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NURSING & COMPASSIONATE CARE IN THE AGE OF ARTIFICIAL INTELLIGENCE:

Engaging the Emerging Future

October 2020

ABOUT THIS REPORT

This report is one of a series of reports commissioned by Associated Medical Services (AMS) Healthcare. The goal of these reports is to inform nurses in all roles and sectors, other health professionals, educators, health-service administrators, researchers and policy makers about the opportunities and potential challenges of emerging technologies powered by artificial intelligence.

This report is the collective effort of a number of individuals who contributed their time and expertise. A full list of acknowledgments is provided at the end of the report. To begin, we would like to acknowledge key individuals whose drive and expertise has made this report possible:

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About RNAO

The Registered Nurses' Association of Ontario (RNAO) is the professional association representing registered nurses, nurse practitioners and nursing students in Ontario. RNAO's mission is to advance healthy public policy and to promote the full participation of nurses and nursing students in shaping and delivering health services now and in the future. RNAO cultivates knowledge-based practices and promotes excellence in nursing to advance quality care and individual and collective health.

About AMS Healthcare

AMS focuses on healthcare's past and its future. Its work fosters a Canadian health-care system that advances technologically, while remaining rooted in compassion and a rich understanding of our medical history. AMS Healthcare convenes networks and funds crucial activities in health-care research, education, leadership and clinical practice. By combining work on the past and the future of health care, AMS ensures people are always at the centre of Canadian care.

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EXECUTIVE SUMMARY

"For new digital healthcare technologies to reach their full potential and deliver significantly better patient outcomes…the whole health and care system will need to anticipate and plan for the future." (p. 11)[1]

The age of artificial intelligence*[1](AI) is emerging across the globe, and Canada is at its forefront. AI enables computer systems to perform activities that usually require human intelligence. To maintain its leadership edge, the federal government launched the $125 million Pan-Canadian AI Strategy in 2017, becoming the first country in the world to announce a national strategy to advance AI research and innovation in a number of areas, including health. Globally, investment in artificially intelligent health technologies (AIHT) is predicted to exceed $36 billion by 2025. This trend is due in part to growing demand from the public for a modernized health system. According to a 2019 survey, Canadians support the use of AIHTs to augment patient care and health outcomes.

As the public's demand for these technologies grows, the Canadian clinical landscape will likely undergo significant changes that will have a ripple effect across all health sectors and across all domains of the nursing profession. Further, it is foreseeable that the nursing-AI interface will include non-traditional forms of caring, likely altering the nurse-patient relationship and potentially affecting the delivery of person- and family-centred compassionate care. The emerging future constitutes a major paradigm shift that necessitates strong and proactive nursing leadership—in all roles and sectors—to inform discussions about opportunities and challenges for patient care and the profession; enabling a collective vision.

This report, underpinned by a scoping review, provides pertinent information to stimulate critical reflection and fuel these discussions. Readers will find an overview of emerging AIHTs that are likely to influence nursing practice in the near future. The implications of these emerging trends across the care continuum and all domains of nursing are discussed in detail. Although much of the discussion centres on nursing within the context of the Ontario health system, these technologies will impact all jurisdictions and all health professions.

RNAO and AMS believe nurses have a shared responsibility to assess the ethical, health, and cost benefits of emerging AIHTs, and to successfully integrate those technologies it deems beneficial for nursing care to positively impact patients, communities and health-system outcomes. This report is our urgent call for our profession to engage and prepare for the emerging future. Whereas there is consensus that AIHTs, such as robots, will not directly replace nurses, it is imperative that nurses proactively and clearly articulate how person- and family-centred compassionate care will be conceptualized and delivered at the interface between nurses and AIHTs. This emerging future demands timely, strong and proactive nursing leadership, especially in education, administration and practice. Such leadership will advance well-informed and ethical discussions and influence decisions about the components of nursing care that can be safely performed by robotic devices as well as those that can be enhanced by predictive analytics. Proactive leadership is also required to advocate for those non-negotiable aspects of care that must be performed by nurses to ensure safe, ethical, high-quality, clinical and compassionate, person-centred care.

In all clinical contexts, executive leadership is required to: actively champion and guide the nursing-AI interface; encourage and support the contribution of nurse leaders in all roles and levels of an organization--from the board rooms to the front-lines of care; and ensure appropriate patient engagement throughout the technology lifecycle. In large health organizations, the implementation of these complex technologies will necessitate governance structures that integrate nursing informatics

* Throughout this report, terms displayed in this manner are further defined in the Glossary.

roles such as chief nursing informatics officer to assist nursing and other executive leaders to make informed clinical and business decisions as well as to lead the technical aspects of implementation. It is important for executive leadership to advocate for technology-related governance structures that include these roles and afford nurses decision-making authority.

In nursing education, nurses and nursing students require the strong leadership of nurse educators in academic institutions and clinical practice to proactively prepare them to provide safe, ethical, high-quality care—that is person-centred and compassionate—in environments enriched by AIHTs. Contemporary nursing curricula must incorporate innovative pedagogies that build capacity in basic health informatics competencies, data/digital literacy, and data governance. Interprofessional educational opportunities that combine nursing and engineering principles are also needed to equip nurses with knowledge and skills in user-centred design principles to enhance their contributions as co-designers and co-developers of AIHTs.

Proactive nursing leadership is also essential to formulate new policies and procedures, to support changes to nursing roles, models of care, workflows and scope of practice; as well as to ensure ethical, privacy and safety imperatives are accounted for and reflected in nursing and health-system policy, nursing codes of ethics and pertinent legislation.

Finally, with the anticipated growth of AIHTs in nursing, there is an important leadership role for nurse researchers to play in the collection of empirical evidence on key knowledge gaps, including: 1) the impact of these technologies on patients and their families, nurses, and other caregivers; 2) implementation facilitators and barriers, 3) potential or actual risks to patients, families and caregivers, 4) patients', families', and caregivers' experience of person- and family-centred compassionate care, 5) issues related to access; and 6) short, medium and long-term cost-benefit, financing and ethical considerations.

The report outlines 15 key recommendations intended to: 1) support efforts to prepare nurses and nursing students to leverage AIHTs to augment the patient experience while ensuring the delivery of high-quality, clinical, person-centred compassionate nursing care; and 2) facilitate the successful interface of relevant emerging AIHTs within the nursing profession. Among these recommendations, the eight listed below serve as a call for immediate action to establish a strong foundation upon which the remaining seven recommendations will be built:

1. Create forums for open dialogue between nurses and patients to raise awareness of the patient-nursing-AIHT interface; gain patients' and nurses' perspectives; and foster understanding of the roles and responsibilities of nursing in shaping effective, meaningful and ethical utilization of relevant AIHTs and timely outcome evaluation.
2. Explore the impact of AI on patients, families, caregivers and nurses and their perception of the delivery of person- and family-centred compassionate care augmented by AIHTs.
3. Identify evidence-based best practices to guide ethical implementation of appropriate AIHTs across the care continuum to enhance person-centred, compassionate nursing care.
4. Identify new care delivery models, responsibilities and competencies for nurses in all roles and sectors to support the interface between nursing science, person- and family-centred compassionate care and AI.
5. Conduct a thorough review and reform of nursing curricula to ensure congruency of the nursing role with present needs and future demands of emerging AIHTs.
6. Develop a strategic plan to build capacity for basic informatics skills and data/digital literacy in the existing and future nursing workforce.
7. Implement new and revised professional codes of ethics and standards of practice that articulate nurses' responsibilities and accountabilities in relation to the use of AIHTs.
8. Prioritize rigorous, nurse-led interprofessional research to inform policies and procedures to support the co-design, development, implementation and evaluation of AIHTs in nursing.

INTRODUCTION

"…a new era has begun and…there are innumerable ways in which nursing practice is affected, at times without one's awareness" (p. 19)[2]

A new era in health care and in nursing has begun.[3] Global spending on health technologies powered by AI is predicted to exceed $36 billion by 2025.[4] This trend is due in part to growing consumer demand for increased use of digital health technologies in clinical practice.[1] Canada is a world leader in AI research.[5] In 2017, Canada became the first country in the world to announce a national AI strategy, investing $125 million in the advancement of AI research and innovation in a number of areas, including health.[5] News of the *Pan-Canadian AI Strategy* prompted the provincial governments of Alberta, Ontario and Quebec to each invest $80-$100 million to augment the federal funding and advance AI research and development in their jurisdictions.[6] The private sector also invested more than $100 million in these research programs.[6] AI is likely to become a transformational force in the Canadian health system. To make full use and optimize these investments in AIHTs, health professionals must be adequately prepared.

In Canada, nursing is the largest group of regulated health professionals accounting for approximately 50 per cent of the workforce in health care.[7] As AI becomes more established in Canada, these changes will have a ripple effect across all domains of the profession, in every sector and each province and territory. Based on their knowledge, experience, connection to patients, families, the interprofessional team and the health system, nurses are well-positioned to advance discussions and influence decisions related to AIHTs in terms of the need, relevance, usefulness, ethics and adoptability. Nurses also have the responsibility to identify and shape new roles and care delivery models to support the appropriate use of AIHTs.[8]

Currently, Ontario has various nursing care delivery models. In hospitals, primary nursing is the most commonly-used model, whereby registered nurses (RN) or registered practical nurses (RPN) are assigned to patients according to their acuity and stability level, with RPNs caring for stable patients with predictable outcomes. In long-term care facilities, team-based models of care, comprising a skill mix of nurse practitioners (NP), RNs, RPNs and unregulated care providers (UCP), are commonly used.[9] A case management or care co-ordination model is currently being used in home and community care, which is also based on a staffing mix of NPs, RNs, RPNs and UCPs.[9] In primary care, nurses practice within interprofessional team-based models of care.[10] Within these models, the nursing roles for NPs, RNs and RPNs vary based on the setting (e.g., solo physician clinics, family health teams, community health centres, nurse practitioner-led clinics, and Aboriginal health access centres).[9] NPs are increasingly being introduced as members of the health team where they work independently and/or collaboratively as part of an interprofessional team.[9]

As is the case in many jurisdictions, Ontario's health system is undergoing major transformation to optimize service delivery. One significant change has been the introduction of a single health system administrator (Ontario Health) and multiple, integrated health organizations from different sectors (Ontario Health Teams).[11] In this new model of care, an integrated team of health professionals provides comprehensive, co-ordinated care across the continuum for a specific population within a defined geographic area.[12] Through this model, it is anticipated patients will experience improved and continuous access to co-ordinated care and system navigation services, wherever and whenever they are needed.

There has also been an exponential increase in virtual care delivery models in the Ontario health system in response to a $12 million investment by the provincial government to expand the virtual delivery of health services across the province and across the care continuum.[13] Virtual care refers to "any interaction between patients and/or members of their circle of care, occurring remotely, using any forms of communication or information technologies, with the aim of facilitating or maximizing the quality and effectiveness of patient care." (p. 4)[14] Ontario's new focus on virtual care has been fueled in part by the federal government's investment of $240.5 million to create and augment digital health technologies aimed at improving access to virtual mental health supports, and enhancing the virtual delivery of health care for Canadians.[15] Many of Ontario's virtual care delivery models use existing technologies (e.g., telephone, secure messaging, video conferencing and telehomecare) enabled by a partnership between Canada Health Infoway and Ontario Health (Ontario Telemedicine Network).[16] Evidence of this is easily found in the primary care sector, where NPs are increasingly providing virtual care using the telephone or video-conferencing technology.[28] Similarly, physicians now regularly conduct e-visits with patients using one or more of these technologies.[16] The *2020 National Survey of Canadian Nurses: Use of Digital Health Technology in Practice* also found a significant increase in the use of virtual care among nurses when compared to a similar survey conducted in 2017.[17] The respondents perceived that additional resources are needed to enhance nurses' ability to effectively provide virtual care.

Canada's growing interest in virtual care and AIHTs will undoubtedly expand in the near future. An Ipsos poll conducted in 2019 found the majority of Canadians support the use of virtual care delivery models to improve access to care, enhance the patient experience and lead to better health care.[18] More than 50 per cent of respondents agreed the next 10 years will see an increase in AIHTs, such as robots. They also agreed these technological advancements will have a positive impact on health-care delivery and health outcomes. Many respondents were optimistic about these emerging technologies, while some were apprehensive about privacy risks and "losing the human connection of health care." (para 5)[18]

One of the signature roles of nurses in assessing AIHTs is the analysis of their potential to interfere with the interpersonal relationship between patient and caregiver,[19,20] and the experience of person- and family-centred, compassionate care. Compassionate care is a core component of nursing that uses a person-centred approach in which the individual and their values and preferences are at the centre of care.[21] Through person- and family-centred, compassionate care nurses ensure they are fully engaged with their patients, recognizing patients' individual needs and forming therapeutic relationships.[22] Person- and family-centred, compassionate care is central to nursing practice. Yet, little research has explored how AIHTs might affect the nurse-patient relationship and the delivery of person- and family-centred, compassionate care.

In 2019, AMS Healthcare commissioned RNAO to address this knowledge gap by conducting a scoping review to explore the existing and predicted influences of emerging trends in AI on the patient/caregiver experience of compassionate nursing care and on the nursing profession more broadly.[23] The purpose of this joint report is to: 1) present a synopsis of the results of the scoping review describing the emerging AIHTs that are currently being used or trialed in nursing; 2) discuss the impact of these technologies on person- and family-centred compassionate care and the nursing profession; and, 3) delineate key recommendations that serve as a call to action for the nursing profession and all stakeholders to critically examine how emerging trends in AI will transform the roles and functions of nurses and begin to proactively engage in shaping the emerging future.

Scoping Review Methodology

Informed by the methodological framework developed by Arksey and O'Malley and further advanced by Levac et al., RNAO's research team undertook a comprehensive scoping review to examine the potential for emerging trends in AIHTs to transform nurses' roles and their ability to provide person- and family-centred compassionate care in the next decade and beyond.[24,25] The review process involved six steps: 1) identifying the research questions; 2) identifying relevant literature; 3) selecting relevant literature to review; 4) charting the data; 5) collating, summarizing and reporting results; and 6) consulting subject matter experts.[24]

A steering committee was convened to identify the research questions and an effective search strategy. The group included a patient advocate and nurses from a variety of settings (e.g., hospital care, home and community care, and long-term care) and domains (e.g., clinical practice, research and education). The steering committee was co-chaired by two doctorally-prepared nurses with independent programs of research focused on health informatics and the integration of AI and digital health technologies in nursing practice and education. The remaining committee members had considerable knowledge and experience with the use of AI or digital health technologies in nursing and health care.

The steering committee identified four research questions through discussion and consensus:

1. What influences do AIHTs have, or are predicted to have, on the patient/caregiver experience of compassionate care delivered by nurses?
2. What influences do emerging trends in AIHTs have, or are predicted to have, on all domains of nursing?
3. What influences do emerging trends in AIHTs have, or are predicted to have, on nursing education across all domains?
4. What involvement do nurses have, or are predicted to have, in the co-design of AIHTs?

In collaboration with an information specialist, RNAO's research team identified an effective search strategy. Pertinent electronic databases from which to source published research literature relevant to the questions were identified, namely: MEDLINE, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Embase, PsycINFO, Cochrane Database of Systematic Reviews, Cochrane Central, Education Resources Information Center (ERIC), Scopus, Web of Science and Proquest. Search terms and inclusion/exclusion criteria were developed through consultation with the co-chairs and steering committee members, and by examining relevant publications.

A targeted search for relevant grey literature was also undertaken to complement the search for published research literature. This search focused on two sources: targeted electronic databases and websites. The same search terms were used to explore the Proquest, CINAHL and PsychINFO databases for grey literature (i.e., theses and dissertations, discussion papers and white papers). For the targeted website search, search terms and inclusion/exclusion criteria were developed by examining relevant publications, and through consultation with the co-chairs and information specialist. Specific search strings were developed by the information specialist, different from those used to search the databases, due to the inherent character limits of performing a targeted website search using online search engines (e.g. Google). This search was limited to the following websites: World Health Organization, National Health Service, Office of the National Coordinator for Health Information Technology, Institute for Research on Healthy Public Policy, Canada Health Infoway, Canadian Association of Schools of Nursing, and Healthcare Information and Management Systems Society.

For the purposes of this scoping review, a nurse was defined as any type of nurse (e.g., RN, RPN, licensed practical nurse, NP) across the five domains of nursing identified by RNAO (i.e., administration, education, clinical practice, policy and research).[26] The term "AI health technologies" was limited to digital health technologies that are powered by AI.

Literature focused on electronic medical records (EMR), telehealth systems, genomics, virtual reality devices, and other technologies that do not unequivocally incorporate AI were excluded. A technology was considered "emerging" if this qualifier or a synonym (e.g., new, innovative) was used to describe it in the literature, or if the co-chairs or steering committee identified the technology as emerging based on their professional expertise.

The scoping review framework emphasizes the value of a search strategy that allows for the breadth of the evidence to be gathered.[24] Guided by this principle, two main concepts ("artificial intelligence" and "nursing") were used in the database search to allow for a broader search. The term "compassionate care" was not used. However, when analyzing the results, each article was assessed for its relevance to compassionate care as previously defined, and inferences made accordingly. All qualitative and quantitative studies, discussion papers and white papers were eligible for inclusion. The complete search strategy has been published separately.[23]

Results were limited to peer-reviewed and grey literature published in the English language between 2014 and 2019. This search strategy identified >14,000 articles through the database search and >2,300 articles through the targeted website search. After removing duplicates and applying the inclusion/exclusion criteria, 141 articles (128 from database sources and 13 from targeted websites) were included in the scoping review (Appendix B).

Consultations with the steering committee after the completion of the scoping review resulted in the inclusion of additional sources of information (i.e., "handpicked" articles) to ensure recent technological advancements were reflected in the report.

SYNTHESIS OF FINDINGS

"Emerging technologies…will strengthen…[nurses'] ability to collect data, assimilate these data into information, apply newly discovered knowledge, and gain wisdom to improve care delivery." (p.4)[27]

This section provides a synthesis of the findings from: 1) the articles included in this scoping review, which analyzed various types of studies (e.g., quantitative, qualitative, mixed-methods, systematic reviews and scoping reviews); 2) the targeted grey literature that included reports, editorials and opinion papers; and 3) additional sources of information (i.e., "handpicked" articles). The findings are presented below and categorized as follows: emerging AIHTs; nursing, compassionate care and AI; nursing education and AI; and nurses' involvement in the co-design of AIHTs.

Emerging AIHTs

The scoping review identified four main categories of AIHTs that are currently being used or trialed in nursing in a variety of clinical contexts. These categories are: virtual health-care assistant applications ("apps"), predictive analytics, smart healthcare and robotics.

Virtual Health-Care Assistant Apps

Globally, there has been an early adoption of virtual health-care assistant (VHCA) apps across all aspects of the patient's journey.[29,30] These apps integrate chatbots* to simulate interactive human conversation between artificially intelligent care providers (AICP)* and patients.[31] Increasingly, chatbots are being designed with digital avatars* that possess human-like features and attributes.[30] Current developments in the ability to sense and respond to a person's emotions are enriching the design of digital avatars, enabling them to detect, interpret and express emotions and other behaviours during interactions.[30] Some VHCA apps incorporate digital avatars that can repeat statements expressed by the patient and respond with facial gestures or body movements that convey attentiveness and comprehension of the information communicated.[30] These features enable VHCA apps to perform functions such as clinical assessments, health teaching, surveillance of medication adherence and chronic disease management.[32,33,34,35]

This groundbreaking technology is already present on the Canadian health-care landscape in a national home health organization where more than 9,000 nurses are using a VHCA (called Tess) to support patients who have been diagnosed with mental health conditions.[35,36] Tess engages with patients to provide counseling, mental-health education, and to promote the use of various coping mechanisms.[35,36]

Predictive Analytics

Predictive analytics* that incorporate AI use machine learning* to identify patterns in data and forecast future outcomes.[37] The application of AI-powered predictive analytics to patients' historical and real-time data in EMR systems to support personalized treatments is an emerging trend in health care with great significance to patients and to nursing.[4,27]

There are several applications of artificially intelligent predictive analytics in the nursing literature, both in hospital and community setting. For instance, AI-powered predictive analytics are augmenting nursing care through early identification of patients at risk for various conditions (e.g., hospital readmission, falls, pressure injury, moderate or severe pain, hospital-acquired urinary tract infection, and severe sepsis and septic shock).[27,38,39,40,41,42,43,44,45] Furthermore, AI-powered predictive

analytics are being used in conjunction with sensory technology to enhance fall-prevention programs.[46,47] Hospitals in Canada and the United States are using the latter to reduce falls and fall-related injuries by alerting nurses, via mobile devices, of patients' fall-risk scores, enabling them to intervene proactively.[46,47] In the first year of implementing similar technology, the University of Arkansas for Medical Sciences reported its rates for falls and fall-related injuries were reduced by 11 per cent and 60 per cent, respectively.[47]

In home and community care settings, AI-powered predictive analytics, integrated with sensory technology, is facilitating the remote monitoring of patients diagnosed with congestive heart failure to alert nurses of early signs of decompensation.[48] Other potential applications for this technology in home and community care include forecasting patient wellness to optimize staffing allocation and predicting mortality risk among older adults to enhance patient/family decision making and end-of-life care.[49,50]

Smart Healthcare

Smart healthcare* is an emerging technological advancement fueled by the integration of smart sensors, wearables, network communications, predictive analytics and AI.[51] Smart healthcare affords new opportunities for nurses and other health professionals to more effectively monitor patients in hospitals and community-based settings.[52] Increasingly, smart healthcare is being utilized to identify and predict changes in a person's health status, enabling nurses and/or family members to intervene proactively.[53]

In the hospital setting, AI and sensory technology have been used synergistically to explore the potential for autonomous granular patient monitoring in an "intelligent" (or smart) intensive care unit (ICU).[54] The literature reviewed provided some support for using similar technology to conduct continuous, real-time patient assessments in the ICU. This emerging trend could potentially reduce nurses' physical workload in this setting and improve health outcomes through timely, accurate predictions and detections of adverse events.[54] Further investigation is needed to ascertain the validity of this.

Smart healthcare is growing in popularity in community-based settings where smart homes are being perceived as a potential alternative to assisted living or admission into a long-term care facility.[55] Smart home technology supports aging-in-place by extending the person's independence and increasing their quality of life.[55] The technology uses motion sensors and AI to support remote monitoring, identify and predict changes in the person's health status, and intervene when necessary.[53,56,57] Smart home technology is also appealing to health system planners as a strategy to decrease hospital admissions and the associated costs.[55]

Smart healthcare is becoming increasingly popular in Canada.[58] The first Canadian smart hospital is expected to open in Ontario in 2021.[59] The design incorporates "a connected health strategy…to provide quality health care [for patients] both inside and outside the…hospital setting." (para 1)[59] It is predicted that more smart hospitals will soon emerge in the province to facilitate the delivery of virtual care to hospital out-patients in their homes.[58]

Robotics

The use of robotics* in nursing is another trend that is emerging globally with important investments in research and development. In the United States, for example, the National Science Foundation has invested more than $3 million in research and development to promote the use of robots in nursing.[4] The current explosion of research in robotics has resulted in robots that have demonstrated the ability to perform specific clinical functions and, with the aid of AI, to simulate clinical decision-

making.[61] The Japanese government has invested heavily in the research and development of robots to assist in nursing, focusing primarily on personal care robots* for use in rehabilitative and elder care.[62,63] Although there is very limited peer-reviewed research literature that examines the use of robotics in patient-care areas, there are many anecdotal reports of the adoption of robotic devices across the continuum of care, including in hospitals, home and community care and long-term care.[60]

Hospital Care

In the hospital setting, humanoid robots* are already being deployed to assist nurses. For instance, a personal care robot (Robear) is currently being utilized in Japan to perform tasks such as transferring patients from a bed to a wheelchair and assisting patients, with restricted mobility, to stand.[61] In Canada, Humber River Hospital (HRH) is the first hospital to use the humanoid robot "Pepper" in a health-care setting. HRH currently has two Peppers "on staff." [64] One of these robots is used in the Child Life Program to help decrease patient anxiety, increase comfort, and provide health information. The second Pepper greets patients, families and visitors at the hospital's main entrance, answering questions and sharing information as needed.

Robots are also being developed to work as assistants in surgical care areas. For example, "Quirubot" is equipped with voice and instrument recognition technology that enables it to assist scrub nurses during surgical interventions.[65] In addition, service robots* are being used to deliver equipment and supplies (e.g., medications, water) to meet the needs of patients in a timely manner.[60,65] In Japan, for example, service robots distribute and collect patient food trays autonomously.[65] It is predicted that in the future, robots will be integrated with EMR systems, enabling them to respond autonomously to physician orders, retrieve relevant items or supplies (e.g., medication and dressing trays), and deliver these items to patient rooms.[68]

Other potential applications of robotics in nursing, in hospital settings, are being explored. For example, an innovative and collaborative project involving the Duke University Pratt School of Engineering and School of Nursing is focused on the development of TRINA, a remote-controlled robot designed to assist with the delivery of care for patients diagnosed with infectious diseases. This robot is designed to mitigate the risks associated with human contact.[4] This work is still in the early developmental phase. Preliminary testing in a nursing simulation lab found that TRINA performed approximately 60 per cent of the predefined tasks, but was 20 times slower than a typical nurse. Ongoing development is planned to augment the robot's fine motor skills.[66]

Home and Community Care

Robotics in nursing is rapidly advancing in the home and community care sectors.[63] This trend is being driven by the development of personal care robots to support independent community living among the elderly and those with physical limitations.[63] Applications of robotic devices in home and community care settings include: supporting individuals diagnosed with dementia; preventing falls and fall-related injuries; providing medication reminders; assisting with activities of daily living; collecting biometrics; informing family members and health professionals of a person's safety and health status; and promoting social interaction.[63] Social assistive robots* are also gaining popularity in the home care setting to promote cognitive and emotional well-being among individuals in need of companionship.[60] MARIO, for example, is a mobile companion robot that provides social interaction and personalized entertainment.[65]

Telepresence robots* have been used to support nursing care in the home to facilitate remote patient monitoring through video chat/conferencing.[62] This technology has also been used to support community-based care. The Telehealth Community Health Assistance Team (TCHAT) project is one example of this emerging trend.[4] This nurse-led initiative involved the use of a telepresence robot for

health promotion and chronic disease management among residents in an independent living and retirement community. The project consisted of one in-person visit at the beginning of the initiative, and subsequent follow-up, remote visits from NP students (specializing in adult gerontology) who served as telehealth coaches. Findings from the participants and responses from the NP students suggest the initial face-to-face intervention, coupled with robotic telehealth visits, was mutually satisfying. The project highlighted the importance of the nurse's role in the planning, implementation and evaluation of telehealth robots to facilitate meaningful patient interactions. The growing interest in robotics in nursing in this sector will support the shift from institutionalized care to community-based care by addressing patients' need for virtual, remote monitoring and social interaction.[67]

Long-Term Care

Robotics in nursing is also growing exponentially in the long-term care sector. Advancements in this area are being fueled by the Japanese government's efforts to mitigate nursing shortages and support its aging population.[65] In this sector, personal care robots have been deployed to assist nurses by performing less complex tasks, including transferring and ambulating residents and assisting with activities of daily living.[65,68] RobotBathtub is one example of a personal care robot.[65] Smart walkers and smart canes are examples of other robotic devices used as assistants to enhance residents' mobility.[65] Robots are also commonly used as a substitute for pet therapy in this sector.[65] Paro, a seal-like robot, is used in many long-term care facilities as part of a dementia care program and has been found to have a positive impact on the residents' moods.[65] Matilda, a social assistive robot, has been utilized in elder care for multimodal interactions, including verbal communication, emotional support and dance therapy.[65] Lastly, long-term care facilities have also used a recreation program (Pepper-CPGE) in which Pepper, a humanoid robot, conducts an exercise routine tailored to the person's functional level.[62] The program is reported to be an effective strategy that increases patient engagement for those requiring long-term care and rehabilitation.[62]

The emerging future of robotics in nursing is predicted to include ongoing development of robots with enhanced capabilities to further support nursing and patient-care activities.[60] It is also forecasted that robots will become more accepted in other clinical settings, including primary care and out-patient clinics.[68]

Nursing, Compassionate Care and AI

Caring is fundamental to nursing. It is a key value and quality indicator of nurses' support for individuals along their journey to health and wellness.[67] Compassion is widely recognized as an essential component of caring.[70] There is consensus in the literature that the emerging trends in AIHTs may affect the nurse-patient relationship and the experience of caring.[4,62,67] However, literature on the potential impact of AI on person- and family-centred, compassionate care is lacking. For this reason, findings related to AI and caring in nursing were generalized to AI and compassionate care for the purposes of this report. Readers are therefore asked to view the term caring as synonymous with compassionate care in the discussion below.

Impact of AI on Compassionate Care

Despite the growing interest in and the predicted expansion of robotics in nursing, the impact of this technology on the patient-care experience has received little attention in nursing research.[67] The extant literature is anecdotal, techno-centric and aligned with one of two perspectives: humanistic and post- or trans-human.[67]

Proponents of the humanistic perspective view nursing and caring as purely human activities.[67] They are cautious about the use of robots to support patient care,[67,71] viewing this interaction as impersonal, objectifying and dehumanizing.[72,73] Authors writing from this perspective purport that the nurse-robot interface will negatively impact the patient and caregiver experience of caring.[74,75,76,77,78] They are also apprehensive about the potential effect of this technology on nurses' ability to engage in caring interactions with patients.[79,80,81,82,83]

Conversely, advocates of a post- or trans-human perspective support the re-conceptualization of nursing and caring; thus creating a new world of nursing in which nurses, AIHTs and caring co-exist.[67] From this vantage point, they do not see robots as a threat to nurses or caring. Rather, they envision that the nurse-robot interface will enrich the patient/caregiver experience of caring.[67] Examples to support this view are more prevalent among the elderly.[84,85] When used as part of dementia care, social or companion robots have anecdotally provided stimulation, improved mood, reduced loneliness, enhanced feelings of caring and increased well-being.[84,85]

The potential exists for other AIHTs—such as predictive analytics, AICP apps and smart healthcare services—to enhance the patient experience of caring. These technologies have reportedly been found to support person- and family-centred care, a key tenet of compassionate care, by enhancing nurses' ability to make informed decisions based on high quality, real-time data about a person's circumstances and preferences.[86,87]

Articles written from a post- or trans-human perspective also emphasize ways in which robots might enhance caring in nursing; one of which could be the delegation of tasks.[88] Research suggests that between eight and 16 per cent of nursing time is spent on non-nursing activities and tasks that should be delegated to others.[4] Proponents of a post- or trans-human perspective believe the delegation of routine tasks to robots may enhance the therapeutic relationship, by allowing nurses to spend more quality time with patients to get to know their preferences and respond appropriately to their needs.[67,89,90,91] There is some evidence that health professionals (including nurses) have used robots to enhance caring/compassionate care for patients in diverse health-care settings by improving communication and social interaction.[92,93,94]

Compassionate Care in the Age of AI

The technological advancements that are propelling health care towards the use of robots in nursing stem from a post- or trans-human paradigm that envisions the synergistic possibilities of interfacing human and AI as superior to mere human capabilities.[67] From this perspective, nurses are encouraged to not merely focus on how technology detracts from humanistic aspects of caring, but rather to re-imagine their roles and the possibilities that may be realized through the convergence of nursing, AI and caring.[67] This shift is even more important given the advances seen in emotionally responsive robots.

Robotic engineers are advancing robots' ability to respond emotionally to people and circumstances.[4] Technological advancements in affective sensing and processing, powered by AI, are giving robots the ability to detect and interpret emotions and other behavioural signs as well as express emotions during their interactions with humans.[30] Emotionally responsive robots have demonstrated the ability to repeat statements expressed by patients and respond with appropriate facial and body gestures that demonstrate their attentiveness to and understanding of what the patient has expressed verbally or through their behaviour. These features enable emotionally-responsive robots to convey emotional caring and empathy in a manner that is both interactive and human-like.[30] Emotionally-responsive robots are more commonly referred to as social assistive or companion robots.

Nursing Education and AI

The integration of AI in nursing will require a thorough examination of both formal and informal educational programs and curricula designed for existing and future nurses.[62] The majority of the articles reviewed examined formal nursing education programs in academic institutions at all levels (i.e., undergraduate, graduate and doctoral).[56,61,62,80,95,96] Fewer articles examined nursing education and AI in the context of clinical settings.[105,106,107] The findings are presented below within these two categories: nursing education in academic institutions; and nursing education in clinical settings.

Nursing Education in Academic Institutions

The predicted convergence of AIHTs and nursing will have a significant impact on schools of nursing necessitating a thorough review and reform of undergraduate nursing curricula to support new nursing competencies at the undergraduate and graduate levels.[56,62,80,95,96] Basic health informatics* knowledge and skills will likely be a required nursing competency; therefore, this content should be threaded throughout the nursing curricula.[97,98] The introduction of AI in nursing will also require curricular revisions to incorporate concepts (e.g., data literacy, technological literacy, and AI algorithms) to prepare future nurses to work with artificially intelligent machines and to analyze and interpret big datasets.[33,62,95] Furthermore, nursing students will require a thorough understanding of the ethical implications of AI technology in the clinical context, and their responsibilities as health professionals using these technologies.[62]

Nursing faculty in academic institutions will also need to adopt new and innovative pedagogies that support multidisciplinary teaching modalities.[56,62,80,95,96] Collaborative teaching strategies are recommended that include partnerships with information technologists, robotics engineers and computer programmers to adequately prepare undergraduate nursing students to work in clinical settings with the emerging AIHTs.[62] It is anticipated that undergraduate nursing curricula that integrate engineering principles will enhance the development of AIHTs and increase students' understanding of the technology they will be expected to use in real-world clinical environments.[62,63,66] A few universities have already established a joint nursing-engineering degree program based on the conviction that contemporary health-care challenges necessitate a multidisciplinary approach to realize solutions that are both person-centred and sustainable.[66]

It is foreseeable that simulation laboratories in schools of nursing will also be transformed. Along with the existing cadre of high-fidelity simulators, robots are expected to be increasingly available to give nursing students hands-on experience with the technology.[62] It is perceived that students who work with robots in their undergraduate programs will be better prepared to transition to real-world clinical environments with interprofessional teams that may include robots as members.[63] It is also predicted that nurse educators will use AI-powered chatbots with digital avatars, designed as 'virtual patients' and 'virtual tutors', to simulate interactive clinical scenarios. These are expected to help students understand specific nursing concepts, enhance their self-confidence and self-efficacy, and improve their communication skills.[100,101] Using AIHTs in the undergraduate curriculum may also enhance students' clinical reasoning skills.[102]

Other AIHTs may also be used to enhance student learning. For instance, a wearable armband that uses machine learning* has been developed to support hand hygiene training in clinical education.[103] The technology measures the effectiveness of the student's hand-washing technique and provides feedback to enhance learning and reduce nosocomial infections. It is foreseen that this technology may have further potential in clinical practice laboratories to support students learning other motor and manual skills. Similarly, the AI-powered "Face Tracker" technology supports simulation-based learning by enabling nurse educators to assess their students' emotions at various points of a clinical

simulation and more effectively tailor the learning experience to their needs.[99] Face Tracker can also be used to help students understand and anticipate their patients' emotional response to various nursing interventions.[99]

Fewer articles focused on nursing education and AI at the post-graduate level and there is consensus that nursing graduate degree programs should incorporate more advanced AI content.[33,56,61,62,63,89,97,98,104] The recommended topics include: ethics, privacy, research and engineering concepts.[33,56,61,62,63,89,97,98,104] Doctoral nursing degree programs will require the inclusion of even more in-depth AI concepts to support future nurse scientists' need for new competencies and knowledge related to specialized data science methods (e.g., predictive modeling, machine learning, data management, biostatistical programming, risk adjustment, multivariable regression, and big data governance). Privacy issues (including security breaches or 'cyberthreats') must also be considered.[33,104] The scoping review identified two American universities that have integrated data science within the core curriculum of their doctoral nursing degree programs.[104]

In addition to the proposed curricular revisions at all levels of formal nursing education programs in academic institutions, authors stressed the importance of equipping students with interpersonal and therapeutic communication skills to convey empathy and compassion in a technology-rich clinical environment.[80,96]

Nursing Education in Clinical Settings

As AIHTs are increasingly deployed in clinical settings, it will be important for nurses to constantly upgrade their skills.[61,63,91] Educational resources and professional development opportunities will be required for nurse educators to enhance their own capacity and knowledge base to train nurses employed in clinical settings.[1,33] More in-services will be needed to enable nurses to safely and effectively integrate AIHTs within their practice.[105,106,107] Furthermore, nursing education will require customization to meet the needs of different audiences.[1,33]

Nurses' Involvement in the Co-Design of AIHTs

Multiple studies discussed the importance of nurses' involvement in the co-design of AIHTs. Nurses have a valuable contribution to make in this area given their understanding of the inherent complexities of the clinical environment.[68] Nurses have key insights into practices that are effective and ineffective, and strategies to improve the patient experience and optimize outcomes.[66] Further, given nurses' expertise in person- and family-centred approaches to care, they can advocate for technology that addresses patients' needs and preferences,[79] and identify innovative ways to integrate AIHTs in patient care.[98]

In spite of these benefits, the scoping review yielded only two articles on nurses' involvement in the co-design of AIHTs. Both articles discussed nurses collaborating with engineers and programmers to develop robots; however, details of the nurses' contribution were not provided.[4,66] A few barriers to nurses' involvement in the co-design process were identified, including the cost of hiring doctorally-prepared nurses[108] and communication challenges between nurses and information technology (IT) professionals attributed to the lack of familiarity with each others' discipline.[100] For example, technical terms used by IT professionals may be unfamiliar to nurses, and IT professionals may not fully comprehend nursing concepts. In one study, these communication barriers were mitigated by avoiding technical jargon and interacting frequently to clarify concepts and terminology.[100]

IMPLICATIONS FOR NURSING PRACTICE

"Systems and technologies that assist in clinical practice are adjunct to, not replacements for, the nurse's knowledge and skill." (p. 16)[125]

This section of the report presents a discussion of the results of the scoping review in relation to nursing practice in Ontario in the coming years. It begins with general comments about the potential influences of AI on nursing practice holistically. Then, it provides a futuristic look at nursing practice across the care continuum and presents a discussion of the implications of the emerging AIHTs for the nursing profession.

Implications for Clinical Practice in General

In the future, nurses and AIHTs will co-exist, as both will be necessary and expected.[71] The consensus is clear that emerging AIHTs will not replace nurses. Instead, novel nurse-patient interactions involving AIHTs will exist that may augment nursing practice and patient care.[8] These new human-technology interactions will be characterized by non-traditional roles necessitating the reconceptualization of nursing practice.[109] In such a context, it is vital for nurses to influence how person- and family-centred compassionate care will be conceptualized and enacted.[109] In the post- or trans-human era that is also emerging, it will be essential for nurses to guide discussions and influence decisions about the components of nursing care that can be safely performed by AIHTs; and to advocate for those non-negotiable aspects of care that must remain within nurses' scope of practice to ensure safe, ethical, high-quality and,[8] more specifically, person- and family-centred, compassionate care. The collection of data that measures person- and family-centred compassionate care in AI-powered clinical environments will be essential to evaluate the care from the patients' and caregivers' perspectives.

Researchers have also identified the need for new virtual and digital care delivery models, corresponding workflows, and new nursing roles contextualized to the area of clinical practice.[4,35,109,110] Additionally, there will be more demand for smart healthcare and VHCA apps to support remote patient monitoring and virtual models of care.[30,32,34,35] These impacts will be experienced in varying degrees, depending on the sector (discussed below).

Implications across the Care Continuum

Primary Care

Primary care is the entry level into the health system, providing a central role in care co-ordination across the continuum.[10] Whereas the literature reviewed did not explicitly focus on AI in primary care, three care-delivery models that are predicted to emerge in the age of AI are applicable to this sector. Thus, they enable a futuristic look at a primary care sector with increased access to AIHTs and the implications for nursing practice in this sector.

Glauser, for example, predicts the nursing-AI interface will enable an increase in nurses working within a care co-ordination model as delegators or care co-ordinators.[111] In this future world of nursing, Glauser envisions nurses co-ordinating and overseeing patient care through the use of various AIHTs and delegating tasks to other health workers while assuming overall accountability to ensure care is delivered appropriately. These (primary care) nurses of the future will also likely use VHCA apps to help patients enhance their capacity for self-management.

In the age of AI, an increase in virtual nursing roles is also predicted. Nurses are foreseen working as information (i.e., system) navigators in a case-management model, facilitating patients' access to

care through the use of mobile devices and virtual technology.[8,96,111] It is also anticipated that these (primary care) nurses will use AI-powered telepresence robots to facilitate e-visits and e-consults.[4]

Finally, it is also predicted there will be an increase in nurses employed as independent practitioners delivering care for a caseload of patients across the continuum.[4] Although not explicitly stated in the literature, this independent practitioner model of care is consistent with the care delivery model in NP-led clinics. In primary care settings of the future, it is foreseeable that these independent (nurse) practitioners will use AI-powered predictive analytics to identify patients at risk for a variety of conditions (e.g., falls, stroke, urinary tract infections), enabling the timely development of a person-centred plan of care that increases the patient's safety and comfort.

RNAO's *Enhancing Community Care for Ontarians* (ECCO) 3.0 report proposes similar care co-ordination and system navigation roles for nurses in the primary care sector.[11] RNAO envisions an integrated system of care in Ontario with a strong community care sector anchored in primary care (Figure 1). RNAO also "urges the transition of the approximately 4,500 care co-ordinators currently employed within LHINs (and not performing hospital discharge functions) into interprofessional primary care teams, with their salary and benefits intact" (p. 29).[11] Some of the features of AI presented here will greatly extend these roles and enhance and their effectiveness.

Figure 1: ECCO Model 3.0 [11]

Added benefits of these new roles would be the realization of the full scope of practice for primary care nurses,[10] and their ability to leverage digital health technologies (such as AIHT) to advance health equity by mitigating challenges with access to care that are often experienced by marginalized populations.[30]

The Ontario government envisions a modernized health system that provides 24/7 access to co-ordinated care and navigation services across the continuum.[11] In primary care organizations of the future, RNAO recommends a care delivery model that supports continuity of information, relationships and clinical management.[112,113] It will be important for nurses to harness AIHT to contribute to the realization of this vision.

The deployment of AIHTs in primary care organizations of the future will require nurses with the knowledge and skills to shape the nurse-technology interface. Primary care nurses of the future will also need adequate education and decision-support tools to help them identify: patients who are appropriate for virtual care; interventions that can safely be completed virtually; and clinical conditions that are conducive to patients' use of AIHTs, such as VHCA apps.

Hospital Care

In the foreseeable future, the acuity of hospitalized patients is expected to increase with the shift towards home and community care in Ontario.[9] The integration of AIHTs is likely to increase the complexity of this practice setting. These changes will necessitate a highly-educated and skilled nursing workforce with enhanced abilities to analyze and synthesize information from a variety of sources to effectively provide care for hospitalized patients.[9]

Given this complexity, primary nursing care delivery models composed entirely of NPs and RNs are proposed for hospitals of the future.[9] These models of care must also support new nurse-patient interactions involving AIHTs.[8] These new models must be shaped by nurses and allow for the reconceptualization of nursing and patient-care,[109] in ways that support accessible, person- and family-centred, evidence-based care that is safe and timely. With the interface of human and technology roles forecasted for the future, robots may be used to assist with less complex nursing tasks,[109] including: transferring and ambulating patients; monitoring vital signs; and promoting medication adherence.[67,65,85,114] Increasingly, patient-care activities involving hazardous tasks, such as infectious disease protocols, may be enhanced through the use of various types of robots.[4] Finally, the growing interest in emotionally responsive robots may advance their use as companions in institutionalized settings to support the care of the elderly and pediatric populations.[68,115,116] It is predicted that companion robots may enhance person-centred care through their ability to collect detailed information about the person's preferences, goals and values.[68,115,116] The use of robotic devices in hospitals of the future will require nurses with the requisite knowledge and skills to effectively use the technology to optimize patient outcomes and person- and family-centred compassionate care.

In complex practice settings, such as hospitals, the interface of AI and nursing will give rise to new and enhanced workflow processes predicted to increase the speed, accuracy and efficiency of nursing care delivery.[27,43] One area where this is expected to have a major impact on nursing practice is the integration of AI with EMR systems.[68] For instance, it is foreseeable that specific nursing tasks and provider orders entered into the EMR may trigger robots to independently obtain and deliver the necessary supplies (e.g., linen, medications, catheters, dressing supplies) to patients' rooms; thus achieving more timely and efficient workflows.[68] It is also predicted that the integration of voice recognition technology and EMR systems may expedite nursing documentation.[68] AI-powered predictive analytics are also expected to introduce new and enhanced workflows. A study found that AI-powered predictive analytics used to identify nursing diagnoses reduced nurses' decision-making time from 35.5 minutes to 19.8 minutes.[27,43] Other articles noted that AI-powered predictive analytics can accelerate the detection of changes in a patient's health status, facilitating more efficient care.[27,43] The use of AI-powered predictive analytics in this context will require nurses with training in data literacy to accurately interpret the data.[4]

Lastly, the predicted interconnection of networked homes and hospital systems will see an increase in the demand for smart healthcare. This trend may engender virtual care delivery models where nurses employed in smart hospitals use a variety of AIHTs to provide virtual care for out-patients, collecting and analyzing pertinent information and providing timely and targeted interventions.[111]

The new virtual and digital care delivery models envisioned for hospitals of the future are congruent with the provincial government's plan for the hospital sector wherein patients with acute illnesses and complex care needs receive highly specialized care supported by the optimal use of digitized health technologies.[117] These models of care are also consistent with RNAO's vision for hospital care in the future, staffed entirely by NPs and RNs providing and co-ordinating all aspects of the patients' care during their stay.[9,11]

Home and Community Care

The Ontario government's vision of an expanded home and community care sector will be realized in the near future.[117] As more care is provided closer to home, the acuity of patients in this sector is expected to increase.[9] A new team-based model of care is proposed to ensure patients receive home and community care from a consistent team of health professionals (e.g., NPs, RNs, RPNs, UCPs) to achieve continuity of information, relationships and clinical management throughout their journey towards health and wellness.[112,113]

With the predicted prevalence of AIHTs, there will likely be an increase in virtual care in this sector. It is foreseeable that RNs will conduct the initial patient assessment, either in-person (depending on the need) or virtually using AI-powered telepresence robots equipped with video chat or videoconferencing functionality.[4] RNs will co-ordinate patient care by delegating specific interventions to others (e.g., RPNs, UCPs) or by integrating robotic devices (e.g., companion robots) into the plan of care. Between appointments, it is envisioned that RNs will monitor the patient's progress virtually through the use of VHCA apps or smart home technology, depending on the person's condition and the needs identified.[4]

To function effectively in the technology-rich home and community care settings of the future, health professionals will require new knowledge and skills to support novel interactions among nurses, patients/families and UCPs involving AIHTs. The education will need to be tailored to different members of the care team. For example, RNs will require education and decision-support tools that help identify: patients who are appropriate for virtual care; interventions that can be completed virtually; and clinical conditions that are conducive to patients' use of AIHTs, such as AICP apps. RNs will also require resources to assist, support and educate patients and their families about the selection and use of these technologies.[67] Furthermore, RNs will require training to develop a person-centred plan of care that incorporates the most appropriate technology to address the person's goals and preferences (e.g., companionship, remote monitoring, fall prevention and health teaching).[4,61] Nurses will also require education to enhance their ability to evaluate outcomes from the use of AIHTs, patients' responsiveness to this intervention, and to take appropriate corrective action when needed.

Long-Term Care

To realize the Ontario government's plan for a modernized health system that facilitates access to an integrated team of health professionals providing comprehensive, co-ordinated care across the continuum,[117] significant changes will be required in the long-term care sector. This will include substantive changes to both the physical and technological infrastructures of long-term care facilities, as well as changes to care delivery and staffing models.[118]

In long-term care homes of the future, it is predicted that nursing care will become increasingly complex due to the combined effect of a greater number of residents with multiple co-morbidities and the interface of AI and nursing aimed at enhancing information management, clinical decision-making and care delivery.[66] The complexity of this clinical setting will necessitate a new team-based

nursing* care delivery model, such as the one proposed by RNAO. This model consists of a new staffing skill mix and increased ratios of RNs and RPNs.[9] In this model, residents are assigned to the most appropriate nurses (RN or RPN) to oversee their care for the duration of their care journey.[9] Residents also receive care from the same staff consistently, ensuring continuity of information, relationships and clinical management.[112,113]

In the age of AI, it is predicted that under the supervision of regulated staff, robots will perform some aspects of resident care (e.g., transferring, monitoring vital signs and social stimulation).[67,65,85,114] It is foreseeable that service robots will be integrated with EMR systems to achieve greater workflow efficiencies, such as the timely delivery of supplies (e.g., linen, dressing supplies) to resident rooms.[68] AI-powered telepresence robots with video chat or conferencing capabilities may also be used more frequently to support virtual care models and increase access to health professionals.[4] This technology may also be used to facilitate virtual family conferences and virtual visits. Thus, the care delivery model adopted for long-term care homes in the future must support the use of AIHTs by nurses, residents and UCPs.[8]

RNs employed in long-term care homes of the future may also be expected to use AI-powered predictive analytics to identify residents at risks for various conditions (e.g., falls, pain and pressure injury).[27,43] The use of AI-powered predictive analytics in this context will require nurses with training in data literacy to accurately interpret the data.[4] Nurses will also require additional training to analyze and synthesize information from a variety of sources to effectively care for residents for the duration of their care journey.

Public Health

There is a paucity of literature regarding the use of AIHTs in nursing in the public health sector. In the age of AI, it is likely public health nurses will use AIHTs to promote population health. One article reported on the development of a robot to assist with the delivery of care for patients diagnosed with infectious diseases.[4] In Canada, a smartphone contact tracing app that utilizes machine learning and Bluetooth technology for disease surveillance and to predict the risk of community spread is currently in use.[119] These emerging trends will likely increase the prevalence of other AI-powered population health technologies in public health settings of the future to support disease surveillance, medical diagnosis, contact tracing and remote monitoring of infectious patients to limit the spread of the disease. It is foreseeable that public health nurses of the future will also use AI-powered telepresence robots for health promotion.

IMPLICATIONS FOR NURSING LEADERSHIP, POLICY AND RESEARCH

"… there must be mechanisms in place to ensure advanced technology does not dehumanize care. While automation will improve efficiency, it should not replace human interaction." (p. 9) [1]

Emerging AIHTs, such as predictive analytics and robotics, constitute a major paradigm shift with broad implications for the nursing profession. This section of the report presents a discussion of the ripple effect in nursing leadership, policy and research.

Nursing Leadership

The emerging nursing-AI interface will necessitate changes in multiple areas, including clinical practice, scope of practice, nursing education, core competencies, regulations, standards of care and policy (i.e., organizational and health-system policies).[4,57,62,67,98] Visionary nursing leadership is required across sectors, domains and roles to shepherd the profession through these uncharted territories.[120] The successful integration of these emerging technologies in nursing is a shared responsibility.[120] Therefore, nurse leaders in all roles and in all sectors must proactively seek to understand how these technologies can optimize care delivery; enabling them to make informed decisions about appropriate strategies to effectively integrate AI in nursing in ways that add value to the profession and to patients.[106] Strong, visionary leadership is necessary at multiple levels of clinical practice and in nursing informatics,* education, policy and research, as detailed below.[106,120]

Executive leaders

Executive nursing leadership has an essential role to play in the reconceptualization of nursing and caring within future AI-powered health organizations. As the profession prepares for the future, executive leadership is needed to advance well-informed and ethical discussions and influence decisions about the components of nursing care that can be safely performed by AIHTs. Strong executive leadership is also required to advocate for those non-negotiable aspects of care that must be performed by nurses,[8] to ensure safe, ethical, high-quality care, and more specifically, compassionate, person-centred care. Furthermore, executive nursing leadership is necessary to identify appropriate care delivery models, nursing roles, competencies and best practices to support the nursing and technological caring paradigm.

Executive leaders must also champion these changes and establish new management and leadership models to guide the technology-nurse integration.[120] Furthermore, these leaders must actively encourage and support nurses in all roles, ensure their full contribution, as well as encourage patient and family engagement throughout the technology lifecycle.[120] The implementation of complex technologies, such as robotic devices, predictive analytics and smart healthcare in clinical practice, requires governance structures with integrated nursing informatics roles.[120] It is important for executive leadership to advocate for technology-related governance structures that include these roles and afford nurses decision-making authority.[120] A significant barrier to the actualization of these executive nursing leadership priorities is limited technical knowledge, which lessens leaders' effectiveness at important decision-making tables in health organizations. Yet, without their leadership and extensive nursing and patient/family involvement, organizations risk implementing AIHTs that may fail to adequately meet the needs of nurses or patients, leading to unintended consequences.[120]

In addition, when preparing the nursing workforce for the age of AI, it is important for nurse executives to consider whether existing regulations, or the nature of the existing workforce (i.e., unionized or non-unionized), will support or impede the new care delivery models and nursing roles.[121] Nurse executives must also ensure there is adequate staffing and the appropriate skill mix for the new care delivery models. Administrators in long-term care facilities must advocate for changes to enhance and evolve care delivery and optimize the use of AIHTs in this setting, where appropriate. Outcome measures will also be needed to determine the effectiveness of the technology and its ability to improve access and promote safety and quality of care.

Staff Nurses

Staff nurses have a key leadership role at all stages of the technology lifecycle: needs assessment, procurement, selection, implementation, adoption, evaluation and ongoing optimization.[120] Their expertise is vitally important during the co-design and testing of AIHTs to ensure those who use the technology will continue to meet professional standards of practice and promote patient safety.[30]

Staff nurses will need new competencies to practice safely and efficiently in AI-powered work environments.[30] For example, they will require new knowledge and skills to identify the ideal conditions for using a particular technology and the potential risks that may result from usage.[30] Additional competencies are discussed in the section entitled, *Implications for Nursing Education*. Clinical nurse specialists will play a heightened leadership role in gaining the necessary competencies for effectively using AIHTs and assisting others with their adoption.

Nursing Informaticians

There are at least two nursing informatics leadership roles that will be critical to the successful integration and sustainability of complex AIHTs in health organizations. The first role is a chief nursing informatics officer (CNIO) to assist nurses and other executive leaders to make informed clinical and business decisions to guide the procurement and implementation of AIHTs.[8,120] As a nursing executive with clinical and informatics expertise, the CNIO will be well-positioned to advocate for the retention of essential and highly-valued elements of nursing care while knowledgeably negotiating the transference of aspects of patient care that are amenable to ethical and safe completion by robotic devices. The CNIO will also be a valuable partner in discussions about appropriate care delivery models and new competencies required by nurse leaders in all roles (i.e., from executive leadership to staff nurses) and to lead the technical aspects and the educational programs for integration of AI in patient care. This role will be particularly important in large health organizations.

The second nursing informatics leadership role is a nursing informatician with specialized knowledge and skills pertinent to these emerging technologies. The role will connect people, information and technology in virtual and digital models of care.[8,109] Nursing informaticians will also have a key leadership role in the management, analysis and interpretation of clinical data, ensuring the visibility of nursing's contribution to health outcomes.

Nurse Educators

Nurse educators in clinical practice and academic institutions also have an essential leadership role to play in the successful integration of AI in nursing.[88] Currently, there is a dearth of nursing faculty with the technical skills and knowledge to prepare nursing students for emerging clinical environments enriched with AIHTs. This is a significant challenge for the profession.[88,97,109] This topic is further discussed in the section, *Implications for Nursing Education*.

Nursing and Health-System Policy

Proactive leadership will also be needed to develop new policies and procedures to support new models of care, new nursing roles, new workflows, and the changes to nurses' scope of practice.[4,67,96,101,121] For example, new policies are needed to address the ethical concerns pertaining to the use of AI-powered predictive analytics and robotic devices in nursing.[4,30,88,116] One such concern pertains to the impact of AI on clinical judgment arising from the inability to validate the accuracy of risk scores generated by AI-powered predictive analytics.[122] The ability to provide clear rationale for one's clinical decisions is a fundamental ethical responsibility.[122] Yet, many existing professional codes of ethics and standards of practice do not address the current or future use of AIHTs to assist in clinical decision-making.[4] Professional codes of ethics and standards of practice must clearly stipulate that the use of digital health technologies such as AIHTs is intended to augment rather than replace nurses' clinical judgment.[4,123,124] In the United States, the American Nurses Association's *Code of Ethics for Nurses with Interpretive Statements* addresses this concern with the statement: "Systems and technologies that assist in clinical practice are adjunct to, not replacements for, the nurse's knowledge and skill." (p. 16)[125]

New nursing and health system policies will also be required to address concerns related to patient safety and ethical practice.[30] One such concern relates to the unintended consequences associated with AIHTs that might potentially jeopardize patients' health and well-being.[30] For example, patients may be harmed due to technology failures or malfunctioning or lapses in infection control measures carried out by robots.[126,127,128,129]

AI in nursing also brings new privacy and ethical implications that require the enactment of legislation and policies that eliminate or mitigate these concerns. Privacy concerns accentuated in the literature centre around the volume of patient data required to realize the benefits of AI-powered predictive analytics.[118,130,131,132] Without adequate cyber security, patient privacy will be vulnerable to cybercrimes with huge potential for data leaks.[118,130,131,132]
Other ethical concerns include the appropriateness of allowing patients to develop an emotional attachment to robots, and the use of robots as a video surveillance system or "policing" method for elderly patients in their homes.[65,85,131,133] The question has also been raised about where responsibility lies if negligence occurs through nurses' use of AIHTs capable of performing tasks independently.[30,134,135] These privacy and ethical issues must be addressed in policy when implementing AIHTs.

It is also important to identify and address real or potential health inequities related to AIHTs.[116] For instance, although these technologies have the potential to enhance access to care and health-service delivery, they may also accentuate health inequities by increasing the digital divide.[116] Due diligence is required to ensure vulnerable populations and people in rural and remote areas have access to continuous, co-ordinated care.[116] In reality, people in rural and remote areas may have a greater need for virtual care and remote patient monitoring than people living in urban areas.[57] Health-system policy makers need to address the suboptimal levels of telecommunication infrastructure in some rural and remote areas.

Lastly, the potential for algorithmic bias is another major concern with the increased use of AI-powered predictive analytics.[109] The aforementioned challenges related to the lack of transparency with predictive analytics increases the potential for bias in the data used to develop the algorithms and for the technology to inadvertently reinforce existing societal inequities.[109] The gravity of this trend was addressed by Booth at al.: "As champions of social justice, nurses must generate not only the skills and knowledge to participate in data science involving artificial intelligence, but also become the voices for marginalized populations who stand to suffer the most from the automation of

inequalities." (p.15)[109] These concerns reinforce the need for legislation to guide the design of robots and predictive analytics that will support the nurse-technology interface in the age of AI.[30]

Nursing Research

Nurse researchers also have an important leadership role in the integration of AIHTs in nursing. They need to address key knowledge gaps.[136] For example, there is currently a paucity of empirical evidence on: 1) the impact of these technologies on nurses, patients, families and caregivers; 2) implementation facilitators and barriers; 3) potential or actual risks to patients, families and caregivers; 4) patients', families', and caregivers' experience of person- and family-centred compassionate care; 5) issues related to access; and 6) short, medium and long-term cost-benefit, financing and ethical considerations.

RNAO's *Person- and Family-Centred Care* best practice guideline emphasizes that person- and family-centred care is the anchor of nurses' clinical care.[148] Person- and family-centred compassionate care is a core component of nursing practice, and as such, there is a need for deeper inquiry and interdisciplinary research into the influences of AIHTs (e.g., robotic devices and predictive analytics) on this phenomenon. Nurses are well-positioned to lead interdisciplinary inquiry into this area of research, given our understanding of the complexities inherent in various clinical contexts. Also invaluable is nurses' ability to evaluate the technology's safety, effectiveness, compatibility with nursing workflows, and other factors likely to impact patients' experiences and health outcomes.[68] Nurse-led research will ensure AIHTs are appropriately designed to meet the needs of patients, rather than patients being made to fit the technology.[61] For instance, nurse-led interdisciplinary research to explore the design of smart home technology can help developers understand real-world applications of the technology, ensuring meaningful data are displayed on clinical dashboards that support virtual nursing care delivery models.[55]

With the growing acceptance of interconnected AI-powered technologies, researchers need to reconsider the types of questions that can be asked and the types of analytical approaches available to successfully analyze massive quantities of data.[137] While the future of research in an AI-powered health environment appears promising, researchers will also need to explore how central tenets of the research process evolve with the presence or function of AIHTs. Subjects like research privacy, ethics and informed consent will all need to be reinterpreted,[109] in light of AIHTs that will likely challenge traditional interpretations of these concepts and related methods in previous research activities. For instance, topics related to equity and transparency of AIHTs used in health-care activities should be immediately explored by nursing research, as a proactive mechanism from which to build a foundation of knowledge expertise and insight in this emergent domain. Since many AIHTs have the potential to revolutionize various activities in the health-care experience (sometimes through largely invisible or subtle processes), nursing research needs to proactively lead this change and assist in the development of structures to support new and emergent domains of research. Given the forecasted surge in the use of AIHTs by nurses and patients, nursing research will require adequate resources and talent to recognize emergent knowledge gaps that need filling for the purposes of both policy makers and practitioners to ensure patients, families and the health system continue to benefit from the unique and added value of the nursing role.

IMPLICATIONS FOR NURSING EDUCATION

"The transformation of curricula and professional practice focusing on interpersonal and intrapersonal intelligence with attitudes that value human skills will ensure nursing's place/role in a society dominated by machines and scientific progress." (p. 4) [80]

As leaders, nurse educators in clinical practice and academic institutions have an essential role to play in preparing nurses and nursing students for the future world of AIHTs. To help future-proof the nursing workforce, educators must create a learning environment where nurses and nursing students can evolve their understanding of novel nurse-patient interactions involving AIHTs alongside other core nursing topics (e.g., therapeutic relationships, caring, physical presence).[138] Through this experience, nurses and nursing students will gain insight on the extent to which new AI technologies will impact existing communication patterns between patients, caregivers and other members of the interprofessional team.[80]

Curricula will need to be assessed for its contemporary relevance and its ability to proactively prepare nursing for health systems of the future, where the blending of roles, activities and decision-making between nurses and AIHTs becomes increasingly difficult to separate.[109] More specific educational requirements for nurses in clinical practice and for nursing students are detailed below.

Nurses in Clinical Practice

Nurses in clinical practice will require ongoing professional development opportunities (e.g., courses and workshops) prior to the implementation of any AIHT.[139,140] Effective use of AIHT may enable nurses to use AI-powered predictive analytics to prioritize educational topics for their patients prior to discharge. Further, nurses may also be able to use chatbots with digital avatars to augment their health-teaching activities and/or provide opportunities for patient review and testing before discharge. Clinical nurse educators will need curricula that teach nurses how to work with and relate to robotic devices in terms of both receptivity and the requisite knowledge and skills. Nurses will also require adequate preparation related to the use of AI-powered predictive analytics and the management of large data sets, to understand how these systems work and to generate insights for nursing-related activities.[141,142]

AIHTs will create a range of ethical, privacy and equity-related implications that will need to be identified, mitigated and understood, and as such must be incorporated into nursing curricula as important nursing and health-care topics.

Nursing Students

Undergraduate Education

Exposing students to robots and other intelligent technologies during their undergraduate education will help to prepare them for future roles where they may use robotic devices to support patient care.[63] It is envisioned that in the future, there will also be the need for curricular revisions to include opportunities for students to learn how to: assess and evaluate the safety and ethics of using robotic devices for health-care activities; help patients select the appropriate AIHT to support their health-care requirements; and troubleshoot technological issues that patients may experience that impact well-being and quality care, and in some cases they may design robotic devices to enable specific aspects of the nursing care process.[63]

While contemporary nursing curricula should incorporate data/digital literacy, data governance and privacy, and the ethical implications of AI across aspects of education,[143] the embedding of informatics content or other hybridized, interprofessional educational opportunities should also be considered.[97,98] For instance, undergraduate nursing programs that combine nursing and engineering principles can advance the development of AIHTs and further assist nurses' understanding of key principles underpinning the AIHTs they will likely encounter in the clinical setting.[66,63] To date, no universities have created an entirely new discipline (e.g. "nurse-engineering"); however, two universities have created unique collaborations or joint degrees to improve patient experiences and health system efficiencies using technology.[66] Finally, authors have discussed the importance of maintaining a continued focus on human communication competencies and empathy in nursing undergraduate programs.[80]

Post-Graduate Education

Several articles highlight the need to integrate content on AI research design, basic engineering concepts, privacy and the ethics of AI within the graduate nursing program.[56,106,108,143] At the doctorate level, the literature recommends including more in-depth content about predictive modeling, biostatistical programming, data management, risk adjustment, multivariable regression, machine learning, governance of big data and cyberthreats.[108,143] Further, nursing education at the post-graduate level should also explore a foundation in developing research talent related to the implications of AI upon society and health services. Given the nuanced ethical, privacy and equity implications that will likely arise from the use of AIHTs, post-graduate education should begin to develop specific educational opportunities for nurses to gain expertise in a variety of future-forward knowledge domains, including (but not limited to): 1) the impacts of algorithmic bias upon care delivery and predictive analysis; 2) the increased interfacing of the roles of nurses and patients as impacted by AIHTs; 3) the analysis and use of primary and secondary data, generated both actively and passively through advanced AIHTs; 4) hidden or invisible implications and impacts of AIHTs upon people, their health and their well-being; and, 5) how traditional research methods and theory can be used, evolved or updated to better serve as methodologies within digital ecosystems where traditional interpretations of various ways-of-knowing may no longer be accurate or appropriate.

CONCLUSION

"…nurse leaders can amplify the voice of the profession as well as represent patient needs in this technological evolution…"[106]

Canadians support the use of AIHTs and virtual care delivery models to improve access to care and augment the patient experience and health outcomes.[18] The accelerated adoption of virtual care delivery models in response to the COVID-19 pandemic has many members of the public and health professionals alike hoping that the trend will persist after the pandemic wanes. Thus, Canada's growing interest in virtual care and AIHTs will likely converge as public demand for both increases.

RNAO and AMS Healthcare believe nurses have a shared responsibility to assess the health, ethical and cost-benefits of emerging AIHTs, and to successfully integrate those technologies deemed beneficial to nursing care, patients, communities and health-system outcomes. Strong and proactive nursing leadership in all roles and sectors is required to guide discussions and influence decisions about aspects of nursing care that can be safely performed by AIHTs and to advocate for those non-negotiable aspects which must remain within nurses' scope of practice to ensure safe, high-quality clinical, and person- and family-centred, compassionate care.

This report has highlighted significant factors for nurse leaders in all roles and in all sectors to consider as the nursing workforce prepares for future clinical environments enriched by AIHTs. Nurse educators in clinical practice and academic institutions will be essential in leading efforts to prepare nurses and nursing students for the future world of AIHTs. Nurse researchers will also have an important role to play in leading interprofessional research in this area of inquiry and supporting nursing practice by addressing key knowledge gaps.[136]

Forums are required to enable nurse leaders in all roles to gain a broader understanding of the emerging AIHTs and their potential impact on nursing education, practice, administration, research and policy, as well as on nurses' caring paradigm. Forums for dialogue are important to stimulate critical reflection and discussion on actions to shape the future, build capacity in executive nurse leaders and the nursing workforce, and identify strategies to integrate these technologies in ways that are aligned with nursing values.[67]

The recommendations in the next section of this report represent an RNAO-AMS joint call for the profession and all stakeholders to engage, actively lead and co-create the future interface of AIHTs and nursing within health systems in Canada and, more specifically, in Ontario. The future is already here and the time to act is now.

RECOMMENDATIONS

"This…[report] can help open needed dialogue around planning for the future and is a call to action for the nursing profession to conceptualize its position on exponential technological growth and fundamental care provision." (p. 2479)[67]

The recommendations outlined below were formulated by the steering committee through a process of consensus decision-making, informed by the scoping review. They are intended to: 1) support efforts to prepare nurses and nursing students to leverage AIHTs to optimize clinical and, person- and family-centred, compassionate care; and 2) facilitate the successful integration of emerging AIHTs within the nursing profession. Among the 15 recommendations are eight (numbers 1 to 8) that serve as a call for immediate action to establish a strong foundation upon which the remaining seven recommendations will be built.

Recommendation	Accountability
1. Create forums for open dialogue between nurses and patients to raise awareness of the patient-nursing-AIHT interface; gain patients' and nurses' perspectives; and foster understanding of the roles and responsibilities of nursing in shaping effective, meaningful and ethical utilization of relevant AIHTs and timely outcome evaluation.	Professional associations in partnership with nursing leaders in all domains
2. Explore the impact of AI on patients, families, caregivers and nurses and their perception of the delivery of person- and family-centred compassionate care augmented by AIHTs.	Professional and labour associations with nursing leaders in all domains
3. Identify evidence-based best practices to guide ethical implementation of appropriate AIHTs across the care continuum to enhance person-centred, compassionate nursing care.	RNAO and relevant stakeholders
4. Identify new care delivery models, responsibilities and competencies for nurses in all roles and sectors to support the interface between nursing science, person- and family-centred compassionate care and AI.	Professional associations in partnership with nursing leaders in all domains
5. Conduct a thorough review and reform of nursing curricula to ensure congruency of the nursing role with present needs and future demands of emerging AIHTs.	Council of Ontario University Programs in Nursing (COUPN), College of applied arts and Technology (CAATS)
6. Develop a strategic plan to build capacity for basic informatics skills and data/digital literacy in the existing and future nursing workforce.	COUPN, CAATS
7. Implement new and revised professional codes of ethics and standards of practice that articulate nurses' responsibilities and accountabilities in relation to the use of AIHTs.	Regulatory bodies, professional associations
8. Prioritize rigorous, nurse-led interprofessional research to inform policies and procedures to support the co-design, development, implementation and evaluation of AIHTs in nursing.	Nurse researchers in all domains

Recommendation	Accountability
9. Engage patients, families, caregivers and nurses in all phases of the co-design and implementation of AIHTs (i.e., from needs assessment to outcome evaluation).	Governments, Ontario Health, professional associations and nursing leaders in all domains
10. Actively pursue ongoing continuing education for professional growth and development in basic informatics knowledge and skills, as well as data/digital literacy.	Professional and labour associations, academic institutions and health organizations
11. Advocate for the inclusion of data from marginalized populations in AI-powered predictive algorithms that will enable analytics that serve to address health inequities and prevent bias.	Professional associations and civil society groups
12. Advocate for access to AIHTs that are beneficial for all marginalized communities.	Professional associations and civil society groups
13. Fully utilize nurse informaticians in collaboration with other health professionals and disciplines to guide the design, procurement, implementation and evaluation of AIHTs.	Health organizations in all sectors
14. Create a forum for open dialogue to develop national, provincial and territorial strategic plans to guide discussion on the cost-benefit of AIHTs in nursing, paying close attention to the congruency with ethical practice design, implementation and evaluation frameworks.	Professional and labour associations
15. Advocate for new and revised evidence-based legislation and policies to protect patients' safety and privacy and preserve person- and family-centred compassionate care when implementing AIHTs across the care continuum.	Professional, labour and sector associations, governments, academic institutions and health organizations

REFERENCES

1. Health Education England. (2019). *The Topol review: Preparing the health care workforce to deliver the digital future* [White paper]. Retrieved from https://topol.hee.nhs.uk/wp-content/uploads/HEE-Topol-Review-2019.pdf
2. Birckhead, L. (1978). Nursing and the technetronic age. *Journal of Nursing Administration, 8*(2), 16-19.
3. Intelligent Living. (2020). Smart field hospital, staffed by robots, opened in China. Retrieved from https://www.intelligentliving.co/smart-field-hospital-robots-china/
4. Robert, N. (2019). How artificial intelligence is changing nursing. *Nursing Management, 50*(9), 30-39.
5. United Nations Educational, and Scientific Cultural Organization. (2018). Canada first to adopt strategy for artificial intelligence. Retrieved from http://www.unesco.org/new/en/media-services/single-view/news/canada_first_to_adopt_strategy_for_artificial_intelligence/
6. Canadian Institute for Advanced Research. (2019). AICAN 2019: Annual report of the CIFAR Pan-Canadian AI Strategy. Retrieved from https://www.amii.ca/wp-content/uploads/2019/04/ai_annualreport2019_web.pdf
7. Registered Nurses' Association of Ontario (RNAO). (2017). 70 years of RN effectiveness. Retrieved from https://rnao.ca/bpg/initiatives/RNEffectiveness
8. Booth, R. (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.
9. Registered Nurses' Association of Ontario. (2016). Mind the safety gap in health system transformation: Reclaiming the role of the RN. Retrieved from https://rnao.ca/mind-the-gap
10. Registered Nurses' Association of Ontario. (2012). Primary solutions for primary care: Maximizing and expanding the role of the primary care nurse in Ontario. Retrieved from https://rnao.ca/sites/rnao-ca/files/Primary__Care_Report_2012.pdf
11. Registered Nurses' Association of Ontario. (2012). Enhancing community care for Ontarians (ECCO) 3.0. Retrieved from https://rnao.ca/policy/ecco-30-enhancing-community-care-ontarians
12. Ministry of Health and Long-Term Care. (2019). Ontario health teams: Guidance for health care providers and organizations. Retrieved from http://health.gov.on.ca/en/pro/programs/connectedcare/oht/docs/guidance_doc_en.pdf
13. Daily Hive. (2020). Ontario invests $12 million to expand online mental health resources. Retrieved from https://dailyhive.com/toronto/ontario-mental-health-online-services-support-coronavirus?auto=true
14. Women's College Hospital Institute for Health Systems Solutions and Virtual Care. (2015). Virtual care: A framework for a patient-centric system. Retrieved from https://www.womenscollegehospital.ca/assets/pdf/wihv/WIHV_VirtualHealthSymposium.pdf
15. Canadian Healthcare Technology. (2020, May 6). Canada invests in virtual care, mental health tools. Retrieved from https://www.canhealth.com/2020/05/06/canada-invests-in-virtual-care-mental-health-tools/
16. Canada Health Infoway. (2020). Expanding Access to Virtual Care Services in Ontario. Retrieved from https://infoway-inforoute.ca/en/5266-solutions/rapid-response-to-covid-19/8537-expanding-access-to-virtual-care-services-in-ontario
17. Canada Health Infoway. (2020). National survey of Canadian nurses: Use of digital health technology in practice. Retrieved from https://infoway-inforoute.ca/en/component/edocman/resources/reports/benefits-evaluation/3812-2020-national-survey-of-canadian-nurses-use-of-digital-health-technology-in-practice

18. Ipsos. (2019). Canadians optimistic over the role technology will play in the health care system of the future. Retrieved from https://www.ipsos.com/en-ca/news-polls/The-Future-Of-Connected-Health-Care
19. Gallagher, A., Nåden, D., & Karterud, D. (2016). Robots in elder care: Some ethical questions. *Nursing Ethics, 23* (4), 369-371. DOI: 10.1177/0969733016647297
20. Vandemeulebroucke, T., de Casterlé, B. D., Welbergen, L., Massart, M., & Gastmans, C. (2019). The ethics of socially assistive robots in aged care: A focus group study with older adults in Flanders, Belgium. *The Journals of Gerontology: Series B*, 1-12. DOI:10.1093/geronb/gbz070
21. Curtis, K. (2015). Compassion is an essential component of good nursing care and can be conveyed through the smallest actions. *Evidence-Based Nursing*, 18, p. 95. PMID: 25673277
22. Registered Nurses' Association of Ontario. (2017). Compassionate care scoping review report. Toronto, ON: Author.
23. Buchanan, C., Howitt, M.L., Wilson, R., Booth, R.G., Risling, T. & Bamford, M. (2020). Nursing in the age of artificial intelligence: Protocol for a scoping review. *Journal of Medical Internet Research, 9*(4): e17490. doi: 10.2196/17490
24. Levac, D., Colquhoun, H., & O'Brien, K. Scoping studies: Advancing the methodology. *Implementation Science*, *5*(69). PMID: 20854677
25. Arksey, H. & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19-32. DOI: 10.1080/1364557032000119616
26. Registered Nurses' Association of Ontario (2007). Professionalism in nursing. Retrieved from https://rnao.ca/sites/rnao-ca/files/Professionalism_in_Nursing.pdf
27. Carroll, W. M. (2019). The synthesis of nursing knowledge and predictive analytics. *Nursing Management, 50* (3), 15-17. DOI: 10.1097/01.numa.0000553503.78274.f7
28. Taylor, D. (2020, June 30). Nurse practitioner in rural Nova Scotia embraces virtual care for patients. *Canadian Healthcare Technology*. Retrieved from https://www.canhealth.com/2020/06/30/nurse-practitioner-in-rural-nova-scotia-embraces-virtual-care-for-patients/
29. Arndt, R. Z. (2018, December 08). Healthcare providers are teaming with chatbots to assist patients. *Modern Healthcare*. Retrieved from https://www.modernhealthcare.com/article/20181208/TRANSFORMATION01/181209977/healthcare-providers-are-teaming-with-chatbots-to-assist-patients
30. Luxton, D. D. (2014). Recommendations for the ethical use and design of artificial intelligent care providers. *Artificial Intelligence in Medicine*, *62*(1), 1-10.
31. Palanica, A., Flaschner, P., Thommandram, A., Li, M., & Fossat, Y. (2019). Physicians' perceptions of chatbots in healthcare: Cross-sectional web-based survey. *Journal of Medical Internet Research, 21*(4). DOI: 10.2196/12887. Retrieved from https://www.jmir.org/2019/4/e12887/
32. Miller, E., & Polson, D. (2019). Apps, avatars, and robots: The future of mental healthcare. *Issues in Mental Health Nursing*, *40*(3), 208-214. DOI:10.1080/01612840.2018.1524535
33. Health Education England. (2018). *The Topol review interim report: Preparing the healthcare workforce to deliver the digital future* [White paper]. https://www.hee.nhs.uk/sites/default/files/documents/Topol%20Review%20interim%20report_.pdf
34. Joerin, A., Rauws, M., & Ackerman, M. L. (2019). Psychological artificial intelligence service, Tess: Delivering on-demand support to patients and their caregivers [Technical Report]. *Cureus*, *11*(1), e3972.
35. Ackerman, M., Virani, T., & Billings, B. (2017). Digital mental health – Innovations in consumer driven care. *Canadian Journal of Nursing Leadership, 30* (3), 63-72.
36. Singularity University. (2017). Meet Tess, the chatbot helping people around the world cope with stress, anxiety, and depression. Retrieved from https://su.org/wp-content/uploads/2018/06/Singularity-University-SU-CS-X2AI-EN.pdf

37. Deloitte. (2019, July 19). Predictive analytics in healthcare: Emerging value and risks. Deloitte Insights. Retrieved from https://www2.deloitte.com/us/en/insights/topics/analytics/predictive-analytics-healthcare-value-risks.html
38. Lo, Y. et al. (2019). Using machine learning on home healthcare assessments to predict fall risk. *Studies in Health Technology and Informatics*, *264*, 684-688.
39. Kwon, J. Y., Karim, M. E., Topaz, M., & Currie, L. M. (2019). Nurses "seeing forest for the trees" in the age of machine learning: Using nursing knowledge to improve relevance and performance. *Computers, Informatics, Nursing: CIN*, *37*(4), 203.
40. Li, H.-L., Lin, S.-W., & Hwang, Y.-T. (2019). Information and data mining to explore the factors that predict pressure injuries for patients at the end of life. *Computers, Informatics, Nursing: CIN*, *37*(3), 133-141.
41. Cramer, E. M., Seneviratne, M. G., Sharifi, H., Ozturk, A., & Hernandez-Boussard, T. (2019). Predicting the incidence of pressure ulcers in the intensive care unit using machine learning. *eGEMs (Generating Evidence & Methods to improve patient outcomes), 7* (1), 1-11. DOI: 10.5334/egems.307
42. Byrne, M. D. (2017). Machine learning in healthcare. *Journal of PeriAnesthesia Nursing, 32* (5), 494-496.
43. Lodhi, M. K., Stifter, J., Yao, Y., Ansari, R., Keenan, G. M., Wilkie, D. J., & Khokhar, A. A. (2015). Predictive modeling for end-of-life pain outcome using electronic health records. *Advanced Data Mining,* 56-68. DOI:10.1007/978-3-319-20910-4_5
44. Park, J. I., Bliss, D. Z., Chi, C.-L., Delaney, C. W., & Westra, B. L. (2020). Knowledge discovery with machine learning for hospital-acquired catheter-associated urinary tract infections. *CIN: Computers, Informatics, Nursing, 38* (1), 28-35.
45. Ginestra, J. C. et al. (2019). Clinician perception of a machine learning-based early warning system designed to predict severe sepsis and septic shock. *Critical Care Medicine, 47*(11), 1477-1484. DOI:10.1097/ccm.0000000000003803
46. Coahran, M. et al. (2018). Automated fall detection technology in inpatient geriatric psychiatry: Nurses' perceptions and lessons learned. *Canadian Journal on Aging, 37*(3), 245-260.
47. Sensmeier, J. (2017). Harnessing the power of artificial intelligence. *Nursing Management*, *48*(11), 14-19.
48. Guidi, G., Pollonini, L., Dacso, C. C., & Ladanza, E. (2015). A multi-layer monitoring system for clinical management of congestive heart failure. *BMC Medical Informatics and Decision Making, 15*(Suppl 3), S5.
49. Sparks, R. S., & Okugami, C. (2016). Tele-health monitoring of patient wellness. *Journal of Intelligent Systems, 25* (4). DOI: 10.1515/jisys-2014-0175
50. Sullivan, S. S., Hewner, S., Chandola, V., & Westra, B. L. (2019). Mortality risk in homebound older adults predicted from routinely collected nursing data. *Nursing Research*, *68* (2), 156-166. DOI: 10.1097/nnr.0000000000000328
51. Chawla, N. (2020). AI, IOT and wearable technology for smart healthcare-A review. *International Journal of Recent Research Aspects, 7*(1), pp. 9-13.
52. Tian, S., Yang, W., Le Grange, J. M., Wang, P., Huang, W., & Ye, Z.. (2019). Smart healthcare: Making medical care more intelligent. *Global Health Journal, 3*(3), 62-65. Retrieved from https://www.sciencedirect.com/science/article/pii/S2414644719300508
53. Nguyen-Truong, C. K. Y & Fritz, R. L. (2018). Health-assistive smart homes for aging in place: Leading the way for integration of the asian immigrant minority voice. *Asian/Pacific Island Nursing Journal, 3*(4), 154-159. DOI: 10.31372/20180304.1087
54. Davoudi, A., Malhotra, K. R., Shickel, B., Siegel, S., Williams, S., Ruppert, M., Bihorac, E., Ozrazgat-Baslanti, T., Tighe, P. J., Bihorac, A., & Rashidi, P. (2019). Intelligent ICU for autonomous patient monitoring using pervasive sensing and deep learning. *Scientific Reports*, *9*(1), 1-13.
55. Dermody, G., & Fritz, R. (2019). A conceptual framework for clinicians working with artificial intelligence and health-assistive smart homes. *Nursing Inquiry, 26*(1), e12267.
56. Fritz, R. L., & Dermody, G. (2019). A nurse-driven method for developing artificial intelligence in "smart" homes for aging-in-place. *Nursing Outlook*, *67*(2), 140-153.

57. Fritz, R. L., Corbett, C. L., Vandermause, R., & Cook, D. (2016). The influence of culture on older adults' adoption of smart home monitoring. *Gerontechnology, 14* (3). DOI: 10.4017/gt.2016.14.3.010.00
58. Hedieh Javaheri, H., & Rajakulendran, N. (2018). Breaking the mould: The transformation of Ontario's hospitals. Retrieved from https://www.longwoods.com/content/25595/breaking-the-mould-the-transformation-of-ontario-s-hospitals
59. Mackenzie Health. (2020). Mackenzie Health names new Vaughan hospital in honour of $40 million donation from the Cortellucci family. Retrieved from https://www.newswire.ca/news-releases/mackenzie-health-names-new-vaughan-hospital-in-honour-of-40-million-donation-from-the-cortellucci-family-854411982.html
60. Frazier, R. M., Carter-Templeton, H., Wyatt, T. H., & Wu, L. (2019). Current trends in robotics in nursing patents: A glimpse into emerging innovations. *CIN: Computers, Informatics, Nursing, 37*(6), 290-297.
61. Pepito, J. A., & Locsin, R. (2019). Can nurses remain relevant in a technologically advanced future? *International Journal of Nursing Sciences, 6*(1), 106-110. DOI:10.1016/j.ijnss.2018.09.013
62. Tanioka, T., Yasuhara, Y., Dino, M. J. S., Kai, Y., Locsin, R.C., & Schoenhofer, S.O. (2019). Disruptive engagements with technologies, robotics, and caring: Advancing the transactive relationship theory of nursing. *Nursing Administration Quarterly, 43*(4):313-321. DOI:10.1097/NAQ.0000000000000365
63. Sharts-Hopko, N. C. (2014). The coming revolution in personal care robotics. *Nursing Administration Quarterly, 38*(1), 5-12
64. Humber River Hospital Foundation. (2018). Meet Pepper, Humber River Hospital's humanoid robot. Retrieved from https://www.hrhfoundation.ca/blog/pepper/
65. Maalouf, N., Sidaoui, A., Elhajj, I. H., & Asmar, D. (2018). Robotics in nursing: A scoping review. *Journal of Nursing Scholarship, 50*(6), 590-600.
66. Glasgow, M. E. S., Colbert, A., Viator, J., & Cavanagh, S. (2018). The nurse-engineer: A new role to improve nurse technology interface and patient care device innovations. *Journal of Nursing Scholarship, 50*(6), 601-611.
67. Archibald, M. M., & Barnard, A. (2018). Futurism in nursing: Technology, robotics and the fundamentals of care. *Journal of Clinical Nursing, 27*(11-12), 2473-2480.
68. Clipper, B., Batcheller, J., Thomaz, A. L., & Rozga, A. (2018). Artificial intelligence and robotics: A nurse leader's primer. *Nurse Leader, 16* (6), 379-384. DOI: 10.1016/j.mnl.2018.07.015
69. The Japan Times. (2013). Robot niche expands in senior care. Retrieved from https://www.japantimes.co.jp/news/2013/06/19/national/social-issues/robot-niche-expands-in-senior-care/
70. Bickford, B., Daley, S., Sleater, G., Hebditch, M., & Banerjee, S. (2019). Understanding compassion for people with dementia in medical and nursing students. *BMC medical education*, *19*(1), 35. https://doi.org/10.1186/s12909-019-1460-y
71. Locsin, R. C. (2017). The co-existence of technology and caring in the theory of technological competency as caring in nursing. *The Journal of Medical Investigation, 64(*1.2), 160-164.
72. Nairn, S. (2016). On being a Luddite in the new world of technological nursing care. *Nursing Philosophy*, *7* (1), 3-5.
73. Vandemeulebroucke, T., de Casterlé, B. D., & Gastmans, C. (2018). How do older adults experience and perceive socially assistive robots in aged care: a systematic review of qualitative evidence. *Aging & Mental Health*, *22*(2), 149-167.
74. Zafrani, O., & Nimrod, G. (2019). Towards a holistic approach to studying human-robot interaction in later life. *The Gerontologist, 59*(1), e26-e36.
75. Moyle, W., Jones, C., Pu, L., & Chen, S.-C. (2018). Applying user-centred research design and evidence to develop and guide the use of technologies, including robots, in aged care. *Contemporary Nurse, 54*(1), 1-3.

76. Vandemeulebroucke, T., Dierckx de Casterlé, B., & Gastmans, C. (2018). The use of care robots in aged care: A systematic review of argument-based ethics literature. *Archives of Gerontology and Geriatrics, 74*, 15-25.
77. Metzler, T. A., Lewis, L. M., & Pope, L. C. (2016). Could robots become authentic companions in nursing care? *Nursing Philosophy, 17*(1), 36-48.
78. Newland, J. (2015). Humans versus artificial intelligence. *The Nurse Practitioner, 40*(9), 13.
79. Backonja, U., Hall, A. K., Painter, I., Kneale, L., Lazar, A., Cakmak, M., Thompson, H. J., & Demiris, G. (2018). Comfort and attitudes towards robots among young, middle-aged, and older adults: A cross-sectional study. *Journal of Nursing Scholarship, 50*(6), 623-633.
80. de Fátima Fernandes, M. N., Esteves, R. B., Teixeira, C. A. B., & da Silva Gherardi-Dona, E. C. (2018). The present and the future of nursing in the brave new world. Revista Da Escola de Enfermagem Da U S P, 52, e03356-e03356.
81. Klein, B., & Schlömer, I. (2018). A robotic shower system: Acceptance and ethical issues. Zeitschrift Fur Gerontologie Und Geriatrie, 51(1), 25-31.
82. Fiorini, L., De Mul, M., Fabbricotti, I., Limosani, R., Vitanza, A., D'Onofrio, G., Tsui, M., Sancarlo, D., Giuliani, F., Greco, A., Guiot, D., Senges, E., & Cavallo, F. (2019). Assistive robots to improve the independent living of older persons: results from a needs study. *Disability and Rehabilitation: Assistive Technology*, 1-11, DOI: 10.1080/17483107.2019.1642392
83. Tuisku, O., Pekkarinen, S., Hennala, L., & Melkas, H. (2019). "Robots do not replace a nurse with a beating heart." *Information Technology & People, 32*(1), 47-67. DOI: 10.1108/itp-06-2018-0277
84. Gustafsson, C., Svanberg, C., & Müllersdorf, M. (2015). Using a robotic cat in dementia care: A pilot study. *Journal of Gerontological Nursing, 41*(10), 46-56.
85. Papadopoulos, I., Koulouglioti, C., & Ali, S. (2018). Views of nurses and other health and social care workers on the use of assistive humanoid and animal-like robots in health and social care: a scoping review. *Contemporary Nurse, 54*(4-5), 425-442.
86. Gannod, G. C., Abbott, K. M., Van Haitsma, K., Martindale, N., & Heppner, A. (2019). A machine learning recommender system to tailor preference assessments to enhance person-centered care among nursing home residents. *The Gerontologist*, *59*(1), 167-176.
87. Nwosu, A. C., Collins, B., & Mason, S. (2018). Big data analysis to improve care for people living with serious illness: The potential to use new emerging technology in palliative care [Review]. *Palliative Medicine, 32*(1), 164-166.
88. Tanioka, T. (2019). Nursing and rehabilitative care of the elderly using humanoid robots. *The Journal of Medical Investigation, 66*, 19-23. DOI:10.2152/jmi.66.19
89. World Health Organization. (2019). Eurohealth: A healthy dose of disruption? Transformative change for health and societal well-being. *Quarterly of the European Observatory on Health Systems and Policies, 25* (3). https://apps.who.int/iris/handle/10665/327753
90. Kriegel, J., Grabner, V., Tuttle-Weidinger, L., & Ehrenmüller, I. (2019). Socially assistive robots (SAR) in in-patient care for the elderly. *Studies in Health Technology and Informatics*, *260*, 178-185.
91. Liang, H.-F., Wu, K.-M., Weng, C.-H., & Hsieh, H.-W. (2019). Nurses' views on the potential use of robots in the pediatric unit. *Journal of Pediatric Nursing, 47*, e58-e64. DOI:10.1016/j.pedn.2019.04.027
92. Sicurella, T., & Fitzsimmons, V. (2016). Robotic pet therapy in long-term care. *Nursing, 46*(6), 55-57.
93. Monteiro, A. P. T. de A. V. (2016). Cyborgs, biotechnologies, and informatics in health care--new paradigms in nursing sciences. *Nursing Philosophy, 17*(1), 19-27.
94. Pfadenhauer, M., & Dukat, C. (2015). Robot caregiver or robot-supported caregiving? International *Journal of Social Robotics, 7*(3), 393-406. DOI: 10.1007/s12369-015-0284-0
95. Murray, T. A. (2018). Nursing education: Our iceberg is melting. *The Journal of Nursing Education, 57*(10), 575-576.
96. Lynn, L. A. (2019). Artificial intelligence systems for complex decision-making in acute care medicine: A review. *Patient Safety in Surgery, 13*, 6.

97. Risling, T. (2017). Educating the nurses of 2025: Technology trends of the next decade. *Nurse Education in Practice, 22,* 89-92.
98. Risling, T. (2018, Feb 5). Why AI needs nursing. *Policy Options.* https://policyoptions.irpp.org/magazines/february-2018/why-ai-needs-nursing/
99. Mano, L. Y., Mazzo, A., Neto, J. R. T., Meska, M. H. G., Giancristofaro, G. T., Ueyama, J., & Júnior, G. A. P. (2019). Using emotion recognition to assess simulation-based learning. *Nurse Education in Practice*, *36*, 13-19.
100. Shorey, S., Ang, E., Yap, J., Ng, E. D., Lau, S. T., & Chui, C. K. (2019). A virtual counseling application using artificial intelligence for communication skills training in nursing education: development study. *Journal of Medical Internet Research, 21* (10), e14658. DOI: 10.2196/14658
101. Skiba, D. (2017). Horizon report: Knowledge obsolescence, artificial intelligence, and rethinking the educator role. *Nursing Education Perspectives, 38*(3),165-167.
102. Sitterding, M. C., Raab, D. L., Saupe, J. L., & Israel, K. J. (2019). Using artificial intelligence and gaming to improve new nurse transition. *Nurse Leader, 17* (2), 125-130. DOI: 10.1016/j.mnl.2018.12.013.
103. Kutafina, E., Laukamp, D., & Jonas, S. M. (2015). Wearable sensors in medical education: Supporting hand hygiene training with a forearm EMG. *Studies in Health Technology and Informatics, 211*, 286-291.
104. Gephart, S. M., Davis, M., & Shea, K. (2018). Perspectives on policy and the value of nursing science in a big data era. *Nursing Science Quarterly, 31*(1), 78-81.
105. Henly, S. J., McCarthy, D. O., Wyman, J. F., Heitkemper, M. M., Redeker, N. S., Titler, M. G., McCarthy, A. M., Stone, P. W., Moore, S. M., Alt-White, A. C., Conley, Y. P., & Dunbar-Jacob, J. (2015). Emerging areas of science: Recommendations for nursing science education from the Council for the Advancement of Nursing Science Idea Festival. *Nursing Outlook, 63*(4), 398-407.
106. Risling, T. L., & Low, C. (2019). Advocating for safe, quality and just care: What nursing leaders need to know about artificial intelligence in healthcare delivery. *Nursing Leadership*, *32*(2), 31-45.
107. Foley, T. & Wollard, J. (2019). The digital future of mental healthcare and its workforce: A report on a mental health stakeholder engagement to inform the Topol Review [White paper]. Health Education England. https://topol.hee.nhs.uk/wp-content/uploads/HEE-Topol-Review-Mental-health-paper.pdf
108. Linnen, D. T., Javed, P. S., & D'Alfonso, J. N. (2019). Ripe for disruption? Adopting nurse-led data science and artificial intelligence to predict and reduce hospital-acquired outcomes in the learning health system. *Nursing Administration Quarterly, 43*(3), 246-255.
109. Booth, R. G., Strudwick, G., McMurray, J., Chan, R., Cotton, K., & Cooke, S. (in press). The future of nursing informatics in a digitally-enabled world: Exploring emergent relationships between nurses, artificial intelligence, and robotics for the advancement of nursing practice. In M. Kennedy & P. Hussey (Eds.), *Health Informatics. Introduction to Nursing Informatics* (5th ed.). New York: Springer.
110. Strudwick, G., Wiljer, D., & Inglis, F. (2020). Nursing and compassionate care in a technological world: A discussion paper. Retrieved from http://www.ams-inc.on.ca/wp-content/uploads/2020/02/Nursing-and-Compassionate-Care.pdf
111. Glauser, W. (2017). Artificial intelligence, automation and the future of nursing. *The Canadian Nurse, 113*(3), 24-26.
112. Registered Nurses' Association of Ontario. (2020). BPSO OHT evaluation plan: Implementation of the person-and family-centred care best practice guideline. Toronto: ON Author.
113. Reid, R., Haggerty, J., & McKendry, R. (2002). Defusing the confusion: Concepts and measures of continuity of healthcare. Retrieved from https://www.researchgate.net/publication/245856177_Defusing_the_Confusion_Concepts_and_Measures_of_Continuity_of_Health_Care

114. Ding, M., Matsubara, T., Funaki, Y., Ikeura, R., Mukai, T., & Ogasawara, T. (2017). Generation of comfortable lifting motion for a human transfer assistant robot. *International Journal of Intelligent Robotics and Applications, 1* (1), 74-85. DOI: 10.1007/s41315-016-0009-z
115. Beran, T. N., Ramirez-Serrano, A., Vanderkooi, O. G., & Kuhn, S. (2015). Humanoid robotics in health care: An exploration of children's and parents' emotional reactions. *Journal of Health Psychology, 20*(7), 984-989.
116. Kuziemsky, C., Maeder, A. J., John, O., Gogia, S. B., Basu, A., Meher, S., & Ito, M. (2019). Role of artificial intelligence within the telehealth domain. *Yearbook of Medical Informatics, 28*(1), 35-45. DOI: 10.1055/s-0039-1677897
117. Ministry of Health. (2019). Ontario expanding home and community care services: Major investments in frontline care critical to ending hallway health care. Retrieved from https://news.ontario.ca/mohltc/en/2019/09/ontario-expanding-home-and-community-care-services.html
118. Salzmann-Erikson, M., & Eriksson, H. (2017). Letter to the editor: Prosperity of nursing care robots: An imperative for the development of new infrastructure and competence for health professions in geriatric care. *Journal of Nursing Management, 25*(6), 486-488.
119. Mila. (2020). A smart and ethical contact-tracing app to fight covid-19. Retrieved from https://mila.quebec/en/a-smart-and-ethical-contact-tracing-app-to-fight-covid-19/
120. Registered Nurses' Association of Ontario. (2017). Adopting eHealth solutions: Implementation strategies. Retrieved from https://rnao.ca/sites/rnao-ca/files/bpg/Digital_Health_Guideline.pdf
121. Jamieson, T., & Goldfarb, A. (2019). Clinical considerations when applying machine learning to decision-support tasks versus automation. *BMJ Quality & Safety, 28* (10), 778-781. DOI: 10.1136/bmjqs-2019-009514
122. Chin-Yee, B., & Upshur R. (2019). The impact of artificial intelligence on clinical judgment: A briefing document. Retrieved from http://www.ams-inc.on.ca/wp-content/uploads/2020/02/The-Impact-of-AI-on-clinical-judgement.pdf
123. Ganapathy, K., Abdul, S. S., & Nursetyo, A. A. (2018). Artificial intelligence in neurosciences: A clinician's perspective. *Neurology India, 66*(4), 934-939.
124. Skiba, D. J. (2017). Augmented intelligence and nursing. *Nursing Education Perspectives, 38*(2), 108-109.
125. American Nurses Association. (2015). *Code of ethics for nurses with interpretive statements* (2nd ed.). Silver Spring, MD: Author. Retrieved from http://www.r2library.com/resource/title/9781558105997
126. Demange, M., Pino, M., Kerhervé, H., Rigaud, A.-S., & Cantegreil-Kallen, I. (2019). Management of acute pain in dementia: A feasibility study of a robot-assisted intervention. *Journal of Pain Research, 12*, 1833-1846. DOI: 10.2147/jpr.s179640
127. Bemelmans, R., Gelderblom, G. J., Jonker, P., & de Witte, L. (2015). Effectiveness of robot Paro in intramural psychogeriatric care: A multicenter quasi-experimental study. *Journal of the American Medical Directors Association, 16*(11), 946-950.
128. Poncette, A.-S., Spies, C., Mosch, L., Schieler, M., Weber-Carstens, S., Krampe, H., & Balzer, F. (2019). Clinical requirements of future patient monitoring in the intensive care unit: Qualitative study. *JMIR Medical Informatics*, *7*(2), e13064.
129. Huisman, C., & Kort, H. (2019). Two-year use of care robot Zora in Dutch nursing homes: An evaluation study. *Healthcare, 7* (1), 31.
130. Lee, H., Piao, M., Lee, J., Byun, A., & Kim, J. (2020). The purpose of bedside robots: Exploring the needs of inpatients and healthcare professionals. *CIN: Computers, Informatics, Nursing, 38* (1), 8-17.
131. Effken, J.A. (2014). Issues, impacts and insights column: What's new in healthcare robotics? *Online Journal of Nursing Informatics, 18*(3), p. 1
132. Woods, J. S., Saxena, M., Nagamine, T., Howell, R. S., Criscitelli, T., Gorenstein, S., & M Gillette, B. (2018). The future of data-driven wound care. *AORN Journal*, *107*(4), 455-463.

133. Rantanen, T., Lehto, P., Vuorinen, P., & Coco, K. (2018). The adoption of care robots in home care—A survey on the attitudes of Finnish home care personnel. *Journal of Clinical Nursing, 27*(9-10), 1846-1859.
134. Meetoo, D., & Rylance, R. (2018). AI: revolution or apocalypse? *The British Journal of Nursing, 27*(19), 1092-1092.
135. Paulson, S. S., & Scruth, E. (2017). Legal and ethical concerns of big data: Predictive analytics. *Clinical Nurse Specialist, 31*(5), 237-239.
136. Menon, U., Cohn, E., Downs, C. A., Gephart, S. M., & Redwine, L. (2019). Precision health research and implementation reviewed through the conNECT framework. *Nursing Outlook*, *67*(4), 302-310.
137. Mieronkoski, R., Azimi, I., Rahmani, A. M., Aantaa, R., Terävä, V., Liljeberg, P., & Salantera, S. (2017). The Internet of Things for basic nursing care – A scoping review. *International Journal of Nursing Studies*, *69*, 78-90. https://doi.org/http://dx.doi.org/10.1016/j.ijnurstu.2017.01.009
138. Canadian Nurses Assocation. (2013). Responding to the National Expert Commission's call to action proceedings of a think tank on the future of undergraduate nursing education in canada. Retrieved from https://docplayer.net/44107875-Responding-to-the-national-expert-commission-s-call-to-action-proceedings-of-a-think-tank-on-the-future-of-undergraduate-nursing-education-in-canada.html
139. Carrière, R., MacDonald, A., & Chan, Y. (2016). Past, present and future: The outlook from mid-career nurse informaticians. *Nursing Leadership*, *28*(4), 8-17.
140. Perry, L. (2019). Machine learning: Great opportunities, but will it replace nurses? *International Journal of Nursing Practice, 25* (1), e12725. DOI: 10.1111/ijn.12725
141. Ginestra, J. C., Giannini, H. M., Schweickert, W. D., Meadows, L., Lynch, M. J., Pavan, K., Chivers, C. J., Draugelis, M., Donnelly, P. J., Fuchs, B. D., & Umscheid, C. A. (2019). Clinician perception of a machine learning-based early warning system designed to predict severe sepsis and septic shock. *Critical Care Medicine, 47*(11), 1477-1484. DOI:10.1097/ccm.0000000000003803
142. Peirce, A. G., Elie, S., George, A., Gold, M., O'Hara, K., & Rose-Facey, W. (2020). Knowledge development, technology and questions of nursing ethics. *Nursing Ethics*, *27*(1), 77-87. DOI: 10.1177/0969733019840752
143. Gephart, S. M., Davis, M., & Shea, K. (2018). Perspectives on policy and the value of nursing science in a big data era. *Nursing Science Quarterly, 31*(1), 78-81.
144. Canadian Nurses Association. (2017). Joint position statement: Nursing informatics. Retrieved from https://www.cna-aiic.ca/en/nursing-practice/the-practice-of-nursing/nursing-informatics
145. Editors of Encyclopaedia Britannica. (2020). Robotics technology. Retrieved from https://www.britannica.com/editor/the-editors-of-encyclopaedia-britannica/4419
146. Saba, V. & McCormick, K, (2015). *Essentials of Nursing Informatics (6th ed.).* New York: McGraw Hill.
147. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., The PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. Open *Medicine, 3*(3); 123-130.
148. Registered Nurses' Association of Ontario. (2015). Person- and family-centred care. Toronto, ON: Author. Retrieved from https://rnao.ca/sites/rnao-ca/files/FINAL_Web_Version_0.pdf

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APPENDIX A: GLOSSARY

Artificial Intelligence: A collection of techniques used to teach computers to simulate human learning, reasoning, communication and decision-making.[4]

Artificially Intelligent Care Provider (AICP): AI-powered health technology designed to simulate the actions of human care providers. They exist in various forms, such as avatars and robots (humanoid or non-humanoid). AICPs have been used to provide health teaching and coaching, assist with medication adherence, and direct individuals to relevant health-care resources.[30]

Avatar: A graphical representation of a character in a computer application ("App").[32]

Case Management/Care Co-ordination: A model of nursing care delivery in which patients are assigned to case managers (typically registered nurses), who develop and oversee their plan of care and co-ordinate services to address their health-care needs.[9]

Chatbot: A computer system that uses AI to simulate interactive human conversation via text or speech.[32]

Health Informatics: The integration of "health-care science, computer science, information science, and cognitive science to assist in the management of health-care information". (p. 232)[146]

Humanoid Robot: A robot designed with characteristics similar to those of a human.[64]

Nursing Informatics: The integration of "nursing, its information and knowledge and their management with information and communication technologies to promote the health of people, families and communities worldwide" (para 1)[144]

Machine Learning: A type of AI that uses algorithms to derive knowledge from data by interpreting the data independently and without being explicitly programmed. As more data are presented to the ML application, the computer learns from the data and corrects the output.[4]

Personal Care Robot: A robot designed to provide assistance with an individual's physical needs (e.g., hygiene or activities of daily living).[63]

Predictive Analytics: A branch of data analytics that uses various techniques, including machine learning, to analyze patterns in data and predict future outcomes.[37]

Robotics: The "design, construction and use of machines (robots) to perform tasks done traditionally by human beings."[145]

Service Robot: A robot designed to perform specific tasks with or without human intervention (e.g., transportation of supplies).[68]

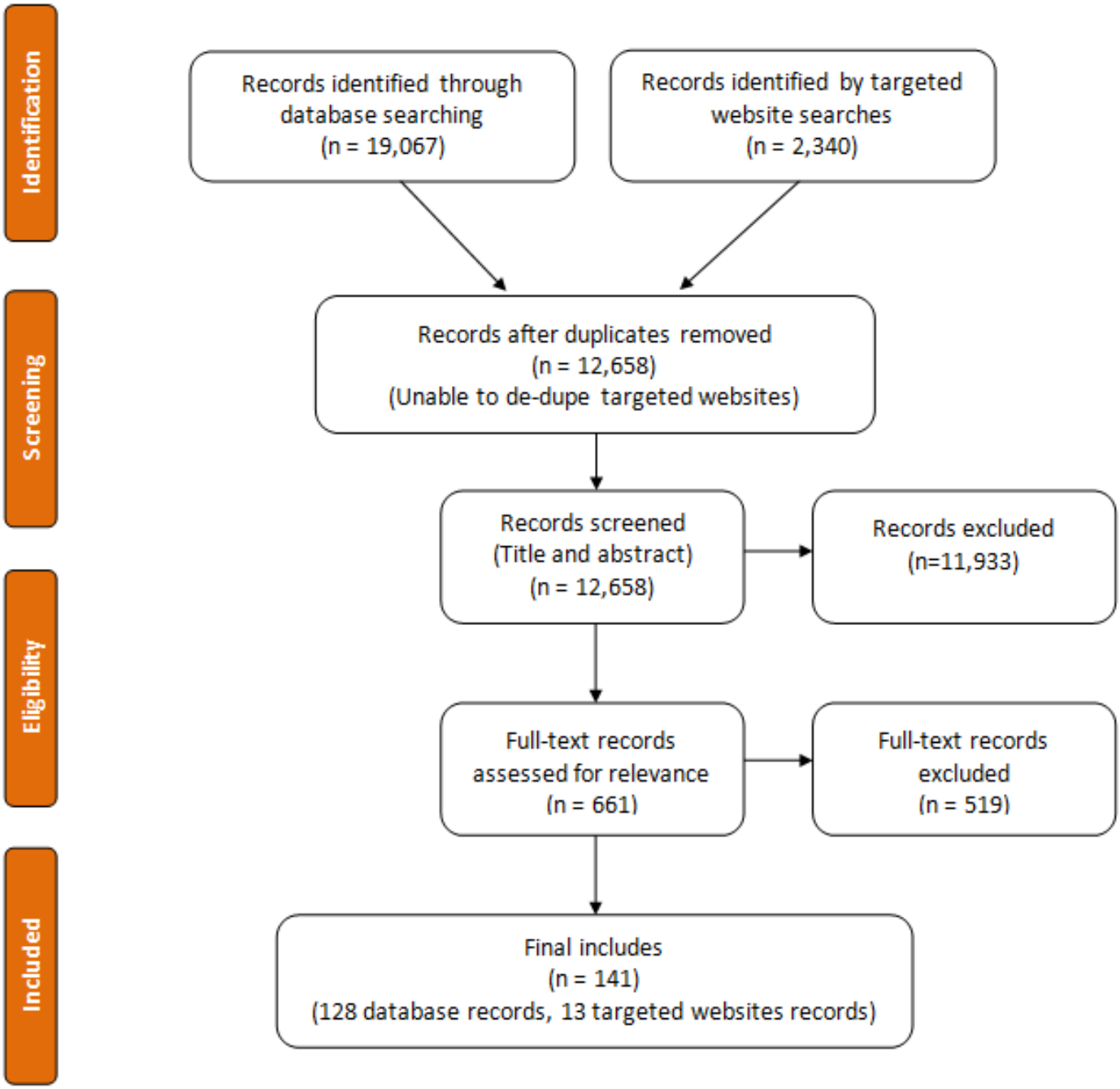
Smart Healthcare: A system that uses advanced technologies (e.g., wearable devices and AI) to access information and connect people and institutions to support health care.[52]

Social Assistive Robots: Robots designed to provide emotional support for patients.[65]

Team-Based Nursing: A model of care delivery in which a team of nurses is assigned to care for a group of patients based on their physical location.[9]

Telepresence Robot: A robot designed with a video screen mounted on a moving pedestal.[62]

APPENDIX B: RNAO PRISMA FLOW DIAGRAM



Adapted from Moher et al.[147]