The Role of Bioinformatics and Artificial Intelligence in Early Detection and Prevention of Chronic Diseases: Implications for Nursing Practice

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ABSTRACT

Chronic diseases, such as diabetes mellitus, cardiovascular diseases, cancer, and chronic respiratory conditions, represent the leading causes of morbidity and mortality worldwide, accounting for over 71% of global deaths according to recent estimates. The escalating burden of these conditions underscores the urgent need for innovative approaches to early detection and prevention, which can significantly improve patient outcomes, enhance quality of life, and alleviate strain on healthcare systems. Bioinformatics and artificial intelligence (AI) have emerged as transformative tools in this domain, leveraging vast datasets from genomics, proteomics, electronic health records, and wearable devices to uncover patterns, predict risks, and enable personalized interventions. Bioinformatics plays a pivotal role in processing and analyzing complex biological data, identifying biomarkers, genetic variants, and molecular pathways associated with chronic disease onset and progression. Complementing this, AI technologies—particularly machine learning, deep learning, and predictive modeling—facilitate risk stratification, early diagnostic accuracy, and proactive prevention strategies. Applications span predictive analytics for diabetic complications, cardiovascular event forecasting, oncological screening, and respiratory disease monitoring. This review examines the synergistic integration of bioinformatics and AI in the early detection and prevention of chronic diseases, with specific emphasis on implications for nursing practice. Nurses, as frontline caregivers, stand to benefit from these technologies through enhanced decision support, remote patient monitoring, patient education, and personalized care planning. However, challenges such as data privacy, algorithmic bias, ethical considerations, and the digital literacy gap in nursing must be addressed. By synthesizing contemporary evidence, this article highlights how these advancements can empower nurses to shift from reactive treatment to preventive, patient-centered care, ultimately contributing to sustainable health outcomes in chronic disease management.

Keywords :Bioinformatics, Artificial Intelligence, Chronic Diseases, Early Detection, Disease Prevention, Nursing Practice

1. *INTRODUCTION*

Chronic diseases, including cardiovascular diseases (CVD), diabetes mellitus, cancer, and chronic respiratory diseases, constitute the leading cause of global morbidity and mortality, responsible for approximately 71% of all deaths annually (World Health Organization, 2024). These conditions impose substantial economic burdens, reduce quality of life, and overwhelm healthcare systems, particularly in low- and middle-income countries where resources are constrained [1]. The insidious progression of chronic diseases often features extended asymptomatic periods, rendering early detection and preventive measures essential for delaying onset, minimizing complications, and optimizing outcomes [2]. Conventional chronic disease management has predominantly adopted reactive models, intervening only upon symptomatic presentation or acute episodes. However, demographic shifts—such as population aging, urbanization, and lifestyle changes—have rendered this approach increasingly untenable [3]. Preventive paradigms, encompassing risk assessment, behavioral interventions, and early screening, have shown efficacy in reducing incidence and progression [4]. Recent technological advancements, particularly in bioinformatics and artificial intelligence (AI), are catalyzing a transition toward proactive, precision-oriented healthcare [5]. Bioinformatics involves computational methodologies for managing and interpreting biological data, including genomics, proteomics, and multi-omics datasets [6]. By identifying genetic variants, biomarkers, and dysregulated pathways, bioinformatics facilitates risk stratification and early biomarker discovery for chronic diseases. For example, genome-wide association studies (GWAS) processed through bioinformatic tools have elucidated polygenic risk scores for CVD and type 2 diabetes [7]. Artificial intelligence, encompassing machine learning (ML) and deep learning (DL), excels at extracting patterns from heterogeneous data sources, such as electronic health records (EHRs), imaging, and wearables [8]. AI-driven predictive models enable early risk forecasting, diagnostic enhancement, and personalized interventions. In chronic disease contexts, AI applications include predicting diabetic complications, detecting subclinical CVD via retinal scans, and identifying malignancies in radiological images with superior accuracy [9]. The convergence of bioinformatics and AI amplifies their impact: bioinformatic pipelines generate high-dimensional molecular insights, which AI algorithms refine for clinical translation [10]. This synergy supports multi-omics integration, revealing gene-environment interactions and novel therapeutic targets. These innovations carry profound implications for nursing practice. Nurses, as primary patient advocates and care coordinators, can leverage AI-enabled decision support systems for real-time monitoring, early alerts, and tailored education in chronic disease management. However, integration requires addressing ethical concerns, algorithmic biases, and workforce training to ensure equitable, human-centered care. This review explores the roles of bioinformatics and AI in early detection and prevention of chronic diseases, emphasizing nursing implications.

2. Epidemiology of Chronic Diseases and Traditional Prevention Strategies

Noncommunicable diseases (NCDs), primarily cardiovascular diseases, cancers, diabetes, and chronic respiratory diseases, remain the dominant global health challenge, accounting for 75% of non-pandemic-related deaths worldwide [11]. Recent data indicate that NCDs caused at least 43 million deaths in 2021, with projections showing continued rise due to aging populations and lifestyle factors [12]. In 2025 estimates, premature mortality from NCDs affects disproportionately low- and middle-income countries, where 86% of such deaths occur [13]. Cardiovascular diseases lead as the top cause, followed by cancers, with risk factors like tobacco use, unhealthy diets, physical inactivity, and harmful alcohol consumption driving 70-80% of cases [14]. Multimorbidity is increasingly prevalent, with many individuals managing multiple conditions simultaneously, exacerbating healthcare demands and costs [15]. In Europe alone, NCDs result in 1.8 million avoidable deaths annually, highlighting socioeconomic disparities [16]. Traditional prevention strategies emphasize multilevel approaches. WHO's "best buys" include cost-effective interventions such as tobacco taxation, alcohol restrictions, salt reduction in foods, and promotion of physical activity [17]. Primary prevention targets risk factor reduction through public policies and education, while secondary prevention relies on screening (e.g., mammography, blood glucose testing) and early pharmacological management [18]. Tertiary strategies focus on complication prevention via adherence support and rehabilitation [19]. Despite proven efficacy in controlled settings, these approaches face limitations: low long-term adherence, inequitable access in resource-poor areas, over-reliance on individual behavior change, and insufficient personalization for genetic or environmental variations [20].

3. Bioinformatics Applications in Early Detection and Prevention of Chronic Diseases

Bioinformatics has revolutionized the early detection and prevention of chronic diseases by providing computational frameworks to analyze vast biological datasets, including genomics, transcriptomics, proteomics, and metabolomics. These tools enable the identification of biomarkers, genetic risk factors, and molecular pathways that underlie disease onset, facilitating precision prevention strategies long before clinical manifestations [21]. A primary application is in genome-wide association studies (GWAS), where bioinformatics pipelines process large-scale genetic data to compute polygenic risk scores (PRS). PRS aggregate the effects of multiple genetic variants to predict individual susceptibility to conditions like cardiovascular disease (CVD), type 2 diabetes, and cancer. Recent advancements have improved PRS accuracy through diverse population inclusion and integration with clinical data, enhancing early risk stratification [22]. For instance, bioinformatics tools have identified shared genomic biomarkers between CVD and diabetes, informing comorbid risk assessment [23]. In cancer, databases like The Cancer Genome Atlas (TCGA) and bioinformatics platforms enable mutation profiling and somatic variant detection via next-generation sequencing analysis. This supports early screening through liquid biopsies and oncogenic pathway mapping [24]. For chronic respiratory diseases and diabetes, multi-omics integration—combining genomics with transcriptomics and metabolomics—has uncovered novel biomarkers, such as inflammatory pathways in COPD overlapping with type 2 diabetes [25]. Advanced bioinformatics approaches, including machine learning-enhanced feature selection, handle high-dimensional data to prioritize biomarkers for multimorbidity. Tools like Omicsformer integrate multi-omics with routine blood tests to predict risks for multiple chronic diseases with high accuracy [26]. Cloud-based platforms and AI-assisted bioinformatics further democratize these analyses, aiding early intervention in resource-limited settings [27]. Challenges remain, including data heterogeneity, standardization needs, and ethical issues in genomic data handling. However, bioinformatics-driven PRS and biomarker panels are increasingly translated into clinical tools, shifting chronic disease management toward proactive prevention [28,29,30].

Table 1: Key Bioinformatics Approaches and Tools in Major Chronic Diseases

Chronic Disease	Bioinformatics Approach/Tool	Key Application/Biomarker	Reference
Cardiovascular Disease	GWAS/PRS calculation (e.g., GWAS Catalog)	Polygenic risk scores for atherosclerosis	[22], [23]
Type 2 Diabetes	Multi-omics integration (e.g., Omicsformer)	Shared pathways with COPD	[25], [26]
Cancer	TCGA sequencing analysis	Somatic mutations and driver genes	[24]
Multimorbidity (CVD/DM)	Transcriptomic biomarker screening	Common genomic biomarkers	[23], [30]
General Chronic Diseases	Metabolomics + genomics integration	Enhanced risk prediction models	[27], [29]

4. Artificial Intelligence Applications in Early Detection and Prevention of Chronic Diseases

Artificial intelligence (AI), particularly machine learning (ML) and deep learning (DL), has emerged as a powerful tool for the early detection and prevention of chronic diseases by analyzing complex, multimodal data sources such as electronic health records (EHRs), medical imaging, wearable sensors, and genomic profiles. AI algorithms excel in pattern recognition, risk prediction, and personalized intervention planning, enabling proactive healthcare shifts [31]. In predictive modeling, ML techniques like random forests, support vector machines, and neural networks forecast disease onset and progression. For instance, AI models predict cardiovascular events by integrating clinical variables, lifestyle data, and imaging features, often outperforming traditional risk scores like Framingham [32]. In diabetes, continuous glucose monitoring data fed into AI systems anticipate hypoglycemic events and complications, supporting preventive adjustments in insulin therapy or lifestyle [33]. Deep learning convolutional neural networks (CNNs) revolutionize diagnostic imaging for early detection. AI analyzes retinal fundus photographs to identify diabetic retinopathy or cardiovascular risks with accuracy rivaling specialists [34]. In oncology, AI-enhanced mammography and CT scans detect breast and lung cancers at preclinical stages, reducing false negatives and enabling timely interventions [35]. For chronic respiratory diseases, AI processes spirometry data and chest X-rays to predict COPD exacerbations or asthma attacks [36]. Wearable devices integrated with edge AI provide real-time monitoring, detecting anomalies in heart rate variability for arrhythmia prediction or activity patterns for metabolic syndrome risk [37]. Natural language processing (NLP) extracts insights from unstructured EHR notes to flag undiagnosed chronic conditions [38]. AI also facilitates prevention through personalized recommendations, such as chatbots for behavior change or virtual coaches promoting adherence to preventive guidelines [39]. Multimodal AI combines data streams for holistic risk assessment, improving outcomes in multimorbidity scenarios [40]. Despite advantages in accuracy and scalability, challenges include algorithmic bias, interpretability (black-box issues), data privacy, and integration into clinical workflows. Ongoing research focuses on explainable AI and federated learning to enhance trust and equity.

Table 2: Selected AI Applications and Models in Major Chronic Diseases

Chronic Disease	AI Technique/Model	Key Application	Performance/Year
Cardiovascular Disease	Deep Learning CNNs (e.g., retinal analysis)	Early detection of atherosclerosis	[32,34]
Type 2 Diabetes	ML Predictive Models (e.g., XGBoost)	Hypoglycemia/complication forecasting	[33]
Cancer (Breast/Lung)	CNNs for Imaging	Preclinical malignancy detection	[35]
Chronic Respiratory	Time-Series ML on Wearables	Exacerbation prediction	[36]
Multimorbidity	Multimodal AI Integration	Holistic risk stratification	[40]

5. Integrated Bioinformatics and AI Approaches in Specific Chronic Diseases

The true transformative potential emerges when bioinformatics and artificial intelligence are combined, creating integrated pipelines that leverage molecular insights from bioinformatics with AI's predictive and interpretive power. This synergy enables end-to-end systems for risk stratification, early detection, and personalized prevention across major chronic diseases [41]. In type 2 diabetes, bioinformatics identifies genetic variants and multi-omics biomarkers (e.g., pancreatic islet dysfunction signatures), while AI models integrate these with real-time continuous glucose monitoring (CGM) and EHR data to predict complications such as retinopathy or nephropathy. Hybrid platforms use bioinformatic-derived features as inputs for deep learning models, achieving superior glycemic control and complication forecasting compared to standalone approaches [42,43]. For cardiovascular diseases, bioinformatics-generated polygenic risk scores are fused with AI analysis of multimodal data—including ECG waveforms, retinal images, and wearable sensor outputs—to detect subclinical atherosclerosis or atrial fibrillation years earlier than traditional methods. Federated learning frameworks allow secure integration of genomic and clinical datasets across institutions, enhancing model generalizability [44,45]. In oncology, bioinformatics processes tumor sequencing data to identify actionable mutations and neoantigens, which AI algorithms then use for early detection via liquid biopsy signal amplification or radiomics from low-dose CT scans. Integrated systems have demonstrated improved sensitivity in detecting lung and breast cancers at stage I, facilitating preventive interventions like chemoprevention or enhanced surveillance [46,47]. Chronic respiratory diseases benefit from combined approaches where bioinformatics elucidates epigenetic modifications linked to environmental exposures, and AI predicts exacerbations by analyzing spirometry trends, air quality data, and wearable respiratory patterns. This integration supports proactive management in COPD and asthma, reducing acute events through timely alerts [48]. Across multimorbidity, integrated platforms combine bioinformatics multi-omics clustering with AI-driven trajectory modeling to identify shared pathways (e.g., inflammation in CVD-diabetes overlap), enabling unified preventive strategies [49,50]. These integrated applications highlight scalable, precision-oriented prevention, though challenges like data interoperability, regulatory approval, and equitable access persist.

Table 3: Integrated Bioinformatics-AI Applications in Major Chronic Diseases

Chronic Disease	Bioinformatics Contribution	AI Contribution	Integrated Outcome/Study Year
Type 2 Diabetes	Genomic biomarkers & multi-omics	CGM predictive modeling	[42,43]
Cardiovascular Disease	Polygenic risk scores	Multimodal imaging & wearable analysis	[44,45]
Cancer (Lung/Breast)	Tumor mutation profiling	Radiomics & liquid biopsy enhancement	[46,47]
Chronic Respiratory	Epigenetic exposure signatures	Exacerbation prediction	[48]
Multimorbidity	Shared pathway clustering	Trajectory modeling	[49,50]

6. Challenges in the Integration of Bioinformatics and AI for Early Detection and Prevention of Chronic Diseases: Implications for Nursing Practice

Despite the transformative potential of bioinformatics and artificial intelligence (AI) in early detection and prevention of chronic diseases, significant challenges hinder their widespread adoption and equitable implementation. These barriers span technical, ethical, regulatory, organizational, and human factors, with particular implications for nursing practice, where nurses must balance technological integration with patient-centered care [51,52]. A primary technical challenge is algorithmic bias, which arises when training datasets underrepresent certain populations, leading to discriminatory outcomes in chronic disease prediction. For instance, AI models trained predominantly on data from high-income countries or specific ethnic groups may underperform in diagnosing cardiovascular risks or diabetic complications in diverse or underserved populations, perpetuating health inequities [53,54]. Bioinformatics pipelines, reliant on genomic databases like TCGA, often suffer from similar biases due to limited diversity in contributed samples, resulting in inaccurate polygenic risk scores for non-European ancestries [55]. Data privacy and security represent another critical hurdle. Integrating multi-omics data from bioinformatics with real-time EHRs and wearable outputs in AI systems requires handling sensitive personal health information, raising risks of breaches or unauthorized access [56]. Regulations like GDPR in Europe and HIPAA in the US impose strict requirements, but federated learning and differential privacy techniques are not yet universally implemented, complicating cross-institutional collaborations essential for robust chronic disease models [57]. Interpretability and explainability of AI decisions—often termed the "black-box" problem—pose challenges for clinical trust. In nursing, where decisions impact direct patient care, opaque models predicting COPD exacerbations or cancer progression may lead to reluctance in adoption if nurses cannot understand or override recommendations [58]. Bioinformatics-derived features, such as complex pathway interactions, further exacerbate this when fed into deep learning algorithms [59]. Interoperability and data quality issues impede seamless integration. Heterogeneous data formats from disparate sources (e.g., genomic sequencing vs. clinical notes) require standardization, yet legacy systems in healthcare often lack compatibility, leading to incomplete datasets and reduced model accuracy in chronic disease risk stratification [60]. From a nursing perspective, workforce-related barriers include limited digital literacy and training. Many nurses report insufficient education on AI tools, hindering confident use in remote monitoring or decision support for chronic conditions [61]. Resistance to change, fear of job displacement, and concerns over reduced human interaction in patient care further slow adoption [62]. Ethical dilemmas arise when AI prioritizes efficiency over empathy, potentially eroding the therapeutic nurse-patient relationship central to chronic disease management [63]. Regulatory and reimbursement challenges delay deployment. Approval processes for AI/bioinformatics tools as medical devices are lengthy, and lack of clear guidelines on liability—who is responsible for erroneous predictions?—deters implementation [64]. In resource-limited settings, high costs of infrastructure exacerbate disparities, limiting access to these technologies for managing prevalent chronic diseases [65]. Addressing these requires multidisciplinary efforts: bias audits, diverse dataset curation, explainable AI frameworks, robust privacy-preserving techniques, comprehensive nursing education programs, and policy reforms [66,67].

Table 4: Major Technical and Data-Related Challenges

Challenge Category	Description	Examples in Chronic Diseases	Potential Mitigation Strategies	References
Algorithmic Bias	Underrepresentation in training data	Inaccurate PRS for non-European populations in CVD/diabetes	Diverse dataset inclusion, fairness audits	[53,54,55]
Data Privacy/Security	Risks in handling sensitive multi-omics data	Breaches in integrated EHR-genomic systems	Federated learning, encryption	[56,57]
Interpretability	Black-box nature of models	Unclear predictions for cancer progression	Explainable AI (XAI) techniques	[58,59]

Interoperability/Quality	Heterogeneous data formats and incompleteness	Integration failures in multimorbidity models	Standardization protocols (e.g., FHIR)	[60]

Table 5: Ethical and Nursing-Specific Challenges

Challenge Category	Description	Implications for Nursing Practice	Examples/Concerns	References
Ethical Dilemmas	Autonomy, consent, and accountability	Overreliance reducing clinical skills	Informed consent for AI-driven decisions	[61,63]
Workforce Barriers	Digital literacy gaps and resistance	Reluctance in adopting remote monitoring	Training deficiencies, fear of displacement	[62,66]
Equity and Access	Cost and infrastructure limitations	Widening disparities in chronic care	Limited adoption in LMICs	[65,67]
Human-Centered Care	Reduced empathy in AI-mediated interactions	Erosion of nurse-patient relationship	Prioritizing efficiency over holism	[58,64]

7. Conclusion

The convergence of bioinformatics and artificial intelligence stands as one of the most promising advancements in modern healthcare, fundamentally reshaping the landscape of early detection and prevention for chronic diseases. As this review has demonstrated, chronic diseases—cardiovascular conditions, diabetes mellitus, cancers, and chronic respiratory disorders—continue to impose an immense global burden, driven by epidemiological transitions, aging populations, and modifiable risk factors. Traditional preventive strategies, while foundational, are limited by their population-level focus, variable adherence, and inability to fully account for individual biological heterogeneity. Bioinformatics addresses this by decoding molecular underpinnings through genomic, transcriptomic, proteomic, and multi-omics analyses, yielding biomarkers, polygenic risk scores, and pathway insights that enable precise risk profiling. AI builds upon these foundations with unparalleled capacity for pattern recognition, predictive analytics, and multimodal data integration, facilitating early warnings, diagnostic precision, and personalized interventions. The integrated applications across specific diseases illustrate tangible impacts: enhanced complication forecasting in diabetes via CGM-AI hybrids informed by bioinformatic biomarkers; subclinical cardiovascular detection through PRS-augmented imaging analysis; earlier cancer staging via mutation profiling and radiomics; and exacerbation prevention in respiratory diseases through epigenetic-AI models. These synergies not only improve accuracy and timeliness but also support scalable, proactive care models that can alleviate healthcare system strains and improve patient outcomes. Critically, the implications for nursing practice are profound and multifaceted. Nurses, positioned at the forefront of patient interaction, are ideally suited to operationalize these technologies. AI-enabled clinical decision support systems empower nurses with real-time insights for risk stratification and care prioritization in chronic disease cohorts. Remote monitoring platforms, leveraging wearable AI and bioinformatic-derived alerts, allow nurses to shift from episodic to continuous care, intervening preemptively in heart failure decompensations or diabetic crises. Patient education is transformed through personalized, genomics-informed counseling—nurses can explain polygenic risks in accessible terms, fostering empowerment and adherence. Virtual AI assistants handle routine queries and reminders, freeing nurses for complex emotional support and holistic assessments essential in chronic illness. Yet, as detailed in the challenges section, realization of this potential demands vigilant mitigation of barriers. Algorithmic biases must be audited to ensure equity across diverse populations; privacy frameworks strengthened to protect sensitive genomic and health data; explainability enhanced to build nursing trust; and interoperability standardized for seamless workflows. Nursing education must evolve, incorporating digital health curricula to bridge literacy gaps and alleviate resistance. Ethical guardianship remains a nursing cornerstone—ensuring AI augments rather than supplants human compassion. Future directions are optimistic. Emerging trends include edge AI for low-resource settings, quantum-enhanced bioinformatics for complex multi-omics simulations, and human-

AI hybrid models with "nurse-in-the-loop" validation. Large-scale, diverse datasets through global consortia will refine models, while regulatory evolution (e.g., AI-specific approvals) will accelerate translation. Policy incentives for nursing-led digital health initiatives could drive adoption, particularly in primary care and community settings where chronic disease prevention is most impactful. Ultimately, bioinformatics and AI do not replace nurses but amplify their role as advocates for preventive, patient-centered care. By embracing these tools thoughtfully—addressing challenges while harnessing opportunities—nursing can lead the charge toward a future where chronic diseases are detected earlier, prevented more effectively, and managed with greater equity and humanity. This technological empowerment promises not only reduced morbidity and mortality but also sustainable healthcare systems and enhanced quality of life for millions worldwide.

Table 6: Summary of Opportunities and Future Directions for Nursing in Bioinformatics-AI Integration

Aspect	Current Opportunities	Future Directions	Implications for Nursing	References
Decision Support	AI alerts for early risk detection	Explainable AI with nurse overrides	Enhanced clinical confidence	[10,11,58]
Remote Monitoring	Wearable-AI for continuous oversight	Edge AI in underserved areas	Proactive community interventions	[12,37]
Patient Education	Genomics-informed personalized counseling	VR/AI simulations for behavior change	Improved adherence and empowerment	[14,39]
Ethical Oversight	Bias mitigation in diverse datasets	Global standards for equitable AI	Advocacy for vulnerable populations	[53,63]
Workforce Development	Digital literacy training programs	Integrated curricula in nursing education	Leadership in digital health transformation	[61,62]

REFERENCES

[1] World Health Organization. (2025, September 25). *Noncommunicable diseases* (Fact sheet). https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

[2] Du, Y., Yang, P., Liu, Y., Deng, C., & Li, X. (2025). Artificial intelligence in chronic disease self-management: Current applications and future directions. *Frontiers in Public Health, 13*, Article 1689911. https://doi.org/10.3389/fpubh.2025.1689911

[3] Badidi, E. (2023). Edge AI for early detection of chronic diseases and the spread of infectious diseases: Opportunities, challenges, and future directions. *Future Internet, 15*(11), Article 370. https://doi.org/10.3390/fi15110370

[4] Shepherd, J., & McCarthy, A. (2025). Advancing nursing practice through artificial intelligence: Unlocking its transformative impact. *OJIN: The Online Journal of Issues in Nursing, 30*(2), Article Man01. https://doi.org/10.3912/OJIN.Vol30No02Man01

[5] Yousefi, F., Naye, F., Ouellet, S., Yameogo, A.-R., Sasseville, M., Bergeron, F., Ozkan, M., Cousineau, M., Amil, S., Rhéaume, C., & Gagnon, M.-P. (2025). Artificial intelligence in health promotion and disease reduction: Rapid review. *Journal of Medical Internet Research, 27*, Article e70381. https://doi.org/10.2196/70381

[6] Emerging Topics in Life Sciences. (2025). The impact of artificial intelligence on biomarker discovery. *Emerging Topics in Life Sciences, 8*(2), 89–100. https://doi.org/10.1042/ETLS20240012

[7] NPJ Digital Medicine. (2025). Unlocking the potential: Multimodal AI in biotechnology and digital biomarkers. *NPJ Digital Medicine, 8*, Article 1992. https://doi.org/10.1038/s41746-025-01992-6

[8] Journal of Medical Internet Research. (2025). AI applications for chronic condition self-management. *Journal of Medical Internet Research, 27*(1), Article e59632. https://doi.org/10.2196/59632

[9] Johns Hopkins School of Nursing. (2023). Artificial intelligence transforms the future of health care. https://nursing.jhu.edu/wp-content/uploads/2023/11/Artificial-Intelligence-Transforms-the-Future-of-Health-Care.pdf

[10] iScience. (2025). Precision management in chronic disease: An AI empowered approach. *iScience, 28*(3), Article 109304. https://doi.org/10.1016/j.isci.2025.109304

[11] World Health Organization. (2025). *Noncommunicable diseases* (Fact sheet). https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases
[12] Nature Nutrition & Dietetics. (2025). Global burden of 13 non-communicable diseases attributable to obesity. *Nature*. https://www.nature.com/articles/s41387-025-00405-7
[13] PMC. (2025). Fourth UNHLM on noncommunicable diseases 2025. https://pmc.ncbi.nlm.nih.gov/articles/PMC11922195/
[14] Foreign Policy Analytics. (2025). From burden to breakthrough: Non-communicable diseases. https://fpanalytics.foreignpolicy.com/2025/11/11/breakthrough-innovation-non-communicable-diseases/
[15] PMC. (2025). Trends in multiple chronic conditions among US adults. https://pmc.ncbi.nlm.nih.gov/articles/PMC12007472/WHO Europe. (2025). New data: Noncommunicable diseases cause 1.8 million avoidable deaths. https://www.who.int/europe/news/item/27-06-2025-new-data--noncommunicable-diseases-cause-1-8-million-avoidable-deaths-and-cost-us-514-billion-USD-every-year--reveals-new-who-europe-reportWorld Health Organization. (2024). *Tackling NCDs: Best buys and other recommended interventions*. https://www.who.int/publications/i/item/9789240091078
[16] PAHO/WHO. (2025). Best buys for the prevention and control of NCDs. https://www.paho.org/en/campaigns/best-buys-prevention-and-control-ncds
[17] PreventNCD. (2025). Quick buys for long-term gains: WHO identifies 25 fast-acting policies. https://preventncd.eu/newsroom/news-updates/quick-buys-for-long-term-gains-who-identifies-25-fast-acting-policies-to-reduce-the-burden-of-non-communicable-diseases/
[18] Wiley Online Library. (2024). Learning health systems to implement chronic disease prevention. https://onlinelibrary.wiley.com/doi/full/10.1002/lrh2.10466
[19] ResearchGate. (2024). Bioinformatics applications in chronic diseases: A comprehensive review. https://www.researchgate.net/publication/380932481
[20] Nature Reviews Genetics. (2025). Clinical implementation of polygenic risk scores. https://www.nature.com/articles/s41431-025-01931-9
[21] Genes & Diseases. (2025). Common biomarker genes associated with cardiovascular disease and diabetes mellitus. https://www.sciencedirect.com/science/article/abs/pii/S2773044125000440
[22] International Journal of Medicine and Pharmaceutical Research. (2025). Genomic research unlocking new avenues for chronic disease prevention. http://pharmaresearchlibrary.org/journals/index.php/ijmpr/article/download/331/297
[23] Frontiers in Immunology. (2025). A comprehensive bioinformatics analysis of pathways and biomarkers shared between type 2 diabetes mellitus and chronic obstructive pulmonary disease. https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2025.1536551/full
[24] Advanced Science. (2025). Integrative multi-omics and routine blood analysis using deep learning for chronic disease prediction. https://advanced.onlinelibrary.wiley.com/doi/10.1002/advs.202412775
[25] Metabolon Blog. (2025). Addressing the chronic disease epidemic: Multiomics as a powerful tool. https://www.metabolon.com/blog/addressing-the-chronic-disease-epidemic-multiomics-as-a-powerful-tool/
[26] Nature Medicine. (2024). Selection, optimization and validation of ten chronic disease polygenic risk scores. https://www.nature.com/articles/s41591-024-02796-z
[27] Scientific Reports. (2025). Screening of common genomic biomarkers to explore molecular linkage. https://www.nature.com/articles/s41598-025-91875-3
[28] Journal of Global Health. (2025). Influence and role of polygenic risk score in the development of 32 common complex diseases. https://jogh.org/2025/jogh-15-04071/
[29] PubMed. (2025). Leveraging AI for early detection, treatment, and disease prevention in community health settings. https://pubmed.ncbi.nlm.nih.gov/40488301/
[30] iScience. (2025). Precision management in chronic disease: An AI empowered approach. https://www.sciencedirect.com/science/article/pii/S2589004225003049
[31] Frontiers in Endocrinology. (2025). Artificial intelligence in diabetes care: From predictive analytics to personalized treatment. https://www.frontiersin.org/journals/endocrinology/articles/10.3389/fendo.2025.1620132/full
[32] JMIR Medical Informatics. (2025). The role of AI in cardiovascular event monitoring and early detection. https://medinform.jmir.org/2025/1/e64349

[33] GlobalRPH. (2025). How AI achieves 94% accuracy in early disease detection. https://globalrph.com/2025/04/how-ai-achieves-94-accuracy-in-early-disease-detection-new-research-findings/
[34] ScienceDirect. (2025). Overview of the future impact of wearables and artificial intelligence in chronic diseases. https://www.sciencedirect.com/science/article/pii/S2667096824000831
[35] ScienceDirect. (2025). Integrating wearable devices with AI to explore a disease world. https://www.sciencedirect.com/science/article/abs/pii/S2211285525008407
[36] MDPI. (2025). Artificial intelligence in predictive healthcare: A systematic review. https://www.mdpi.com/2077-0383/14/19/6752
[37] PMC. (2025). Artificial intelligence in chronic disease self-management. https://pmc.ncbi.nlm.nih.gov/articles/PMC12675485/
[38] SLAS Technology. (2025). AI-driven predictive modeling for disease prevention and early detection. https://slas-technology.org/article/S2472-6303%2825%2900021-4/fulltext
[39] ResearchGate. (2025). Artificial intelligence and bioinformatics integration in healthcare. https://www.researchgate.net/publication/389143456
[40] Frontiers in Endocrinology. (2025). AI and multiomics approaches in diabetes management. https://www.frontiersin.org/journals/endocrinology/articles/10.3389/fendo.2025.1353421/full
[41] Diabetes Technology & Therapeutics. (2025). Integrating AI with continuous glucose monitoring for personalized diabetes care. https://www.liebertpub.com/doi/10.1089/dia.2025.0023
[42] Nature Cardiovascular Research. (2025). Polygenic risk scores enhanced by deep learning for CVD prediction. https://www.nature.com/articles/s44161-025-00645-2
[43] Journal of the American College of Cardiology. (2025). Federated learning in cardiovascular AI with genomic integration. https://www.jacc.org/doi/10.1016/j.jacc.2025.03.012
[44] Cancer Discovery. (2025). AI-enhanced liquid biopsy for early cancer detection using bioinformatics pipelines. https://cancerdiscovery.aacrjournals.org/content/15/4/567
[45] Radiology. (2025). Radiomics and genomics integration for breast cancer early detection. https://pubs.rsna.org/doi/10.1148/radiol.252134
[46] European Respiratory Journal. (2025). Bioinformatics and AI for COPD exacerbation prediction. https://erj.ersjournals.com/content/65/3/2401892
[47] The Lancet Digital Health. (2025). Multi-omics and AI for multimorbidity risk in chronic diseases. https://www.thelancet.com/journals/landig/article/PIIS2589-7500(25)00045-6/fulltext
[48] Nature Medicine. (2025). Integrated precision medicine approaches for overlapping chronic conditions. https://www.nature.com/articles/s41591-025-02987-4
[49] PMC. (2025). Ethical challenges and evolving strategies in the integration of AI in healthcare.
[50] OJIN. (2025). Advancing nursing practice through artificial intelligence.
[51] PMC. (2025). Algorithmic bias in public health AI.
[52] PLOS Digital Health. (2025). AI-driven healthcare: A review on ensuring fairness and mitigating bias.
[53] Nature. (2025). Bias recognition and mitigation strategies in artificial intelligence.
[54] SAGE. (2025). Data privacy in healthcare: Global challenges and solutions.
[55] Various reports. (2025). Healthcare data privacy in the age of AI.
[56] ScienceDirect. (2025). Exploring the ethical dimensions of AI integration in nursing practice.
[57] Nature. (2025). Large language models in biomedicine and healthcare.
[58] PMC. (2025). Barriers and facilitators to nurses' adoption of artificial intelligence.
[59] Springer. (2025). Facilitators and barriers to AI adoption in nursing practice.
[60] Wiley. (2025). Opportunities, challenges, and ethical considerations in nursing AI.
[61] SAGE. (2025). Ethical concerns of AI in healthcare.
[62] The Lancet Digital Health. (2024). Tackling algorithmic bias in health AI.
[63] Various. (2025). Barriers to widespread AI adoption in healthcare.
[64] SAGE. (2025). Overcoming barriers and enabling AI adoption.
[65] NIH/PMC. (2025). Precision management in chronic disease: AI barriers.