performance improvement activities, and translational research (bringing research "from the bench to the bedside").

Nurses need to be fully engaged participants in these areas.[18] Nurse researchers and nurses at all organizational levels must not only be educated and fluent in data science, they must also be involved as frontline staff and nurse leaders competent to interpret and act on clinical analytics. Nursing informatics specialists are uniquely positioned and qualified to serve as a bridge between end users and health data engineers and data management vendors.[14] (See *The role of the nursing informatics specialist.*)

The road ahead: Challenges and HIT policy

Who's making sure that the voice of nursing is heard? What are the ongoing challenges in adopting big data technologies for nursing? In fact, many nursing and nursing informatics groups are already engaged in the nursing data strategy. In April 2015, American Nurses Association (ANA) President Pam Cipriano spoke at the national conference of the Healthcare Information and Management Systems Society (HIMSS), a leading organization in the HIT industry with an active nursing informatics working group. In her presentation, Cipriano outlined the need for close collaboration with informatics nurses on data strategies to increase patient safety, improve care outcomes, and monitor care quality. The strategy is aligned with the ONC for Health Information Technology under the U.S. Department of Health and Human Services as well as the University of Minnesota School of Nursing Big Data and Science for Transforming Health Care Conference. These groups, and many others, steer the national big data dialogue for nursing by bringing together nurse scientists, nursing informatics leaders, and policy leaders.[20]

As a third major policy "player," the Big Data Principles Workgroup

The role of the nursing informatics specialist

According to the American Nurses Association, *informatics nursing* is a nursing specialty combining "nursing science, computer science, and information science to manage and communicate data, information, knowledge, and wisdom in nursing and informatics practice."[30] Nursing informatics is a board-certified specialty under the American Nurses Credentialing Center.

The proliferation of EHRs in the U.S. healthcare system initially created the demand for nurses serving at the intersection of clinical care and HIT. No longer limited to EHRs, informatics nursing today encompasses all conceivable clinical data and information systems, including telehealth, medical device integration, big data, and advanced analytics.[31]

Informatics nurses lead the development of data and information systems and workflows that support and reflect professional nursing. They do so in interprofessional collaboration with other healthcare professionals and information technologists, with a keen eye on system usability and workflow design.[32]

of the national HIMSS Nursing Informatics Community developed the white paper "Guiding Principles for Big Data in Nursing."[21] The report details the strategic priorities required for large-scale utilization of big data in nursing, including data standards, data interoperability across health systems, and information security.

While big data technologies can be implemented locally today (within the silo of an organization by unifying existing data sources), using big data at the macro level is hindered by a lack of shared data definitions, shared documentation practices, and standardized assessment tools, to name only a few.[6] Without such standards and data interoperability, the data can't easily be combined to capture the big picture. As a result, the chief strategic aim for nursing and nursing informatics is to formalize the nursing standards that are used uniformly across the United States.[4]

In the past, the ANA has successfully narrowed the total scope of nursing data terminologies to 12 standards.[22] In March 2015, the ANA board of directors adopted a position statement recommending a smaller set of specific nursing reference terminologies standards (Systematized Nomenclature of Medicine—Clinical Terms [SNOMED-CT] and Logical Observation Identifiers Names and Codes [LOINC]) for the coding of nursing assessments, outcomes, problems, interventions, and observations.[23] For example, "acute pain" equals SONMED code 274663001.[24]

In June 2014, the ANA board outlined specific actions by the organization to guide the development and use of data standards in nursing, specifically by collaborating with ONC, the nursing informatics community, and IT/EHR vendors.[25] Vendors have become a focus in the interoperability debate because they historically offered data and system customization for their client hospitals. This has only added to the degree of variability in EHRs across the country.

Still, data interoperability is only one of several key issues being addressed at the national HIT policy level. The ONC, as the chief federal HIT body, published a strategic roadmap in 2014 in which the agency outlines specific stakeholders (including nursing) and its aims for wide-scale adoption of HIT (that is, public health, clinical guidelines, clinical decision support, clinical research, and quality measures).[3] With regard to big data, improving the analytic capabilities across large patient populations and across currently unconnected health systems is part of the ONC's 6-year agenda, meaning that by 2021, the goal is to achieve health data exchanges that are not only interoperable, but are also secure, standardized, and able to integrate with novel databases of patient home monitoring devices or wearable sensors.

The biggest hurdle in achieving this vision continues to be a lack of funding and reimbursement for the use of big data. The Affordable Care Act has resulted in 16.9 million new patients with health insurance, and the federal government has reduced payments in an effort to curb costs and is progressively shifting to a pay-for-quality model (Value-Based Purchasing) for Medicare and Medicaid reimbursement.[26] As a result, the few early adopters of big data in healthcare have focused on use cases supporting quality goals that are tied to reimbursement incentives, most notably the reduction of readmission rates.

Because many nurse-sensitive care outcomes aren't currently part of the reimbursement model, health systems have little financial incentive to invest in big data technologies and resources for nursing. This is true even though these investments would likely pay for themselves in the long run by decreasing adverse events, a cost-avoidance benefit for adopters. Only when nurses at the policy level make the case for the value of nursing analytics and for the improvement of care outcomes

through advanced data technologies will we be able to realize the business case for nursing big data science at the bedside.

Critical role for nursing

Nurses generate vast amounts of data during the course of care delivery. As the owner of these data, our profession has a golden opportunity to harness the power of big data and to improve the safety and care of our patients. Even though the rise of big data is still in its infancy, many professional associations and national governing bodies offer nurses the opportunity to advocate for the funding and support needed to make healthcare analytics fast, meaningful, and easy to use. By taking this action, we can make the IOM's vision of nursing as an equal and respected partner a reality, for the benefit of our patients and communities. ∎

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