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The Gan-Dau model: Person-centered integration of ICOPE framework and smart hospital technologies for healthy longevity

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Abstract

As global population aging accelerates, innovative approaches to community-based care for older adults have become imperative. This paper aimed to examine the pioneering Gan-Dau Healthy Longevity Plan implemented by Taipei Municipal Gan-Dau Hospital, which represented a shift in focus for healthy aging through technology-enabled community integration and smart hospital infrastructure. This comprehensive initiative combined the World Health Organization's Integrated Care for Older People (ICOPE) framework with advanced digital health technologies to monitor and enhance intrinsic capacity in community-dwelling older adults. The program deployed multiple innovative technologies including smart mattresses in reducing pressure injury and fall incidence, IoT-enabled intelligent nursing stations providing real-time patient monitoring, circadian-aligned environmental lighting systems that significantly improved sleep efficiency, and facial expression recognition systems for predicting behavioral and psychological symptoms of dementia. These smart hospital technologies function as a "community health control tower," extending beyond institutional walls through community-based sites (Gandaulogy Academy) that integrated digital biomarkers, wearable sensors, and AI-driven analytics for continuous health monitoring. Evaluation studies involving over 1,700 community-dwelling participants across two waves demonstrated that technology-enabled multidomain interventions produced significant improvements in healthy longevity. This paper contributed to the growing evidence supporting integrated, technology-enhanced approaches to healthy aging while highlighting critical considerations for scalability, equity, and ethical implementation. The Gan-Dau model demonstrated that addressing population aging required not merely technological innovation, but thoughtful integration of digital tools within person-centered care frameworks that prioritize human dignity and equity, offering a replicable blueprint for healthcare systems worldwide confronting demographic transitions.

Keywords: Healthy aging, intrinsic capacity, digital health technology, smart hospital, IoT, artificial intelligence

Introduction

The 21st century has witnessed an unprecedented demographic transition, with the global population aged 60 years and older projected to reach 2.1 billion by 2050, nearly doubling from one billion in 2019 (United Nations, 2019). This demographic shift presents profound challenges to healthcare systems worldwide, necessitating innovative approaches to maintaining health and functional capacity in older populations (Beard et al, 2016). As one of the fastest-aging countries in the world, Taiwan has implemented serial strategies to address population aging since the 2000s. To tackle care fragmentation, Taiwan pioneered geriatrician- or trained clinician-led outpatient services integration, which significantly improved care quality and reduced healthcare utilization (Yen et al, 2021). Besides, Taiwan launched multidisciplinary acute geriatric care units and post-acute care services to promote functional recovery and reduce hospitalization-related disability in older patients, including those with frailty and complex care needs (Chen et al, 2010). Moreover, Taiwan implemented mandatory geriatric training for all postgraduate physicians regardless of specialty and required teaching hospitals to maintain adequate geriatric medicine staff (Chen, 2023), while incorporating primary care physicians with geriatric medicine competencies and multidomain interventions that yielded significant improvements in quality of life and chronic disease management (Lee et al, 2021a). A major policy reform was the 2017 transition from Long-Term Care Program 1.0 to 2.0, which prioritized home and community-based services with substantially increased national funding (Hsu & Chen, 2019), established community-based day care centers in each secondary school catchment area (Lee, Yao & Ramoo, 2023), and created a national municipality-based case management system for individualized care assessment and planning (Kuo et al, 2025). Taiwan is now developing the LTC 3.0 Program to enhance seamless integration of social and medical care and has implemented the WHO Integrated Care for Older People (ICOPE) program nationally to facilitate individualized health promotion at the population level (Meng et al, 2022).

In response to these challenges, the Taipei Municipal Gan-Dau Hospital, managed by Taipei Veterans General Hospital, has pioneered an innovative community-based model for healthy aging. Established in 2000 in Beitou District, Taipei, this 328-bed facility has evolved beyond traditional hospital services to become a hub for community health promotion and age-friendly care innovation (Taipei Municipal Gan-Dau Hospital, 2025). The institution launched the Gan-Dau Healthy Longevity Plan—a comprehensive initiative that integrates cutting-edge research with community-based interventions. This paper aimed to examine the technological innovations and community integration strategies embedded within the Gan-Dau Healthy Longevity Plan, with particular emphasis on the smart hospital technologies deployed to enhance patient safety, improve care efficiency, and support healthy aging. Specifically, it analyzes how digital health technologies, artificial intelligence, smart hospital infrastructure, and the WHO ICOPE framework converge to create a sustainable model for promoting healthy aging in community settings. By synthesizing findings from multiple research studies conducted within this initiative and examining the broader landscape of smart hospital technologies in Taiwan, we illuminate the mechanisms through which technology enables early detection of functional decline, personalized interventions, and enhanced quality of life for older adults.

Theoretical framework: WHO ICOPE

The World Health Organization's publication of the Integrated Care for Older People (ICOPE) framework in 2017 marked a fundamental reconceptualization of healthy aging (World Health Organization, 2017). Moving beyond disease-centered approaches, ICOPE emphasized the optimization of intrinsic capacity—defined as the composite of all physical and mental capacities that an individual can draw upon at any point in time. This framework recognized five key domains: cognition, locomotion, vitality, sensory capacity (vision and hearing), and psychological wellbeing (Beard et al, 2019). The ICOPE approach implemented a stepwise care pathway: (1) screening for declines in intrinsic capacity, (2) in-depth assessment of identified deficits, (3) development of personalized care plans, (4) monitoring and support for implementation, and (5) community engagement and caregiver support (Briggs et al, 2018). This person-centered, integrated approach aimed to detect and reverse capacity declines before they progressed to disability and dependence.

Intrinsic capacity represented a paradigm shift from treating individual diseases to maintaining overall functional ability. Research has demonstrated strong associations between intrinsic capacity and critical outcomes including frailty, disability, mortality, and quality of life (González-Bautista et al, 2021). The concept bridged the gap between biological aging and functional outcomes, providing a holistic framework for understanding healthy aging trajectories. Importantly, intrinsic capacity and frailty represented complementary perspectives—the former emphasizing reserves and resilience, the latter focusing on accumulated deficits (Chew et al, 2021). This dual lens enabled both prevention-oriented interventions to maintain capacity and targeted support for those experiencing decline. The ICOPE framework operationalized this concept through validated screening tools that can be administered in primary care and community settings, making systematic assessment feasible at population scale (Leung et al, 2022).

A critical innovation in ICOPE implementation has been the integration of digital health technologies. The WHO has actively promoted the mAgeing program to scale up mobile health technology for intrinsic capacity monitoring (Gonzalez-Bautista et al, 2023). Digital tools enabled continuous, remote assessment of health status through digital biomarkers—ecologically valid, real-world data that captured subtle changes undetectable through episodic clinical evaluations (Piau et al, 2021). The ICOPE MONITOR app and related digital platforms facilitate self-assessment, automatic data integration, and early warning systems for capacity decline (Vellas, 2025). These technologies addressed key implementation barriers including workforce constraints and geographic disparities in healthcare access. Moreover, digital biomarkers enabled longitudinal tracking of intrinsic capacity trajectories, supporting both individual care optimization and population-level research on aging processes. Despite the availability of the ICOPE MONITOR app, its effectiveness in promoting healthy longevity remained constrained due to the absence of a comprehensive ecosystem integrating personal health and lifestyle data for real-time predictive analytics and tailored recommendations. In response to this gap, the Gan-Dau Healthy Longevity Plan was initiated to establish an integrated framework linking healthy longevity services with digital innovation.

The Gan-Dau healthy longevity plan: design and implementation

Based on the aforementioned challenges, Taipei Municipal Gan-Dau Hospital has transformed from a conventional community hospital into an integrated research and care delivery platform. The institution exemplified the "One Branch Hospital, One Community" initiative promoted by the Taipei Veterans General Hospital, extending age-friendly care models to community settings. This strategic positioning enabled the development of the Gan-Dau Healthy Longevity Plan as both a service delivery program and a rigorous research initiative. The Gan-Dau Healthy Longevity Plan targeted community-dwelling adults aged 50 years and older in the nearby communities of the hospital. To assess the overall effectiveness and community-level spillover effects of the intervention, comprehensive evaluations were conducted across two waves utilizing randomly sampled community-dwelling participants, with 810 individuals enrolled in Wave 1 and 981 in Wave 2 (Chen et al, 2024; Peng et al, 2025).

The Gan-Dau Healthy Longevity Plan leveraged multiple technology platforms to enable comprehensive, continuous monitoring of participants' health status. The implementation reflects a multi-layered technology ecosystem:

1. Assessment Technologies: Standardized digital assessment tools captured intrinsic capacity measurements with high reliability and efficiency. Automated scoring algorithms reduced assessment burden on healthcare workers while maintaining rigorous data quality. Tablet-based or computer-based administration enables both clinic-based and community outreach assessments.

2. Data Integration Infrastructure: A comprehensive digital health record system integrated clinical, functional, and psychosocial data across multiple assessment waves. This longitudinal database enabled both clinical decision support and research analyses examining trajectories of aging over time. The research team designed an intrinsic capacity-based predictive algorithm capable of integrating serial health assessments with intrinsic capacity measurements to provide dynamic estimates of healthy longevity and tailored clinical recommendations (Lai et al, 2025).

3. Remote Monitoring Capabilities: The infrastructure supported remote monitoring through digital biomarkers and wearable sensors, enabling early detection of acute changes and proactive intervention.

4. Artificial Intelligence Applications: Advanced analytics and machine learning algorithms analyzed multi-dimensional data to identify patterns, predict outcomes, and generate personalized risk profiles. These AI capabilities supported both clinical decision-making and research discovery of novel aging biomarkers and intervention targets (Tsai et al, 2022).

Smart hospital as the community health control tower

As part of Taiwan's broader initiative to address population aging through technological innovation (Kuo et al, 2016), Taipei Municipal Gan-Dau Hospital has implemented comprehensive smart hospital technologies to enhance patient safety, improve care efficiency, and support the unique needs of geriatric populations. Taiwan's healthcare system has emerged as an important player in smart hospital implementation, driven by the convergence of advanced manufacturing capabilities, robust digital infrastructure, and pressing demographic challenges. The Long-Term Care 3.0 Plan, launched in 2025, continued to emphasize "aging in place" through community-based services supported by technology, with the vision of "10-minute care circles" requiring robust digital infrastructure connecting healthcare providers, community centers, family caregivers, and older adults themselves (Oxford Institute of Population Ageing, 2025). The digital health ecosystem at Taipei Municipal Gan-Dau Hospital comprised the following applications:

1. Intelligent Smart Mattress System

One of the cornerstone technologies in Taipei Municipal Gan-Dau Hospital's smart infrastructure was the deployment of intelligent mattress systems with integrated pressure sensors and patient monitoring capabilities (Wen et al, 2024). These smart mattresses utilized Internet of Things (IoT) technology to provide continuous, non-invasive monitoring of patients without requiring them to wear additional devices. Smart mattresses employed pressure-sensing matrices that continuously monitored pressure distribution across the patient's body surface (Bai et al, 2020). The system automatically detected areas of sustained high pressure that could lead to pressure injury formation. Real-time data was transmitted to nursing stations, enabling timely repositioning interventions before tissue damage occurred. Studies have demonstrated that such systems can reduce pressure ulcer incidence by up to 40% compared to traditional monitoring approaches (Tak et al, 2023).

Integrated sensors within the mattress detected patient movements, including sitting up, position changes, and bed-exit events (Wen et al, 2024). Unlike traditional bed alarms that relied on weight sensors prone to false alarms, smart mattresses use sophisticated algorithms to distinguish between normal position adjustments and genuine bed-exit attempts. A prior study in a Taiwanese medical center demonstrated that IoT-enabled smart patient care systems reduced bedside fall incidence by 88% compared to traditional systems, while simultaneously reducing false alarms by approximately 60% (Wen et al, 2024).

2. Smart Nursing Station System

Taipei Municipal Gan-Dau Hospital has implemented smart nursing station systems that integrate multiple data streams and provide real-time dashboards for coordinated patient care (Zhu, 2024). These systems represented the evolution from traditional paper-based or basic electronic medical records to fully integrated, AI-enhanced care coordination platforms. Large display screens at nursing stations provided visual representation of all patients on the ward, with color-coded indicators showing patient status, pending tasks, and alert conditions. The system integrated data from smart mattresses, bedside vital sign measurements, electronic medical records, laboratory systems, and radiology information systems, providing a comprehensive view of each patient's condition. The intelligent nursing station employed sophisticated alerting algorithms that prioritized notifications based on urgency and clinical significance. The system also tracked medication administration schedules, wound care protocols, repositioning intervals, and other routine nursing tasks, providing automatic reminders to ensure timely completion (Molinari-Ulate et al, 2023).

3. Smart Environmental Lighting System

Environmental factors significantly impacted patient recovery, safety, and wellbeing, particularly for older adults with sensory and cognitive impairments. Taipei Municipal Gan-Dau Hospital has implemented intelligent lighting and environmental monitoring systems tailored to geriatric care needs. Smart lighting systems automatically adjusted color temperature and intensity throughout the day to support natural circadian rhythms via outdoor sensors. Morning light was blue-enriched to promote alertness, while evening light shifted to warmer tones to facilitate melatonin production and sleep preparation. This was particularly important for older adults experiencing age-related circadian disruption or dementia-related sundowning. Motion-activated night lights provided gentle illumination when patients move toward the bathroom or attempt to exit bed, reducing fall risk while minimizing sleep disruption for roommates (Lalitha et al, 2024). Besides, IoT sensors continuously monitored temperature, humidity, air quality (including CO_2 and volatile organic compounds), and acoustic noise levels to optimize patients' recovery from illnesses.

Taipei Municipal Gan-Dau Hospital conducted a case-control study and demonstrated significant benefits of integrating smart humancentric lighting with smart mattress monitoring systems for enhancing sleep quality in nursing home residents. Using pressure sensors embedded in smart mattresses to continuously monitor sleep efficiency across 9,084 records over three months, researchers compared 39 beds equipped with smart lighting against 53 beds with standard lighting. Results showed that residents with smart lighting experienced significantly fewer sleep disturbances and achieved higher rates of good sleep quality, with 52% attaining sleep efficiency above 85% compared to only 41.1% in the standard lighting group. Logistic regression analysis confirmed that smart humancentric lighting significantly increased the likelihood of achieving better sleep efficiency. This integration of smart mattress monitoring with personalized, circadian-aligned lighting represents a promising non-pharmacological intervention for improving sleep quality and reducing reliance on psychotropic medications in institutional care settings (Lan et al, 2023).

4. Facial Expression Recognition System

Facial expression recognition systems (FERS) have emerged as a transformative technology in smart healthcare, with applications spanning patient monitoring, pain assessment, and emotion-based health surveillance in hospital and long-term care settings. Research has demonstrated that automated emotion recognition enables smart healthcare centers to detect depression and stress early enough to initiate timely interventions, with clinical validation showing that emotion monitoring devices can reduce morbidity and mortality rates while enhancing quality of life (Guo et al., 2024). Pain assessment represented one of the most developed applications, where FERS can provide objective and accurate measurements of pain intensity for patients unable to communicate verbally, critically ill patients, and during the perioperative period (Gkikas & Tsiknakis, 2023). Studies have achieved 80-90% accuracy in detecting pain from facial expressions in intensive care units, demonstrating practical applications that improve patient care while relieving healthcare workers from routine workload (Wu et al, 2022).

In dementia care, emotion recognition had particular clinical significance, as impaired emotion recognition may be a key sign facilitating the diagnosis and early treatment of different neurodegenerative diseases. Taipei Municipal Gan-Dau Hospital implemented the FERS system (Chen et al, 2022) in the community centers, providing a compelling example of this technology's potential in geriatric care settings, where the customized FERS achieved 86% accuracy in predicting behavioral and psychological symptoms of dementia (BPSDs) among older participants in a day care center by analyzing negative emotions and emotional variance patterns over seven-day periods. The ensemble method demonstrated strong correlations between predicted and actual Neuropsychiatric Inventory scores, successfully eliminating inter-rater reliability issues and recall bias inherent in traditional informant-based assessments. This noninvasive approach enabled continuous, real-time detection of BPSD changes, facilitating proactive care plan modifications and early nonpharmacological interventions—exemplifying how facial expression analysis can transform reactive crisis management into preventive intervention within smart hospital ecosystems.

5. Integration with Community-Based Healthy Longevity Program

The smart hospital infrastructure at Taipei Municipal Gan-Dau Hospital extended beyond the physical hospital building to support integrated community-based healthy longevity programs (Lee et al, 2021a). The Taiwan Integrated Geriatric Care (TIGER) study was a randomized controlled trial proved that a multidomain intervention integrated into primary care could improve quality of life in community-dwelling adults aged 65+ with multiple chronic conditions. The intervention consisted of physical exercise, cognitive training, nutrition education, and integrated geriatric care, compared to usual care. Results showed the intervention group had significantly higher quality of life, cognitive performance and chronic condition management, with no serious adverse events (Lee et al, 2021a).

Building on the success of the TIGER model, Taipei Municipal Gan-Dau Hospital established multiple community-based sites, designated as Gandaulogy Academy, to facilitate community-wide implementation and dissemination of the intervention, integrating various digital health applications. At Gandaulogy Academy, vital signs, FER data, and physical activity metrics were recorded during activity sessions and automatically transmitted to the hospital information system, enabling physicians to monitor participants' lifestyle behaviors and activity patterns remotely. The previous study has shown that higher baseline cognitive performance was significantly associated with wearable device adoption. Active users demonstrated significantly greater improvements in walking speed compared to non-active users. These findings suggested that active wearable device use substantially enhanced walking speed and physical activity levels, with potential implications for improved functional outcomes and long-term survival in middle-aged and older adults (Lee et al, 2021b).

Discussion

The global landscape of digital health technology for older adults has expanded dramatically, encompassing wearable devices, telemedicine platforms, smart home systems, mobile health applications, and virtual reality interventions (Baig et al, 2019; Chen, Ding & Wang, 2023). These technologies served multiple functions: self-monitoring and activity tracking, cognitive assessment and training, fall detection and prevention, medication management, social connection facilitation, and remote clinical consultation. Key success factors included intuitive interfaces, accessibility features accommodating sensory and cognitive limitations, demonstrated value in maintaining independence, and explicit attention to privacy and data security (Ienca et al, 2021). The "digital divide" remained a significant concern, with socioeconomic disparities in technology access and digital literacy potentially exacerbating health inequities if not proactively addressed through subsidies, training programs, and alternative delivery modes (De Santis et al, 2023).

A telemedicine implementation study during the COVID-19 pandemic utilized the QOCA remote healthcare system to monitor over 800 cases, demonstrating feasibility and effectiveness of remote monitoring for both home-isolated patients and those in hospital wards (Chang et al, 2025). The system integrated IoT physiological monitoring devices with 4G-connected tablets, enabling continuous tracking of vital signs and video consultation capabilities. Central monitoring modules at nursing stations provided real-time dashboards and automated alerts for abnormal conditions, reducing healthcare worker exposure while maintaining high-quality care. AI applications in healthcare for older people have demonstrated substantial promise across multiple domains (Shiwani et al, 2023; Zhao & LI, 2024). A comprehensive scoping review identified six major categories of AI technologies: robots, exoskeleton devices, intelligent homes, AI-enabled health smart applications and wearables, voice-activated devices, and virtual reality (Ma et al, 2023). These technologies served five key roles: rehabilitation therapists, emotional supporters, social facilitators, supervisors, and cognitive promoters. In the specific context of frailty detection—highly relevant to the Gan-Dau initiative's focus—machine learning models have demonstrated strong predictive performance. A study of Thai community-dwelling older adults developed and validated machine learning models using simple demographic and clinical variables (age, gender, household living arrangement, underlying diseases, BMI, waist and calf circumference, and level of exhaustion) to classify frailty status (Isaradech et al, 2025). The models achieved good discrimination ability and were proposed for integration with electronic medical record systems to provide automated frailty probability scores.

The proliferation of digital health technologies for older adults raised ethical considerations. Privacy and data security were paramount, particularly given older adults' potential vulnerability to exploitation and the sensitive nature of health information (De Santis et al, 2023). Robust data governance frameworks must ensure that continuous monitoring would not become intrusive surveillance, that data collection served genuine health purposes with clear benefit to individuals, and that individuals maintain meaningful control over their information. Digital health technologies may inadvertently exacerbate health inequities if access was limited to affluent, educated populations with high digital literacy (Daniels & Bonnechère, 2024). Proactive strategies to ensure equity included subsidizing device costs, providing training and technical support, designing interfaces for diverse literacy levels, and maintaining alternative non-digital care pathways. The Gan-Dau Healthy Longevity Plan community-based outreach model, conducting assessments in community centers rather than requiring clinic visits, exemplified equity-promoting implementation.

Moreover, the emergence of precision geromedicine represented a transformative shift from reactive disease management to proactive, biomarker-guided interventions targeting fundamental aging mechanisms (Chen, 2024; Kroemer et al., 2025). Recent advances in understanding aging hallmarks—including genomic instability, mitochondrial dysfunction, cellular senescence, and epigenetic alterations—have established a scientific foundation for developing personalized anti-aging therapies (López-Otín et al., 2013, 2023). The gene-centric framework enabled pathway-agnostic, scalable genomic methodologies that can identify which gerogenic pathways were overactive or which gerosuppressive mechanisms were deficient in each patient, allowing for tailored interventions (Kroemer et al., 2025; López-Otín et al., 2024). However, translating these discoveries into clinical practice required substantial technological advancement, particularly in developing validated biomarkers of aging that can serve as surrogate endpoints for evaluating interventions (Moqri et al., 2024). The Biomarkers of Aging Challenge demonstrated promising progress in age prediction and mortality modeling (Ying et al., 2024), yet critical barriers remained, including lack of standardization, insufficient individual-level validation, limited data sharing infrastructure, and unclear regulatory pathways (Herzog et al., 2024). Future development demands longitudinal studies with serial multi-omics measurements across age and health strata to characterize temporal dynamics and interindividual heterogeneity, integration of artificial intelligence and machine learning for analyzing complex multi-dimensional data (Chen, 2021; Moon et al., 2025), and comprehensive validation frameworks that stratify biomarkers by age, sex, and demographic factors (Moqri et al., 2024). Only through these technological advances can precision geromedicine realize its vision of comprehensive biological profiling in midlife, personalized recommendations targeting specific aging vulnerabilities, regular biomarker monitoring, and continuously refined interventions that optimize healthspan and extend healthy longevity (Chen, 2024; Guarente et al., 2024).

As population aging continues globally—with individuals aged 60 or older outnumbering children under five for the first time in 2020—the longevity economy is poised for transformative expansion driven by powerful demographic dynamics and technological convergence. The economic incentives are substantial: Scott and colleagues (2021) estimated that slowing aging to produce a 1-year increase in life expectancy is worth US$38 trillion, rising to US$367 trillion for a 10-year increase, with annual gains equivalent to approximately 4-5% of GDP (Scott et al., 2023). These massive valuations created a virtuous circle in which successful interventions in biological aging generated increasing returns—older populations place higher willingness-to-pay values on longevity improvements, better health makes additional life years more economically valuable, and aging treatments themselves increase both population size and average age, amplifying aggregate social benefits (Scott et al., 2021, 2023). Critically, targeting the biological aging process itself yields greater value than addressing individual diseases because it exploits complementarities across multiple age-related conditions and eliminates competing mortality risks, with the authors demonstrating that reducing the joint incidence of age-related diseases is more valuable by approximately 20-30% than the sum of reducing each disease separately (Scott et al., 2021).

Digital health technologies are emerging as powerful accelerators of this longevity economy. Chen and colleagues (2023) argued that digital technologies offered "tremendous potential for shifting from traditional medical routines to remote medicine and transforming our ability to manage health and independence in aging populations". The integration of artificial intelligence with aging research has opened particularly promising frontiers in biomarker development and predictive healthcare. Zhavoronkov and colleagues (2019) demonstrated that AI-driven "deep aging clocks"—biomarkers that predict biological rather than chronological age—"enabled a holistic view of biological processes and allowed for novel methods for building causal models—extracting the most important features and identifying biological targets and mechanisms". Modern deep learning techniques synthesize data from genomics, transcriptomics, proteomics, metabolomics and lifestyle data to provide comprehensive views of the aging process, with applications spanning target identification, drug discovery, and prediction of health trajectories (Zhavoronkov et al., 2019). Advances in medical imaging demonstrated the power of these AI-driven approaches: Pickhardt and colleagues (2025) developed a CT-based biological age model using explainable AI algorithms that significantly outperformed standard demographic data for predicting longevity.

The technological infrastructure supporting digital healthy aging extended beyond diagnostic tools to encompass wearable biosensors and remote monitoring systems. Kim and colleagues (2019) reviewed how wearable biosensors enabled continuous monitoring of biomarkers, with applications in personalized healthcare and early disease detection. The COVID-19 pandemic accelerated adoption of digital health technologies among older adults, with evidence suggesting that telehealth and remote monitoring technologies offered safe and convenient alternatives to in-person healthcare visits, though significant barriers remained (Chen et al., 2023; Evangelista et al., 2019). However, realizing the potential of digital technologies in the longevity economy requires addressing persistent barriers to access and adoption. Chen and colleagues (2023) identified challenges including cost of devices, trust and familiarity with technology, concerns about privacy, physical or cognitive impairments limiting device manipulation, and user interface designs that may not accommodate older users' needs. The COVID-19 pandemic revealed stark disparities, with studies suggesting substantial proportions of older adults unready for video-based telehealth due to inexperience with technology or communication difficulties (Chen et al., 2023). Additionally, the development and validation of AI-based health tools have been criticized for underrepresentation of older adults even in clinical trials for conditions where they comprised the majority of patients, raising concerns about algorithmic bias and equitable access to AI-driven innovations.

The convergence of substantial economic incentives, technological capabilities, and demographic imperatives suggested the longevity economy will increasingly integrate AI-driven predictive healthcare, personalized interventions based on biological age assessment, and digital platforms enabling continuous health optimization throughout the lifespan. As Zhavoronkov and colleagues (2019) concluded, modern AI is "expected to contribute to the credibility and prominence of longevity biotechnology in the healthcare and pharmaceutical industry, and to the convergence of countless areas of research". With cost of age-related chronic diseases projected to reach $47 trillion globally by 2030, and with rising burdens marking what researchers characterize as a new epidemiological transition focused on delaying degenerative diseases (Scott et al., 2021), the development of accessible and effective digital healthy aging ecosystems represents both a multi-trillion-dollar economic opportunity and a critical societal imperative for addressing the healthcare needs of rapidly aging global populations.

Conclusions

The Gan-Dau Healthy Longevity Plan implemented by Taipei Municipal Gan-Dau Hospital represented a transformative model for addressing population aging through the strategic integration of digital health technologies, smart hospital infrastructure, and community-based interventions. This initiative demonstrated that the convergence of WHO's ICOPE framework with advanced technological capabilities—including IoT-enabled monitoring systems, artificial intelligence-assisted clinical decision support, and intelligent environmental controls—can create a sustainable ecosystem for promoting healthy longevity at the population level.

The implications of this model extended across multiple dimensions of geriatric care innovation. First, the integration of smart hospital technologies with community-based health promotion illustrated how healthcare institutions can transcend traditional boundaries to become "control towers" for community health management. Second, the Gan-Dau experience demonstrated the feasibility of implementing precision geromedicine approaches that shift from reactive disease management to proactive optimization of intrinsic capacity. By leveraging digital biomarkers, wearable sensors, and AI-driven analytics, the program will enable continuous monitoring of functional trajectories and early detection of capacity decline before progression to disability. The successful integration of multidomain interventions with digital health platforms has produced significant improvements in quality of life, physical performance, and chronic disease management. These findings suggested that technology-enabled personalized interventions can effectively target the fundamental processes of biological aging rather than merely treating individual age-related diseases. Third, this initiative provided critical insights into the economic and societal value proposition of investing in healthy longevity infrastructure. Given that slowing aging to achieve even modest increases in life expectancy generates economic value measured in trillions of dollars, and that the burden of age-related chronic diseases continues to escalate globally, the Gan-Dau model illustrated how strategic deployment of digital technologies can create both immediate clinical benefits and long-term returns on investment through prevention of frailty, reduction of healthcare utilization, and maintenance of functional independence. The integration of research and service delivery within a single institutional framework accelerates the translation of scientific discoveries into practical applications while generating rigorous evidence to guide policy and practice.

However, realizing the full potential of this model requires careful attention to critical challenges. The digital divide remained a persistent barrier, with disparities in technology access, digital literacy, and user interface design potentially exacerbating health inequities rather than ameliorating them. The Gan-Dau approach of establishing community-based sites (Gandaulogy Academy) that provided both technological infrastructure and human support represented one strategy for promoting equity, but sustained efforts in subsidizing devices, providing training programs, and designing age-friendly interfaces remained imperative. Privacy and data security considerations demand robust governance frameworks that balance the benefits of continuous monitoring with respect for individual autonomy and protection against surveillance overreach. The ethical implementation of AI-assisted healthcare tools required addressing algorithmic bias, ensuring transparent decision-making processes, and maintaining meaningful human oversight.

Looking forward, the Gan-Dau Healthy Longevity Plan offers a blueprint for healthcare systems worldwide grappling with demographic transitions. The model's emphasis on community integration, multi-stakeholder collaboration, and technology-enabled person-centered care aligns with global imperatives to develop sustainable approaches to healthy aging. As precision geromedicine advances through improved biomarker validation, multi-omics integration, and AI-driven predictive analytics, initiatives like Gan-Dau will serve as essential testbeds for translating scientific innovations into population health improvements. The convergence of substantial economic incentives, demographic imperatives, and technological capabilities suggests that the longevity economy will increasingly depend on integrated digital health ecosystems capable of supporting continuous health optimization throughout the lifespan. Ultimately, the Gan-Dau experience demonstrated that addressing population aging required not merely technological innovation, but thoughtful integration of technology within frameworks that prioritized human dignity, equity, and person-centered care. By positioning smart hospitals as community health control towers that extended care beyond institutional walls, and by combining cutting-edge digital tools with evidence-based multidomain interventions grounded in the ICOPE framework, Taipei Municipal Gan-Dau Hospital has established a model that other institutions and healthcare systems can adapt to their local contexts. As global populations continue to age, such integrated, technology-enhanced approaches to healthy longevity will become increasingly essential for maintaining quality of life, optimizing healthcare resource utilization, and realizing the vision of societies where people can age with health, dignity, and independence.

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