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How artificial intelligence

By Nancy Robert, PhD, MBA-DSS, BSN

Artificial intelligence (AI) is often described as the new electricity. Just as the invention of electricity transformed the way we live, work, and play, AI is poised to transform the world we live in. By 2025, research predicts that global AI healthcare spending will equal $36.1 billion.[1] In 2017, China announced its goal to become a global leader in AI by 2030. And on February 11, 2019, the US issued the executive order Maintaining American Leadership in Artificial Intelligence, directing all federal government agencies to implement strategic objectives aimed at accelerating AI research and development.[2]

With technology investments of this magnitude and extensive government programs to advance AI, healthcare teams will be significantly impacted as innovations such as intelligent robots are launched into healthcare and patient home settings. This article provides an overview of AI, including how AI algorithms and robots are changing the nurse's role and challenges facing the nursing profession as AI is integrated into healthcare delivery.

What's AI?

AI isn't a new technology. Its roots began in 1956 when Stanford University computer scientist John McCarthy coined the term while leading the Dartmouth Summer Research Project. Since then, the AI field has experienced many ups and downs.[3] (See *Figure 1*.) Historically, we didn't have the

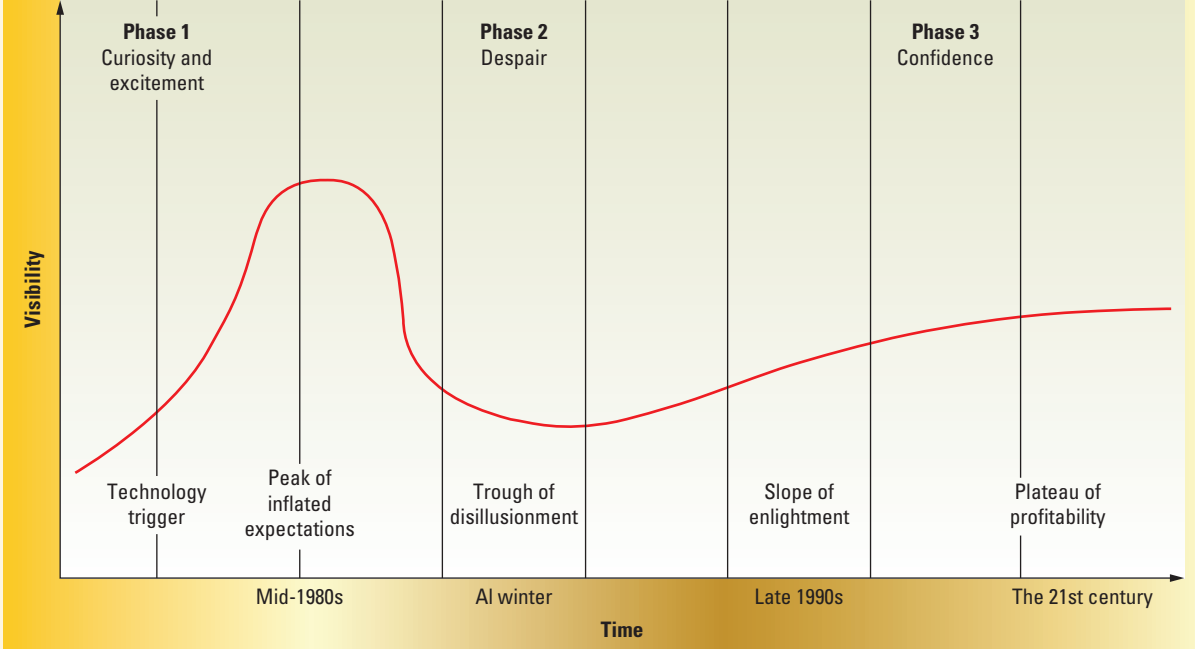
is changing nursing

computational power and supporting technologies to process vast amounts of data, which caused doubt in AI's ability to ever deliver on expectations. Beginning in 2011, the field started to see leaps in progress, with advances in computer processing capabilities, access to large data sets needed to train AI systems and the ability to process them, and discoveries in algorithm designs that are the foundation for AI processing. (See *Algorithms—the building blocks of AI.*) An example is the successful use of graphics processing unit chip technology, originally designed for the gaming industry, to help accelerate the development of AI applications in self-driving vehicles and healthcare. This technology brought new processing power to computer scientists at a reasonable cost, opening up opportunities for AI experimentation. Also in 2011, computer scientist Andrew Ng proved that computers can learn what an object is without being told what it represents. His research used 10 million online videos of cats; over time, the computer learned what a cat was. This breakthrough technology is used today in speech recognition systems.

A literature search reveals that there are a variety of AI definitions, with some more focused on technologic attributes whereas others describe human aspects of intelligent machines. A description of AI by Sara Castellanos, technology writer for *The Wall Street Journal*, captures the essence of what it aims to deliver: "Artificial intelligence encompasses the techniques used to teach computers to learn, reason, perceive, infer, communicate, and make decisions similar to or better than humans."[4] AI isn't one technology, but rather a collection of technologies that perform various functions depending on the task or problem being addressed.[5] (See *Figure 2.*) Often when people refer to AI, they're speaking about one or more of these computing technologies that you may already be using in your work for functions such as staffing optimization or at home for functions such as thermostat and lighting control.

A term used interchangeably with AI is *cognitive technology,* such as the famous Watson computer that won the *Jeopardy!* Challenge in 2011. Following this success, Watson was trained in 13 different types of cancer by experts at Memorial Sloan Kettering Cancer Center. One function of Watson

Figure 1: The hype cycle for new technology



is to rank evidence and provide patient-relevant, evidence-based treatment options. Vice President of IBM Analytics Steven Astorino describes cognitive computing as the "ability of computers to simulate human behavior of understanding, reasoning, and thought processing."[6]

Machine learning is a frequently used technology in which computers act intelligently on a specific task or problem without being explicitly programmed. The computer uses algorithms to derive knowledge from data and interprets data for itself. As more data are presented to the machine learning application, the computer learns from the data and corrects outputs. Machine learning can be supervised, unsupervised, semisupervised, or reinforcement learning depending on the kind of data being input into the program and the type of outputs that can be expected.[7]

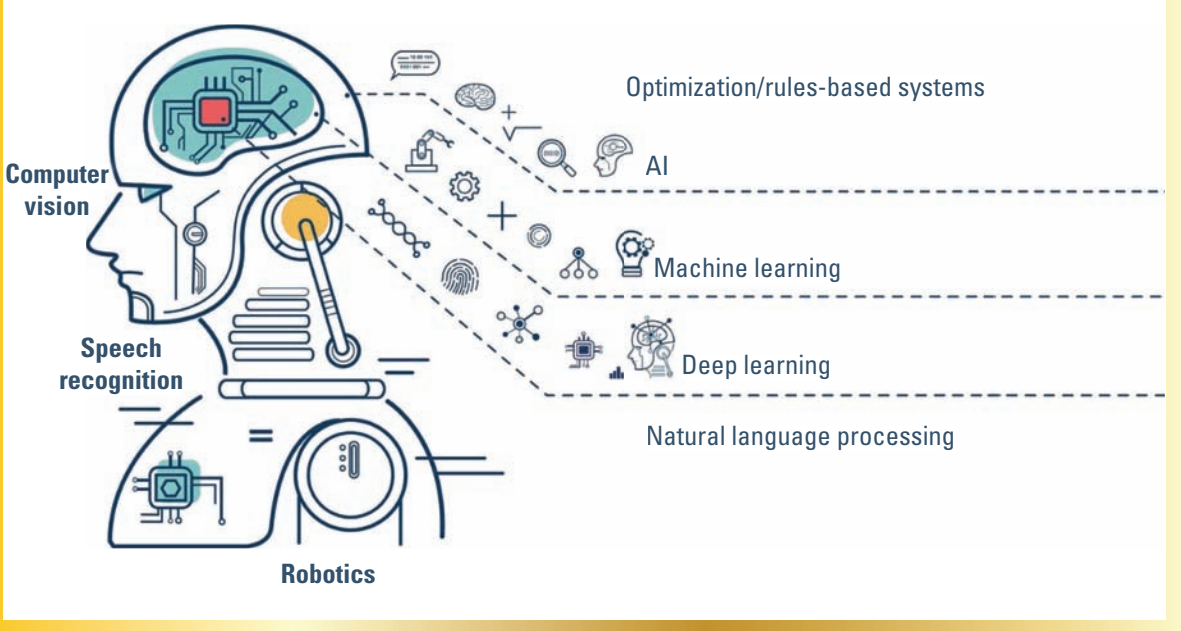
Another term encountered in AI is *deep learning*—a subset of machine learning. This computer science approach involves networked algorithms called *neural networks* because the inspiration for their creation was how neurons are networked in our brain. In deep learning, a set of mathematical instructions such as an algorithm, which is called a *node*, works like a neuron to fire the algorithm, process it as instructed, and pass its information to another node in the computer. That algorithm is then used as input by another node in the neural network. Data move through the nodes in a direction specified by the algorithm. A deep learning model can contain billions of nodes embedded in many layers. For context, Ng's model for comput-

Algorithms—the building blocks of AI

According to the Merriam-Webster dictionary, an algorithm is "a step-by-step procedure for solving a problem or accomplishing some end." In the field of AI, algorithms are automated instructions that tell a computer what to do. The instructions are mathematically driven and can be as simple as "if X, then Y" actions or encompass complex mathematical layers of instructions to execute a task or find an answer to a problem. The algorithm manipulates data in a variety of ways, such as sorting, inserting, replacing, or searching for a data attribute. It solves problems when it carries out the instructions.

When you hear someone talk about a machine that learns, the machine is executing a structured set of mathematical procedures. The machine learns how to correct itself based on data used to train the application or by iterating on data used by the application once deployed. How the machine learns to correct itself depends on the mathematical models selected for the task. Data scientists and machine learning programmers are the team members who select and adjust the mathematical models used in applications.

Figure 2: AI cognitive technologies



iStock.com/www.facebook.com/PlargueDoctor

ers learning to identify cats contained over 1 billion connections.

How are nurses using data generated by smart algorithms?

Yale New Haven Hospital (YNHH) nursing was an early adopter of the Rothman Index, a tool that reflects patient acuity and risk.[8] Director of Nursing Professional Practice Dr. Judith Hahn, Strategic Analytics Innovation Scientist Dr. Joan Rimar Sr., and Clinical Informatics Manager Leslie Hutchins highlighted what it takes to introduce new algorithms into nursing and interprofessional practice. In a personal communication, Hutchins described the goal of YNHH technology implementations as "providing the right advisory, at the right time, so we can look at what's meaningful information to achieve desired patient outcomes."

Rothman Index scores are calculated using electronic medical record (EMR) data associated with 26 variables, including 11 nursing assessment metrics, displayed in graphs. The introduction of the Rothman Index was accompanied by skepticism about its validity and reliability to produce actionable results. The technology initially didn't have ample peer-reviewed literature to convince nurses and other clinicians that the results would make a difference in patient care. However, research now suggests that Rothman Index performance is positively impacted by nursing assessment data, so the potential for nurses to impact patient care is significant.[9]

Technology will change how nurses spend time delivering patient care, but the need for nurses will remain.

At YNHH, nurse SWAT teams use the Rothman Index to identify at-risk patients. A SWAT team is a group of experienced nurses trained in critical care, advanced cardiovascular life support, and trauma care. SWAT teams now receive immediate warning notifications on mobile phones when the index indicates patient deterioration. The SWAT team reviews the EMR and, as needed, assesses the patient and collaborates with clinical nurses and medical staff on pertinent aspects of care. SWAT nurses describe themselves as "a second set of eyes."[10] The data used to generate the index are derived from routine nursing documentation. Timely input of nursing assessment data is critical to the calculation and value of index scores because the index updates in real time from the EMR. For acceptance and continuous use of the index, clinicians may need an "a-ha" moment when they discover that the data do make a difference when working with their patients and families. For example, at YNHH palliative care team members found Rothman Index graphs useful in goals of care discussions. (See *Figure 3.*)

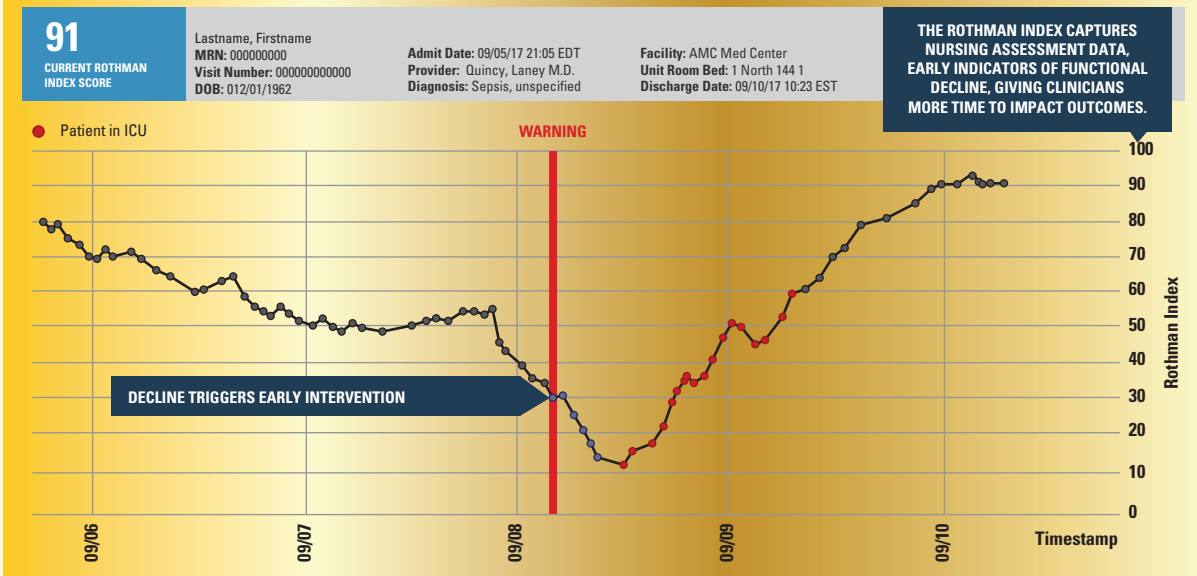
As new algorithms are integrated into patient care processes, it will be essential for nurses to gain experience in interpreting multiple data results and integrating new information into nursing practice. Based on their Rothman Index implementation experience, the YNHH team offered best practice advice on how to integrate new data into patient care:

- Having a growth mindset in the organization is important. Prepare teams to learn new ways to gather and use patient data and information.
- Tool experience is local and must be integrated into existing practices based on frontline provider experiences. Tool usage depends on stories told about the usefulness of the new technology; word-of-mouth dissemination complements formal education and is key for adoption.
- Tools must be easy to use, and output interpretation must be intuitive.
- Tools must benefit patient care. Ideally, they allow nurses to spend more time at the bedside and gain a better understanding of the patient's illness and needs.

How are robots changing the nursing profession?

Robotic engineers are advancing what robots can do and how they emotionally respond to circumstances. Emotionally responsive robots are commonly called social or companion robots. Although we aren't at the stage of robots taking over, they're entering healthcare delivery sites, our homes, and our workplaces. Social robots are designed to interact in ways that make them human by responding to human interactions.[11] Sophia is an example of a social robot conceived as a companion for

Figure 3: The Rothman Index



Note: All data are fictitious.

older adults that demonstrates the potential of technologic advancements to improve how robots function.[12] In 2018, Sophia was redesigned with mobility capabilities and is now the first robot to be given citizenship in a country (Saudi Arabia).[13] Researchers around the globe are creating robots to help people drive, impact suicide rates, support clinical telehealth applications, and more. As robots learn to perform nursing functions, such as ambulation support, vital signs measurement, medication administration, and infectious disease protocols, the role of nurses in care delivery will change. Research suggests that between 8% and 16% of nursing time is spent on nonnursing activities and tasks that should be delegated to others.[14] Nurses with robot support will have the ability to take back this time and spend more of it with patients. (See *Examples of robots in use today.*)

Beginning in 2014, nursing-centered robotics project grants have been funded by the National Science Foundation (NSF) to promote the use of robots in nursing activities. To date, NSF has invested over $3 million in learning how robots can perform nursing functions. Does this mean that nurses are destined to become obsolete? Absolutely not; quite the opposite is occurring. Nurses are actively engaged in the creation and use of robots designed for patient care and older adult support. The robots are viewed as assistants that can help nurses at the bedside or in the community.[15] An example of a robot collaboration is found at Duke University Pratt School of Engineering and School of Nursing. Interdisciplinary teams are working on developing the Tele-Robotic Intelligent Nursing Assistant (TRINA), a remote-controlled robot, to address healthcare workers who are at "high risk for infection due to routine interaction with patients, handling of contaminated materials, and challenges associated with safely removing protective gear."[16] TRINA is tested in the nursing simulation lab and currently performs about 60% of predefined nursing tasks; however, it's 20 times slower than a nurse. Although it isn't expected that the robot will be ready for release in the near future, lessons learned and development research will inform future projects.

The University of Cincinnati College of Engineering and Applied Science, College of Allied Health Sciences, and College of Arts and Sciences and Maple Knoll Village, a local independent living and retirement community, collaborated to launch a nurse-led telehealth robot project called TCHAT (Telehealth Community Health Assistance Team). The goal of the project was to evaluate nurse-led interventions for the promotion of healthy lifestyles and chronic illness management using a telepres-

ence robot. The project was a combination of one in-home visit to start the healthcare program and follow-up telehealth remote visits in the home. Data were collected on participant health outcomes and the usability of and satisfaction with the robot intervention.[17]

Findings from home participants receiving the telehealth coaching and responses from the adult gerontology NP students who served as telehealth coaches suggest that the combination of a face-to-face live intervention coupled with robotic telehealth visits is satisfying for both providers and patients. Lessons learned in the pilot included the importance of technology infrastructure to support robot connectivity through the internet. During the pilot, the robot froze and became disconnected at times due to lack of bandwidth in the patient's home. The pilot demonstrated that the nurse's role in the planning and implementation of telehealth robots is essential to designing meaningful interventions that can leverage new technology.

In a personal communication, University of Cincinnati College of Nursing Dean and Vice President for Health Affairs Dr. Greer Glazer and Assistant Dean for Technology Dr. Matthew Rota shared their insights about nursing's role in technology deployment. Strategically, both agree that nurses will need to learn how to team with data scientists to make the most of what technology can offer. Although nursing and computer science are distinct disciplines, knowledge and skill transfer between the disciplines is essential as technology progresses for nurses to learn how to make sense of the data. Conversely, data scientists need to gain insights about patients and factors that impact health outcomes. With the advent of applications such as telehealth and smart robots living in patient homes, Dr. Glazer envisions that the role of nursing will evolve into "becoming coaches to help guide individuals to achieve improved health and health management outcomes." Both Dr. Glazer and Dr. Rota agree that robots will never totally replace nursing's role in patient care; providing touch and establishing relationships with patients are cornerstones of the nursing profession. In discussing managing patient disease and death, Dr. Glazer opined, "If I'm dying, I find it hard to believe I would choose a robot over a human to help me through the event. Nuances in human behavior will keep nurses on the front line of care."

Home care supported by new devices and/or robots collecting medical information, such as heart monitoring, urinalysis, and range-of-motion analysis, is changing nursing practice. As new and more sophisticated AI tools become available to support nurses anytime/anywhere, the nurse will be able to fulfill a practitioner role, delivering care across the continuum. According to Dr. Glazer, this will function like a practitioner caseload model where the patient receives continuity of care from a nurse. A significant barrier to achieving Dr. Glazer's nurse coach/practitioner vision is acceptance by other healthcare disciplines of nurses' ability to practice at the top of their license. Dr. Rota noted that nurses will need to grow into these roles and learn how to integrate new technologies and tools. He sees the

Examples of robots in use today[11-13]

- Buddy
A home robot
https://buddytherobot.com/en/buddy-the-emotional-robot
- Little Sophia
A robot for kids age 8 and older that teaches STEM, coding, and emotional engagement
www.kickstarter.com/projects/1240047277/little-sophia-by-hanson-robotics
- Lynx
A home companion
https://ubtrobot.com/products/lynx
- Miko2
A kids' robot that understands emotions
www.miko.ai
- PARO
An animal therapy robot
www.parorobots.com
- Pepper
A hospital receptionist
www.bbc.com/news/technology-36528253
- Pillo
An AI-powered health companion
www.pillohealth.com
- Professor Einstein
A robot that teaches science and general information
www.hansonrobotics.com/professor-einstein
- ROBEAR
A nursing care robot
www.riken.jp/en/pr/press/2015/20150223_2
- Sophia
A social robot companion for older adults
www.nationalgeographic.com/photography/proof/2018/05/sophia-robot-artificial-intelligence-science
- Vortex
A programmable robot that teaches kids STEM
www.youtube.com/watch?time_continue=5&v=ssv7tcXJSnQ

nursing profession changing as nursing programs ramp up technology components in curricula.

How are nurses collaborating on AI applications?
Microsoft CNO and National Director, US Provider Industry, Molly McCarthy views AI as a tool that supports nursing by allowing nurses to practice at the top of their license. McCarthy has observed that today's nurses spend time doing things that should be performed by someone else with different skills. In the future, AI tools will relieve nurses of these activities, enabling them to focus their efforts on professional activities that utilize the full extent of their education, training, and experience.

Microsoft is involved in applying AI technologies in three core healthcare application areas—clinical, financial, and operational—working with nursing teams to identify areas where AI technologies can provide added value for the healthcare team and patients. According to a Microsoft spokesperson, "Nurses are integral to the design, development, and deployment of health information technology. Having these experts on our team helps Microsoft empower nurses throughout the healthcare industry's digital transformation journey." For example, Cincinnati Children's Hospital Medical Center (CCH) has been a test bed for innovation using mobile apps designed to enhance the patient experience. At CCH, data collected from the EMR help predict disease and identify how to prevent adverse events. Nurses are team members who help design and deploy new applications. McCarthy envisions that AI systems will continue to work in the background, with nurses being the integrators of data provided by AI tools. Nurses will need to learn how to integrate AI results into evidence-based practice while balancing that information with wisdom gained through nursing experience.

Implementing new ways of working is always challenging and the deployment of AI technologies is no exception. McCarthy suggests that AI teams can achieve success if they incorporate the following implementation processes into AI projects:
- Identify a proof of concept that involves frontline users (physicians, nurses, and interprofessional team members) who have a pain point to resolve. The pain point must be important enough for team members to give time to the project.
- Cultivate a growth mindset that embraces new practices and accepts failures as part of the process. Culture and leadership are keys to success.
- Respect that clinicians have limited time to contribute; be prepared with essential information, answers to common questions, and feedback.
- Identify measurable outcomes that are meaningful and contribute to organizational goals.
- Look outside healthcare to see how AI technologies have helped advance other industries and learn from others.

What are potential impacts of AI on nursing's role?
AI project teams. Given the pace of AI applications being developed for healthcare, it's likely that you'll be involved in some aspect of using or creating a new AI system. If you're recruited to be part of an AI team, the data scientist will determine the best type of data and algorithms to use for the AI application. Your role as an expert or end user is to provide feedback to the data scientist about the validity of the data utilized to design and train the system and the assumptions used to define the data, and review results generated by the computer. You become the quality check for the data inputs and outputs by evaluating:
- Do the results make sense?
- Are any data variables missing?
- Are any of the results surprising?
- Are you confident that you know what the data represent and how to use the results?
- Would you trust the results enough to act on them with your patients?

Ethical considerations. A key concern of AI practitioners today is managing bias. If computer algorithms are trained using biased information, they'll give back biased results. A high-profile bias case was found in a parole system used to determine the risk of recidivism. The AI results unearthed biased recommendations based on whether the parolee was Black or White. Although data integrity has always been a concern of data scientists, this discovery by ProPublica raised awareness about the bias issue.[18] A study by the Massachusetts Institute of Technology found three areas where bias can creep into an AI project: framing the problem or task to be solved, selecting flawed data to train the system (the data don't reflect current reality or the data represent existing biases), and selecting data that include attributes that will skew the algorithm results.[19,20]

Provision 4 of the American Nurses Association's *Code of Ethics for Nurses* clearly states that the nurse is accountable and responsible for nursing

practice and the impact on patient care.[21] The code addresses accountability for nursing judgments, decisions, and actions, and specifically refers to systems and technologies as aids rather than substitutions for nursing skill and judgment. The code states, "Systems and technologies that assist in clinical practice are adjunct to, not replacements for, the nurse's knowledge and skill."[21] As a nurse using new technologies or helping to build them, it's your responsibility to ask about the data used to train the system and how the system results were checked for bias.

A second aspect of bias to consider is the issue of algorithm transparency: Does the AI system have the capability to explain the results? The US Department of Defense is leading efforts in explainable AI, recognizing that if combat soldiers are to understand and trust AI recommendations, then the user must understand how the computer reached its decision.[22] Holzinger and colleagues argue that now is the time for medical AI to push toward building explainable systems with the goal of engendering trust in system results.[23] A question to ask your organization when deploying new technologies is, "How are the results monitored to judge the accuracy of recommended decisions?"

Technology companies have established new ethics positions that help AI teams navigate bias issues, issuing specific statements about fairness, accountability, and the transparency of data used in the creation of AI systems. In healthcare, we have nurse ethicists; perhaps now is the time to establish the role of AI ethicist for healthcare projects.

Changing roles. In 2017, the McKinsey Global Institute (MGI) published the report "Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation."[24] Although discussions of AI replacing human workers have taken place since the beginnings of the technology, this report stirred great debate about the global impact of AI. MGI models predict that by 2030, nearly 75 million to 375 million workers worldwide will need to switch occupations due to AI technologies. However, the report also emphasizes that new roles and jobs will be created. American Economic Association researchers agree with the MGI predictions, finding that some tasks will be favorable for automation, but few jobs can be fully automated. They also predict that workers will train into new roles.[25]

Into the future

Nursing will be impacted as new AI technologies assume some tasks performed by nurses today. Technology will change how nurses spend time delivering patient care, but the need for nurses will remain. Nursing experience, knowledge, and skills will transition to learning new ways of thinking about and processing information—the nurse will become the information integrator, health coach, and deliverer of human caring, supported by AI technologies, not replaced by them. NM

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Nancy Robert is a managing partner for Polaris Solutions, a technology and product consulting company, in Madison, Conn., and a former American Nurses Association executive vice president and chief product and marketing officer.

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