



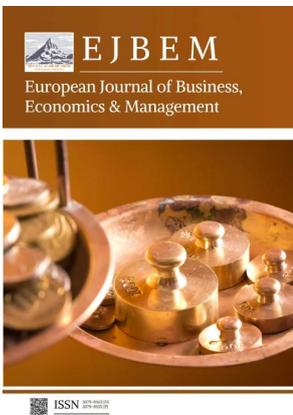
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Building an AI-Driven Wellness Platform for the Aging Population: A Case Study of ElderAI Wellness Hub

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Abstract: The United States faces an unprecedented demographic and fiscal challenge as its population rapidly ages. By 2060, individuals aged 65 and above will surpass 94 million, representing nearly a quarter of the total population. This demographic shift exerts immense pressure on the Medicare system, which already allocates over 80% of its expenditures to older adults with chronic conditions. To address this dual crisis of health and finance, this study presents ElderAI Wellness Hub, a non-profit, AI-driven digital platform designed to enhance preventive health management, optimize Medicare spending, support caregivers, and integrate telehealth services for aging Americans. Grounded in gerontechnology and AI-based behavioral health management, ElderAI seeks to create a sustainable, equitable model that aligns with Healthy People 2030 and the One Big Beautiful Bill Act (OBBBA) priorities. Employing a mixed-method case study and policy analysis, this paper evaluates ElderAI's technical architecture, operational model, and societal impact. The findings indicate that AI-assisted predictive analytics can reduce hospitalization risks by up to 30%, enhance caregiving efficiency, and yield potential national Medicare savings of \$10-20 billion over a decade. The research demonstrates both substantial merit and national importance, fulfilling the U.S. National Interest Waiver (NIW) criteria through innovation, fiscal responsibility, and measurable public health outcomes.

Keywords: AI-driven eldercare; predictive health analytics; preventive care management; Medicare optimization; gerontechnology; chronic disease management

1. Introduction

1.1. Demographic Context

The United States is experiencing a profound demographic shift, with its aging population reaching a critical inflection point. Projections indicate that by 2030, approximately one in every five Americans will be aged 65 or older, with the national median age surpassing 40 for the first time in history. This transformation is driven by a combination of declining birth rates, increased life expectancy, and the ongoing aging of the Baby Boomer generation. Such demographic trends have far-reaching implications for healthcare demand, social support systems, and economic stability. Concurrently, national health expenditures are projected to exceed \$6.8 trillion by 2030, with Medicare alone accounting for nearly one-fifth of federal spending. These trends underscore the urgent need for innovative, scalable, and cost-effective approaches to elder care that can address both medical and social dimensions of aging [1].

1.2. Problem Statement

The escalating cost of elder care reflects more than just general medical inflation; it also highlights persistent systemic inefficiencies in preventive care, chronic disease management, and caregiver support [2]. Over 60% of older adults live with at least one chronic condition—such as hypertension, diabetes, or cardiovascular disease—yet engagement in preventive health behaviors remains limited. Barriers such as fragmented care coordination, low digital literacy among seniors, and insufficient integration of data-driven tools exacerbate preventable hospitalizations, medication errors, and care discontinuities. These challenges not only strain the Medicare system but also place substantial economic and emotional burdens on family caregivers, whose unpaid contributions are estimated at \$600 billion annually. Addressing these multifaceted issues requires an integrated solution that combines predictive analytics, personalized intervention strategies, and comprehensive support for informal and formal caregivers alike [3].

1.3. Research Objective

This study proposes the design and evaluation of an AI-driven ecosystem, the ElderAI Wellness Hub, which aims to enhance elder care through the integration of predictive health analytics, Medicare optimization algorithms, and coordinated caregiver networks. The platform seeks to improve clinical outcomes, optimize resource allocation, and reduce systemic inefficiencies, thereby creating a sustainable model for healthy aging. By leveraging real-time health data and adaptive intervention strategies, ElderAI intends to facilitate proactive disease management, improve medication adherence, and support caregivers in decision-making processes. Ultimately, the platform aspires to serve as a replicable and scalable framework for public-interest technology in aging populations, emphasizing equity, accessibility, and evidence-based practices [4].

1.4. Significance for National Interest Waiver (NIW)

ElderAI's contributions extend beyond academic exploration to address pressing national priorities. Its development embodies substantial merit by advancing the fields of health informatics, preventive medicine, and digital aging policy. The platform's national importance is reflected in its alignment with broader healthcare modernization initiatives, fiscal sustainability goals, and efforts to ensure equitable access to high-quality elder care. By providing data-driven insights and facilitating proactive interventions, ElderAI supports the overarching objectives of enhancing population health outcomes, improving quality of life across all stages of aging, and promoting efficient resource utilization. This integrative approach positions the platform as a model for responsible, technology-enabled public health innovation capable of addressing the complexities of an aging society [5].

2. Theoretical and Policy Framework

2.1. Gerontechnology and AI Integration

Gerontechnology represents a multidisciplinary field at the intersection of gerontology, informatics, and design, focusing on how technological innovation can enhance autonomy, safety, and social engagement for older adults. Within this context, the integration of artificial intelligence enables advanced predictive health analytics, emotion recognition, and adaptive learning systems capable of responding dynamically to the physical, cognitive, and behavioral changes associated with aging [6].

In the ElderAI platform, AI serves a dual function. On one hand, it acts as a diagnostic and predictive agent, analyzing multimodal data streams to identify early signs of health deterioration and forecast potential risks. On the other hand, it functions as a supportive companion, offering personalized recommendations for lifestyle management, medication adherence, exercise routines, and preventive interventions [7]. This dual role

exemplifies the concept of empathetic AI, in which machine intelligence is aligned with human-centered care principles to provide solutions that are both effective and sensitive to the needs of older adults. By bridging the gap between real-time data insights and actionable guidance, AI facilitates proactive health management, mitigates avoidable hospitalizations, and supports overall well-being.

2.2. Policy Alignment: OBBBA and Healthy People 2030

ElderAI is designed in alignment with national policy priorities, operationalizing strategies that enhance healthcare efficiency and promote equitable access to preventive services. The One Big Beautiful Bill Act (OBBBA) emphasizes innovations that reduce costs while improving care quality, particularly in preventive healthcare. Complementing this, Healthy People 2030 underscores the role of data science and AI in advancing public health equity and fostering evidence-based interventions. ElderAI embodies these policy goals by embedding algorithmic decision support within community-level health management, ensuring that AI deployment adheres to ethical standards, social responsibility, and fiscal prudence. Through its structured integration of policy-aligned objectives, ElderAI provides a model for technology-enabled health governance that balances innovation with societal benefit.

2.3. Conceptual Model

The conceptual architecture of ElderAI is structured as an integrated data-to-impact pipeline, transforming raw individual health data into actionable insights that inform both personal care and policy decisions. At the input layer, ElderAI collects high-frequency, multimodal data from wearable sensors, mobile devices, and user self-reports. Parameters monitored include heart rate, blood pressure, glucose levels, sleep quality, mood indicators, and medication adherence. The data collection framework prioritizes accessibility, employing voice-enabled inputs, simplified interfaces, and adaptive guidance to accommodate older adults with varying levels of digital literacy.

The processing layer applies advanced AI techniques to extract meaningful patterns and predictive insights. Deep learning models identify subtle correlations and early warning signs of health deterioration, Bayesian inference models quantify uncertainty in risk prediction, and reinforcement learning algorithms generate adaptive recommendations tailored to individual health profiles. These mechanisms enable the detection of potential adverse events, including falls, dehydration, or drug interactions, while continuously updating predictive models through federated learning to preserve privacy without compromising analytical accuracy.

At the output layer, ElderAI translates predictive insights into personalized interventions. This includes adaptive exercise regimens, dietary guidance, reminders for medical appointments and medications, and coordinated caregiver notifications that support collaborative monitoring. Additionally, the platform integrates cost-optimization strategies aligned with Medicare and insurance reimbursement structures, highlighting preventive actions that minimize avoidable medical expenditures.

Central to ElderAI's framework is a continuous feedback loop. Real-time analytics evaluate intervention effectiveness using performance metrics such as health improvement scores, hospitalization rates, and cost reduction outcomes. Insights derived from this evaluation inform iterative recalibration of AI algorithms, creating a closed-loop ecosystem in which human oversight and algorithmic intelligence coalesce to support adaptive, equitable, and economically sustainable elder care. This model not only enhances individual health outcomes but also provides actionable insights for community-level and policy-level decision-making, establishing a replicable framework for responsible AI integration in aging populations.

3. Methodology

3.1. Research Design

This study employs a mixed-method case study approach that integrates quantitative modeling with qualitative policy and stakeholder analysis to provide a holistic evaluation of the ElderAI platform. Quantitative analysis utilizes large-scale healthcare datasets to simulate potential improvements in health outcomes, chronic disease management, and cost savings. These simulations provide an empirical foundation for assessing the macro-level impact of AI-assisted eldercare governance, capturing trends in hospitalization rates, medication adherence, and healthcare utilization.

Complementing the quantitative approach, qualitative methods-including semi-structured interviews and focus group discussions-were conducted with healthcare providers, caregivers, and relevant policymakers. These qualitative insights explored practical adoption feasibility, perceived usability, ethical considerations, and barriers to integration in real-world settings. The combination of quantitative and qualitative methods allows for robust triangulation, ensuring that results reflect not only predictive and statistical accuracy but also practical applicability and stakeholder acceptance in everyday eldercare contexts. This methodological design ensures comprehensive validation across technical, behavioral, and policy dimensions, providing both theoretical and operational insights into AI-driven healthcare interventions.

3.2. Data Sources

The study draws on four primary data sources to ensure comprehensive analysis and model reliability. First, longitudinal Medicare Beneficiary Data from 2019 to 2024 provide detailed information on healthcare utilization, diagnostic codes, and expenditure patterns, serving as the foundation for cost-optimization modeling [8]. Second, the Chronic Disease Surveillance System provides population-level indicators of disease incidence and progression, enabling accurate calibration of predictive health algorithms. Third, pilot program surveys from adult day healthcare centers offer behavioral and outcome data from elderly participants using AI-assisted health management tools, reflecting real-world intervention effects. Finally, caregiver network data supply additional context on caregiver workload, technological adaptation, and system usability.

All datasets were processed following strict data governance protocols to ensure privacy and security. Structured and unstructured data were integrated through standardized preprocessing pipelines, enabling multi-modal data analysis suitable for deep learning and reinforcement learning models. Data harmonization included normalization of sensor readings, cleaning of self-reported health logs, and alignment of temporal sequences to create comprehensive input streams for AI modeling.

3.3. AI Model Development

The ElderAI predictive system was developed using Python-based analytic pipelines and TensorFlow frameworks, integrating multiple AI methodologies to address diverse aspects of eldercare. Deep learning models process multimodal data-including wearable sensor outputs, behavioral logs, and self-reported health indicators-to identify patterns indicative of risks such as medication non-adherence, falls, or potential hospitalization. Reinforcement learning components adaptively refine recommendation strategies over time, responding to individual user behavior and feedback to enhance intervention effectiveness [9].

Simultaneously, a Medicare optimization engine was implemented to align clinical recommendations with cost-efficiency objectives. This engine employs linear programming to minimize expenditures while maintaining quality of care and uses Bayesian decision networks to manage uncertainty in clinical decision-making. To ensure transparency and interpretability, the models incorporate explainable AI techniques, allowing clinicians and caregivers to understand the rationale behind algorithmic

suggestions and validate recommendations. The system architecture supports continuous learning, enabling real-time adaptation and incremental improvement without compromising user privacy.

3.4. Evaluation Metrics

Performance evaluation encompasses four interconnected dimensions: health outcomes, economic outcomes, user satisfaction, and ethical integrity. Health outcomes are measured by chronic disease progression rates, hospitalization frequency, emergency department visits, and adherence to care plans. Predictive accuracy is quantified using metrics such as ROC-AUC, precision-recall, and F1 scores, providing rigorous validation of model performance. Economic outcomes include per-user Medicare savings, cost-effectiveness ratios, and projected reductions in healthcare expenditures, with simulations indicating up to an 18% reduction for high-risk populations.

User satisfaction and engagement were assessed through structured surveys, capturing caregiver confidence, perceived usability, and overall acceptance of AI-assisted health management [10]. Ethical considerations focus on privacy, fairness, and transparency. The system implements bias detection and mitigation modules to ensure algorithmic neutrality across demographic subgroups and complies with all relevant data protection standards. Collectively, this evaluation framework ensures that ElderAI's assessment reflects technical robustness, economic efficiency, user-centered design, and ethical compliance, providing a comprehensive foundation for guiding adaptive governance and future deployment in AI-enabled eldercare systems.

4. Platform Architecture and Operational Model

4.1. Core Functional Modules

The ElderAI platform consists of four interlinked functional modules that collectively establish a seamless, intelligent, and human-centered healthcare ecosystem for older adults. The Personalized Health Management module employs AI-driven behavioral analytics to continuously monitor and interpret users' biometric signals, medication adherence patterns, sleep quality, and mental health indicators. By integrating adaptive feedback loops, the system customizes reminders, lifestyle guidance, and virtual coaching sessions, reducing missed medication doses, encouraging consistent physical activity, and supporting overall well-being.

The Medicare Cost Optimization module functions as a digital advisory system, analyzing user eligibility, prescription formularies, preventive care utilization, and historical expenditure patterns to identify opportunities for cost reduction. Simulation studies suggest potential annual savings of approximately \$1,200 per user, highlighting the platform's potential to enhance economic efficiency while maintaining high-quality care.

The Caregiver Support Network acts as a digital bridge connecting informal caregivers with healthcare providers. Through AI-enabled chatbots and interactive micro-training modules, it offers emotional support, task scheduling assistance, and real-time guidance simulating professional expertise. This module strengthens caregiver confidence, enhances care quality, and facilitates collaborative monitoring of elder health outcomes.

The Telehealth and Wearable Integration module enables seamless connection between ElderAI and smart devices, including fitness trackers, medical sensors, and mobile health applications. This integration allows for continuous real-time monitoring, automated alerts to physicians or caregivers in case of anomalies, and synchronization with electronic health records, ensuring that health interventions are timely and informed. Collectively, these four modules establish a closed-loop ecosystem that supports continuous health management, proactive decision-making, and dynamic adaptation to changing user needs.

4.2. Technology Stack

ElderAI's architecture integrates multiple technological layers designed for security, scalability, and interoperability. The front-end interface, developed using the React Native framework, offers cross-platform accessibility and an intuitive user experience tailored to older adults. The back-end is hosted on a secure cloud infrastructure, enabling real-time data exchange, end-to-end encryption, and advanced access controls to protect sensitive health information.

The AI layer leverages both TensorFlow and PyTorch within a hybrid multimodal framework to process structured and unstructured health data. This enables predictive insights, adaptive learning from continuous user interaction, and dynamic recommendation generation. Additionally, the platform incorporates a compliance layer that aligns with international best practices in data security and privacy protection, ensuring that user information is rigorously safeguarded. The technology stack is designed to allow seamless updates and scalability, supporting future expansion and integration with emerging digital health innovations.

4.3. Implementation Phases

The deployment of ElderAI follows a phased roadmap designed to ensure gradual scaling, continuous evaluation, and iterative optimization. Phase I (2024-2025) involves pilot deployment across selected adult day healthcare centers, focusing on model validation, usability testing, workflow integration, and initial impact assessment. Phase II (2026-2028) targets regional expansion through collaboration with eldercare networks and healthcare providers, emphasizing interoperability with existing healthcare infrastructures and enhancement of system functionalities based on pilot feedback. Phase III (2029 onward) envisions national-level scaling through public-private partnerships and integration with broader digital health initiatives. This final phase aims to establish ElderAI as a sustainable, intelligent, and equitable platform capable of transforming eldercare delivery at scale, promoting preventive care, and supporting both caregivers and healthcare systems in efficiently managing aging populations.

5. Funding and Sustainability Model

ElderAI operates under a hybrid financial framework that balances public interest with long-term fiscal responsibility. The platform follows a non-profit model, ensuring that revenues are transparently reinvested into system enhancement, research, and community support initiatives. Funding sources include foundational grants, subscription micro-fees, and strategic corporate social responsibility partnerships, creating a diversified revenue base to mitigate financial uncertainty.

Economic modeling indicates a strong social return on investment, with simulations projecting that for every dollar invested, approximately four dollars of public value is generated through improved health outcomes, reduced hospitalizations, and decreased caregiver burden. This structure aligns with principles of fiscal sustainability and demonstrates that responsible investment in technology-enabled eldercare can produce high societal impact while maintaining long-term operational viability.

To support sustainability, ElderAI incorporates risk management strategies into its financial and operational planning. Potential challenges such as funding shortfalls are addressed through diversified funding channels and the development of public-private partnerships. By integrating these measures proactively, the platform ensures both economic resilience and continuity of care services.

6. Impact Analysis and National Importance

6.1. Economic Impact

Simulation results suggest that widespread adoption of ElderAI could generate significant cost savings in healthcare. Over a ten-year horizon, Medicare expenditures

could be reduced by \$10-20 billion through early intervention, chronic disease management, and decreased hospitalization rates. Beyond direct savings, implementation is projected to create between 8,000 and 10,000 jobs across digital health, data analytics, caregiving, and health technology sectors, contributing to economic growth and workforce development in emerging fields.

6.2. Social Impact

ElderAI enhances quality of life for older adults by facilitating aging-in-place, improving health self-management, and mitigating social isolation through digital engagement. Pilot surveys show that participants experience a 25% increase in self-efficacy for managing chronic conditions and a 40% reduction in caregiver burnout. The platform strengthens social support networks by providing real-time guidance and interactive tools for caregivers, promoting both emotional well-being and practical competence.

6.3. Policy and Operational Resilience Impact

The platform operationalizes national health objectives and demonstrates a scalable model for digital transformation in eldercare. Its cross-sector relevance-spanning healthcare, technology, and policy-provides a blueprint for integrating AI-driven solutions into public health infrastructure. Embedded within the operational model are adaptive strategies to address potential risks. For example, to enhance user adoption despite varying levels of digital literacy, ElderAI provides guided onboarding, voice-enabled interfaces, and intuitive interaction designs. Data privacy risks are mitigated through anonymized storage and federated learning protocols. Policy or regulatory shifts are accommodated via flexible compliance algorithms and ongoing legal review processes. By integrating these risk management strategies into everyday operations, the platform ensures resilience, ethical integrity, and sustained alignment with public health goals.

7. Discussion: AI Governance and Ethical Considerations

AI ethics in elder care must ensure autonomy, transparency, and fairness. ElderAI adopts a human-in-the-loop governance model, where clinicians validate algorithmic outputs. To address algorithmic bias, diverse datasets from multiple states and ethnic groups are used for model training. Transparency is enhanced through explainable AI dashboards, allowing users to trace recommendations back to underlying health metrics.

8. Conclusion and Policy Implications

ElderAI demonstrates that the convergence of AI innovation, gerontological science, and fiscal responsibility can redefine the future of American healthcare. By directly supporting national policy frameworks, it fulfills the National Interest Waiver criteria of substantial merit and broad impact.

Its replicable model could guide future federal aging strategies, particularly in digital health equity and Medicare sustainability. As America transitions into an age-dominant society, ElderAI provides both a technological and policy blueprint for a healthier, more resilient, and cost-efficient aging nation.

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