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Special Article

RNAO's Artificial Intelligence Innovations: A Novel Strategy to Advance Evidence-Based Nursing Practice

Innovaciones en inteligencia artificial de la RNAO: Una estrategia novedosa para avanzar en las prácticas de enfermería basadas en evidencia

Inovações em inteligência artificial da RNAO: uma nova estratégia para avançar nas práticas de enfermagem baseadas em evidências

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ABSTRACT

Introduction. Artificial intelligence and machine learning methodologies, such as prediction, pattern recognition, or general inference based on the data used in clinical aspects, must fit within the intended purposes of developing it. This article aims to provide high-level, non-technical details of the initiative and a comprehensive approach that has been taken to integrate AI-powered techniques in evidence-based nursing practices appropriately. **Methodology.** A multi-pronged phased approach was considered for developing artificial intelligence tools. This approach includes conducting a scoping review, analyzing data to identify patterns of impactful intervention, employing data triangulation, enhancing data collection based on impactful intervention strategies, and developing a prototype (pilot) for an artificial intelligence tool. The process encompasses piloting, testing and training, validation, and implementation. **Results.** In this early stage of piloting the tool, the primary focus was identifying patterns from various information gathered from healthcare organizations. This analysis revealed opportunities for knowledge generation, facilitated the expedited implementation of guidelines, and enhanced resource efficiency. **Discussion.** Focusing on a data-driven model to inform best practices for implementing guidelines and identifying the most impactful interventions is facilitated by extensive in-house data storage. The triangulation of approaches to guideline development, implementation, and evaluation contributes to developing this scientifically validated artificial intelligence and machine learning initiative. **Conclusion.** Any artificial intelligence technique requires extensive data. To provide healthcare organizations with the best available evidence, purposeful efforts must be made to structure data collection and ensure data quality before expanding the development of artificial intelligence tools.

Keywords:

Practice Guidelines as Topic; Evidence-Based Nursing; Machine Learning; Artificial Intelligence; Health Information Systems

RESUMEN

Introducción. La inteligencia artificial y metodologías de aprendizaje automático, como la predicción, reconocimiento de patrones, o inferencia general basada en datos utilizados en aspectos clínicos, deben encajar entre las razones previstas para su desarrollo. El objetivo de este artículo es brindar detalles no técnicos de alto nivel, sobre la iniciativa y el acercamiento exhaustivo que fue tomado para integrar técnicas impulsadas por IA en prácticas de enfermería basadas en evidencia apropiadamente. **Metodología.** Un abordaje de múltiples enfoques por fases se consideró para desarrollar herramientas de inteligencia artificial. Este abordaje incluye la realización de una revisión integrativa, el análisis de datos para identificar patrones de intervención de impacto, el empleo de triangulación de datos, la mejora en la recolección de datos basados en estrategias de intervención de impacto, y el desarrollo de un prototipo (piloto) para una herramienta de inteligencia artificial. El proceso agrupa una prueba piloto, realización de pruebas y entrenamiento, validación, e implementación. **Resultados.** En esta etapa temprana de la prueba piloto de la herramienta, el enfoque principal fue identificar patrones de las diferentes fuentes de información recolectada por organizaciones de la salud. Este análisis reveló oportunidades para la generación de conocimiento, facilitó una implementación acelerada de las guías, y potenció la eficiencia de los recursos. **Discusión.** Enfocándose en un modelo basado en datos para informar acerca de las mejores prácticas para la implementación de guías e identificar las intervenciones con mayor impacto es facilitado por un extenso almacenamiento interno de datos. La triangulación de los enfoques para el desarrollo de la guía, la implementación y la evaluación contribuye al desarrollo de inteligencia artificial y metodologías de aprendizaje automático científicamente validadas. **Conclusión.** Cualquier técnica de inteligencia artificial requiere una gran cantidad de datos. Para proveer a organizaciones de la salud la mejor evidencia disponible, deben realizarse esfuerzos significativos para estructurar la recolección de datos y asegurar la calidad de estos antes de expandir el desarrollo de herramientas de inteligencia artificial.

Palabras clave:

Guías de Práctica Clínica como Asunto; Enfermería Basada en la Evidencia; Aprendizaje Automático; Inteligencia Artificial; Sistemas de Información en Salud

RESUMO

Introdução. A inteligência artificial e as metodologias de aprendizagem automática, como predição, reconhecimento de padrões ou inferência geral baseada em dados utilizados em aspectos clínicos, devem se enquadrar entre as razões previstas para o

seu desenvolvimento. O objetivo deste artigo é fornecer detalhes não técnicos de alto nível sobre a iniciativa e a abordagem abrangente que foi tomada para integrar técnicas impulsionadas por IA em práticas de enfermagem baseadas em evidências adequadamente. **Metodologia.** Foi considerada uma abordagem multifásica para desenvolver ferramentas de inteligência artificial. Esta abordagem inclui a realização de uma revisão integrativa, a análise de dados para identificar padrões de intervenção de impacto, o emprego da triangulação de dados, o aprimoramento na coleta de dados com base em estratégias de intervenção de impacto e o desenvolvimento de um protótipo (piloto) para uma ferramenta de inteligência artificial. O processo inclui um teste piloto, testes e treinamento, validação e implementação. **Resultados.** Neste estágio inicial do teste piloto da ferramenta, o foco principal foi identificar padrões provenientes das diferentes fontes de informação coletadas pelas organizações de saúde. Esta análise revelou oportunidades para a geração de conhecimento, facilitou a implementação acelerada das diretrizes e aumentou a eficiência dos recursos. **Discussão.** A concentração num modelo baseado em dados para informar as melhores práticas para a implementação de diretrizes e identificar intervenções com maior impacto é facilitada pelo amplo armazenamento interno de dados. A triangulação de abordagens para o desenvolvimento, implementação e avaliação das diretrizes contribui para o desenvolvimento de inteligência artificial e metodologias de aprendizagem automática cientificamente validadas. **Conclusão.** Qualquer técnica de inteligência artificial requer uma grande quantidade de dados. Para fornecer às organizações de saúde a melhor evidência disponível, é preciso fazer esforços significativos para estruturar a coleta de dados e garantir a qualidade dos dados antes de expandir o desenvolvimento de ferramentas de inteligência artificial.

Palavras-chave:

Guias de Prática Clínica como Assunto; Enfermagem Baseada em Evidências; Aprendizado de Máquina; Inteligência Artificial; Sistemas de Informação em Saúde

Introduction

The advent of electronic health records (EHR) and data warehousing technologies has broadened the potential for developing and implementing AI-powered technologies in the healthcare industry (1). Artificial intelligence (AI) and its subfields of machine learning, reinforcement learning, and deep learning refers to the theory and development of computer systems designed to perform tasks that normally require human intelligence. Examples of computer-aided system transitions are analyzing massive data related to visual perception, HER implementation, speech recognition, pattern recognition, telemedicine platforms, and decision-making.(2–5) Information gathered by each healthcare organization leads to the application of “big data analytics,” which is inevitable in supporting decision-making in clinical and nursing professions. Advancements in computer technology in the past three decades, together with the massive data collected in healthcare organizations, have been affirmative to the development of artificial intelligence (AI)-powered technologies in the healthcare industry. Moreover, data science and statistics pave the way to unravel hidden information and patterns in the data effortlessly by compiling information from different resources. Thus, opens a new era of data-supported decision-making approaches merged and driven by philosophical, ethical, and methodological foundations to ensure the accessibility of the best scientific knowledge to inform evidence-based practices.

Evidence-based practice (EBP) in nursing and AI-powered techniques are two significant scientific methodologies. EBP relies on scientific knowledge by synthesizing evidence through a well-defined methodology, while AI techniques rely on data-driven knowledge generation (4). Although

EBP and data-driven knowledge represent distinct approaches, their integration aims to support nurses and interprofessional teams using EBP with data-driven solutions, ultimately enhancing patient care.

Clinical decision-making is often strictly based on standard guidelines and protocols that satisfy safety and accountability requirements (6,7). However, deviating from established protocols in complex care environments to adapt treatments for a more personalized regimen can benefit patients. In such dynamic settings, machine learning (ML) methods can be valuable tools (8–10) for optimizing patient care outcomes in a data-driven manner, especially in acute care settings. For example, ML and deep-learning techniques can optimize an objective function (e.g., medication dosage) based on complex and multidimensional data (e.g., patient medical history extracted from EHRs). There are many broad applications of AI and ML in health care. For example, AI and ML tools collect medical imaging data to help radiologists identify lesions, tumors, and suspicious spots on the skin (11,12).

Building on automation, AI has the potential to revolutionize health care by addressing some existing challenges. It can improve the day-to-day life of health practitioners by freeing up time to look after patients, raising staff morale, and improving retention. It can even get life-saving treatments to market faster. At the same time, questions have been raised about the impact AI could have on patients, practitioners, and health systems, and its potential risks; there are ethical debates about how AI and the data that underpins it should be used. This short article elucidates the application of AI that supports EBP, can improve the nursing process, e.g., screening, assessment,

and evaluation of clinical interventions, and leads to better patient care.

Evidence-based practice in nursing

EBP requires nurses to determine clinical decisions supported by high-quality scientific evidence and corroborated with internal evidence (clinical judgment). Scientific literature demonstrates that advances in evidence-based practice have improved care systems and health outcomes. However, getting and synthesizing up-to-date scientific clinical information can be challenging in front-line practice settings, especially if access to healthcare journals is limited. For example, different guidelines with conflicting recommendations are published in the same clinical area and available through multiple resources. When this happens, users face confusing and potentially misleading dilemmas, leading to lower-quality care and poor patient outcomes.

Moreover, it is difficult to identify best practices for a specific clinical topic because appropriate guidelines are simply unavailable. For example, many professional organizations continue to recommend low-bed rails as a routine nursing practice to avoid falls, although insufficient or lower-quality evidence supports this. Significant barriers exist in adopting or implementing evidence-based nursing (13–16). Implementing EBP in nursing requires basic research skills and excellent clinical judgment when incorporating patient, family, and caregiver preferences.

Furthermore, results from evidence-based research can be translated into effective nursing practices that may impact policies in health system outcomes considerably (17). The availability, uptake, and consistent use of clinical evidence at the point of care using clinical practice recommendations can reduce outcome variation.

The Registered Nurses' Association of Ontario has been funded by the Government of Ontario in Canada since 1999 to develop Best Practice Guidelines (BPGs). The RNAO also supports the implementation and sustainability of BPGs through their Best Practice Spotlight Organization® (BPSO®) program since the inception of the BPSO program in 2003 (1). The RNAO recognized the value of a technology-enabled AI tool that would support nurses and healthcare organizations in ensuring the latest evidence is incorporated into practice and identifying the most impactful intervention for better patient care. AI initiative at RNAO begins with understanding the potential scope and expansion of AI-powered techniques in guideline development, implementation, and evaluation.

Methodology

Robust real-world evidence is essential for standardizing care within organizations and across the continuum of care. Recently, the healthcare industry has emphasized the development of high-quality evidence and data-engineering technologies to resolve challenges and support solving clinical problems with better decisions. However, a clear framework is needed to integrate EBP with “big data analytics.” Additionally, substantial data storage capacity is required to collect the necessary data for developing sophisticated algorithms that can replace traditional techniques.

To address this, RNAO launched an AI and machine learning (ML) initiative with a wider scope of aligning EBP and big data analytics (Figure 1). The hypothesis is that integrating AI with EBP will enhance clinical decision-making and patient outcomes by enabling more precise and efficient application and generation of evidence, improving guideline adherence, and facilitating real-time data-driven solutions for care strategies. Through this work, RNAO aims to:

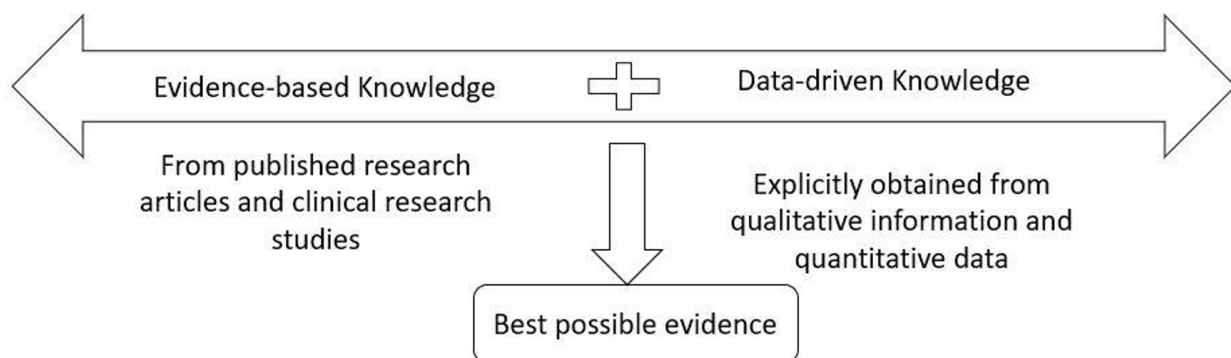


Figure 1. A paradigm: Evidence-based practice and data-driven model
Source: prepared by authors

- Gain a deeper understanding of the best EBP on clinical topics
- Produce implementation strategies and practice changes that improve patient, organizational, and health-system outcomes
- Advance the capacity of healthcare organizations for rapid learning and continuous quality improvement.

To initiate the process of AI development, we adopted Natural Language Processing (NLP) methods to perform text analytics on the data received from healthcare organizations concerning clinical practice change, organizational policies, and education provided to providers and or person and their families. This unsupervised analysis aims to build impactful evidence from practice. In addition, longitudinal data based on BPG-specific processes and outcome indicators have been considered for trend analyses to identify patterns and shifts over time, providing valuable insights into evolving clinical practices, organizational policies, and educational needs. The neural network with defined variables of interest—e.g., organization size, is designed to handle time-series information to capture temporal dependencies and trends across multiple time points. Advanced techniques(18) of Temporal Convolution Networks (TCNs) are adept at modeling the data to more accurately produce insights into trends and changes over time and to make them useful for analyzing evolving clinical conditions, persons' health status, and long-term health outcomes. These findings will highlight areas of improvement, identify emerging trends, and inform strategic decisions for enhancing healthcare delivery and policy development. By leveraging numerical data with contextual insights, the AI model can benefit from enhanced feature representation, leading to more accurate predictions and robust actionable insights from the EBP implementation approaches. Different phases of scaling RNAO Artificial Intelligence techniques.

For almost two decades, healthcare organizations worldwide have diligently monitored and evaluated their shift to evidence-based practice by adopting RNAO's BPG. RNAO BPGs are "systematically developed statements to assist practitioners and client decisions about appropriate healthcare for specific circumstances" (14). These BPGs are developed based on the best available evidence and updated as needed, including recommendations for nurses and other health professionals, administrators, educators, and policymakers to improve clinical and work-environment outcomes. RNAO guidelines meet international standards.

Nurses' engagement in EBP has increased significantly since 1999 when RNAO created the BPG Program in partnership with the Ontario government, Canada. Nurses show more confidence in practice, leading to better teamwork, governance, and decision-making. The program has also delivered significant improvements in patient health outcomes by improving the consistency and quality of nursing care and providing people with access to high-quality nursing services. RNAO's BPG Program also helps BPSO implement EBP. Health-service organizations from different sectors and academic organizations globally participate in the BPG program (16,17).

The primary goal of the BPG Program is to support registered nurses (RN), nurse practitioners (NP), and registered practical nurses (RPN/LPN) by providing them with BPGs for client care and better patient outcomes. The secondary goal is to position nurses as knowledge professionals and robust contributors to health outcomes. Key features of the BPG program are the development, implementation, and evaluation of evidence-based guidelines. RNAO provides support and resources to BPSOs to implement BPGs in a structured way that leads to practical implementations and monitors impacts on patient and organizational outcomes. Through the BPG program, RNAO has developed two data systems, which, used together, support BPSOs.



- The Nursing Quality Indicators for Reporting and Evaluation® (NQuIRE®) system collects quantitative data from BPSOs to monitor and evaluate the impact of BPG implementation through structure, process, and outcome indicators.
- MyBPSO collects qualitative data from BPSOs from their reports on strategies they have used to advance EBP uptake and sustainability. Some examples are deliverables related to capacity development and implementation, evaluation, dissemination, and sustainability planning to support EBP in nursing.

Figure 2 illustrates a complete cycle of information flow from RNAO BPGs to healthcare organizations and back to the RNAO NQuIRE data system that supports future implementation of AI-tool.

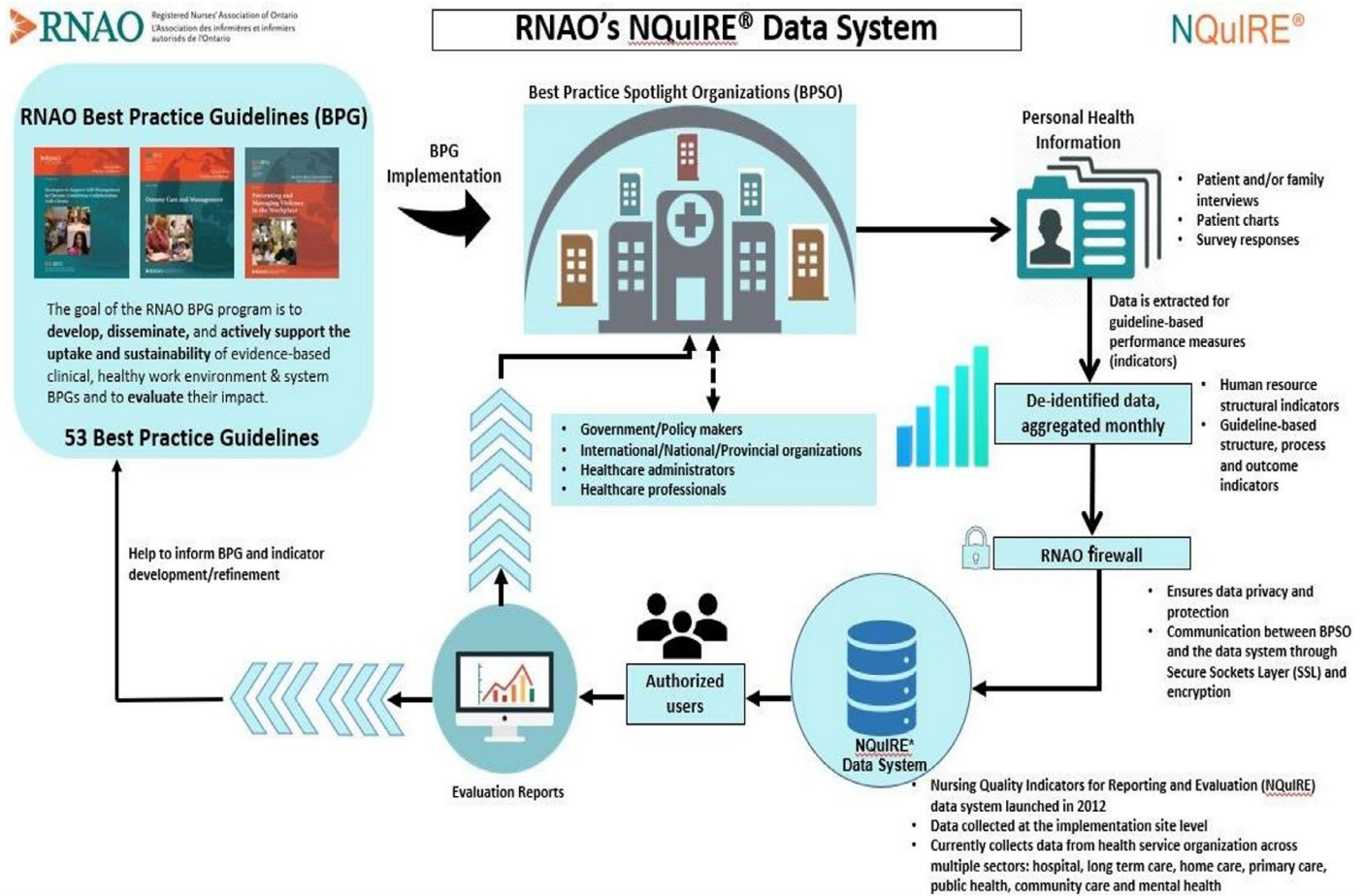


Figure 2. RNAO NQuIRE data system Layout.

Source: prepared by authors

Results

Why are AI initiatives important? Information is key to organizing and developing any initiative to deliver better outcomes (19). Over the past two decades, RNAO has collected a vast amount of data from current and new BPSOs containing substantial information on BPG implementation. Quantitative data was collected for BPG-specific indicators with additional information such as funding jurisdictions, locations, size, in-patient care days/visits, etc. where, as contextual information comprised of: the percentage of champions within the clinical and non-clinical staff, practice changes, organizational policies implemented, educational sessions provided, aids in support for implementing BPGs etc. As the BPSO program expands, the need to organize data expands alongside it. A deeper understanding of outcomes and impacts across BPSOs helps to derive meaningful information that supports all health-service organizations implementing and using BPGs. With advancements in computer technologies,

RNAO has taken the next step in the BPSO program by implementing AI and ML initiatives to address data needs.

By exploring existing solutions and streamlining ideas related to the RNAO BPG program and research, three phases of scaling AI in BPSO settings over time are defined.

Phase 1: RNAO is likely to address the significant time of nurses, optimize healthcare operations, and increase the adoption of evidence-based nursing practice. Certain approaches in this phase include applications (18) that power nursing in health care delivery – from the front lines to health system management levels – and lead to better patient care and health outcomes. Broader approaches to AI link natural language processing (NLP), ML, and deep learning (DL). Figures 3a and 3b describe an overview of the nested algorithm developed for the phase 1 approach to developing the AI tool for BPSOs.

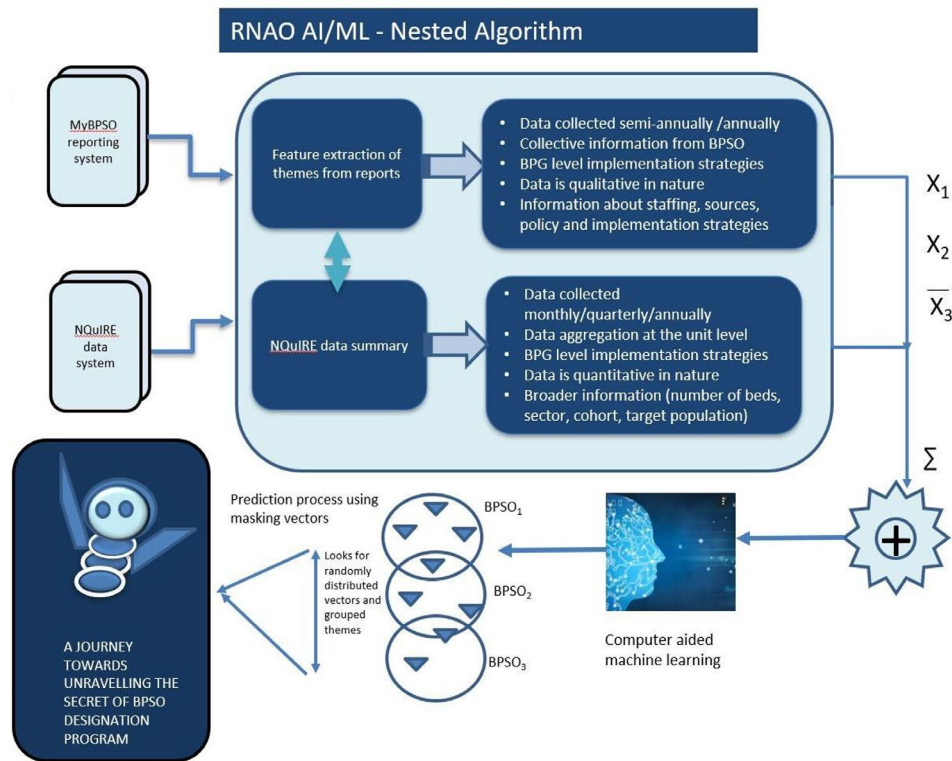


Figure 3a. Data flow for phased AI process.

Source: prepared by authors

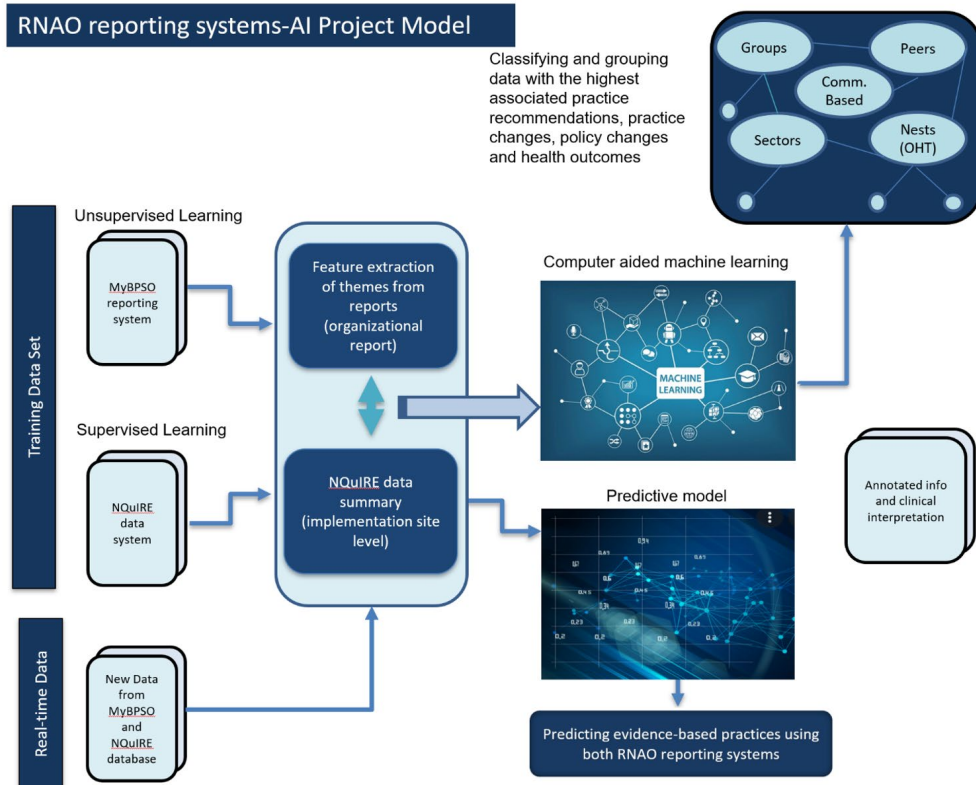


Figure 3b. AI Project Model

Source: prepared by authors

RNAO conducted a scoping review (5,20) on the use of various AI and ML techniques registered in the Open Science Framework database (19,21). In this phase, the process also includes AI applications based on data available in the RNAO data system and already in use in the clinical area, such as data for falls, pressure injuries and pain, person-and-family-centered care, and substance use related to mental health (22,23). RNAO is looking at a spectrum of AI solutions – encoding clinical guidelines or existing clinical interventions through an evidence-based approach – which is augmented by different models that learn from data within specialized clinical areas.

Phase 2: In this phase, RNAO expects to enhance AI-powered techniques and corresponding decision support to stakeholders through solutions that support tracking implementation strategies and related outcomes. The RNAO also anticipates developing AI-powered alerting systems, or virtual assistants, to support nurses by assisting with care plans and nursing processes when required. An example of such development is in the area of care transition and person and family-centered care. Care transitions are one of the specialized areas of focus for implementing AI related to EBP.

This phase could also include broader use of NLP solutions and neural network techniques, as well as more use of AI in various areas of improvement where advances are already being made. This requires AI to be embedded along with EBP more extensively in BPSOs through engagement by BPSOs, patients, families, and caregivers. The scaling up of RNAO's AI deployment is fueled by a combination of technological advancements and the capacity of BPSOs to adopt AI tools within their organizations.

Phase 3: In this phase, AI solutions in clinical practice are developed and made available to BPSOs. The focus is to scale clinical decision-support tools to implement and evaluate BPGs in specific clinical topics. Lessons learned from each sector will be expanded to develop and implement the tools into clinical practice. Ultimately, stakeholders should expect to view AI as an integral part of healthcare practice. AI works through testing, training, validating, and practicing, from how we learn to how we develop and investigate to support and deliver patient care and how we help improve the health system.

In all these phases, different techniques such as, but not limited to, descriptive statistics, inferential methods, NLP for text analytics, indexing, and Neural network (TCN) are required to conduct data analysis, data triangulation, and improved data collection based on impactful implementation. Various stages of AI development included a prototype (pilot), piloting, testing and training, validation, and implementation.

Essential considerations for RNAO's use of AI in this phase are:

- The integration of broader information from BPSOs
- Continuous improvement of data collection techniques (including webform/reporting system enhancements) and the quality of data gathered.
- Greater confidence from BPSOs and patients, family, and caregivers within the BPSOs.

The RNAO expects the clinical and data experience gained through this project to reform the EBP-AI culture in healthcare organizations for a better future and improved health outcomes.

Discussion

How will AI and ML benefit the BPG Program and BPSOs? More than a thousand health service and academic organizations on five continents actively engage in the BPG Program. BPSOs enter formal partnerships with RNAO to systematically implement multiple BPGs and evaluate implementation outcomes. RNAO's BPG Program oversees several different BPSO models and groupings tailored to support specific target communities, geographic regions, or national jurisdictions. The reach of BPSOs has expanded beyond Canada into other countries, including Chile and China. Typical examples are as follows: RNAO has different BPSO models: BPSO Direct, BPSO Host (National – e.g., government, regulatory body, Regional – e.g., geographic area, province, Specialty - e.g., Francophone, Long-Term Care), BPSO OHT (Integrated systems of care such as Ontario Health Teams to work across multiple sectors to implement BPGs collectively). Moreover, Indigenous-focused BPSOs collaborate with RNAO to create a tailored BPSO program to honor Indigenous ways of knowing and support holistic community wellness. RNAO also has BPSO Consortia that provide a forum for knowledge exchange, support, and collaborative activities within specific jurisdictions.

Given the diverse range of models, structures, and health sectors within RNAO's BPG program, systemized and standardized structures are crucial to ensuring diverse stakeholders add value by improving health outcomes. While developing AI, variables such as funding sources, jurisdictions, and relevant contexts from different countries are considered. The program is expanding, and when the data quality improves from other countries, AI-techniques will update with a specific period. There are various reasons for initiating AI and ML within the BPG Program. First, AI has the potential to revolutionize EBP in nursing (24) and address the diverse needs of BPSOs. Second, AI initiatives can lead to EBP by identifying core recommendations from guidelines and indicators to evaluate outcomes—for example, predicting and preventing falls, ensuring patient and family-centered care approaches in nursing care, and encouraging successful health-promoting behaviors such as lactation or

quitting tobacco use. Implementing core recommendations and indicators reduces the diversity of BPSO patterns in implementing BPG, resulting in better integration across the health system. Finally, RNAO's AI project also helps nurses improve patient outcomes (19) by focusing on faster and more systematic implementation strategies and better evaluation approaches through impactful indicators. Giving nurses EBP at their fingertips ultimately means more time spent looking after patients, which, in turn, improves staff morale and retention.

Given the benefits associated with AI-tool in healthcare and the collection of massive data, RNAO develops a robust platform that can support healthcare professionals with a patient's need. Furthermore, healthcare professionals can distill down their judgment with results and hidden patterns that are discovered into a better machine-intelligible form. This supports healthcare professionals to delegate work on their patient care -- time-effective and resource allocation.

RNAO's AI project uses information collected through the NQuIRE and MyBPSO data systems to identify the most effective clinical and work environment interventions for better outcomes. All AI approaches link to existing BPG development, implementation, and evaluation processes and extrapolate the data based on changing BPSO needs or the processes required to address them. For example, in long-term care (LTC) homes, a different approach for evaluating the impact of implementing RNAO's Preventing Falls and Reducing Injury from Falls BPG is required because fall screening and assessment are mandated in LTC settings across Ontario by healthcare legislation. When the AI tool is developed, indicators related to screening and evaluation are automated to 100 percent as part of the requirement by creating the most impactful intervention and predicted outcomes. This approach enhances the effectiveness of the day-to-day practices of nurses and other health professionals using RNAO's clinical and healthy work environment BPGs. Depending on the BPG used, this learning has tremendous potential to improve persons' quality of life (21) and prevent harm by predicting pressure injuries, infections, pain, and falls and offering early intervention strategies.

Conclusion and future work

RNAO BPGs enable organizations and their healthcare teams to create evidence-based cultures, improve the quality and consistency of care, increase access to quality services, and reduce costs. BPGs help organizations enrich their work environments. With the help of AI and ML techniques, RNAO identifies the specific BPG recommendations and combinations of interventions that will significantly impact health outcomes. These outcomes are visible through trends associated with quantitative data collected over time. This data already provides BPSOs with a deeper understanding of their work, which they use for rapid learning and practice changes. As the BPSO program expands, the AI tool will

foster a better understanding of the implementation process that enables validation of massive data collected at RNAO, leading to identifying strategies for improving practice and outcomes.

This groundbreaking work in AI work has progressed through the development and implementation of proposed AI-generated solutions, with knowledge-sharing events, educational sessions, and lots of interdisciplinary collaboration between BPSO leaders, RNAO staff, and clinical nurses in various settings. This will result in an even more significant impact on patient care when results will be shared through the learnings gained through the broader healthcare community and the public.

Generally, any AI/ML initiative is required high quality data, healthcare organizations submit the best available evidences, focus on structuring data collection, ensure data quality, and thus expand the scope of developing AI tools using publicly available information. RNAO is advancing towards collecting and analyzing high-quality data and progressing towards real-time automation for generating actionable insights. This data-driven approach enhances the real-time functionality and accuracy of our AI system ongoingly. Thus, the AI and ML initiative will hope to revolutionize the EBP worldwide for future enhancement in guideline development, implementation, evaluation, policy development, and decision-making. Furthermore, researchers need to consider more alignment between the two theories and exhibit more advantages of technological impact on clinical interventions.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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