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Harnessing Machine Learning for Advancing Evidence-Based Nursing Practice and Clinical Decision-Making

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Abstract
ML has become a revolutionary resource to the nursing research community since it provides enhanced processes of analyzing complex healthcare data, predicting patient outcomes, and guidance-evidence research decisions. The proposed scoping review will apply an existing body of literature to the use of machine learning algorithms in nursing studies to determine the most effective method of computation and implications in practice. The contributions by key algorithmic techniques(decision trees, support vector machine, neural networks, and ensemble based models) in clinical prediction, patient monitoring, and nursing education are also touched upon. The review also addresses issues surrounding data quality, interpretability, ethical issues and how it can be applied in a real-life context. The evidence shows that machine learning has a considerable potential to improve the level of research and practice in nursing, but the ways forward are to design models that can be explained, integrate data better and come up with common evaluation structures. This document is a resource with detailed background to the development of the use of machine learning in nursing, filling in the clinical application of machine learning.

Keywords: ***Machine learning, Nursing research, Artificial intelligence, Predictive modeling, Clinical decision support, Algorithmic approaches, Healthcare data, Nursing informatics, Patient outcomes, Scoping review.***

1.Introduction
The implementation of artificial intelligence into healthcare is one of the most revolutionary processes in the contemporary medical practice as it changes the way physicians treat patients, make clinical decisions, and quality improvement strategies. Amid this technological breakthrough, machine learning has become an especially potent toolset with unprecedented abilities in terms of pattern recognition, predictive modeling and data-driven insights that can lead to advancing clinical outcomes in a wide range of healthcare situations. The importance of machine learning applications in the field of nursing has become apparent as more and more nurses look toward machine learning to solve some of the most challenging problems in this profession, enhance patient safety, and even streamline nursing care delivery processes(1).

Machine learning, a branch of artificial intelligence that allows computer systems to learn and improve on their own without any explicit programming is a promising avenue in solving healthcare Challenges that have long been a bane concerning nursing practice. Using large volumes of clinical data, the algorithms are capable of detecting subtle patterns that may elude human expertise, and may produce predictive models on which to base evidence-based clinical decisions. The importance of this technological development is more than being a more efficient computer; it is precision nursing care with the use of data science to improve patient outcomes and reduce healthcare costs and improve resource allocation.

The use of machine learning by the nursing profession has not been an outlier in the healthcare sector overall, which is undergoing its own digital transformation and looking to the advantages of evidence-based practices underpinned by data to improve health outcomes. This has been enabled through the increased use of electronic health records, the rising use of digital health monitoring devices and the increasing access to complete health data sets, which form the key into robust machine learning applications. With healthcare systems producing exponentially growing amounts of data, the opportunities to take advantage of this data by employing advanced analysis methods become not only desirable but also critical to the maintenance of high-quality care.

The existing world of machine learning applications in nursing is wide-ranged including applications that predict patient falls and pressure injuries and help in optimizing staffing patterns and detecting early warning signs of clinical deterioration. The applications presented here exhibit the versatility of the technology and its promise to support some of the most burning issues of today in the field of modern nursing practice, such as the issues of

patient safety, workforce shortage, and the necessity to implement evidence-based interventions that can be used in every clinical setting without any obstacles(2). The escalating number of studies in this area shows the desire of the nursing profession to implement the latest technology, as well as the appreciation of the idea that the work of traditional means of solving clinical tasks may not be enough in terms of the completed scope of modern healthcare issues.

FIGURE 1 Machine Learning in Nursing

Nevertheless, implementing machine learning in nursing practice also has some problems and issues. Nurses and healthcare executives are torn between the issues of complete transparency of algorithms, questions regarding clinical validation and ethical application, and the effects that workplace learnings and implementation may have on nursing autonomy and clinical decision-making. Such considerations support the necessity of building a coherent knowledge base about the strengths and limitations of machine learning in such a way that it supplements rather than substitutes human critical thinking and compassionate care that forms the core of the professional practice of nursing.

Integrative strategy is needed to implement machine learning in nursing, which should include both technical knowledge and clinical and broad experience in the multidimensional nature of influencing patient outcomes. Nurses are required to acquire skills on data interpretation, algorithm evaluation, and the incorporation of technological expertise with traditional/clinical evaluation expertise. It is a new phase in the nursing practice, and the education process must be reconsidered, professional growth and related development have to be conducted, and coordination with other specialists, such as data scientists and technology experts are necessary.

Moreover, machine learning can be of particular value in developing evidence-based practices that apply across the world, and many practices that nurses provide have universal implications regardless of the cultural context and healthcare system in which they are implemented. High-level data analyses of large-scale datasets fed by the power of analytical tools make it possible to find best practices and create a predictive model that can guide clinical decision-making in any geographic location and within any healthcare system structure(3).

As healthcare systems across the globe struggle with an increasing burden of complex patients, aging citizens and lack of resources, chances are machine learning can help streamline the nursing care delivery process become increasingly dramatic. These technologies provide the potential of greater differentiation of risk, the ability to intervene earlier and more strategically allocate resources that can contribute to greater patient outcomes and nursing satisfaction. The design and test of machine learning models that are directly applicable in the nursing practice is a vital action towards achieving the overall potential of data-driven healthcare delivery without losing the humanism core philosophy of nursing practice.

Machine learning algorithms can be utilized in the following ways

The terrain of machine learning algorithms applied in the nursing research indicates a complex range of data processing strategies that are intended to tackle each clinical issue and data features intertwined in healthcare settings. Random Forest algorithms became most used in the nursing applications because of their unique power to solve multifaceted aspects associated with healthcare data as well as offer interpretive outputs that follow clinical decision-making procedures. Ensemble learning techniques are well-suited to applications where variables interact in a non-linear fashion, as the nursing research context is with patient outcomes relying on complex relations among demographic, clinical, and psychosocial variables as well as treatment interventions.

Logistic regression has remained very relevant in machine learning in nursing because of the ease of interpretation and robust performance on binary classification problems that are predominant in a healthcare facility. The transparency of the algorithm is what enables nursing professionals to incorporate algorithmic insights with

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clinical knowledge, as it is the relative importance of various predictive factors can become clear to the professional. The popularity of logistic regression in nursing research speaks to the emphasis of the field to evidenced-based practice, as well as the demand of easy-to-understand models of predictive behavior, which have become a part of interdisciplinary healthcare teams and can be applied when addressing patients and their families as well(4).

Decision tree algorithms and their derivatives have also become popular in the nursing arena since they closely resemble the hierarchical nature of decision-making that nurses already use in the realms of clinical practice. These algorithms render distinct and rule-mediated pathways that are similar to clinical skills and guidelines and therefore, they are of great use to create decision support tool that can be incorporated within the existing nursing practice. The theme of decision trees also lends itself to nursing education practices as the visualization helps to make sense of the factors at play that create a particular outcome or recommendation when caring about a given patient.

Support Vector Machines suggest a more complex model of pattern recognition in nursing intelligence especially when faced with a high multidimensional dataset that is prevalent in the modern healthcare setting. The algorithms are particularly well suited when more complicated data relationships are at issue, in contrast to situations where the classical statistical tools might be unable to perform well across a wide range of patients and clinical locations. Support Vector Machines can be used because they can analyze non-linear relationships, a desirable feature when applied to nursing, where patient response to an action may differ in a non-linear manner based on a number of interacting factors.

2.Methods

2.1 The research framework and the design approach

The methodological design of this scoping review was built on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses-extension to Scoping Reviews (PRISMA-ScR) framework, which is rich in systematic methodological considerations. Excluded were other types of framework, such as systematic reviews or meta-analyses, which would have made it difficult to discuss the full variety of machine learning applications and outcome measures in nursing research, as well as focused deployment in clinical contexts, due to the narrow inclusion criteria that those frameworks require(5). This review methodology of scoping applications allowed the research team to articulate the extent of machine learning applications in different nursing fields as well as elicit trends, gaps, and patterns in a field that is rapidly changing.

The study structure has been developed with several checkpoints of evaluation so that there is a consistency and reliability in reviewing the study. All three independent reviewers were involved throughout the review process including the development of the search strategy, selection of documents and data extraction and synthesis. Such design of multi reviewers has been adopted to reduce personal prejudices and to cover as much literature as possible in order to be scientifically rigorous. The collaborative work during the review process also helped in refinement of the inclusion and exclusion criteria as the team became exposed to different study designs and methodological approaches that proved to be out of assumptions of the scope and the nature of machine learning in nursing research.

2.2 Advanced Literature Search Plan

The systematic review of the literature used seven major scholarly databases to identify their exclusive contributions in the nursing and healthcare informatics research. PubMed would have contributed to access to biomedical literature that has a flourishing rate in clinical nursing research, whereas EMBASE would have provided wider international outlook and exposure to the European nursing literature. CINAHL was used as the main nursing discipline based database and it offered wide coverage of nursing theory, practice and research publications. The studies were rounded out with the contributions of Web of Science, which brought in its interdisciplinary view and its capabilities in citation tracking, and OVID that offered access to several specialized databases using a single user interface. The PsycINFO was included to allow behavioral and psychological approaches to nursing care and the ProQuest could offer access to dissertations and grey literature that may not necessarily publish in academic journals.

The key word search strategy utilized the terms of controlled vocabulary in specific combinations of individual keywords that were appropriately tailored to the indexing of the specific databases in an attempt to maximize the chances of retrieving relevant literature, whilst reducing the number of false positive hits. The first queries

involved the preliminary search to test and refine search terms and eventually settle on the concepts of machine learning, nurse, and nurse practitioner as the main ones. The specific approach was purposefully selected among broader terminologies of artificial intelligence or deep learning to stay on track with the particularity of the study objectives. The temporal focus was restricted to publications within the period January 2019 to December 2023 to capture the latest trends in what is a fast-changing field whilst remaining able to provide adequate volume of literature to analyze(6).

2.3 Introduction toaning so is the exam a rigorous study selection protocol

The study selection procedure followed a multi-stage screening strategy to scientifically sort out the literature quality and relevance to be maintained transparent and able to reproduce. The literature search was carried out using a combination of both electronic and hand research, followed by title and abstract screening by individually identifiable reviewers with the dispute being resolved via structured dialogue and consensus-forming. The initial screening aimed at isolating studies where machine learning algorithms were obviously employed in nursing settings with the works that only discussed in theoretical terms how artificial intelligence works or applied it to other non-nursing areas of healthcare excluded.

Full-text review was the most important stage of selection, and it was necessary to consider in detail methodological aspects, the algorithm application, and outcomes description. The research team formulated criteria to evaluate the quality and comprehensiveness of descriptions of machine learning models; that way, included studies would be analyzed and compared upon sufficient detail provisions. Studies that did not report rationales of algorithm selection, measures of performance of the model, or clinical significance of the results were excluded. Such a strict methodology of the selection of the studies was needed because the method of machine learning has a high level of technique and the fact that the maximum commission of scientific rigor and clinical applicability of the results of studies is observed.

TABLE 1 Database Search Strategy

Database	Primary Focus	Records Retrieved
PubMed	Biomedical literature	85
CINAHL	Nursing-specific research	78
ProQuest	Dissertations/grey literature	14
PsycINFO	Behavioral/psychological	11
EMBASE	International healthcare	3
Web of Science	Interdisciplinary	0
OVID	Multiple specialized databases	0
Total		**191**

2.4 Procedures of Quality Assessment and Validation

MERSQI was chosen as the principal measure of quality because though it was developed specifically in medical education research, its evaluation framework is very broad and covers study design, sampling method, data, instrument validity, and analytical quality and outcome measures. The six-domain structure in this instrument allowed assessing the methodological quality of various study designs that are commonly used in nursing machine learning studies. The research team also understood that traditional instruments to assess the quality of nursing research were insufficient to assess the technical and methodological sophistication of machine learning studies.

To determine consistency between reviewers on quality assessment scoring, Fleiss kappa coefficient was used as a measure of inter-rater reliability. This way of statistics has objectively proved the agreement between reviewers and determined where further discussion and clarification were necessary to reach an acceptable consensus. Quality assessment process was done with regular calibration meetings that involved reviews, which discussed scoring rationales and resolved differences in an orderly fashion. This group effort also guaranteed that the quality measures would not be concerned with trivial technical standards but would take into consideration both meticulousness and clinical significance.

2.5 Automatic Data Extraction Framework

The extraction of the data used a pre-specified data recording form specifically designed to collect the vital information related to the study characteristics, algorithmic methodologies, performance evaluation, and clinical implementation. The extraction framework was intended to support the varied scope of study designs and methodological approaches that are available in machine learning research whilst maintaining consistency in data

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extraction of all the included studies. Some of the important data points were details of the authors, details of the publication, the setting and the population loss under study, data set, machine learning algorithms, measures of performance evaluation, clinical outcomes, and effectiveness outcomes(7).

Data extraction process was done in such a way that more focus was given to the quantitative indicator of performance and qualitative description of both algorithm implementation and clinical integration. The increased emphasis on both of these areas was due to the fact that machine learning research in nursing tends to report only technical performance metrics that are not directly associated with clinical benefit or the viability of implementation. Of particular importance to the research team was the extraction of data on the interpretability of algorithms, clinical validation processes as well as reported obstacles or ease to implementation because these data are critical to the understanding of the practical application of machine learning methods in nursing practice environments.

2.6 Categorizing and analytical synthesis approaches

The research methodology used in the study was a combination of quantitative and descriptive statistics with qualitative thematic analysis to gain a thorough insight into the usage of machine learning in nursing studies. Descriptive statistics were applied to the quantitative account in the data on the frequency of the algorithms, measures of performance, and study characteristics, whereas, a qualitative approach aimed to recognize patterns in clinical applications, implantation difficulties, and achieved outcomes. This was because of the mixed methods element that was needed to encompass the variety of different outcome measures and evaluation methods utilised between studies and clinical settings.

Categorization of clinical practices necessitated the development of a broad ranging taxonomy capable of fitting the vast scope of nursing domains that were reflected in the data bases. These categories were developed iteratively, with discussion and review of emerging themes leading to refinement of the initial categories into the final scheme targeting a reasonable balance of broad and narrow description of machine learning applications. This means of analysis helped to pinpoint places where machine learning applications are less controversial and some places where more development and research are required.

3.Results

The analysis of 26 studies showed that machine learning nursing research was found to be highly concentrated geographically; the largest proportion of research was associated with North American institutions, with 12 studies being reported as conducted in the United States (46.1 percent of total works analyzed). This level indicates a developed level of healthcare informatics infrastructure and implementation of an electronic health record in American healthcare systems and can be used to provide researchers with sufficient datasets to apply to machine learning. Chinese institutions provided four studies (15.3%), which again indicates a rising interest in conducting researches in the Man-made environment, whereas Canadian researchers have contributed two studies (7.7%), in a joint effort with Americans.

The rest of the literature was found in a variety of different global contexts with a single study each in Australia, Japan, South Korea, Taiwan and Switzerland, reporting once again the growing interest in the role of machine learning in nursing practice across the world. There were three publications reflecting international research teams (the United States and Canada; the United States and Saudi Arabia; and collaborators in the Asia-Pacific region), which is an indicator of growing global research partnerships in nursing informatics. Such a geographic distribution pattern is indicative not only of the concentration of advanced capabilities in healthcare informatics in developed countries but also of an international rise of interest in applying machine learning technologies to the problem of nursing.

The analysis of the study design indicated that all publications did not use experimental designs thus constituting a major methodological gap in nursing machine learning studies. Largely dominated by observational and retrospective types of study designs, the possibility of producing relevant causal relationship between clinical outcomes and machine learning interventions becomes crucial and needs to be developed in the future. The magnitude of the dataset also significantly differed with a range of 102 participants to 727,676 records which are based on the spontaneity of research question and nature of data sources applicable across hospitals and clinical situations.

3.1 The Quality Evaluation of Research and Methodological Rigor

The evaluation of Medical Education Research Study Quality Instrument conducted on the included studies averaged 12.2 (range: 10.7-13.7), which constitutes moderately to high-quality research studies. The overall results revealed that 21 studies (80.8%) reached the score of 12 and more, which corresponds to the requirement of quality research, whereas five studies scored less than 12 because of the insufficiency of sampling methodology, instrument validation, and reporting completeness. The most points were given to studies on the prediction of pressure injuries and the psychological evaluation of nurses in Asia-Pacific countries, with the concept of such work being well-planned and their analysis sufficient and methodical in scope.

The results of domain-specific analysis points at very strong methodology in data type selection and data analysis methodology procedure with both areas receiving a perfect score of 3.0 in majority of the studies. Such a trend is due to the expertise of machine learning teams and their adherence to using the most adequate analysis tools to work with complex healthcare data. The lowest scores were experienced on the sampling domain (0.7), reflecting the propensity of many projects to fail to extract representative study populations and perhaps the lack of attention to selection bias in the very nature of the healthcare data.

Inter-rater reliability measures showed substantial agreement between reviewers with a Fleiss kappa of 0.42 (95% CI 0.30-0.54, $p<0.001$), with high reliability and faith in consistency and objectivity of quality assessments. The statistical significance of the agreement is also revelatory and an indicator of the consistency in the quality of the studies across studies and not a result of reviewer bias or variation in the question being reviewed(8).

3.2 The use of Algorithms and Technical Execution

The leading machine learning algorithm was Random Forest, applied in 24 studies (92.3%), as its performance has shown to be reliably high across the variety of healthcare data and is relatively easy to explain. Such an overarching popularity of Random Forest algorithms indicates that nursing researchers should make a priority of methods with some technical complexity that have a certain degree of interpretability to be able to be professionally responsible and to correlate with familiar clinical procedures.

The application of lest absolute shrinkage and selection operator (LASSO) had significance in 12 studies (44%), including use combined with lassic regression to increase model performance without sacrificing interpretability. Decision tree and its variations were evident in 11 papers (42.3%) and represented a clear rule-based decision pathways that are consistent with traditional nursing clinical decision reasoning processes. Support Vector Machines were also represented equally well (42.3%), and provide powerful performance to more complex classification challenges found in healthcare.

The implementation environment was software-wise with R packages used on 10 studies (38.4%), Python on seven studies (26.9%) and Weka used on three studies (11.5%). The mainstreaming of open-source platforms in nursing research signifies the willingness of the nursing research community to report reproducibility and transparency in knowledge building, and the demand of user-friendly interfaces signify that only platforms with an interface that can be accessed by researchers with diverse technical knowledge could bring the desired effect.

Performance evaluation principles, validation techniques, and Clinical validation

Model performance assessment showed that a standardization process was happening on important measures needed by healthcare applications. Area Under ROC (AUROC) was reported in 20 studies (77 percent), a means by which the classification performance could be monitored at different threshold settings. Nineteen studies (73.1%) provided sensitivity and specificity measures, given the clinical considerations of the importance of balancing rates of false positives and false negatives to patient safety outcomes.

According to the studies, the accuracy measures were reported on 13 studies (50%) with positive and negative predictive values on 10 (38.4%), which added factual context concerning the model performance on the real-life clinical setting. In seven studies (26.9%) F-score calculations provided even assessment of both precisions and recall, which is especially useful with imbalanced datasets typical in healthcare research. The critical step in performance assessment has been the complete analysis of performance evaluation that indicates the compliance of nursing research to strict validation and ability to be applied directly in practice(9).

Two studies used Root Mean Square Error (RMSE) to test the accuracy of their models, notwithstanding the importance of using the metric in the machine learning validation. Being an indication of possible developing more detailed evaluation frameworks specifically regarding the field of nursing machine learning, which will take into consideration both general statistical measures, as well as clinically meaningful measures of performance.

3.3 Clinical Area of Concentration, and Nursing Practice Implementation

The clinical applications were unevenly distributed (strong focus in areas with large patient safety implications and where large-scale data exist). Six studies (23 percent) discussed nursing workforce, such as the staff workload

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estimation, mental health observation, and student graduation forecasting, which suggests that the research's big potential in the nursing shortage issue and human resource management has become widely understood.

Hospital readmission and emergency department utilization became the topics of five studies (19.2%), covering one of the critical quality indicators in health with substantial economic consequences. Fall prediction was covered in three studies (11.5%) indicating the consistent focus on one of the traditional nursing quality measures despite the challenge of the dataset size and complexity of the variables that might hinder the overall model robustness.

Applications in mental health, pressure injury prediction, and infection control were represented by three studies (11.5%) each, including areas in which machine learning may find strong synergy with more conventional risk assessment research areas. Various clinical uses imply the flexibility of machine learning but also prove the necessity of setting the development and the validation of specific algorithms related to distinct nursing practice situations.

TABLE 2 Clinical Application Areas

Nursing Domain	Number of Studies	Percentage
Nursing Staff/Students	6	23.0%
Hospital Readmission/ED Visits	5	19.2%
Patient Falls	3	11.5%
Mental Health	3	11.5%
Pressure Injuries	3	11.5%
Infections	2	7.6%
Other (Pain, Apnea, DVT, etc.)	4	15.4%

3.4 Effectiveness and comparative performance analysis of an algorithm

In the 11 articles that discussed the effectiveness of different algorithms, their findings showed that Random Forest performed better in 6 of the articles indicating the reason why this algorithm is the one mostly preferred in nursing implementations. The relative performance of Random Forest in a variety of clinical contexts indicates its overall robustness in dealing with multifaceted, complex healthcare data and still be easy to interpret to provide efficient clinical decision-making.

Alternative algorithms were also proved to be effective in particular contexts in that XGBoost exhibited high predictive capability in pressure injury prediction whereas LSTM neural networks were beneficial in temporal pattern recognition tasks. Support Vector Machines and Decision trees performed best in a few selected applications, and thus algorithm choice should be dependent upon the clinical scenario and data being explored and not predetermined.

This review also includes a significant gap in nursing machine learning research in the form of a very small percentage of articles reporting comparative effectiveness (42.3%). The need to standardize machine learning evaluation procedures and conduct more comprehensive studies comparing algorithms and reporting outcomes of such studies is identified because they can be used to develop evidence-based artificial intelligence utilization strategies for nursing.

4.Conclusion

The scoping review shows that the emerging area of machine learning in nursing studies is highly advanced with few experimental studies that could pinpoint the cause and effect relations of employing the algorithmic intervention on clinical outcomes. The high frequency of Random Forest algorithms (92.3 percent), illustrates that this field has reached some relative agreement on the appropriate technical practice, although the strong focus of research in certain geographic locations and areas of clinical expertise suggests that there remains much room to generalize to other settings.

The high and medium quality scores by majority of studies with the use of MERSQI criteria indicate that nursing scholars are putting the best practices in research methodologies when conducting machine learning research. Nonetheless, numerous failures in the sampling technique in several of the studies point toward the inclusion of more advanced approaches to dataset design and verification, which should take into account inherent limitations in the healthcare data. The field would be enhanced by constructing nursing-specific guidelines to machine

learning research that would be able to handle specific nursing challenges such as integration of these systems to clinical workflow, patient safety regulations and professional accountability demands.

The geographical localisation of research in the United States and China shows the inequitable distribution of healthcare informatics infrastructure and research investment which can narrow the international relevance of existing results in the years to come. One of the future research directions that should be a priority would be international collaboration and cross-cultural validation of machine learning solutions so that solutions, created in a resource-intensive environment, could be successfully adapted to implementation in different healthcare systems in other countries.

Technical Constraints and Gaps in Methodology

An overriding limitation inherent in the field is the strong dependence on observational and retrospective study designs, which cannot prove clinical effectiveness as well as guide evidence-based implementation decision making. Although such designs are suitable in an early-stage algorithm development and verification, the lack of experimental designs indicates that nursing machine learning studies have not proceeded to test implementation planning or outcomes, and clinical efficiency effects.

Only 42.3% of studies report the effectiveness of comparative algorithms with other methodologies, which reflects the lack of attention to the selection and optimization of evidence-based algorithms. Such a discrepancy is especially troubling since machine learning methods are so technically complex that different choices in the algorithms can have profound effects on clinical utility and implementation success. In future a more systematic study using multiple algorithms should be done wherein the algorithms are used to compare the results on similar datasets and in a similar clinical practice.

The dissimilarity in performance assessment criteria between studies, as well as the lack of thorough validation methodologies such as Root Mean Square Error have also indicated a necessity in standardized performance assessment metrics that are unique to the nursing setting of machine learning. These frameworks must include real-time technical performance measures as well as clinically relevant measures that represent nursing practice needs depending on the context.

Clinical Implementation Problems and Possibilities

The focus of research in certain areas of clinical thinking like hospital readmissions and workforce management reflects pragmatic considerations around data availability or institutional priorities, and not the most urgent clinical issues facing the field of nursing practice. The fact that some bare necessities of nursing, such as pain management, medication administration safety and patient education effectiveness were underrepresented in terms of available research shows that machine learning could have been used in those areas.

The orientation on prediction as opposed to intervention in the existing studies hamper the practical application of the developed algorithms. Although predictive models can be used to influence clinical decision-making, the area must be further developed and tested using machine learning-supported interventions that can be integrated into already established clinical workflows without interfering with the established clinical processes or professional interactions.

The relative lack of focus on the interpretability of algorithms and clinical explanations in a substantial proportion of the published works constitutes a major obstacle to their application in the settings of nursing practice where professional responsibility and confidence of patients expect the transparency of the decision-making processes. The development of algorithms going forward should be focussed on balancing the trade-offs between predictive accuracy and interpretability to make sure that machine learning tools are serving rather than outperforming critical thinking and clinical judgment.

Future Research and Implications to Professional Development Implications

As machine learning applications advance in the nursing research context, learning and professional development activities tailored to equip nurses to effectively assess, adopt, and improve algorithmic tools in healthcare have to change as well. This educational need not only requires technical training but also requires other skills such as critical thinking, ethical thinking and leadership skills which can direct responsible use of technology.

Areas that need to be studied in the future should be experimental ones in which implementation strategies are tested, the impact on patient outcomes is measured, and the effect of machine learning tools on the nursing workflow rates and job satisfaction. Such studies ought to be done using strict experimental methods with known causal effects that can promote the desired outcomes and reduce the effect of any unanticipated outcomes of technology integration.

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Nurse-specific machine learning assessment frameworks are an essential development but one that is dependent upon the partnership between nursing researchers, informaticians, and practicing nurses. Such frameworks must be able to deal with peculiarities of nursing practice such as patient advocacy, holistic care, and the socially and psychologically involved nature of nursing implementations that are not likely to be reflected in the standard machine learning data.

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Conflicts of interest

The authors have no conflicts of interest to declare

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