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Responding to a super-aged society: A community-based model for early frailty detection using AI and smart meter data – Insights from Japan

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Abstract: Japan, at the forefront of a super-aged society where individuals age 65 and older constitute 29.3% of the total population, faces an urgent need for early detection of and intervention in reversible geriatric syndromes known as frailty to prevent older adults from becoming dependent on long-term care. One notable innovation is the frailty detection service "e-Frail Navi", which began operational in 2023 following pilot testing since 2020. This service analyzes household electricity consumption patterns using AI, sending alerts to municipal welfare departments when unusual behavioral patterns are detected, enabling early intervention through professional home visits. A groundbreaking community-based integrated care model leveraging digital technology, 29 municipalities have adopted it as of June 2025. However, several challenges remain regarding the use of such technology, including issues with the accuracy of frailty assessment, ethical and legal concerns, and the potential barriers to use posed by disparities in digital literacy and economic circumstances.

***Keywords*:** super-aged society, frailty, screening, AI system

1. Introduction

Population aging has become a serious global issue. According to reports from the World Health Organization (WHO), by 2030, one in six people worldwide will be age 60 years or older; by 2050, the global population age 60 years or older will double, reaching 2.1 billion; and the population age 80 years or older is estimated to triple between 2020 and 2050, reaching 426 million (*1*). Japan is also experiencing an unprecedented demographic shift. According to the annual report on an Aging Society published by the Cabinet Office in 2025 (*2*), the population age 65 and above has reached 36.24 million, accounting for 29.3% of the total population. This percentage is projected to rise to 30.8% by 2030. Amidst this rapid demographic shift toward an aged society, the health of older adults has become an increasingly pressing concern.

Frailty is a clinical syndrome in older adults and is characterized by progressive decline in physiological reserve and increased vulnerability to external stressors. It results in a heightened risk of postoperative complications, higher hospitalization rates, a longer duration of hospitalization each year, and increased mortality, marking it as a significant public health concern (*3,4*). According to a meta-analysis, the global prevalence of frailty among community-dwelling older adults ranges from 12% to 24%, based on data from 1,755,497 participants across 62 countries and regions (*5*). A Japanese epidemiological study (*6*) has reported that the prevalence of frailty among older adults age 65 and above is 8.7%, while approximately 40.8% are classified as prefrail. This indicates that nearly half of the older population in Japan faces health risks associated with frailty. However, frailty is influenced by a wide range of factors. In addition, frailty is a serious concern across all regions of Japan, as shown in Figure 1. According to one review, over 30 different factors have been identified as contributing to its development (*7*). That said, a reassuring fact is that frailty is a dynamic and reversible geriatric syndrome that lies between self-reliance and the need for care and is reversible. Reasonable preventive interventions can help older adults resume living independently (*8*).

How to identify frailty more accurately has become an urgent priority worldwide. There is no established gold standard for frailty screening globally. The most direct and effective tool for assessing frailty is the Frailty Screening Tool, but since there is no globally recognized gold standard, each country has adopted its own

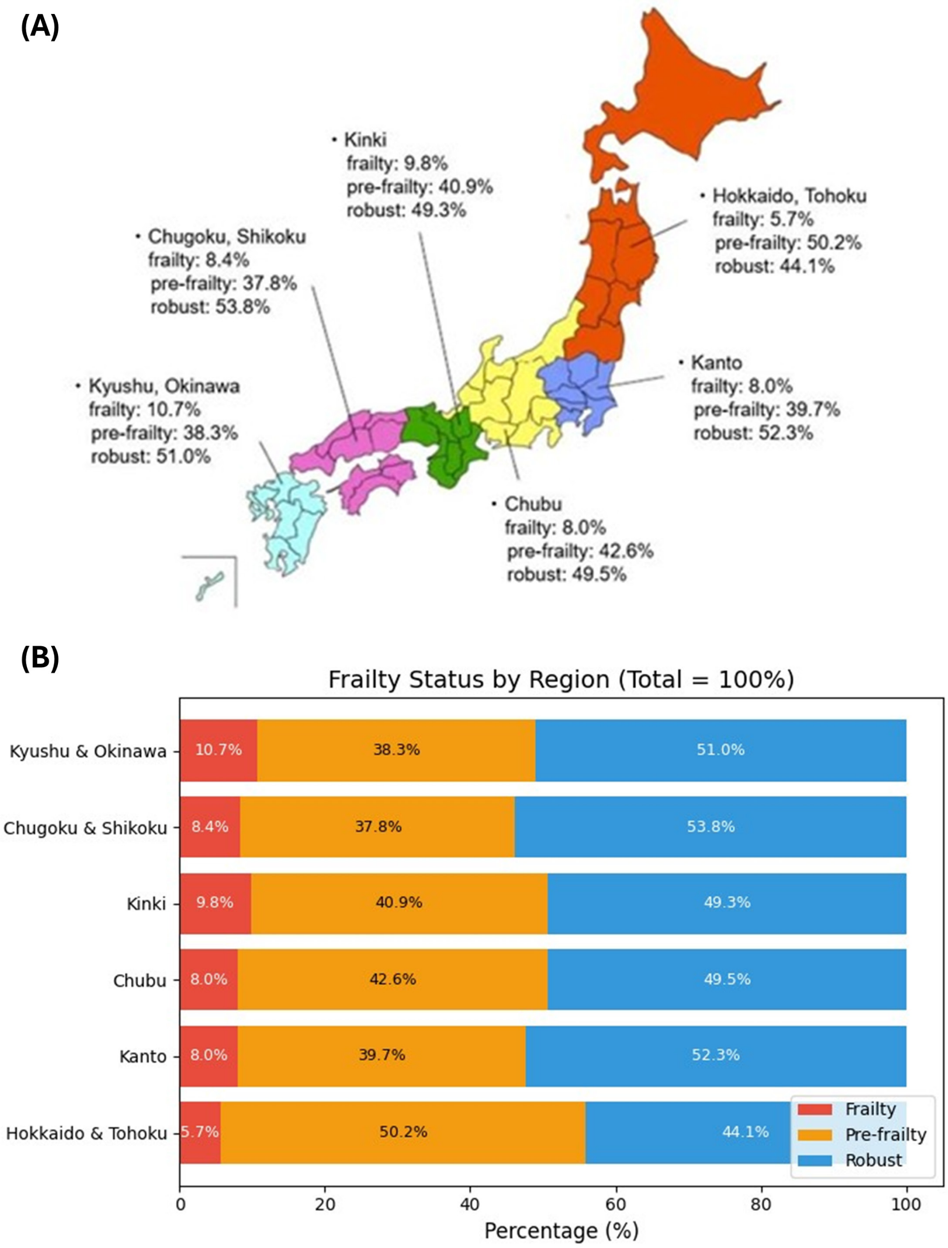

Figure 1. Frailty status by region in Japan. (A) The prevalence of frailty by region; **(B)** The breakdown for each region. *Data source*: *https://www.tmghig.jp/research/release/2020/0903.html*.

evaluation scale for domestic use (*9*).

In Japan, two primary methods are used to evaluate frailty: One is the Japanese version of the Cardiovascular Health Study frailty criteria (J-CHS) (*10*), which were developed based on Fried *et al*.'s phenotype model and the Cardiovascular Health Study (CHS) criteria, and which were revised in 2020. Another approach utilizes the Frailty Index (FI) based on the accumulation deficit model proposed by Rockwood *et al*. (*11*).

Conventional frailty assessments often relied on face-to-face, time-limited, subjective screening methods. This has led to concerns about difficulty in accurately evaluating individuals' daily living situations (*12*). Therefore, innovative, scalable, and non-intrusive methods of monitoring are needed to bridge the gap.

2. Technological innovations in Japan: Using electricity data and AI to prevent frailty

Japan has adopted significant measures to address the limitation of conventional frailty assessment methods through technological innovation. The integration of household electricity usage data with artificial intelligence (AI) algorithms has emerged as a promising approach for early detection and monitoring of frailty (*13*). As shown in Figure 2, one pioneering effort in this field is "e-Frail Navi", a frailty detection service developed by Chubu Electric Power and data science company JDSC since 2020 and officially launched in April 2023.

The frailty detection service "e-Frail Navi"

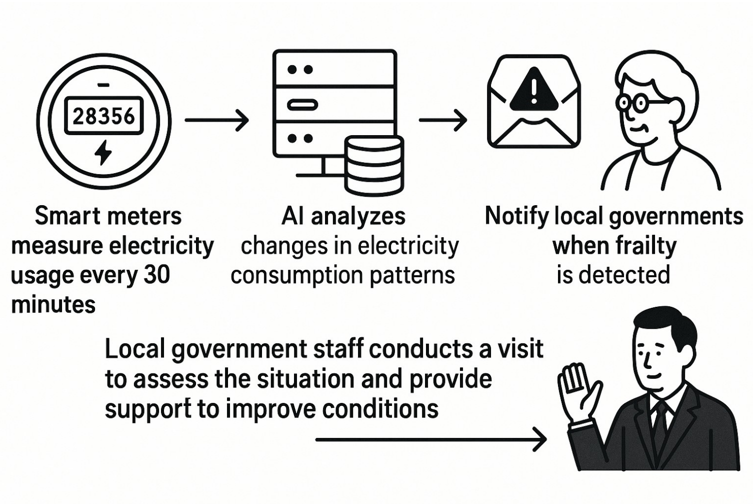

Figure 2. Structure of the frailty detection service "e-Frail Navi". *Data source*: *https://business-development.chuden.co.jp/service/e-frailtynavi.*

collects anonymized power consumption data from smart meters in individual households, particularly focusing on single-person elderly households. By analyzing fluctuations in electricity usage over time — such as changes in appliance use, cooking times, or heating patterns — the AI algorithm can infer daily routines and detect deviations that may indicate early signs of physical or cognitive decline. For instance, a noticeable delay in morning electricity use could suggest delayed waking and may signal fatigue or depression. Similarly, decreased evening activity may signal social withdrawal or mobility issues. Reduced usage of kitchen appliances may reflect decreased appetite or difficulty preparing meals — both of which are associated with frailty. Importantly, this approach requires no active participation from the older adult and is thus suitable even for those with cognitive impairment or reluctance to use wearable technology. When behavioral anomalies are detected, alerts are sent to municipal welfare departments to enable early intervention. Several municipalities have already incorporated this system into their community-based integrated care networks. This technology aligns with national policy goals of promoting "aging in place", preventing the progression of frailty, and reducing unnecessary hospitalizations and long-term care facility placements.

The practical implementation of AI-powered frailty monitoring systems has opened up new pathways for the integration of digital tools into eldercare. Moving forward, such systems could go beyond detecting frailty to identifying other age-related risks, such as dementia. At the individual level, further technological advances are expected to enable AI to establish personalized behavioral baselines and gradually improve the sensitivity and specificity of its predictions over time. From a societal perspective, such systems could transform community-based care models by providing a comprehensive understanding of individuals' health status and facilitating the formulation of personalized care plans.

Moreover, in the context of an aging population and declining birthrate, AI technologies can help reduce the burden on human caregivers and alleviate workforce shortages in the healthcare sector while maintaining the quality of care. For families living far from their elderly relatives, timely updates on their condition can provide reassurance and peace of mind.

3. Global uses and challenges

Many countries are integrating AI in healthcare. In the United States, Medicare-supported initiatives have the potential to incorporate AI-powered monitoring technologies into home healthcare services (*14*). The United Kingdom's NHS Long Term Plan advocates for digital health monitoring for older adults (*15*), and Germany's Digital Health Act encourages the utilization of digital health applications (*16*). However, few of these programs have specifically focused on early detection of frailty. Japan's AI-powered frailty monitoring model provides a scalable template and serves as a valuable reference for other countries seeking to enhance preventive care for aging populations. As of fiscal year 2023, 3 municipalities had adopted the system, with 10 additional adoptions expected in 2024 and a further 27 projected for 2025 (*17,18*). Additionally, since August 2025, a pilot program has been conducted to test an app designed to provide personalized guidance and feedback in coordination with the service (*19*).

However, several challenges exist for global adoption of this approach. First, there are concerns about the accuracy of this system as a tool for early detection of frailty. While empirical studies have reported accuracy rates exceeding 80%, with 8 out of 11 individuals diagnosed with frailty showing improved health status (*17*), accuracy varies among municipalities from year to year, indicating room for further improvement. As this technology is adopted in more regions and the volume of data increases, its accuracy and practical utility can be verified and improved. Second, ethical and legal considerations are crucial. Issues such as data privacy, informed consent, and algorithmic transparency must be addressed. According to a survey by Mizuho Research & Technology, as of February 2025, there were 800 eligible participants in the surveyed regions, with approximately 160 actual users (*20*). Public trust in AI systems can be enhanced through robust governance frameworks, community education, and participatory design approaches that involve elderly individuals and their families in the development process. Third, disparities in digital literacy and economic status may limit the adoption of these technologies among vulnerable populations. In low- and middle-income countries, infrastructure limitations such as unreliable electricity supply and a low rate of smart meter usage can be significant barriers to implementation. Finally, establishing a global consensus on ethical standards and data governance is essential for the responsible use of AI in health-related contexts. The WHO and other international health organization can play a key role in providing policy guidelines to ensure safety, equity, and effectiveness.

4. Conclusion

Frailty monitoring using power consumption data and AI represents a promising frontier in geriatric care. Japan's experience provides valuable insights into the practical implementation, benefits, and challenges of this innovative approach. Amidst the global trend of aging, scalable and non-intrusive monitoring technologies will become essential components to support preventive care, enable early intervention, and promote healthy aging. By fostering cross-sectoral collaboration and international exchanges of knowledge, these tools can contribute to more resilient and responsive eldercare systems worldwide.

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