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Artificial Intelligence in Geriatric Healthcare: Opportunities and Challenges in a Transforming Landscape

[1]Mr. Ashwin Sankaran ,[2]Ms. Priyanka Singla
[1]Strategic Technology Executive In Control Family Foundation Bedford,MA, USA
[2]Assistant Professor Bhagwan Parshuram Institute of Technology Delhi, India

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***Abstract*—** The quick ageing of world populations has brought a set of complicated problems for healthcare systems, such as new disease trends, the escalating cost of health and long-term care, a labor shortage, and the old-age income security issue. Artificial intelligence (AI) has come up as a revolutionary technology is the potential to handle these problems by improving the health care of the aged through early diagnosis, personal care, remote medication, and decision support. But the introduction of AI in elderly care is a vector of conflicting issues including machine learning limitations, ethical and legal ambiguities, and social acceptance barriers. This study is a review of literature that assesses the use of artificial intelligence in the digital transformation of geriatric healthcare by answering four key research questions: (1) the most popular AI techniques, (2) application scenarios, (3) planned future research, and (4) benefits of AI-based digital transformation in the industry. An in-depth analysis is provided the security mechanisms of intelligent healthcare systems and DT-inspired innovative methods demonstrate their function in increasing healthcare outcomes for older people. Even though the shower promises this review hit home some pivotal issues like data privacy concerns, the opacity of AI models, insufficient ethical and regulatory frameworks, and mistrust of society toward AI technologies. It emphasizes the importance of solid, interdisciplinary methods to overcome these limitations, concentrating on improving transparency, ethical accountability, and public trust. The purpose of the publication is to provide an outlook into both the prospects and the problems, therefore, the publication is directed to researchers, policymakers, and practitioners who are working on the advancement of AI-powered innovations in senior healthcare, which, along with demographic changes characterized by the complexity of the landscape necessitate the study of possible solutions, among which is the proposed Ecological network.

Keywords— Geriatric Healthcare, Geriatric care AI tools, Common Elders Care Tasks, Ecological Framework, Digital transformation.

I. Introduction

The ageing population has grown to be a significant worry for the development of civilization in the twenty-first century. The rate of population ageing is predicted to accelerate by 2050 when 16% of the world's population will be 65 and older [1]. Almost every country is on the trajectory of increasing its population of senior citizens. The Chinese government based its data on its Seventh National Census in 2021, which showed that 18.7%, or 1.41 billion people, were over 60 years old, while 13.5 per cent were over 65 [2]. The world over, older people are now the majority. This situation poses new problems, such as the transforming disease pattern, increased healthcare and long-term care demand, possible labor shortages, disallowed savings, and maybe old-age income security. This demographic transition imposes acute demands on healthcare systems that ought to address the increasing need for high-quality, low-cost, and sustainable elderly care.

In recent decades, healthcare has typically relied on the availability of skilled human resources that have been in short supply and the finitude of infrastructure [3]. The long-standing methodologies have reflected this development, causing them to need to catch up in today's changing society and the heterogeneous, intricate headaches brought about by age [4][20].

However, artificial intelligence (AI) has altered the situation under these conditions by bringing in novel ways to improve the standard, effectiveness, and accessibility of elderly healthcare[5][21-24]. Today, AI-enabled systems are widely used in many sectors (e.g., remote patient monitoring, individualized treatment plans, early identification of chronic illnesses, and clinician support systems) [6]. These technologies have the potential to be a way to better the health of the patients and cut down the burden on the healthcare infrastructure as well as the caregivers. Even though AI can become an essential innovation in enhancing senior citizens' health, the inseparability of the two processes poses many difficulties. Data issues, such as privacy, fraud, ethical vice, and resistance to technology, still need to be solved before equitable and practical solutions can be accessed [7]. Furthermore, customized AI solutions that go beyond a one-size-fits-all strategy are required due to the diversity of the ageing population and the complexity of their healthcare requirements. This publication thoroughly examines the potential, difficulties, and future research and application avenues of AI-driven digital transformation (DT) in elder healthcare. By emphasizing important findings and summarizing current knowledge, this work aims to contribute to the ongoing conversation on using AI to revolutionize aged care in a sustainable and equitable manner. The study seeks to address the following four key research questions (RQs):

1. Which artificial intelligence techniques are most applied in elderly healthcare research?
2. What are the critical application areas of AI in the geriatric healthcare sector?
3. What is the anticipated future direction for AI research in elderly healthcare?
4. How does AI-enabled digital transformation benefit the elderly healthcare landscape?

Section II conducts a literature survey of the study. Section III depicts the research methodology. Section IV illustrates the result analysis, including limitations, challenges, and possible recommendations. Finally, section V presents the conclusion and future work of the study.

II. Literature Review

Multimorbidity and long-term ailments mainly affect older people, and their progression over time increases the chances of frailty and related syndromes like falls, delirium, functional impairment, and incontinence [8]. Intelligent chronic illness monitoring, along with early AI-initiated diagnosing, can be the means for timely interventions, thus making the burden on healthcare systems and older people less stressed[25][26].

Some AI applications research in geriatric nurturing has been done from various angles. Prathiba Udupa et al. [9] stress the fact that well-being is a critical issue for older people, and thus, a wireless sensor network that can detect their movements in real-time and thus convert the environment into a smart home is needed and should be inexpensive, sturdy, and flexible. The proposal of EAI, explainable artificial intelligence, by Salman et al. [10] in the IoMT healthcare model for older adults is proposed in this research. Machine Learning and Deep Learning methods were only partially capable in some areas. Thus, due to the overpopulation of the ageing population, the model needed to be more accurate in disease forecasting and control. Daniele Cafolla et al. [11] developed a predictive algorithm based on a remote health monitoring program to help doctors in medical treatment and prevention. The methodology anchoring is stealthily carried out by creating the functionality of AI to extract meaningful information from advanced sensor technologies, analyze the data, and, thus, create a report with the patient's total health assessment. Some recently developed reasoning algorithms, including Bayesian Networks and Decision Trees, were employed to abstract the sensor data into higher semantic levels. From this angle, patient surveillance is vital to avoiding the bottleneck of the traditional method, and thus, the advent of personalized healthcare solutions comes nearer. Muhammad et al. [12] present a development of a model that

tracks older people's activities and offers automated assistance. The model applies an artificial neural network (ANN) algorithm, which is clever and powerful. The model is divided into two parts: training and validation, with a cloud for communication. The training phase consists of three layers: sensory, preprocessing, and application. The sensory layer stores the raw data, and the preprocessing layer takes care of the missing values through moving averages and normalization. Then, the output is sent to the application layer, which has two parts: prediction and performance.

Many research studies have been carried out to find a person's health problems, including diabetes diagnosis [13], heart risk assessment [14], and blood pressure and heart rate monitoring, a few examples in this category. Furthermore, findings indicate that research on AI tools for entertainment purposes [15] and for treating mental health issues, such as the depression detection tool and a loneliness reliever [16], have been carried out.

The literature review has assessed that previous studies neglected some significant aspects, such as trustworthiness, explainability, ethics, privacy, legality, and biases in AI systems of geriatric healthcare.

III. Methodology

Our study comprehensively analyzed the role of AI tools in healthcare, especially elder care. Around 200 papers were initially identified through keyword-based searches, among which the most relevant ones are those dealing with terms such as “elder care system,” “geriatric care system,” “automation of geriatric care,” “AI-driven geriatric care,” “senior care,” “ML-based elder care,” and “AI solutions for geriatric healthcare” in the first place. These sources are available in different well-regarded databases, such as IEEE, Elsevier, Google Scholar, and MDPI. Out of the original 200 articles, the other articles were chosen according to specific inclusion-exclusion criteria, shown in the first part of Fig. 1.

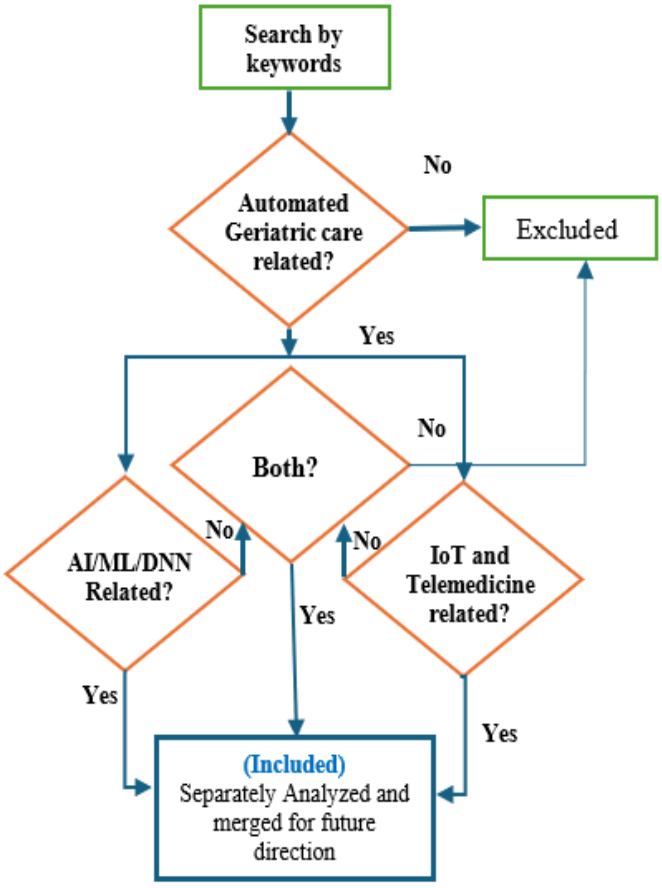

Fig.1. Exclusion and Inclusion criteria

Space limitations imply that only 19 selected articles are presented in this study. Furthermore, we investigated the shortcomings of current AI instruments, enumerating problems in privacy, transparency, lawful AI, trustworthy AI, and ethical considerations. The comprehensive methodology, including the selection process, is represented in Fig. 2.
The process for evaluating articles according to standards is described in the flowchart (fig. 1), which begins with a search using pertinent keywords. Afterwards, articles are vetted to see if they have anything to do with automated geriatric care; if not, they are eliminated. If they do, the next stage is to determine whether they use artificial intelligence (AI), machine learning (ML), or deep neural networks (DNN); articles that don't fit this description are examined for their applicability to telemedicine or the Internet of Things (IoT) in elder care. Articles that fit these requirements are analyzed, whereas those that don't aren't. This systematic methodology guarantees that only the most pertinent papers are included for additional analysis and integration to guide the creation of future directions in the study topic.

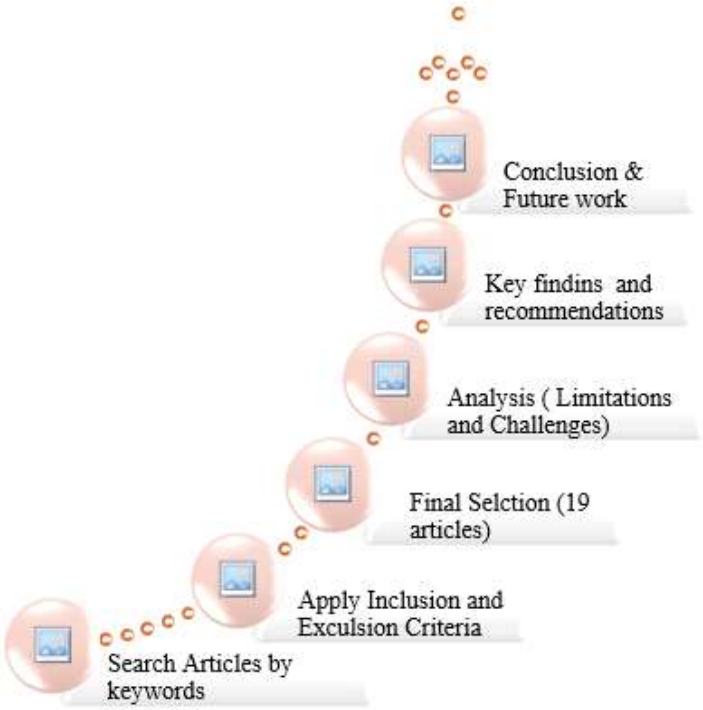

Fig.2. The study approach

IV. Results analysis of the study

This section summarizes the findings, points out lacunae in the exiting work, highlights the challenges, and contemplates possible solutions based on a comprehensive study analysis about integrating AI and IoT in senior care.

A. Common problems in senior cares

The research on the extensive study of geriatric care summarizes the most common phenomena in elderly care, which are visually represented in Fig. 3 [17-18].

Fig.3. Common Issues of geriatric care

Chronic health conditions: These include heart disease, diabetes, dementia, and arthritis, to name a few. Long-term monitoring and care are necessary for all of this. Mobility Issues: Falling, having trouble doing everyday tasks, and being more prone to injury are all consequences of decreased mobility brought on by ageing or illness. Cognitive Decline: Alzheimer's disease, dementia, and other cognitive-related disorders affect memory and decision-making, reducing the ability to live independently.

Medication management: It is widespread for elderly adults to be on several kinds of medications; this puts them in danger of side effects, interactions, and failure to comply with their prescribed medications. Social Isolation: Many seniors face loneliness that can have adverse effects on their mental and physical health, including an increased risk of depression and cognitive decline.

Sensory Disabilities: In seniors, disabilities related to sensory loss, such as loss of vision due to diseases like macular degeneration or cataracts and hearing loss due to presbycusis, make daily activities difficult and may lead to social isolation. These disabilities require special support to promote the continuation of independence.

Nutritional Management: Adequate nutrition is complicated for older people due to a decline in appetite, inability or lack of cooking skills, or unavailability of nutritious foods.

Home Safety: Poor home modifications, such as missing grab bars, non-slip mats, or proper lighting, can lead to a few hazards and make accidents or falls likely.

Caregiver Burden: Family members or professional caregivers may experience physical, emotional, and financial stress while providing care and consequently become burnt out.

B. Enhancement of the geriatric healthcare management

The integration of AI technologies marks the inflexion point for advancement in senior healthcare management. It flips care delivery to be personalized and efficient, while wearables for remote monitoring, mobility support systems, cognitive assistance, and medication management morph into AI-powered tools for elderly care. Fig.4 shows the AI-powered geriatric healthcare management way [19].

Fig.4. AI-based geriatric health management tools.

Wearable Devices & Remote Monitoring: Wearable gadgets such as smartwatches or fitness bands incorporate Artificial Intelligence to examine various physical indicators (heart rate, oxygen level, etc.) and the physical activity performed. If detected, certain unusual activities are flagged by AI algorithms, and the healthcare provider or caregiver can receive a notification for possible intervention. AI systems can collate health data from wearable devices to track health changes for a client in the long run while monitoring a senior client's medication regimen, general health and any other risks in real time.

Mobility Support AI: Exoskeletons that are designed especially for seniors who are frail and are unable to walk Chicago to the case; such mobility enhancing devices blend with the body to balance the movements of the kinesiology– such devices also come with artificial limbs designed for improving the overall independence of the seniors. AI helpers in the form of Canes and Walkers can also help grown-ups prevent falls - they are designed to scan surfaces to identify uneven ones and adapt automatically.

Cognitive Support AI: AI Apps also track how much time a senior has spent on activities that require memory, concentration, and problem-solving; the system then provides recommendations for various exercises to the users and for the AI to combat cognitive decline among seniors. Virtual assistants that employ AI can assist the elderly in talking, remembering tasks, and interacting with the digital world, which provides provisions for all the initial indications of cognitive disorders.

Medication Management by AI: AI-powered devices automatically dispense the correct medication at the right time, ensuring adherence to prescribed regimens and reducing the risk of errors. AI-based apps send reminders to seniors to take their medications, adjust dosages, or schedule follow-up visits with healthcare providers.

Social Isolation Support AI: Social robots and virtual assistants can help prevent seniors from feeling isolated by providing them with social contact, shared activities, or communication opportunities with family or friends. Seniors needing assistance can engage in virtual consultations and social activities with their doctors, children, or friends through mobile apps and other software applications.

Sensory Disabilities Support AI: AI-driven advanced hearing aids can enhance the understanding of speech and sounds for seniors with hearing impairment by integrating sensors with other advanced AI features. By combining AI applications into gadgets like smart glasses or mobile smartphones, seniors can independently identify objects, receive voice text prompts to read, or even move from one place to another.

Artificial Intelligence in Nutrition Management: Senior-focused AI Nutrition Apps analyze users' dietary patterns,

propose healthy foods in accordance with their medical conditions, like diabetes, and issue timely reminders to maintain the right nutrition. AI-powered devices can assist seniors in their cooking techniques by suggesting recipes and teaching them how much food to serve, which is ideal for healthy living.

AI-based Home Security System: AI-based safety gadgets like motion sensors and cameras keep track of activities within the home, raising the alarm when there is abnormal behaviour or a trigger such as a fall or some danger and notifying caregivers or family members. It may also turn on or turn off the lights and the heating units, as well as the security systems, to ensure that the senior is in a safe, warm, and friendly environment that is easy to use.

AI in Caregiver-Client Relationships: Monitoring systems that assess the caregiver workload and stress level can also suggest the practical organization of the tasks and offer the possibility of short breaks from care tasks or appropriate professionals. Such platform applications can also assist caregivers in managing their emotions, resolving stressful situations through various methods, and gaining support within the community.

C. Existing AI tools for geriatric healthcare and their Shortcomings as well as challenges

AI technologies are now being incorporated into care for older adults, targeting the major priorities of geriatric medicine: managing chronic diseases, support for mobility, cognitive decline, and social isolation. Wearable technology and cutting-edge technologies like ML and NLP provide more widespread and customized senior care. Table 1 reviews some standard AI tools used in geriatric healthcare [19].

Table 1. Commonly used geriatric care AI tools

SI	AI tools for geriatric healthcare	Features	Limitations
1	Apple Watch	Heart rate, fall detection, emergency SOS, activity tracking	Expensive; limited battery life;
2	KardiaMobile	EKG monitoring, instant results, and data sharing with doctors	Does not replace full cardiac monitoring; limited accuracy for certain arrhythmia; requires regular calibration.
3	Amazon Echo	Voice-activated reminders, smart home control, medication alerts, companionship	Privacy concerns due to data collection; may not recognize all voice commands; requires Wi-Fi.
4	Paro Therapeutic Robot	Interactive, responds to touch and sound, provides comfort and companionship	High cost; limited functionality beyond emotional support; requires regular maintenance.
5	Teladoc	Virtual doctor visits, 24/7 access to healthcare professionals, chronic condition management.	Internet access is required; lacks physical examinations; may not be suitable for emergency care.
6	MedMinder	Smart pill dispenser, medication reminders, caregiver alerts	Expensive initial cost; limited to specific pill sizes; requires consistent Wi-Fi or cellular connection.
7	Ring Security System	Smart cameras, motion detectors, emergency alerts, home monitoring	Subscription costs for advanced features; privacy concerns; may be complicated for some seniors to manage.
8	CarePredict	Wearable technology, activity monitoring, predictive health analytics, caregiver alerts.	High costly, false alarms are possible; requires regular charging and internet connectivity.

Figure 5 sums up the critical challenges for AI-driven geriatric healthcare, from ethical ones-data ethics, fairness, standards of clinical practice-to legal issues-general legislation, regulatory provisions-security-cinched hardware/ software security, human factors, protection of genetic resources-privacy-data security and cybersecurity-to societal acceptance-trust. The challenges identified above imply further complexity in integrating AI responsibly and effectively into senior care.

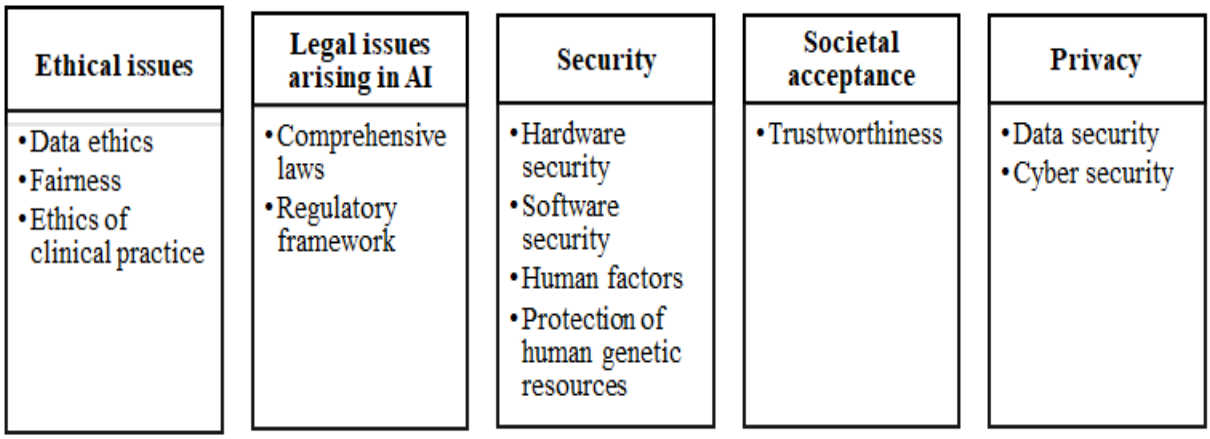

Fig.5. Challenges of AI driven geriatric healthcare

D. Possible solutions and recommendations

We have presented a structured approach to the integration of AI in geriatric care, addressing core areas that focus on trustworthiness, ethics, lawfulness, bias mitigation, and transparency using blockchain-based data privacy, illustrated in Fig.6. This framework has been built on supporting responsible and effective adoption into practice while considering patient safety and adherence to regulatory standards. Finally, our study proposes integrating all possible solutions with the existing AI-based elder care management, which is called an Ecological network, as shown in Fig. 7.

AI-based ecological network

- **Preclinical Phase**: Identify the problem, develop algorithms, and rigorously test them for accuracy and reliability.
- **Clinical Application**: Start with small-scale trials and refine based on feedback.
- **Big Data Infrastructure**: Use blockchain and advanced technologies to ensure secure, high-quality data, and maintain an up-to-date system.

Ethical adoption of AI in geriatic care

- **Ethical Oversight**: Ensure adherence to ethical guidelines and prioritize patient safety and consent.
- **Fair Practices**: Implement transparent, unbiased approaches in research, development, and application.
- **Standardization**: Establish and maintain consistent protocols and practices to ensure quality and comparability across studies.

Trustworthy AI

- Imrove AI tools explainability, transparency, robustness while mitigating biases for fairness and reliability

Establishment and perfection of the legal system

- Establish flexible, adaptive laws based on 'do not harm', ensuring AI tools comply with these regulations

Improvement in feasibility of AI in the real world

- Devolap user friendly AI tools with stable, robust performnace.

Fig.6. Recommendations for resolving the challenges.

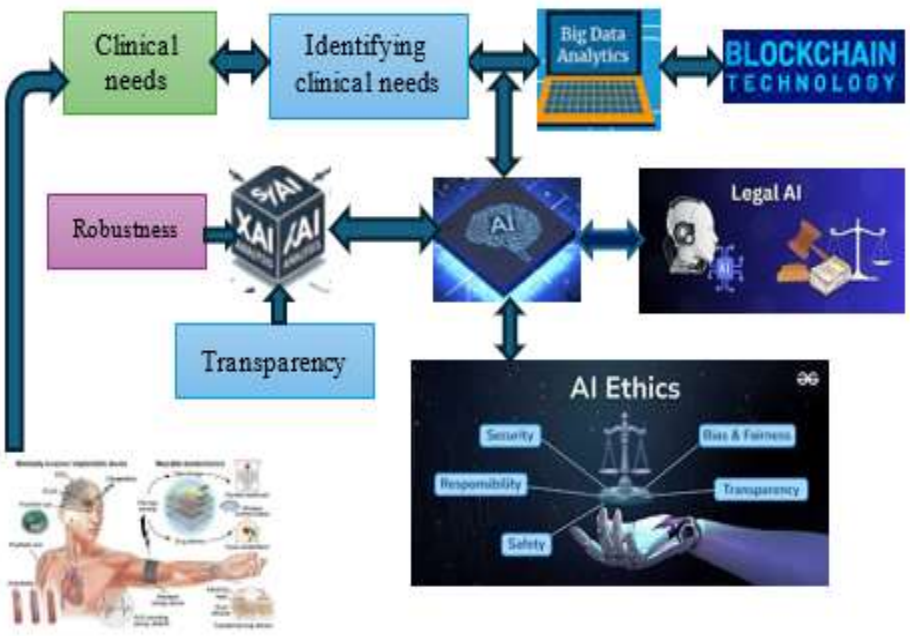

Fig.7. Proposed Ecological Framework.

This AI-powered exocytic network architecture for senior care overcomes the shortcomings of earlier systems by combining blockchain and big data to improve access, data security, and procedural efficiency. Clinical needs are determined, a lot of data is gathered, and with AI, senior patients receive tailored insights thanks to the model.
Blockchain guarantees this data's security and privacy, which also addresses issues with data breaches and access limitations that previous systems have. It continuously develops algorithms, reviews processes, and trains the model using actual clinical trials to dynamically adjust to each patient's changing needs. It is, therefore, more responsive, secure, and efficient than conventional frameworks for managing geriatric patients.

V. Conclusion and future work

The rising population of older adults across the globe is stirring up traditional care models. Still, AI-based health monitoring technologies can help in elder care by assisting caregivers, lightening their load, and improving care. Nevertheless, these technologies must be developed with the health care practitioner and ethical considerations in mind to advance older adults' health status genuinely. It is imperative to tackle fundamental ethical challenges such as transparency, explanation, privacy, legality, protection from cyber-attacks, stability, eliminating bias, and the question of legal jurisdiction in the case of harmful activities. Surviving research tends to disregard these multifaceted problems, which our suggested Ecological network can solve.

This methodology manifests a full-fledged solution, thus giving researchers more options to explore and laying the groundwork for safer and more effective senior care.

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