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Nursing and Compassionate Care in a Technological World:

A Discussion Paper



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Introduction

Technology has permeated Canadian healthcare settings where nurses practice. Nursing assessments often rely on biomedical technologies for physiological monitoring (e.g., vitals machines) and diagnostic testing (like glucometers). Some physiological markers may be monitored at a distance using wearable sensors and mobile health applications. Intravenous therapy is frequently delivered through smart infusion pumps. Documentation is completed in electronic health record systems. The list of current and historical uses of technology by nurses is clearly extensive.

While nurses have long worked in technology-laden environments,^{1,2,3} nurses in the future will work in contexts with increasingly sophisticated technologies, such as those supported by artificial intelligence (AI), machine learning, automation, and robotics. This future technological context of healthcare presents both opportunities and challenges for the nursing profession. For example, how will the nursing role be shaped and influenced in the presence of these technologies? How can the nursing profession most effectively leverage these technologies in clinical, educational, administrative, research, and other contexts? How can nurses deliver person-centered compassionate care through and with technologies supported by AI, machine learning, automation, and robotics while preserving both the art and science of nursing?

To date, the nursing community has focused on supporting nurses in obtaining the technical skills and competencies needed within changing clinical landscapes.^{4,5} Much less discussion has considered the implications of AI and related technologies for the future of nursing and for nurses' ability to provide compassionate, person-centered nursing care.⁶ Without this critical discussion and thoughtful plan for the future, the nursing profession may find itself in a difficult situation where the nursing role is unclear. As stated in a recent Canadian article:

The voice and influence of nursing care can be amplified in this digital future, if we are able to harness the power of this technology in advancing our abilities to provide skillful evidence-informed care. However, the opposite is also possible. Now is the time when we must commit to engaging the integration of AI into our workplaces and equip ourselves and our profession with the enhanced nursing intelligence needed to ensure future success. ^{7 (p42)}

Purpose

The purpose of this paper is to enable Registered Nurses, Registered Practical Nurses, and Nurse Practitioners to engage in meaningful discussions about compassionate care in a technological world, with a specific emphasis on AI and related technologies. We provide relevant background information, describe the current context of technology, and discuss current and potential implications for the nursing profession in a number of areas: clinical practice, education, leadership, research, and professional considerations (regulatory, legal and ethical).

Terminology

Given the future-focused nature of this paper, we will discuss primarily AI and related technologies. The definition of AI used in this paper is as follows:

The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. ^{8 (p44)}

A list of other future-focused technologies (e.g., virtual/augmented reality, chat bots, natural language processing) and their respective definitions is provided in a glossary in Appendix A.

These technologies raise some shared and some unique implications for nursing. The glossary should open the way to rich conversations about the future of nursing and compassionate care in a technological world. With regards to compassion, a definition inspired by the Oxford Handbook of Compassion Science has been used. This handbook describes compassion as having the following components: 1) awareness of the suffering or need of another; 2) feeling ‘moved’; 3) recognizing the feeling of being ‘moved’ as a response to another; 4) making the judgment that the other is suffering; and 5) engaging in an action or behavior to attempt to alleviate the suffering.⁹ Compassion is a different concept than empathy, as empathy does not necessarily result in an action or behavior.

Methodology

This paper was developed using two methods, as described below: 1) expert panel consultation and 2) a rapid literature review.

Expert Panel Consultation

Nurses with expertise in the technology and digital health field have been consulted in the development of this paper. These nurses have advanced degrees in field-relevant disciplines, and actively work as educators, researchers, clinicians, and/or administrators in the Canadian nursing and technology context. Experts provided input into the literature review search strategy, methodology for developing the paper, topics of importance, structure of the paper, Canadian context, implications, and suggested background reading.

Rapid Literature Review

A modified rapid literature review^{10,11} was conducted, drawing upon the expertise of a health sciences librarian and recommendations from an expert panel. Medline and the Cumulative Index of Nursing and Allied Health Literature (CINAHL) were searched using a comprehensive search strategy that is detailed in Appendix B. A total of 5616 non-duplicate citations were identified between the academic databases. All non-duplicate citations were screened using a set of inclusion and exclusion criteria, as detailed in Appendix C. Once these criteria were applied, a total of 135 citations were identified. These references were reviewed in full to identify important topics for this paper. Identified citations were categorized based on the technology being examined in the paper and the domain of interest (clinical practice, education, leadership, research, regulation, legal issues, and ethics). The screening process results, along with inclusion and exclusion criteria, are described in Appendix C. A grey literature search was also conducted using common Internet search engines.

Nursing, Technology and Compassionate Care: The Past and the Present

The question of how technology can be meaningfully used by nurses to provide person-centered compassionate care is not a new one.¹⁻³ A 1992 article by Mary Lou Peck raises concern over the potential loss of tender loving care brought on by the use of technology, arguing that computers cannot provide such care “because it involves feelings and human connection that are beyond mere technology”.^(p183) However, Peck also recognized that to provide patients with care that they want and expect, nurses would need to understand and be comfortable using technology in their practice.¹ She describes nurses’ future use of technology in the following way:

[Nurses] will not have to memorize as many details, for these can be found in the computer when needed, but they will still require the wisdom that puts the client in the centre of the multitude of available health recourses. They will have less physical work to do, but their

task of providing an environment in which the patient can find healing will still carry the importance that it did in Florence Nightingale's day. ^{1 (p188)}

Often embedded within these earlier discussions was the notion of there being no care or healing without compassionate care.¹² Nurses have long emphasized the importance of their role in providing compassionate, humanized care alongside the use of technology in care delivery. In fact, it has been said that caring is the most essential ingredient to any curative process¹² and that caring is the backbone of the nursing profession. Thus, it was argued that if nurses could practice compassionate care while effectively integrating the latest technologies into their practice, the profession would be well positioned to have a long and positive future.¹

In the current environment, nurses need to be aware how technologies can enable compassionate care, while also recognizing some of the drawbacks. Opportunities to provide compassionate care stemming from technology can include improving the accessibility of services,¹³ increasing privacy or anonymity when discussing sensitive topics,¹⁴ and providing education related to compassionate care.¹⁵ Drawbacks can include impersonal care,¹⁶ miscommunication stemming from the absence of social cues,¹⁷ poor quality and design of the technology,¹⁸ poor positioning of technology in clinical care encounters¹⁹ and discrepancies in access to, and comfort with, technologies in clinical care.^{20,21}

Many of these lessons from the past and present will remain salient in the future. What is unique about the future is the evolution of technologies to perform human-like activities, such as decision-making through AI and task performance by robots.^{6,22} The remainder of this paper focuses on this future technology-enabled healthcare context and its implications for the nursing profession.

Nursing, Technology and Compassionate Care: The Future

Artificial intelligence (AI), and related technologies like machine learning and natural language processing, are some of the most discussed technologies in healthcare today.^{7,8,23,24} Already, in non-healthcare contexts, applications of AI have significantly shaped the lives of Canadians. For example, product and music recommendations, predictive internet searches, and fraud prevention at financial institutions are now commonplace and guide the decision-making of Canadians in many facets of life. While it is expected that clinically relevant uses of AI applications will emerge en masse in the coming years, the timeframe in which this will happen is currently unknown.

We cannot predict exactly how AI and related technologies will transform healthcare. However, experts in the field expect two emerging uses of technology to scale and spread in the coming decade:

1. Leveraging data and information to generate insights, support decision-making, and optimize processes; and,
2. Using automation and robotic technologies to support various activities of life and work.

Both of these potential developments are described below.

Leveraging Data and Information

The diffusion of social media and related Internet technology over the last 15 years has generated a digital ecosystem that is saturated with data related to people: their attitudes (e.g., reactions to events and phenomena), purchasing habits (e.g., online purchases through electronic vendors like Amazon or eBay), health and lifestyle choices (e.g., PatientsLikeMe, 23andMe), and thousands of other activities that are collected and aggregated by online technologies. The collection of information through health-related technologies (e.g., monitors, digital pumps, electronic health records, social media) has generated the potential to develop

insights that has never been previously possible. In order to make sense of these vast amounts of healthcare data, various AI-facilitated data analytic techniques using machine learning and deep learning algorithms²⁵ have been developed.

Nurses and other health professionals have spent decades collecting and documenting patient information and clinical care, often using flowsheets and standardized data collection mechanisms, which have recently been embedded within electronic health record systems and other technologies. AI can help to generate personalized insights from these large volumes of data; improve clinical knowledge related to specific causal pathways of illness and treatment; enhance clinical decision support in complex tasks and processes; and improve workflow and efficiency.²⁴ With improvements in natural language processing and similar mechanisms, even narrative and hand-written documentation that nurses have produced may be used for these purposes in the coming years.^{26,27} These forms of data, combined with the increasing amount of patient-generated data from smartphones, wearables, and self-assessments, can be used to produce new knowledge and to better support patients in their interactions with the healthcare system.

Automation and Robotic Technologies

The increasing use of automation and robotic technologies in other industries has led some to believe that nurses and other health professionals will also experience various changes to their modern role as healthcare providers. While most experts remain optimistic that health professionals will not be replaced by robots, some warn that clinician roles will experience significant disruption in the coming decades. As outlined by Coiera:

[W]e probably will see little change to clinical practice from AI in the next 5 years. We should certainly see changes in 10 years, and there is a real prospect of massive change in 20 years. For students starting medicine today, by the time they are mid-career, substantial technology-induced disruption will have occurred. Predicting where disruption is most likely to occur is hard, but if it feels routine today, then it is likely to be a target for the machine tomorrow. **28 (p2331)**

The outcomes of this disruption are uncertain and are expected to bring both opportunities and challenges for healthcare providers. It is important that nurses be proactive in responding to this changing technological landscape, which will certainly have implications for professional roles, policies, and nurse–client relationships. As Booth et al. warn, if nurses do not fully appreciate this technological evolution, they “may miss a vital opportunity to become agents of change in this quickly evolving domain — a domain where remaining static is incompatible with a prosperous or productive future”. **29 (p283)**

Currently, one of the most discussed potential benefits of emerging health-related automation and robotic technologies is that nurses will be afforded additional time in their roles with patients to perform human-focused and more complex care activities.³⁰ This may allow nurses to hone their skills in other facets of their roles, rather than as collectors of data and tenders of machines and monitors. The burden of technical tasks, such as documenting within the electronic health record, has been associated with the significant problem of professional burnout.^{31,32} With AI-enabled speech recognition technology already present in a number of settings,^{33,34} nurses may find themselves spending less time in front of computers entering clinical data. Technologies may increasingly assist with documentation tasks.

It has also been proposed that nurses may take on new roles that involve overseeing, delegating, and coordinating care conducted by other members of the health workforce and by technologies like robots.³⁵ Others worry that nurses may be replaced either by less qualified staff, who can simply act on the outputs of clinical decision-support systems, or by robots and technologies that can perform tasks that nurses normally would do.³⁰ One nurse stated:

As human decision-making, physical presence and human labour are all being supplanted or replaced in different areas of society (including healthcare) by artificial intelligence and

automation, nursing will need to readdress its value proposition to health(care) if it wishes to retain some level of control in this evolution. ^{36 (p64)}

While it is still unclear how automation and robotic technologies will influence nursing, it is important for the profession to generate thought-leadership in this domain to ensure important human-centric activities of the healthcare experience brought by nursing continue in the coming decades.

Implications of AI and Related Technologies

The permeation of AI and related technologies in contexts where nurses work has implications for clinical practice, education, leadership, research, regulation, legislation, and ethics. These implications are described below in turn.

Clinical Practice

While specific examples of how AI and other emergent technologies will impact healthcare are just starting to be seen, the foundations for significant change have already been formed. The increasing use of digital health technologies (e.g., electronic health records, personalized healthcare, decision-support tools, mobile devices) has generated the foundations for a future digital ecosystem that will employ AI and other emerging technologies. Similar technologies have become widely used in other industries. For instance, most aspects of modern-day manufacturing, food preparation, and even some knowledge work industries rely on the powers afforded by systems possessing AI.

A few areas of clinical practice are likely to witness significant evolution. According to KPMG (2018), some of the most significant changes in the coming decades will likely involve how consumers and clients interact with their health and related care.⁸ The growing availability of data to generate insights and personalized treatment recommendations has spawned the potential for new care delivery models. Automation technologies will also influence aspects of the healthcare experience by consumers and clients, namely through displacing human labour in highly repetitive, lower skill, and lower knowledge activities.

Patients are using consumer-facing technologies as a way of staying healthy (e.g., fitness applications), monitoring certain parameters (e.g., heart rate), or addressing a health concern (e.g., medication reminders). Data generated from consumer technologies such as mobile health applications, wearables, and smart home devices have the potential to form a greater portion of inputs for nursing assessments in the future. With increasingly personalized treatments customized to people's genetics or lifestyle arrangements, such "precision medicine" is a significant area of growth that will affect the work of nurses. The increasing desire of individuals to have personalized treatments customized to their genetic or lifestyle arrangements (e.g., precision medicine) is a significant area of growth that nurses need to become more involved with shaping. The rise of companies that offer genomic sequencing and other personalized health advice (e.g., 23andMe, myDNA, PatientsLikeMe) is a hallmark of an increasing desire of consumers to generate personalized and specific interpretations of their healthcare, sometimes without the consultation of traditional models of care offered by modern-day primary and tertiary healthcare.

The clinical documentation demands and use of electronic health record systems have been associated with burnout among some health professionals.^{37,38} Nurses have described challenges with electronic documentation workload for a number of years now.³² In order to apply natural language processing and machine learning methods to nursing documentation for predicting outcomes and developing advanced clinical decision-making supports, increasing documentation demands may be placed on nurses in the short term.³⁹ A thoughtful approach to nursing documentation should be considered so that nurses are not spending more time satisfying the needs of the computer than the needs of patients. Recently, consumer-level

diffusion of various smart personal assistant robots (e.g., Google Home, Amazon Alexa) has demonstrated the abilities of natural language processing. While this form of technology has grown significantly over recent years in potential and ability, due to the privacy implications and fidelity requirements of modern-day healthcare documentation, these types of technology still require significant improvements before they will likely be used in mainstream practice. Regardless, considering natural language conversant technologies like Amazon Alexa are now embedded into over 100 million devices as of early 2019, it seems likely that this kind of AI-powered technology will be seen in healthcare in the coming decade(s).

Key clinical practice questions

- How will nurses' roles change if their current tasks are augmented and disrupted by AI and other technologies?
- What do nurses currently do that may be done by lesser skilled professionals who can follow AI-supported decisions?
- How can nurses ensure that the 'human role' of healthcare is not lost in the increasing use of AI and other automation technologies?

Education

One of the challenges that exists is a lack of faculty across Canada that have the knowledge and comfort to prepare nursing students to practice in AI-enabled environments.⁴⁰ It is important that this group be better equipped to train the future generation of nurses.⁴¹ As stated by Risling (2017), "nurse educators, both in practice and education, will be essential in leading a successful technological evolution for nursing"^(p91)

The advent of AI and other emergent technology in healthcare has created significant pressure for nursing educators. For example, the wide-scale diffusion of social media technology into nursing education has demonstrated its potential to reframe many established ideas about professionalism. These changes have required educators and regulatory bodies to develop new policies related to professionalism and communication in social media. As AI and related technologies become more established in healthcare, nursing education will need to remain proactive in understanding how nurses interact with technological systems so that both nurses and technology can inform decision-making. In essence, nursing educators need to become more comfortable with the fact that future healthcare systems will be significantly underpinned with AI and related technologies, and that both human and technology elements will act together (not in isolation) to generate care actions. The days of viewing technology as a neutral object in the process of delivering care are quickly becoming obsolete.

It is vital for educators to be cognizant that nursing education must include discussion related to AI and the role of robotics. If nursing education fails to engage in these discussions, students will be prepared for an outdated healthcare domain in which all decisions were dominated, and tasks executed, primarily by humans. The future reality will likely be more of a blurred human-technology relationship, where tasks and decision-making are a shared activity, rather than one done in isolation of each other.

Key education questions

- How will nursing faculty be developed and supported to feel comfortable teaching nursing students about future AI-enabled healthcare?
- What are the best teaching and learning methods for supporting nursing students to transition into clinical environments supported by AI and related technologies?
- How will nursing students learn clinical judgment/intuition in the presence of AI and related technologies?

Leadership

Many nurses in senior roles may also be ill-equipped with the knowledge and skill to advocate for nursing in important technology-related decisions at healthcare organizations.⁴²⁻⁴⁵ After all, these nurse leaders likely did not receive education related to technology (undergraduate, graduate, or otherwise), and may feel more comfortable delegating these responsibilities to other professionals, such as those in information technology departments. However, without their expertise, organizations risk implementing technologies that are not used meaningfully by nurses or that produce unintended consequences for nurses and patients.⁴⁶

Evidence suggests that engaging nurses in technology decision-making at multiple levels can improve uptake of the technology by nurses and increase the likelihood that the technology will support desired outcomes.⁴⁷ A recent study has also demonstrated that nurse leaders who manage direct care nursing staff can play an important role in the successful adoption and use of health information technologies, if effective support strategies are used.⁴⁸ These findings suggest that nurses need to have significant involvement in a variety of different roles and at different levels for meaningful adoption of technology to occur. Strong nursing leadership is required to advocate for and ensure that this level of engagement occurs. Nurse leaders at all levels of a healthcare organization have important contributions to make throughout the technology lifecycle: identifying the need for technology; participating in procurement activities; selecting, co-designing, adopting, using, optimizing, and evaluating technology; and engaging patients and family members throughout the process.⁴⁹ Nurse leaders can advocate for appropriate nursing representation at each of these important stages, and ensure that governance structures and processes for technology-related initiatives afford nurses decision-making authority.

Emergent technologies will also generate new and fluid opportunities for nursing leadership. When healthcare environments begin to adopt AI technologies that augment or disrupt traditional care models, nursing leaders will be central in developing new management and leadership models to actively appreciate and utilize these assets. Nursing leaders of the future will have to juggle managing human resources (e.g., budgeting, staffing allocation, skill mix) with managing emergent technological resources, both conceptual (e.g., effects of AI on clinical decision-making) and material (e.g., robotic delivery of supplies, automated medication administration). While the scope of nursing leadership has commonly conceptualized resource allocation as an important aspect of the role, in the future, the meaning of resource may evolve significantly. Much like other areas described in this paper (e.g., Clinical Practice, Education), nursing leadership of the future should become more comfortable with the potential that modern-day nursing roles currently held by humans will be changed by non-human technologies in a significant way. The paradigm of leadership must become attuned to how emergent technologies can enable nurses to scale their scopes of practice and focus on elements of care that only humans can provide.

Key leadership questions

- How will nurse leaders use AI for decision-making?
- How will nurse leaders make use of future AI and related technologies to scale nursing activities that only humans can provide (e.g., caring, intimate care, debriefing after traumatic events)?
- How will evolved approaches to clinical decision-making influence the nursing leader role in the future (e.g., policy, legal, privacy)?

Research

There are substantive opportunities for nurses in clinical practice, education, leadership, regulatory, legal, and ethics contexts to benefit from the work of nurse researchers engaged in technology-related inquiry. Nursing researchers can use rigorous methods to identify key competencies and best practices in digital environments. A research agenda may investigate how nurses engage with technologies, evaluate technology for certain populations and purposes, explore unintended benefits and consequences of using technology in nursing contexts, and describe the influence of technology on compassionate, human-centred care. Meaningful integration of technology within nursing practice should allow nurses to care for patients and families to the full extent of their scope of practice. With such rich clinical data being collected through a variety of technology sources (e.g., nursing documentation in the electronic health record, physiologic markers from wearables), nursing researchers are well positioned to analyze this data through sophisticated approaches like machine learning and natural language processing.⁵⁰ If the findings of these analyses are appropriately integrated back into clinical care processes (e.g., clinical decision supports in the electronic health record), there could be an immediate impact to clinical care.

In essence, AI and related technologies that are currently being implemented into healthcare will offer researchers the ability to ask and address new questions that were never addressable, or very difficult to address in the past. Due to the masses of data currently being collected related to many different healthcare interactions, data science within the nursing profession will likely be a significant area of growth in the coming decades. Unfortunately, the nursing profession has only recently begun to utilize the massive amounts of secondary data generated by its role within healthcare. Researchers in the future should recognize the value of data analytics for both the profession and patient care. Further, they should explore how AI and related technologies influence the profession over time. To date, there is budding research showing how social media technologies have changed elements of professional communication with patients and society.⁵¹ This is a modest step in an important direction. It will be vital for researchers to explore the effects of technologies upon the work of nurses and the role of the nursing profession

Key research questions

- What topics will be important for nursing researchers to examine in the coming decades?
- What sources of secondary data exist currently (or should be collected) to help inform the work of nurses and the growth of the nursing profession?
- How can nursing researchers build capacity within advanced data analytics and utilize the masses of data that currently exist due to the wider scale adoption of electronic health records and related systems?

Regulatory, Legal, and Ethical Considerations

Various regulatory, legal, and ethical considerations exist in the technological landscape in which nurses work. Some technologies (e.g., voice-activated devices, chat bots, smart homes) have been developed at speeds that outpace the ability of organizations and the nursing profession to be thoughtful about these important considerations. Patient privacy in the digital context is an understudied yet important field.^{52,53} How can sophisticated technology and information exchange support patients' expectations of privacy? Who owns this data? What protections are put in place when data is linked between sources or organizations? Patients have indicated concerns regarding the security of their health information when collected via some of these emerging technologies,⁵⁴ particularly when "hacking" of credit card and other personal data is frequently reported.

Biases that may be present in nursing documentation in electronic form may be amplified when machine learning and natural language processing techniques are used. This could result in the further stigmatization or reinforcement of unhelpful biases in clinical care delivery. Nurses can take a greater role as leaders in thoughtfully considering and addressing these regulatory, legal, and ethical considerations.

The effects of AI and related technologies will force regulatory, legal, and ethical professionals to revise and (in some cases) re-envision policy. Since future healthcare ecosystems will be comprised of both human and technological agents that work together in new ways to deliver care, various legal, regulatory, and ethical bodies of the profession need to begin articulating policies that embrace this blurring of human and non-human roles. In sum, policy that conceptualizes technology as something that works “with” humans, rather than “for” humans, is a first step toward appreciating the fluidity of future healthcare models where people and technology interact in seamless fashions. In other industries, this fluidity has begun to raise complex legal, ethical, and existential questions about, for instance, liability for accidents involving self-driving vehicles; diagnoses of various conditions facilitated by AI; the use of facial recognition in public spaces for population surveillance; and the increased use of AI to manage and personalize various activities like shopping and news media recommendations. Without future-forward planning, the profession will be ill prepared for both the policy and liability implications of the not-too-distant future.

Key regulatory, legal, and ethical questions

- How do nurses reconcile incongruences between their clinical judgments and outputs of AI-enabled clinical decision support systems? Subsequently, what regulatory, ethical, and legal implications exist?
- What are the legal implications of following AI-enabled clinical decisions that result in harm to a patient?

Final Thoughts

Within Canada, there is currently limited use of AI and related technologies by nurses; however, it is expected that in the future these technologies will have a significant presence within the healthcare landscape. Given that nurses make up the largest healthcare workforce in the country, the nursing profession needs to be thoughtful about how it will position itself in the context of an AI-enabled healthcare world. These issues should be central to discussions about the future of the profession. As stated in a Canadian Nurse article:

Nurses should be making the decisions around which aspects of their roles can be taken over by technology, and which ones can't. By overseeing the introduction of AI and automated technology, they can ensure that the more holistic aspects of care continue under the new systems. **35 (para6)**

The nursing community in Canada would be wise to either lead or advocate for their significant engagement in the development of any AI and related technology applications in settings where nurses work. Nurses are well positioned to think through critical issues related to ethics, social justice, and compassion as they relate to the application of AI in healthcare.⁷ These are all important elements of ensuring that AI-enabled technologies are used in ways that best support the health and well-being of Canadians.

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Appendix A: Glossary

Technology	Definition
Artificial intelligence	The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages ⁸
Augmented reality	Computer displays that add virtual information to a user's sensory perceptions. Most AR research focuses on "see-through" devices, usually worn on the head, that overlay graphics and text on the user's view of his or her surroundings ⁵⁵
Chat bots	Computer programs that interact with and interpret what is conveyed by a user and use natural languages to respond and create a human-computer interaction. Uses of chat bots include health education for adolescents and cognitive behavioural therapy for treatment of various mental illnesses ⁵⁶
Electronic health/medical records	A longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting ⁵⁷
Machine learning	Scientific discipline that focuses on how computers learn from data through the use of statistics and computer science ⁵⁸
Mobile health applications (apps)	Applications accessed through a smartphone or other mobile device for health and medical reasons. Apps may be used for direct provision of care, real-time monitoring of patient vital signs, and delivery of patient information to practitioners ⁵⁹ . Patients frequently use apps for health-related monitoring, education, and treatment.
Natural language processing	Obtaining data from narratives and natural language that can be structured and used in analyses and computer processing ²⁶
Remote monitoring	Consists of three components: 1) sensing and data-collection hardware to gather physiological and/or movement data, 2) the communication hardware and software to relay data to a remote centre, and 3) the data analysis techniques to extract clinically-relevant information from physiological and movement data ⁶⁰
Robotics	Systems that perform all three defining functions of a robot: acting on environmental stimuli, sensing, and logical reasoning ⁶¹
Social media	Social media services are web-based applications with user-generated content; this content is used by social media services to facilitate the development of social networks online by connecting a profile with those of other individuals and/or groups ⁶²
Smart home	A multitude of sensors capable of continuously and unobtrusively collecting multimodal data within home contexts. Smart home technologies allow users to access and control devices through an internet connection to alter their home environment ⁶³ . Some examples of smart home technologies include robotic telepresence systems, infrared motion sensors, fall sensors, cordless monitor bed alarms, smart temperature controls, and sleep tracking systems.
Telehealth	Electronic and telecommunications technologies and services used to provide care and services at a distance ⁶⁴
Telemedicine/nursing	The practice of medicine/nursing using a telecommunication infrastructure to deliver care to a patient at a distance ⁶⁴
Virtual reality	A technology that allows users to explore and manipulate computer-generated, real, or artificial three-dimensional multimedia sensory environments in real time ⁶⁵
Voice activated technologies	Technology that can carry out functions by voice activation through the use of a smart speaker device ⁶⁶ ; examples include Amazon Alexa and Google Assistant
Wearables	Technologies that can be worn with sensors and/or therapy delivery devices to help facilitate health and social care decision-making and delivery ⁶⁷ . Some examples include wearable sensors for cardiac monitoring, gait monitoring, capturing temperature changes, and sleep monitoring.

Appendix B: Medline Search Strategy

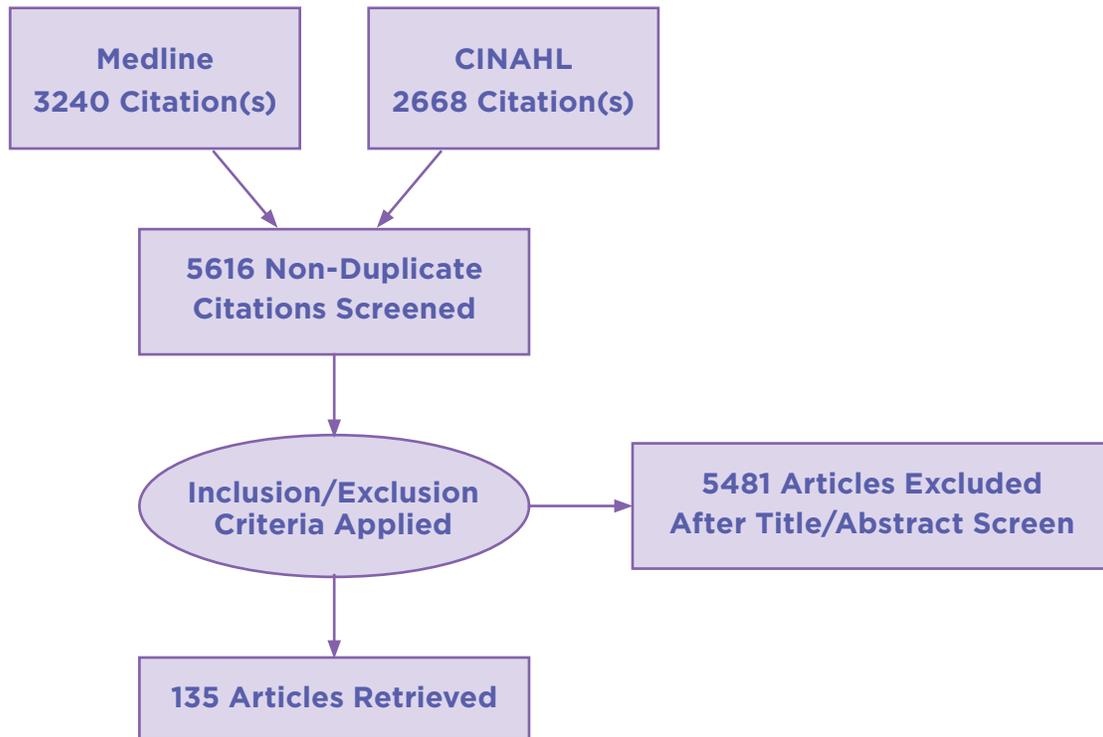
Database: Ovid MEDLINE: Epub Ahead of Print, In-Process & Other Non-Indexed Citations,
Ovid MEDLINE® Daily and Ovid MEDLINE® <1946-Present>

Search Strategy: June 11, 2019

- 1 communication/ or communication barriers/ or health communication/ (86831)
- 2 patient satisfaction/ or patient preference/ (83945)
- 3 nurse-patient relations/ (34627)
- 4 (patient adj1 nurse adj2 (alliance or relationship or rapport)).mp. (863)
- 5 Patient-Centered Care/ (17625)
- 6 ((person or patient* or client* or people or human) adj2 (centr* or center*)).mp. (61836)
- 7 Empathy/ or emotional intelligence/ (19319)
- 8 (compassion* or empath* or sympath* or compassionate care).mp. (161564)
- 9 ((therapeutic or empath* or warm* or interpersonal or compassion*) adj2 (alliance or relationship* or communication or rapport or care)).mp. (16493)
- 10 or/1-9 [compassionate care] (417167)
- 11 computer*.mp. (772481)
- 12 ((monitor or screen) adj4 (computer or internet or online)).mp. (3499)
- 13 (ehealth or e-health).mp. (5293)
- 14 exp telemedicine/ or videoconferencing/ (25596)
- 15 (telemed* or telehealth or teleconferenc* or tele-med* or tele-health or tele-conferenc*).mp. (26324)
- 16 (eportal or e-portal or patient portal).mp. (577)
- 17 exp Computer Systems/ or information technology/ (169621)
- 18 medical records systems, computerized/ or exp electronic health records/ or health smart cards/ (35573)
- 19 exp Medical Informatics/ or Nursing Informatics/ (429995)
- 20 (informatics adj2 (nursing or medical)).mp. (17187)
- 21 (electronic health record* or electronic medical record* or EHR or clinical information system* or health information technolog*).mp. (38587)
- 22 (virtual reality or mobile or technology-assisted or computer-based or internet-based or information technology or web-based or technology-mediated or technology-enabled).mp. (159379)
- 23 virtual reality/ (889)
- 24 Mobile Applications/ or Cell Phone/ or Text Messaging/ (12922)
- 25 ((mobile or smartphone*) adj2 (app or apps or applications* or therapy or therapies)).mp. (7850)
- 26 (mhealth or m-health).mp. (3788)
- 27 therapy, computer-assisted/ or diagnosis, computer-assisted/ (27656)
- 28 computer on wheels.mp. (6)
- 29 workstation on wheels.mp. (3)
- 30 artificial intelligence/ or machine learning/ or robotics/ (45751)
- 31 ((assistive or smart or artificial or intelligent) adj2 technolog*).mp. (3518)
- 32 internet of things.mp. (1363)
- 33 virtual assistant*.mp. (16)
- 34 intelligent personal assistant*.mp. (6)
- 35 (siri or google assistant or amazon alexa or cortana).mp. (227)
- 36 (amazon echo or google home or wink hub or insteon).mp. (3)
- 37 (smart adj2 (home* or hub* or device*)).mp. (1276)
- 38 artificial intelligence.mp. (25113)

- 39 robot*.mp. (43238)
- 40 digital health.mp. (1042)
- 41 (cyber-physical system* or cyberphysical system*).mp. (164)
- 42 virtual healthcare.mp. (24)
- 43 machine learning.mp. (23014)
- 44 cognitive computing.mp. (53)
- 45 Big Data/ (310)
- 46 Precision Medicine/ (14694)
- 47 (precision adj (healthcare or medicine)).mp. (19653)
- 48 telepresence.mp. (272)
- 49 (wearable adj2 (device* or technolog*)).mp. (3723)
- 50 exp Wearable Electronic Devices/ (9594)
- 51 or/11-50 [technology] (1286759)
- 52 exp Nurses/ (84961)
- 53 exp Nursing/ (247032)
- 54 exp Education, Nursing/ (81156)
- 55 future of nursing.mp. (1398)
- 56 nurs*.mp. (706655)
- 57 or/52-56 [Nurses] (714824)
- 58 and/10,51,57 (3495)
- 59 limit 58 to yr="1990 -Current" (3433)
- 60 limit 59 to english language (3240)

Appendix C: PRISMA Flow Diagram of Literature Search and Inclusion/Exclusion Criteria



Inclusion/Exclusion Criteria

- Applicable to Registered Nurses, Registered Practical Nurses, and/or Nurse Practitioners
- Published in any country
- English language
- Focus is on one of the following areas: clinical practice, education, regulatory, legal, ethics, leadership/administration/governance, research
- Technology discussed in the article (broad definition of technology used)
- Exclude articles solely focusing on electronic health records
- No specific date limitation

Appendix D: Additional Reading

- Booth, R.G. (2016). Informatics and nursing in a post-nursing informatics world: Future directions for nurses in an automated, artificially intelligent, social-networked healthcare environment. *Canadian Journal of Nursing Leadership*, 28(4), 61-69.
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