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Proposing a Model for Designing Smart Health-Oriented Products and Services for the Elderly Based on Cognitive Factors

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A B S T R A C T

Purpose: This study aimed to design and validate a cognitive-based smart health-oriented product–service system (PSS) model tailored for elderly care in social security organizations.

Methods and Materials: A qualitative exploratory approach was employed to identify and structure the key dimensions, components, and indicators of the proposed model. Data were collected through semi-structured interviews with 12 experts, including managers, health technology specialists, university faculty, and policymakers in the field of elderly care. Thematic analysis was applied to the transcribed interview data using a two-level coding process—textual and conceptual. The final model was synthesized through iterative categorization and expert consensus validation, comprising both functional system elements and a quality evaluation framework.

Findings: The results identified four core dimensions of the smart PSS: (1) business model, (2) software (cloud) platform, (3) cognitive–biological factors, and (4) physical platform. Each dimension consists of multiple components (totaling 16) and operational parameters (61 indicators). Additionally, a multidimensional quality assessment framework was developed with four evaluation constructs: outcome quality, interaction quality, system quality, and stakeholder satisfaction. The model emphasizes user-centricity, real-time personalization, integration of digital infrastructure, and AI-driven monitoring. Elderly users were positioned as co-creators of value, with service adaptation based on continuous feedback and emotional-cognitive profiling. The model integrates both physical and cyber infrastructure to support comprehensive care delivery.

Conclusion: The proposed smart health-oriented PSS model offers a comprehensive, adaptable, and intelligent framework for improving elderly care services in social security contexts.

Keywords: *Smart Product-Service System, Elderly, Insurance System, Cognitive Factors, Thematic Analysis.*

1. Introduction

The unprecedented demographic transformation driven by population aging poses one of the most profound challenges of the 21st century. According to recent projections, the proportion of elderly individuals is rapidly increasing across many countries, particularly in China, where shifts in population structure are pressuring social security organizations to provide more efficient and intelligent elderly care services. This surge in demand is compounded by a heightened expectation for personalized, accessible, and high-quality services that preserve autonomy and dignity in later life. These developments necessitate a departure from traditional care models toward integrated, smart product–service systems that harness advanced technologies, especially artificial intelligence (AI), digital platforms, and sensor-based devices, to deliver holistic, user-centered, and responsive care solutions (Bai, 2023; Peng et al., 2021).

Smart health-oriented product–service systems (PSS) offer a synergistic model that combines tangible products (e.g., wearable health monitors, home robotics) with intangible services (e.g., telemedicine, digital diagnostics), enabled by networked digital infrastructure. This model is particularly vital in elderly care, where real-time responsiveness, continuity of monitoring, and customization are essential to meeting the complex needs of older adults (Zhao, 2024). By integrating AI-driven decision support, sensor data analysis, and cloud-based services, smart PSS can enhance operational efficiency, user satisfaction, and health outcomes simultaneously. Research shows that such systems reduce the burden on human caregivers while empowering the elderly to take a more active role in managing their health and well-being (Liu, 2024; L. Zhou et al., 2023).

In the context of Chinese social security organizations, the transformation toward intelligent elderly care systems is not merely a matter of technology deployment but also one of organizational, spatial, and cultural adaptation. Several studies emphasize the need for rethinking the spatial distribution of services and resource allocation strategies, particularly in urban centers where population density and service demand are high (Cheng et al., 2022; Zhou & Cao, 2023). Equally, rural regions exhibit disparities in access and quality, requiring context-specific designs for equitable care delivery (Li et al., 2023). Addressing these inequalities necessitates multidimensional strategies that incorporate spatial optimization, needs-based resource distribution, and community-level engagement.

The evolution of AI and telemedicine technologies has further catalyzed this transition. For instance, AI-powered service robots are increasingly utilized to support bedridden or disabled elderly individuals in their homes, performing tasks such as medication reminders, mobility assistance, and emergency response (Wang, 2024). These solutions align with broader shifts in healthcare toward decentralized and home-based models. Similarly, smart assistants for biometric data monitoring can detect abnormalities in vital signs and automatically notify caregivers or emergency services, thereby enhancing safety and responsiveness (Das et al., 2023; Fukunishi & Kobayashi, 2023). Such technological capabilities are particularly beneficial in scenarios where professional caregivers are unavailable or in short supply.

Importantly, these advancements also reflect a broader movement toward person-centered care and co-creation of value between providers and users. Involving the elderly in the design and customization of services not only improves usability but also fosters a sense of agency and satisfaction (Z. Zhou et al., 2023). Studies grounded in the Kano model and user feedback systems demonstrate that preferences among older adults are highly heterogeneous, influenced by cognitive status, digital literacy, and social support systems (Nga, 2023; L. Zhou et al., 2023). Therefore, personalization, adaptability, and feedback integration are critical to the design of successful smart PSS.

In addition to the technological and organizational dimensions, regulatory and ethical considerations also play a pivotal role. Ensuring data privacy, user consent, and alignment with governmental standards is indispensable for the deployment of AI-based health services (Chen et al., 2022; Zhou et al., 2022). Furthermore, developing robust legal frameworks that regulate platform interoperability, accountability, and quality assurance is essential to gain public trust and institutional support. This is particularly pertinent in the context of teledentistry and remote

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diagnostics, where concerns about accuracy and liability are heightened (Thalib, 2022).

From a systems design perspective, a comprehensive smart PSS model for elderly care should comprise four interrelated dimensions: the business model, software (cloud-based) platform, cognitive–biological factors, and physical platform. The business model defines the service logic, value proposition, and financial flow, including actors such as medical institutions, pharmacies, insurance entities, and health service startups (Li, 2022). The software platform facilitates data acquisition, user interaction, and decision-making through cloud services, mobile applications, and AI algorithms. The cognitive–biological layer captures real-time physiological and behavioral data from users, enabling predictive analytics and personalization. Finally, the physical platform includes delivery infrastructure, digital wearables, and embedded devices that bridge the cyber–physical interface.

Equally critical is the dynamic interaction between users (elderly individuals), service providers, and system interfaces. Studies emphasize that elderly users are not passive recipients of care but active participants whose feedback, needs, and behaviors continuously inform system evolution (Lam et al., 2021; Z. Zhou et al., 2023). This co-evolutionary dynamic fosters continuous innovation and quality improvement, particularly when augmented by AI-based data analysis, gamification, and UI/UX design frameworks tailored to cognitive and sensory limitations of older adults.

Moreover, quality evaluation of smart PSS for elderly care demands a multidimensional framework. Indicators should assess not only technical functionality (e.g., system uptime, data security, responsiveness) but also user satisfaction, emotional engagement, and care outcomes. Research in home-based elderly care services and community mutual aid platforms highlights the importance of trust, transparency, and post-service support in ensuring the sustainability of smart service ecosystems (Bai, 2023; L. Zhou et al., 2023).

The transition to smart health-oriented PSS in elderly care also intersects with broader socioeconomic and public health trends. Increasing life expectancy and the urban–rural aging gap necessitate long-term strategic planning and investment in digital infrastructure (Li et al., 2023; Peng et al., 2021). Furthermore, COVID-19 accelerated the demand for contactless and telehealth services, reinforcing the importance of digital transformation in elderly care systems (Lam et al., 2021). As such, integrating AI and digital tools is not a transient trend but a structural imperative for the future of care.

In summary, the shift toward intelligent, data-driven, and user-centered elderly care systems presents both opportunities and challenges. While the potential for improved outcomes, efficiency, and accessibility is evident, successful implementation requires interdisciplinary collaboration, ethical safeguards, policy support, and continuous user engagement. This study responds to these needs by developing a comprehensive model of a smart health-oriented product–service system tailored to the requirements of elderly populations served by social security organizations.

2. Methods and Materials

In the present study, a qualitative method and an inductive approach were employed to achieve the research objectives. This approach was selected because the researcher aimed to explore the phenomenon through an exploratory study and analyze and interpret the data collected from individuals in depth. The purpose of this study was to collect, analyze, and categorize the opinions, thoughts, and ideas presented by organizational and academic experts who were interviewed as the sample. The data were primarily qualitative in nature; therefore, this study follows a qualitative research design, analyzed based on the systematic grounded theory approach by Strauss and Corbin.

Data collection was conducted through in-depth and semi-structured exploratory interviews (based on the research questions and interview protocols) with participants in the study. In thematic analysis, the data type is primarily first-hand (primary) data, which can be obtained through interviews and extraction. The richness of the data that can be drawn from in-depth approaches (such as deep interviews) makes qualitative research particularly valuable in applied domains such as industrial engineering. The final interview questions were derived from the research questions.

Thematic analysis, in general, is conducted at two main levels: textual and conceptual. The textual level involves segmenting and organizing data files, coding the data, and writing analytical memos (disaggregation and breakdown of data). The conceptual level focuses on model development, including linking codes and integrating and relating data. Accordingly, due to the researcher's theoretical sensitivity, the interview transcripts were reviewed and coded multiple

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times. Some concepts and categories were renamed, removed, or added. Overall, both levels of analysis were utilized in this study.

The statistical population of the current study included managers and specialists in the field, such as: directors from the Cognitive Technologies Development Headquarters under the Vice-Presidency for Science and Technology, university faculty members, managers of social security organizations, experts in digital transformation, and healthcare managers and staff in the field of geriatrics. Table 2 provides the demographic characteristics of the expert participants.

In qualitative research, two main sampling methods are typically employed: snowball sampling and purposive judgmental sampling. Both are non-probabilistic and non-random, meaning the researcher consciously selects participants based on their familiarity with the research population. In this study, purposive judgmental sampling was used. The expert panel was identified and selected based on the following criteria: willingness to participate in the research field, theoretical knowledge on the research topic, active involvement at various organizational levels, and a minimum of 10 years of organizational experience in the relevant domain.

Table 1

Descriptive Statistics of Demographic Characteristics

Demographic Category	Demographic Variable	Frequency	Percentage	Cumulative Percentage
Gender	Male	10	80%	80%
	Female	2	20%	100%
Education	Bachelor’s	1	8.2%	8.2%
	Master’s	1	8.2%	16.4%
	Ph.D.	10	83.6%	100%
Age	30–40	2	16.7%	16.7%
	41–50	5	41.7%	58.4%
	51–60	4	33.4%	91.8%
	Above 60	1	8.2%	100%
Years of Experience	10–15	1	8.2%	8.2%
	16–20	3	25.05%	33.25%
	21–25	3	25.05%	58.3%
	Over 25	5	41.7%	100%
Occupational Role of Experts	Cognitive Technologies Development HQ	1	8%	8%
	University Faculty	3	25%	33%
	Social Security Organization Managers	4	33%	67%
	Digital Transformation Experts	2	17%	83%
	Geriatric Healthcare Managers/Staff	2	17%	100%

3. Findings and Results

This study employed semi-structured interviews with an emphasis on an exploratory approach. This decision was based on the objective of the research, which was to conduct an in-depth investigation of the smart health-oriented product-service system and to identify its dimensions, components, and indicators through a qualitative methodology. To design the interview questions, the researcher first reviewed existing literature on smart health-oriented product-service systems and referred to previous qualitative studies in this field. Based on this review, a set of questions was selected as the core questions for the research to facilitate the extraction of relevant data during the interviews. Part of the interview questions was developed with reference to reputable sources, while the remaining questions were formulated based on the researcher’s field observations and personal reflections.

Before conducting the interviews, arrangements were made in person and by telephone regarding the possibility and scheduling of the sessions. Despite extensive efforts, interviews could not be conducted with all targeted individuals due to various reasons, such as some participants' unwillingness to engage and other logistical constraints. Ultimately, 12 expert managers from the fields outlined in Table 2 were interviewed. At the beginning of each session, the overall purpose of the research was explained, and it was emphasized that the interviews would be used solely for academic purposes and that participant identities would remain anonymous in all research reports and published articles.

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Based on the research questions, the following were considered the primary questions in the interviews. However, given the semi-structured nature of the sessions, additional questions were posed in response to participants' answers to clarify meanings and concepts further. At the end of each session, interviewees were invited to add any further comments if they wished.

The interview transcripts were carefully reviewed and transcribed using Microsoft Word and Excel and were prepared for analysis. For analyzing the interview content, thematic analysis—widely used in qualitative research—was employed. In this method, the interview transcripts were first transcribed and completed using notes taken during the sessions. Then, the content was analyzed individually, and initial codes (concepts) were extracted.

The steps followed in the thematic analysis and the results obtained are summarized below:

Step 1 – Familiarization with the Data: This step involved writing out the interview data, repeatedly reading the data, and writing down initial ideas.

Step 2 – Generating Initial Codes: Through a systematic process, notable aspects of the data were coded, and data related to each code were sorted, while relationships between codes were identified.

Step 3 – Searching for Themes: At this stage, the codes were grouped into potential themes, and all data related to each theme were collected.

Step 4 – Reviewing Themes: This step involved ensuring that the themes corresponded with the extracted codes and that the entire data set resulted in a thematic map representing the analysis.

Step 5 – Defining and Naming Themes: To refine the themes, constant analysis was conducted, and clear definitions and labels were assigned to each theme.

Step 6 – Producing the Report: This final stage included selecting vivid examples, finalizing the analysis of codes and themes, connecting the analysis to the research questions and literature, and drafting a scientific report of the findings.

Following the 12 interviews, the codes reached theoretical saturation, and further interviews were discontinued.

Thematic Content Analysis of Interviews

The first step in the analysis involved identifying and extracting concepts from the interview transcripts. At the end of each session, the researcher revisited the transcribed text several times to extract the embedded concepts and perform coding. The process of identifying codes was iterative; that is, it began with an initial review of the literature to extract general and preliminary concepts related to expert capabilities. As new and more specific concepts emerged during the interviews, the literature was revisited to find appropriate equivalents for these new ideas.

From the total of 12 interviews, 151 initial codes or primary concepts were extracted. After reviewing and removing redundant concepts, a total of 104 final concepts were identified, consisting of:

- 4 dimensions
- 16 components
- 61 indicators or parameters
- 4 system evaluation components
- 19 system evaluation indicators

The resulting concepts from the interview analyses are presented in the following tables.

Question 1) Dimensions of the Smart Health-Oriented Product-Service System Model in Social Security Organizations

In the first semi-structured interview question, experts were asked: *"What are the dimensions of the smart health-oriented product-service system model based on cognitive factors in social security organizations?"* The results of the content analysis of the interviews are presented in Table 2.

Table 2

Dimensions of the Smart Health-Oriented Product-Service System

Dimension	Code	Frequency
Business Model	D1	12
Software (Cloud) Platform	D2	12
Physical Platform	D3	4
Cognitive–Biological Factors	D4	8

Based on the content analysis results, experts believe that the smart health-oriented product-service system model based on cognitive factors in social security organizations consists of four main dimensions.

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Question 2) Components of Each Dimension of the Smart Health-Oriented Product-Service System Model

In the second semi-structured interview question, experts were asked: *"What are the components of each dimension of the smart health-oriented product-service system model based on cognitive factors in social security organizations?"* The results of the content analysis of the interviews are shown in Table 3.

Table 3

Identified Components of the Smart Health-Oriented Product-Service System and Frequency of Occurrence

Dimension	System Component	Code	Frequency
Business Model	Service and Product Provider	C1	6
	Customer	C2	12
	Suppliers and Logistics	C3	12
	Cost–Revenue Flow	C4	6
	Services	C5	12
	Products	C6	12
Software (Cloud) Platform	Infrastructure and Cloud Server	C7	5
	Integration with Public–Governmental Systems	C8	10
	Network and Communications	C9	5
	Personalization and Feedback	C10	8
	Experience Management and User Interface (UI, UX)	C11	4
	Legal Guidelines and Educational Manuals	C12	8
Physical Platform	Physical Infrastructure	C13	5
Cognitive–Biological Factors	Clinical Monitoring	C14	10
	Cognitive Surveillance	C15	11
	Medication Management	C16	6

Question 3) Indicators and Parameters of Each Component in the Smart Product–Service System Model

In the third semi-structured interview question, experts were asked: *"What are the indicators and parameters that constitute each component of the smart health-oriented product–service system model based on cognitive factors in social security organizations?"* The results of the content analysis of the interviews are presented in Table 4.

Table 4

Identified Parameters of the Smart Health-Oriented Product–Service System Based on Cognitive Factors

Dimension	System Component	Indicator / Parameter	Code	Frequency
Business Model	Service and Product Provider	Hospitals	P1	12
		Medical Universities	P2	4
		Urban and Rural Health Centers	P3	10
		Insurance Support Organizations	P4	10
		Pharmaceutical Knowledge-Based Companies	P5	4
		Medical Equipment Knowledge-Based Companies	P6	4
		Health Services Startups	P7	3
		Pharmacies	P8	12
		Elderly Care Homes	P9	7
	Customer	Elderly Individuals	P10	12
		Patients and People with Disabilities	P11	12
	Suppliers and Logistics	Emergency Personnel	P12	7
		Delivery Providers	P13	6
		Medical Equipment Stores	P14	4
	Cost–Revenue Flow	Health Sector Financing and Investment	P15	2
		Hardware Implementation and System Management Costs	P16	8
		Software Implementation and System Management Costs	P17	8
		Pricing of Services and Products	P18	8
		System Revenue Stream (subscription, product–service sales)	P19	10
	Services	Treatment	P20	12
		Online and In-Person Medical Care and Consultation	P21	12

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		Other Services	P22	4
	Products	Medications	P23	9
		Health-Oriented Organic Products (e.g., functional foods)	P24	2
		Medical Equipment	P25	9
Software (Cloud) Platform	Infrastructure and Cloud Server	IT-Based and Digitalized	P26	12
		Authentication Tools	P27	7
		Technical Support (computing, user databases, supply chain, messaging)	P28	5
		Big Data Analytics	P29	3
		Online Shop for Pharmaceutical and Health-Oriented Products	P30	2
		Smart Insurance Contracts for the Elderly	P31	4
	Integration with Public–Gov Systems	“My Government” Platform	P32	3
		National Electronic Prescription System	P33	8
		Company and Institution Validation Systems	P34	8
		Online Payment Gateways	P35	9
	Network and Communications	Wired Communication (phone, sensors)	P36	10
		Wireless Communication (RFID, Bluetooth, Wi-Fi, mobile internet, etc.)	P37	10
	Personalization and Feedback	Easy, Moderate, and Advanced User Modes	P38	3
		Service–Product Co-Creation Tools	P39	1
		User Feedback Systems (rating, participation)	P40	6
	Experience Management and UI/UX	User Input Equipment (e.g., biosensors)	P41	3
		User Motion Detection	P42	5
		User Experience Mapping and Evaluation	P43	3
		Gamification	P44	2
		Augmented Reality	P45	3
	Legal and Educational Guidelines	Privacy Standards and Regulations	P46	9
		National Elderly and Disability Laws	P47	3
		System Usage Tutorial Module	P48	12
		Health-Related Media and Resources	P49	7
Cognitive–Biological Factors	Clinical Monitoring	Smart Assistant for Biometric Monitoring	P50	7
	Cognitive Monitoring	AI-Personalized Behavior and Preferences	P51	7
		Personality, Analytical and Creative Thinking Assessment	P52	4
		Analysis of Emotional Needs for Service Design	P53	2
		Stress, Happiness, and Depression Assessment	P54	4
		Cognitive Skill Training via Gamification	P55	3
	Medication Management	Smart Medication Scheduling Assistant	P56	4
Physical Platform	Physical Infrastructure	In-Person User Needs	P57	7
		Service and Product Delivery Infrastructure	P58	12
		Digital Physical Devices (e.g., wearables)	P59	5
		Non-Digital Physical Devices	P60	5
		Remote Surgery via Intelligent Medical Robots	P61	2

Question 4) Components and Indicators for Evaluating the Quality of the Smart Product–Service System

In the fourth semi-structured interview question, experts were asked: *“What are the components and indicators for evaluating the quality of the smart health-oriented product–service system based on cognitive factors in social security organizations?”* The results of the content analysis are presented in Table 5.

Table 5

Components and Indicators for Evaluating the Quality of the Smart Health-Oriented Product–Service System

System Evaluation Component	Code	Frequency	Indicator	Code	Frequency
Result Quality	QA	12	Responsiveness and After-Sales Service	Q1	6
			Confidentiality	Q2	12

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			Fairness	Q3	6
			Customer Orientation	Q4	5
Interaction Quality	QB	12	Safety	Q5	8
			Effectiveness	Q6	8
			Timeliness	Q7	11
			Efficiency	Q8	3
			Exciting and Stimulating Benefits	Q9	12
System Quality	QC	12	Information Security	Q10	10
			Reliability	Q11	4
			Technical Quality	Q12	8
			Alignment with Government Regulations	Q13	5
			Trustworthiness	Q14	10
			Ease of Use	Q15	12
Stakeholder Satisfaction	QC	12	Fulfillment of Essential Requirements	Q16	7
			Fulfillment of Satisfactory Requirements	Q17	5
			Fulfillment of Attractive Requirements	Q18	6
			Fulfillment of Indifferent or Additional Requirements	Q19	2

Based on the review of the literature and previous studies, the components and indicators of the smart health-oriented product–service system are comprehensively presented in Table 5 (considering all existing models and perspectives in this domain). It should be noted that the system comprises four core dimensions: *Business Model*, *Software (Cloud) Platform*, *Cognitive and Biological Factors*, and *Physical Platform*, each of which includes several components and parameters.

Table 6

Dimensions, Components, and Parameters of the Smart Health-Oriented Product–Service System in Social Security Organizations Based on Cognitive Factors

Dimension	System Component	Indicators and Parameters
Business Model	Service and Product Provider	Hospitals, Medical Universities, Urban and Rural Health Centers, Insurance Support Organizations, Pharmaceutical Knowledge-Based Companies, Medical Equipment Knowledge-Based Companies, Health Services Startups, Pharmacies, Elderly Care Homes
	Customer	Elderly Individuals, Patients and People with Disabilities
	Suppliers and Logistics	Emergency Personnel, Delivery Providers, Medical Equipment Stores
	Cost–Revenue Flow	Health Sector Financing and Investment, Software and Hardware Implementation and Management Costs, Pricing of Services and Products, System Revenue Stream (subscription, product–service sales)
	Services	Treatment, Online and In-Person Medical Care and Consultation, Other Services
	Products	Medications, Health-Oriented Organic Products (e.g., functional foods), Medical Equipment
Software (Cloud) Platform	Infrastructure and Cloud Server	IT-Based and Digitalized, Authentication Tools, Technical Support (computing, user databases, supply chain, messaging), Big Data Analytics, Online Shop for Pharmaceutical and Health-Oriented Products, Smart Insurance Contracts for the Elderly
	Integration with Public–Governmental Systems	“My Government” Platform, National Electronic Prescription System, Company and Institution Validation Systems, Online Payment Gateways
	Network and Communications	Wired Communication (phone, sensors), Wireless Communication (RFID, Bluetooth, Wi-Fi, mobile internet-based tech, and similar tools)
	Personalization and Feedback	Easy, Moderate, and Advanced User Modes, Co-Creation Tools, User Feedback Systems (ratings, service participation)
	Experience Management and UI/UX	User Input Devices (e.g., biosensors), User Motion Detection, User Experience Mapping and Evaluation, Gamification, Augmented Reality
	Legal and Educational Guidelines	Privacy Standards and Regulations, National Laws on the Elderly and Disabled, System User Instruction Module, Health-Related Media and Articles
Cognitive and Biological Factors	Clinical Monitoring	Smart Assistant for Biometric Data Monitoring (nutrition, blood sugar, blood pressure, ECG, heart rate, oxygen saturation, height, weight, activity and movement, rest, body temperature, fat percentage...)
	Cognitive Monitoring	AI-Driven Behavioral and Psychological Profiling of the Elderly, Emotional Needs Analysis for Service and Product Design, Personality, Analytical and Creative Thinking Assessment, Stress, Happiness, and Depression Evaluation, Cognitive Skill Training via Gamification
	Medication Management	Smart Medication Scheduling Assistant

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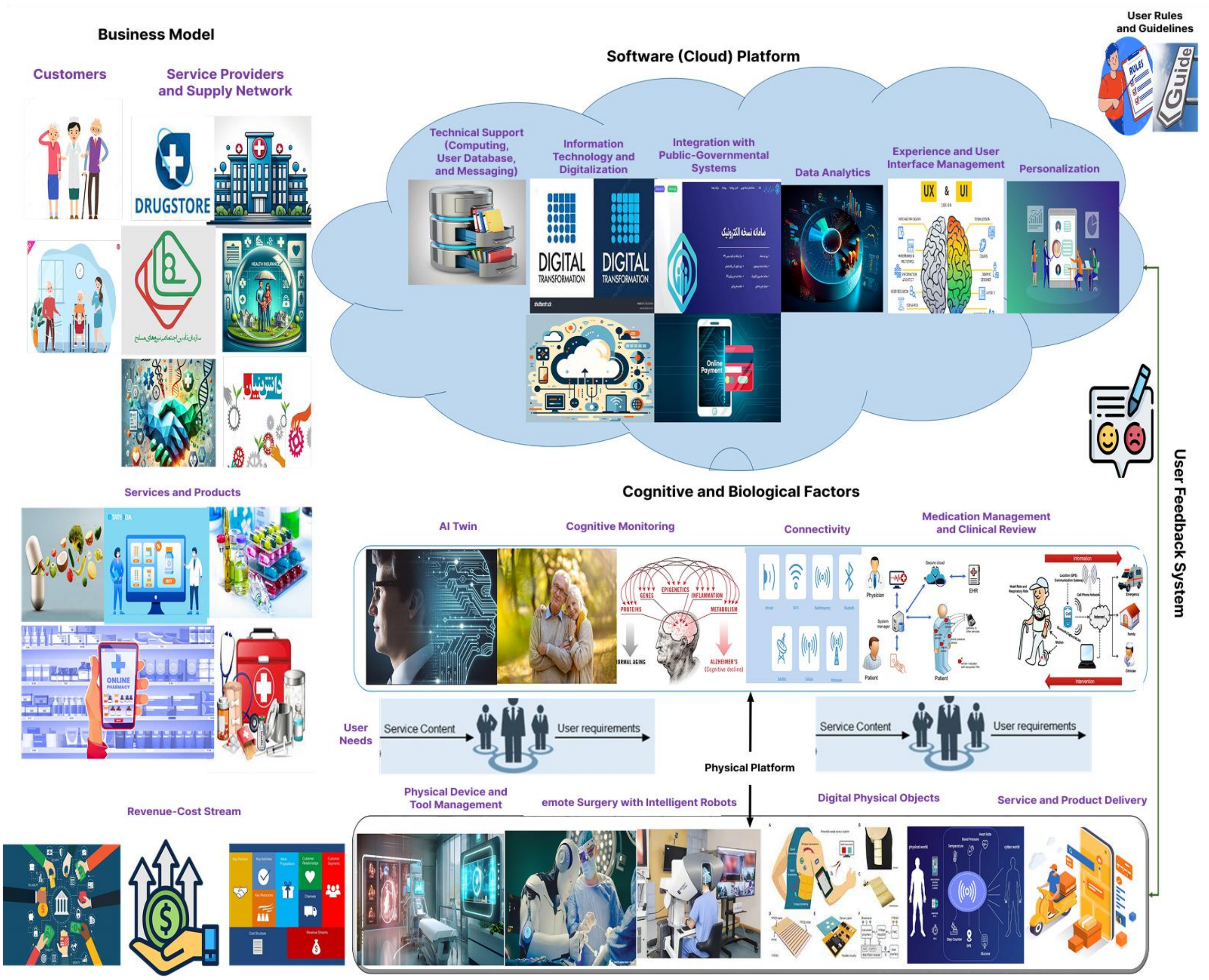
Physical Platform	Physical Infrastructure	In-Person User Needs, Delivery Infrastructure, Digital Physical Devices (e.g., wearables), Non-Digital Physical Devices, Remote Surgery via Intelligent Medical Robots

Given the key actors in the smart health-oriented product–service system, the elderly, products, and service providers play a crucial role. Figure 1 illustrates the overall model derived from the findings of Table 6, presenting the cognitive factor-based smart health-oriented product–service system for social security organizations. Specifically, elderly individuals are the driving motivation for designing the smart health-oriented product–service system in this study, and their needs can be understood by providers as the basis for initiating the development of new product–service offerings.

Figure 1

Cognitive-Based Smart Health-Oriented Product–Service System for the Elderly



Considering the challenges faced by the elderly, providers with relevant capabilities can be integrated to shape the service content, upon which the product architecture, proper interaction modes, and user interface visualization are designed. Subsequently, user satisfaction and emerging needs may lead to iterative product enhancements and the development of new services. In fact, this enables a co-creation value process between the user and the provider. More explicitly, the user is both the starting point (as the source of needs) and the final endpoint (as the recipient and evaluator of services), while the providers act as the source of content (functionality). The product/service serves as a mutual platform between users and providers for

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obtaining, delivering, and exchanging value and achieving reciprocal benefits.

Beyond physical connections among the actors, data flow is essential for networked devices, enabling the creation of e-services, realization of online intelligence, and integration of the physical–cyber space. In particular, data streams arise from aspects such as actor-generated data, which can form the user community, Internet of Things (IoT), and stakeholder networks for purposes like population analysis, agent-based or network computation, and machine self-learning and regulation. These communicative data flows enable the collection of necessary inputs from related nodes. Essentially, the smart health-oriented product–service system is a data-intensive and data-driven framework. Given that the nature of the service is to meet personalized demands, a precise understanding of users' diverse needs is required.

The proposed smart health-oriented product–service system accounts for various user types to recognize distinct needs. Likewise, providers are integrated based on their capabilities to fulfill such needs, with an emphasis in this framework on understanding user needs, analyzing user perceptions, and mapping the voice of the customer to service content. It is expected that the processes of comprehensive user need analysis, provider identification and integration, and systematic product/service development will contribute to effective product creation.

To implement this framework, the development approach is constructed from two perspectives in the physical context: how to extract and interpret user needs, and how to integrate relevant stakeholders and design the product architecture accordingly.

4. Discussion and Conclusion

The present study aimed to design a comprehensive model for a smart health-oriented product–service system (PSS) tailored to elderly care in social security organizations, with a particular focus on cognitive-based personalization. The results revealed that such a system must integrate four primary dimensions: the business model, the software (cloud) platform, cognitive–biological factors, and the physical platform. Each dimension consists of several essential components and associated indicators. The analysis of expert interviews identified 16 key components and over 60 operational parameters, further complemented by a detailed evaluation framework consisting of four quality dimensions: outcome quality, interaction quality, system quality, and stakeholder satisfaction. These findings collectively contribute to the development of an intelligent, user-centric, and data-driven framework for elderly care delivery, one that responds to the increasing complexity and heterogeneity of elderly users' needs.

One of the major findings was the centrality of elderly users in driving system design and evolution. The results clearly showed that the elderly are not passive recipients but active co-creators of value. Their cognitive, emotional, and physical needs shape the structure of services and the development of product functionalities. This is in line with prior work demonstrating the importance of user-centered design in elderly care systems. For example, (Z. Zhou et al., 2023) emphasized that preventive health behaviors in elderly populations are significantly enhanced when social capital and trust mechanisms are embedded within service platforms. Similarly, (Nga, 2023) highlighted how elderly users' willingness to adopt digital banking services is contingent on usability, perceived control, and psychological comfort—factors that are equally relevant in the context of smart healthcare systems. The emphasis on personalization, feedback loops, and adaptive service content in the current model aligns with these perspectives, reinforcing the need to treat elderly users as decision-making agents rather than system endpoints.

In the business model dimension, the findings revealed that service providers—including public hospitals, medical universities, pharmacies, insurance companies, and digital health startups—must collaborate within a shared infrastructure to deliver integrated services. Financial flow mechanisms such as subscription fees, dynamic pricing models, and bundled service packages also emerged as critical enablers of system sustainability. These results corroborate the conclusions of (Li et al., 2023), who found that resource allocation and financial optimization are fundamental to the viability of rural institutional care services in China. Moreover, (Cheng et al., 2022) pointed to the spatial and organizational inefficiencies in urban elderly-care service delivery and advocated for a multi-stage, demand-driven planning framework—an approach that directly resonates with the layered, modular nature of the PSS proposed here.

The software platform dimension was found to be equally critical. Cloud infrastructure, integration with national health systems, and intelligent user interfaces (UI/UX) form the technological backbone of the smart PSS. Key indicators such as digital identity verification, data security, personalized feedback systems, and real-time monitoring

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tools were repeatedly emphasized by the experts. These insights are strongly supported by the literature. For instance, (Liu, 2024) proposed an event-driven architecture for elderly care platforms that combines real-time sensor data with personalized recommendations. Similarly, (Lam et al., 2021) demonstrated how data-driven scheduling and communication systems dramatically improved appointment compliance and service satisfaction among elderly patients during the COVID-19 pandemic. In our findings, ease of use, security, and compatibility with national health portals (e.g., electronic prescription systems) were identified as non-negotiable features, echoing the concerns outlined in (Chen et al., 2022) regarding privacy and interoperability in digital healthcare systems.

Cognitive and biological monitoring also emerged as foundational components of the smart elderly care model. The inclusion of AI-based assistants for tracking physiological data (e.g., heart rate, blood pressure, glucose levels) and cognitive states (e.g., emotional wellbeing, stress, and mental engagement) reinforces the shift from reactive to proactive healthcare. The importance of this shift is well-documented. (Wang, 2024) surveyed the use of intelligent robots for bedridden elderly and emphasized the transformative potential of such technologies in reducing dependency and enhancing quality of life. Furthermore, (Das et al., 2023) demonstrated how EEG and Kinect-based monitoring systems could be integrated to provide comprehensive telehealth solutions for physically impaired older adults. Our findings similarly support the argument that integrating cognitive assessment tools, gamified training modules, and emotional analytics into elderly care platforms significantly increases engagement and autonomy, particularly for users with early-stage cognitive decline or limited mobility.

In terms of the physical platform, the study found that hybrid infrastructures—ranging from smart wearables and biosensors to assistive home devices and robotic surgery interfaces—must be adaptable to various user contexts and preferences. The integration of cyber-physical systems is crucial in enabling seamless transitions between in-person and digital care. According to (Fukunishi & Kobayashi, 2023), predictive models built from insurance claims data can inform infrastructure planning and device deployment, thereby improving care outcomes and cost-efficiency. Additionally, (Zhao, 2024) explored both the opportunities and challenges of incorporating AI into physical care systems in China, stressing the need for human–machine cooperation and continuous system learning. Our findings extend this discourse by highlighting the value of cross-domain collaboration in the design and deployment of these physical components.

A significant contribution of this study lies in its proposed evaluation framework, which introduces multidimensional quality assessment across four constructs: outcome quality, interaction quality, system quality, and stakeholder satisfaction. The selected indicators—such as responsiveness, confidentiality, safety, efficiency, reliability, and compliance with national regulations—are consistent with those found in (Thalib, 2022), who outlined the essential criteria for evaluating AI-based teledentistry services for the elderly. The inclusion of hedonic attributes like emotional stimulation and gamification further reflects the broader shift toward holistic care, as emphasized by (Bai, 2023), who studied smart community-based elderly care in Harbin. Such multi-criteria evaluation not only provides a diagnostic tool for system developers but also aligns service delivery with user expectations and public policy objectives.

Despite the comprehensive design and expert-based validation of the smart PSS model, several limitations should be acknowledged. First, the sample size of experts, although diverse in terms of institutional affiliation and domain expertise, remains limited in scope and may not fully capture regional or international variances in elderly care practices. Second, the study relied heavily on qualitative methods, which, while valuable for model development, may not adequately quantify the strength of relationships between system components or allow for generalizable conclusions. Third, while the model integrates digital, cognitive, and physical dimensions, real-world implementation was not tested in a live environment, and thus the model's operational performance, scalability, and cost-efficiency remain hypothetical. Finally, the fast-paced evolution of AI and digital health technologies may quickly outdate some of the technical elements proposed in this framework, requiring continuous revision and contextual adaptation.

Future research should aim to empirically test the proposed model using pilot implementations in both urban and rural settings to evaluate its adaptability, effectiveness, and user acceptance in real-time contexts. Quantitative validation through structural equation modeling or system dynamics simulation could be employed to examine causal relationships among the system's dimensions and user outcomes. Furthermore, future studies may investigate cross-cultural differences in the perception and adoption of smart elderly care systems, especially in non-East Asian contexts where care traditions and technological familiarity

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differ significantly. Another important direction would be to assess the long-term economic and psychological impacts of using intelligent PSS on elderly well-being, caregiver burden, and healthcare system sustainability. Finally, integrating ethical frameworks and participatory design principles into smart system development remains a crucial avenue for aligning innovation with societal values.

Practitioners and policymakers should prioritize the co-design of elderly care technologies with active input from users, caregivers, and service providers to ensure functional alignment and emotional resonance. Regulatory bodies must develop comprehensive guidelines to standardize data security, system interoperability, and ethical usage of AI in elderly care. Investments in digital literacy programs targeted at elderly populations and training modules for caregivers are essential to bridge the human–machine interaction gap. Healthcare organizations should adopt modular, scalable smart care platforms that allow for future upgrades without disrupting service continuity. Public–private partnerships should be encouraged to mobilize resources, drive innovation, and ensure equitable access to smart care services across demographic and geographic boundaries.

Authors' Contributions

All authors significantly contributed to this study.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

In this study, to observe ethical considerations, participants were informed about the goals and importance of the research before the start of the interview and participated in the research with informed consent.

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