

Research on Digital Approaches to Improving the Quality of Elderly Care Services

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Abstract: *Background:* The global aging population is increasing rapidly, creating an urgent demand for high-quality elderly care services. Traditional care models are often constrained by limited personnel, slow response times, and fragmented health information. *Objective:* This study aimed to evaluate the effectiveness of digital approaches—including Internet of Things monitoring, artificial intelligence demand-matching systems, and remote health management—in improving the quality of community-based elderly care services. *Methods:* A case study was conducted in a Shanghai community that implemented a digital elderly care project. Data were collected over 12 months post-implementation. Key performance indicators such as emergency response time, service matching accuracy, and rescue success rates were compared before and after the digital transformation using descriptive analysis. *Results:* The implementation of digital technologies led to significant improvements: health emergency warning response time decreased from 4 hours to 15 minutes; service demand matching accuracy increased from 65% to 92%; and the emergency rescue success rate improved from 70% to 100%. Additionally, annual hospitalization rates decreased, and service satisfaction scores rose. *Conclusion:* Digital approaches can effectively transform elderly care from a reactive to a proactive model, significantly enhancing service efficiency, health outcomes, and user satisfaction. However, challenges such as low digital literacy among the elderly and data security risks must be addressed. This research provides empirical evidence supporting the digital transformation of elderly care services.

Keywords: Digital approaches; Elderly care services; Internet of Things; Artificial intelligence; Remote health management; Service quality

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1. Introduction

The World Health Organization ^[1] projects that the global population aged 60 and over will reach 2.1 billion by 2050, representing 22% of the world's population. In China, a significant proportion of older adults prefer community-based home care, which blends independent living with external support ^[2]. However, traditional community elderly care services, reliant on manual operations, face several critical limitations.

First, health monitoring is predominantly passive. Older adults are at risk of sudden health incidents, such as hypertensive crises or falls. Traditional models depend on periodic home visits or self-reporting, often leading to delayed detection. A 2013 survey across 15 Chinese communities indicated that 45% of emergency health issues were not identified in a timely manner due to warning delays ^[3].

Second, service matching is inefficient. The allocation of resources like caregivers and meal delivery staff is done manually, frequently resulting in supply-demand mismatches. For instance, older adults with disabilities often wait more than 24 hours for nursing services ^[4].

Third, emergency response systems are fragmented. Coordinating between community centers, hospitals, and families in real time is challenging. The average emergency response time in suburban areas exceeds 25 minutes ^[5].

Digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), and remote management platforms offer potential solutions to these issues by enabling real-time data flow, intelligent analysis, and multi-party coordination. This study investigates the application of these digital approaches through a community-based case study. The primary aim is to assess their effectiveness in improving key service quality indicators and to identify associated challenges and solutions.

2. Core applications of digital approaches in elderly care services

2.1. IoT-enabled continuous health monitoring

IoT technology facilitates the unobtrusive and continuous collection and analysis of health data. Three primary device types were implemented:

Wearable devices: The elderly were provided with smart bracelets that integrated sensors for heart rate, blood pressure, and fall detection. Data are automatically uploaded to a community health platform. Alerts are sent to community nurses and family members via mobile phone if parameters exceed safe thresholds, such as a heart rate over 100 beats per minute or blood pressure exceeding 160/100 mmHg. This reduced the average time to detect health problems from 8 hours to 10 minutes.

In-home devices: Smart mattresses for sleep monitoring and smart gas detectors were installed. In 2023, these smart beds detected 12 cases of nocturnal respiratory distress in the Shanghai community, all of which received timely medical intervention.

Self-service health kiosks: Robot-assisted kiosks in community centers allow older adults to measure blood glucose, blood oxygen, and bone density. Results are uploaded to personal health records, increasing the annual health check-up coverage from 55% to 89%.

2.2. AI-driven service demand matching

AI algorithms optimize resource allocation by integrating demand and supply information.

Demand intelligent collection: The elderly or their family members submit service requests, such as weekly bathing assistance or daily meal delivery, through a community application. The system automatically categorizes these requests into types like daily care or rehabilitation and labels them with an appropriate priority level.

Resource matching: The platform stores caregiver data, including professional qualifications like a disabled care certificate, location, and availability. It matches the most suitable caregiver based on this data; for example, pairing a caregiver with rehabilitation training with a post-stroke patient.

Quality feedback loop: After service completion, users rate the service via the app. This feedback is used to

refine future matching algorithms. In the Shanghai case, AI matching reduced the average service response time from 24 hours to 3.5 hours and increased service satisfaction from 68% to 91%.

2.3. Remote emergency rescue collaboration

A “user-community-hospital” remote collaboration system was established to enhance emergency response.

One-click alert linkage: Older adults use smart bracelets or in-home emergency buttons to call for help. The community care center receives the alarm and confirms it by phone within 30 seconds, while the system automatically dispatches nearby volunteers or medical staff.

Telemedicine integration: The community cooperates with local hospitals on a teleconsultation platform. When an elderly person calls for help due to sudden discomfort, community nurses can initiate a video call with hospital doctors for immediate treatment guidance. In 2023, this platform successfully managed 32 suspected cases of myocardial infarction or hypoglycemia in the Shanghai community, preventing 8 from developing into severe heart attacks.

Route optimization: The system automatically calculates the shortest path to the emergency location based on real-time traffic information and notifies family members via SMS. This reduced the community’s average emergency response time from 25 minutes to 12 minutes.

3. Methodology

3.1. Study design and setting

A single-case study design was employed to conduct an in-depth evaluation of a digital elderly care project implemented in a residential community in Shanghai, China. The project was launched in January 2023. This case study was conducted as part of a community service quality improvement project. Verbal informed consent was obtained from all elderly participants and/or their legal guardians for the use of anonymized, aggregated performance data. The study protocol adhered to the ethical guidelines of Shanghai Jian Qiao University.

3.2. Participants

The study setting involved a total of 586 home-dwelling older adults within the community, 32% of whom were registered as disabled or semi-disabled. All elderly residents enrolled in the community’s care program were included in the service delivery evaluation. Community administrative staff, caregivers, and technical service providers were also engaged in the process analysis.

3.3. Intervention

The digital transformation package included: (1) Deployment of IoT devices such as smart bracelets, smart mattresses, gas detectors, and self-service health kiosks; (2) Implementation of an AI-powered service matching mobile application; and (3) Establishment of a remote emergency rescue coordination platform. The project was funded by a local government grant (approximately \$150,000 USD) with technical support from a healthcare technology company.

3.4. Data collection and analysis

Operational and performance data were collected from the digital system’s backend and community service records for the 12-month period following implementation (January to December 2023). Pre-implementation baseline data

were obtained from community archives for the preceding 12-month period. Key performance indicators (KPIs) included health emergency warning response time, service demand matching accuracy, emergency rescue success rate, annual hospitalization rate, and service satisfaction scores collected via the app’s feedback module. To ensure data quality, IoT devices were calibrated monthly, and service records were cross-verified by community staff. Data analysis involved descriptive statistics to calculate means, percentages, and improvement rates for comparing pre- and post-implementation performance using Microsoft Excel.

4. Case study results: Digital transformation in a Shanghai community

4.1. Case overview

As described in the Methodology (Section 3), the project was implemented in January 2023 in a Shanghai community with 586 home-dwelling older adults.

4.2. Application effects

The digital transformation led to significant improvements across all measured KPIs within the first 12 months, as summarized in **Table 1**.

Table 1. Performance improvements after digital transformation

KPIs	Before digital transformation	After digital transformation	Improvement rate
Health emergency warning response time	4 hours	15 minutes	93.75%
Service demand matching accuracy	65%	92%	41.54%
Emergency rescue success rate	70%	100%	42.86%
Annual hospitalization rate of elderly users	18%	14%	22.22%
Service satisfaction score	68/100	91/100	33.82%

5. Challenges and targeted countermeasures

5.1. Low digital literacy of the elderly

A survey within the community revealed that only 35% of older adults (aged 65+) could operate smart devices independently, which aligns with broader findings on the digital divide among this population ^[6]. To address this issue, the following countermeasures were implemented:

Age-friendly design: Interfaces were simplified with large icons, voice control, and essential functions only, such as a one-click alarm button.

Structured training: Community volunteer staff conducted weekly hands-on training sessions, using illustrated manuals and step-by-step demonstrations, such as teaching the elderly how to submit a meal delivery request in three simple steps.

5.2. Data security and privacy risks

Concerns regarding the potential leakage of sensitive health data were a significant barrier to adoption. The following measures were taken to mitigate these risks:

Encrypted data storage: Collaboration with technology providers ensured the implementation of end-to-end

encryption for all data transmission and storage.

Governance agreements: Confidentiality contracts were signed with all involved parties, including technology providers and caregivers, and semi-annual data security audits were instituted.

5.3. High initial implementation costs

The upfront investment for devices and software posed a challenge, particularly for communities with limited budgets. Mitigation strategies involved a multi-stakeholder cost-sharing model:

Government subsidies: Application for local elderly care innovation funds covered 50% of the device costs.

Cost-sharing models: A portion of the community's existing elderly care budget (20%) was allocated for platform maintenance. Families opting for premium services such as 24/7 remote rescue contributed a small co-payment of \$2 to \$3 per month, a model shown to enhance sustainability^[7].

6. Conclusion

Digital approaches, encompassing IoT, AI, and remote collaboration, fundamentally shift elderly care from a reactive to a proactive and preventive model. The Shanghai case study demonstrates that these technologies can significantly enhance service efficiency, improve health outcomes, and increase user satisfaction. However, persistent challenges such as the digital divide among the elderly and data security require continuous attention.

Future research could explore the integration of emerging technologies like AI-powered social companion agents and 5G-enabled remote rehabilitation. For policymakers and community managers, the priority should be to balance technological innovation with inclusive, elderly-centric design to ensure equitable access and foster the sustainable development of high-quality elderly care services globally.

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Disclosure statement

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