Gerontechnology Design: Navigating Pluralistic Value Conflicts

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Abstract. This study aimed to explore the resolution strategies of multiple value conflicts in gerontological technology design, with a special focus on the integration process of self-service health screening equipment in elderly health ecosystems. By adopting the methodological framework of value-sensitive design and dilemma design, this study aims to address the conflict between autonomy, privacy, and personalization needs that older adults face when using technology products. In the literature review section, we review relevant research in the field of gerontology, with a particular focus on different ways of integrating technology into elder care. We discuss the theoretical background and practical applications of value-sensitive design, as well as methods previously used to explore and address value conflicts in technology design. For our methodology, we adopted qualitative research methods, including literature analysis and case studies. We conducted semistructured interviews and focus groups to gather the views and experiences of older people, healthcare professionals, and stakeholders. Additionally, we conducted a triangular analysis of conceptual studies, empirical studies, and technical studies to gain a comprehensive understanding of the complexities and challenges of gerontechnology design. In the findings section, we propose a value-based description model that identifies key value conflicts in gerontechnology design and provides strategies for resolving these conflicts. We carried out design practice based on the theoretical section, producing product prototypes and interfaces. Our findings indicate that integrating the perspectives and needs of different stakeholders during the design process and fully considering the values and lifestyles of older adults can effectively reconcile value conflicts, thereby increasing user acceptance and satisfaction with gerontechnology products.

Keywords: Gerontechnology · Value-sensitive Design · Dilemma-driven Design · Descriptive Model

1 Introduction

The current state of our world has been shaped by the inevitable trends of aging and technological advancement [1]. Gerontech, which combines elderly care services with smart technology, offers innovative solutions to address the shortage of labor and medical resources, as well as the limitations faced by elderly people in independent living. As

Q. Gao and J. Zhou (Eds.): HCII 2024, LNCS 14725, pp. 114–127, 2024.
https://doi.org/10.1007/978-3-031-61543-6_9

a result, gerontech has emerged as a powerful tool for promoting sustainable development in society. With the rapid development of smart technology and the diverse range of applications, the design of gerontech is characterized by diversity and uncertainty. Scholars emphasize the importance of integrating values from the early stages of technology design, recognizing the multiple values and interests involved [2]. In the design process of gerontech, conflicting values can easily arise, which can impact the interaction between the product and its stakeholders. Therefore, effectively resolving and integrating these contradictions has become an urgent issue. Particularly in the internal design process of prediction, creation, realization, and application, designers are increasingly focusing on analyzing and coordinating the contradictions and oppositions among the multiple values held by stakeholders. In the design of aged technology products, it is crucial to comprehend and balance the needs and expectations of various stakeholders. This ensures that products and services effectively fulfill the requirements of target users while generating value for other relevant entities. This accomplishment necessitates interdisciplinary collaboration, thorough user research, and ongoing iterative design.

Resolving and integrating pluralistic value conflicts in the design process of gerontechnology products has become a pressing issue. This is especially true during the intrinsic technology design processes of prediction, creation, realization, and application. Designers are now paying significant attention to analyzing and coordinating the contradictions and oppositions among stakeholders' pluralistic values. These values are considered beliefs about what is good or desirable and include human autonomy, security, sustainability, or privacy. Ethicists and philosophers of technology have developsed methods such as value-sensitive design (VSD) and responsible research and innovation to incorporate these values into technology design. Inspired by the Delft University of Technology white paper on 'Value Change and Technology Design', our research aims to uncover the key components that harmonize value conflicts in the technological design and application of gerontechnology products. We aim to construct a descriptive model within gerontechnology design. The presence of dilemmas and conflicts in system design not only presents challenges but also provides insights into the interconnectedness of systems. In the field of gerontechnology, these conceptual conflicts, intergroup conflicts, and individual dilemmas are particularly evident in the multidimensional dynamic relationships between technology and users. The design and application of medical care technologies, such as self-service health screening devices, involve complex pluralistic value conflicts between autonomy, privacy, the personalized needs of elderly people, and universal design principles. This study utilizes a dilemma-driven design approach to identify and explore multilayered conflicts and dilemmas in gerontechnology product design. By using self-service health screening devices as a case study and employing the value-sensitive design (VSD) methodology, we develop a descriptive model of pluralistic values.

2 Literature Review

2.1 Literature Review on Dilemma-Driven Design in System Design

Dilemma-driven design is a conceptual approach in system design that focuses on resolving conflicts arising from competing values or requirements. This approach is particularly relevant in fields such as gerontechnology, where designers need to navigate complex value landscapes involving multiple stakeholders. Ozkaramanli and colleagues (2016) elaborate on this concept, emphasizing its usefulness in addressing conflicts within individuals. They argue that dilemma-driven design enables a nuanced understanding of user needs and preferences, especially when these needs conflict with each other or with available technological possibilities [3] (Fig. 1).

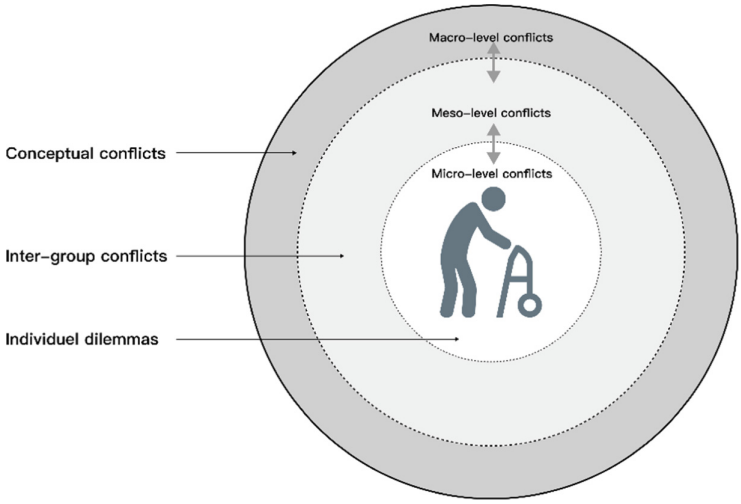

Fig. 1. Visualization based on the dilemma-driven design model.

2.2 Literature Review on Value-Sensitive Design

Value-sensitive design is a methodological system proposed by Batya Friedman, a professor at the School of Information at the University of Washington, in the 1990s. It aims to address ethical issues in the early stages of information technology design. The main focus is on incorporating the values of stakeholders into the design of information systems and making value trade-offs and guidance through specific methods. Value-sensitive design emphasizes the interpretation and maintenance of human values in a principled and comprehensive manner during the design process. It provides researchers and designers with a theoretical approach to uphold human well-being, rights, and justice in the system [4]. The article 'Value-Sensitive Design' by Friedman presents multiple cases illustrating that the criteria for evaluating systems vary depending on the project, including reliability, efficiency, correctness, etc. However, the most crucial aspect is that

technical design should encompass or at least reflect the core human values. [5] Cenci and Cawthorne [6] combined value-sensitive design with the capability approach [7] proposed by Sen, which enhances the ethical democratic introduction of value-sensitive design. This combination provides an 'objective and fair' value selection procedure and guides the resolution of diverse and incommensurable issues with different priorities, values, and legitimate goals.

The lack of commitment to specific ethical theories in practical applications of VSD poses a challenge. However, this makes it suitable for applied science, particularly in the implementation of welfare-oriented technological design in specific social contexts. Jacobs proposed CSD (capability sensitive design) based on VSD and combined it with the relevant theories of the capability approach. The aim was to conduct a normative evaluation of technical design, especially in the context of health and welfare [8]. CSD provides more specific rules than VSD does, serving as a more detailed design guidance method. This approach aligns well with the common goal of technology design, which is to enhance and expand human capabilities and work [9]. CSD focuses on conversion factors and the ability of individuals to transform resources into capabilities while also helping analyze human diversity. The ultimate goal of CSD is to normatively evaluate technical designs based on their ability to extend human value [10]. Value-sensitive design allows designers to repeatedly and iteratively engage in tasks such as value input, value selection, and value trade-offs throughout the design and development process, providing valuable guidance. Methodological guidance and suggestions for medical design. Value-sensitive design is widely used in subdivided fields such as medical equipment design research, medical information design research, and medical service design research [11]. Because of its characteristics, a value-sensitive design can be used as a guiding methodology in this research design.

2.3 Research Status of Shanghai Community Self-service Sign Detection Equipment

As early as 2007, China's former Ministry of Health encouraged organizations from all walks of life to take action in building a healthy lifestyle for all people. By detecting health indicators and chronic disease risk factors early, diseases can be detected and managed in a timely manner, reducing harm and economic consequences. Since then, various community services promoting disease prevention have been launched in China. In recent years, government-led public health institutions known as health huts have emerged in communities. These health huts rely on community public spaces to provide services such as physical examinations, intervention guidance, health promotion, and knowledge acquisition. Before health huts became a business model, many organizations, groups, and individuals volunteered to provide free health services to community residents. Later, medical equipment manufacturers specialized in such projects and collaborated with governments, communities, streets, and other service providers to promote this model. Regional and standardized health cabins began to appear, and communities gradually adopted these devices for convenience [12]. Over time, a comprehensive form of equipment offering various self-service options started to appear in the health cabin project. These machines, also known as 'health all-in-one machines' or 'public health all-in-one machines', are based on cloud platform big data. Multiple

instruments required for daily physical examinations are integrated, and test results are uploaded to personal health files through the ID card login system [13] (Fig. 2).

Fig. 2. Equipment in the Shanghai Health Cabin (from left to right: sign detection equipment, physical fitness detection equipment, interactive screen) (Picture source: https://www.Shxwcb.Com/318196.Html.

3 Methodology

This study is divided into four phases. First, the theoretical foundation and conceptual research stage delves into the theory of value-sensitive design through literature analysis, establishing a solid foundation for subsequent research. Moreover, this paper considers the relevant value of self-service sign detection among stakeholders and communities, preparing for empirical research (Fig. 3).

Through the use of the ternary research method of value-sensitive theory, this study aims to identify value appeals and explore value transformation. By visualizing the ternary relationship diagram based on a previous literature review, the practical transformation path of design as the starting point of value becomes clearer. Additionally, the study investigated the design attributes associated with cost-effectiveness, perceived usefulness, usability, safety, and comfort. Empirical research is conducted through a recruitment and observation interview process involving elderly individuals in the community (Table 1).

The second phase involves empirical research, where data are collected through observation and semistructured interviews. The observations focus on older adults' interactions with existing equipment and their performance within the wellness hut to capture value suppression. The interviews directly gathered the opinions and value demands of stakeholders, providing inspiration and an overall perspective on product design (Fig. 4).

To explore the opinions and values of various stakeholders on self-service testing equipment, the author conducted in-depth semistructured interviews with direct stakeholders. The semistructured interview questions were designed to tap into stakeholders' understanding, opinions, and values of the technology. These questions typically

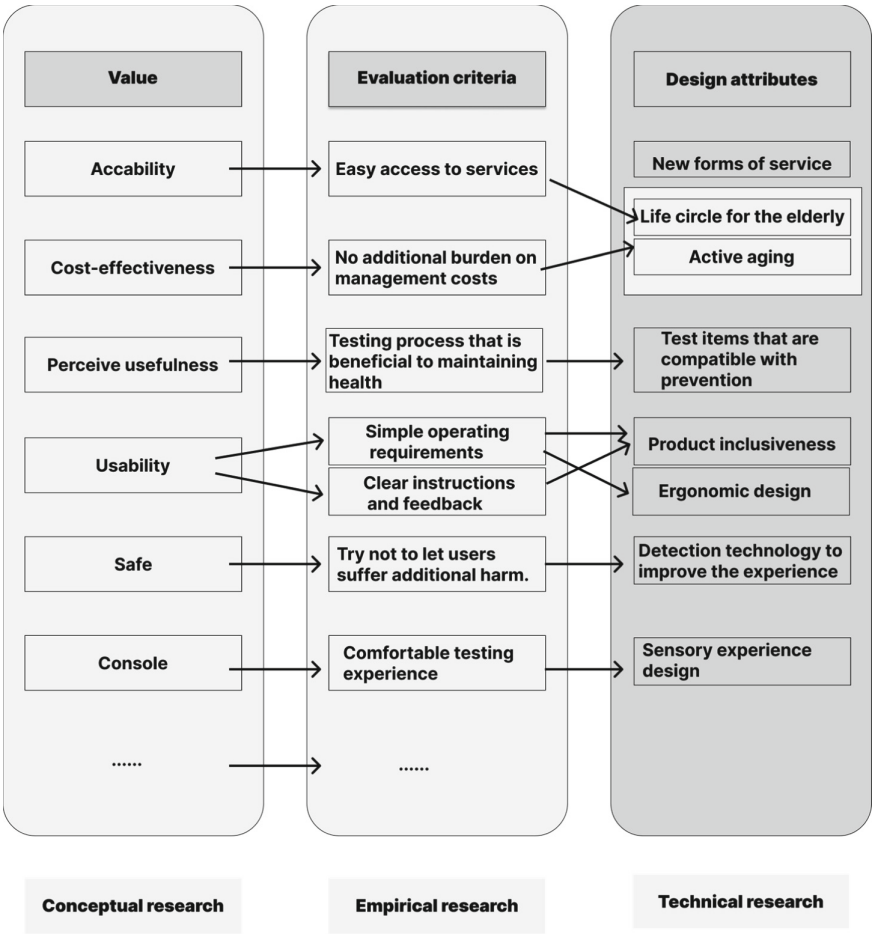

Fig. 3. The Transformation Relationship of Ternary Research.

Table 1. Self-service sign detection for direct stakeholders.

Professionals	Assigned by the service agency for operational sign testing in cooperation with the government
Community volunteers	The active force of community service, with the dual use of services and the provision of services
Elderly users	Elderly residents with various degrees of health needs

focused on the stakeholder's evaluative judgment of the technology (e.g., whether they considered it good or bad) and the reasons behind their judgment. Additionally, other considerations raised by stakeholders were also explored. To gain a better understanding of the current situation, the author also interviewed the person in charge of a community

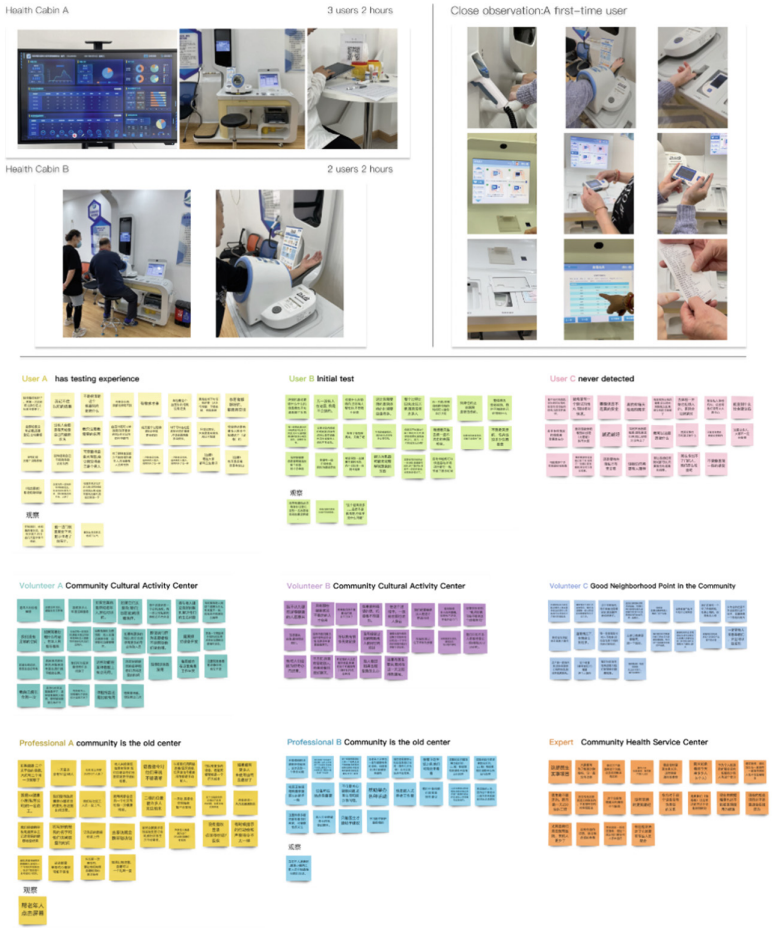

Fig. 4. Research observation and semistructured interview pictures and affinities.

service agency. The interviews focused on the operation of health cabins by the agency and included their views on self-service testing equipment (Table 2).

Table 2. Recruitment criteria.

Recruitment criteria	
Age:	over 60 years old
Ability:	Have enough mobility, feeling and cognitive ability, and be able to complete daily activities independently
Residence:	Long-term fixed residence

Different levels of familiarity with digital interactive devices and community services can result in varying perceptions of self-service testing among users. To gain a comprehensive understanding of different residents' views on self-service health examination equipment, the author conducted interviews with elderly individuals who had different experiences with community services. Three users with varying levels of experience in self-service testing services were recruited for semistructured interviews. The involvement of service providers, including professionals and volunteers, was crucial to the study, as observed in the previous study. Health huts can be found in various locations, such as large local comprehensive senior care centers, personal health service stations, and activity centers for seniors. Additionally, smaller neighbor centers and community services are also worth investigating. The author visited these facilities and conducted offline interviews with a total of 5 service staff. It is important to note that the community volunteers visited by the author were all elderly individuals in the younger age group (Table 3).

Table 3. Summary of the overall basic information of the interviewees.

Object	Code name	Age	Surrounding environment	Medical treatment/medical experience
user	User A	68	Have a relatively complete community health service	Experienced autonomous testing equipment
	User B	70	Community health services with volunteers	
	User C	61	There is no community health service	Have not experienced autonomous testing equipment
Community volunteers	Volunteer A	63	Health Cabin (Community Cultural Activity Center)	Nonprofessional medical background, understand basic health knowledge
	Volunteer B	66	Health Cabin (Community Cultural Activity Center)	
	Volunteer C	61	Good neighborhood in the community	
Professionals	Professional A	55	Health Cabin (community is the old center)	Received professional physical examination training

(*continued*)

Table 3. (*continued*)

Object	Code name	Age	Surrounding environment	Medical treatment/medical experience
	Professional B	35	Health Cabin (community is the old center)	
Expert	Expert A	-	Health Cabin (Community Health Service Center)	Professional medical background

With the exception of the interview with resident C, which was conducted online, most interviews were conducted offline. Recordings and notes were taken during the offline interviews, while typewriting and audio were used to transcribe them. During the online interviews, only notes and some chat records were kept as per the interviewee's request. The online interviews focused mainly on current products and services, as well as participants' views on health maintenance. Since the topic revolves around personal health and because it is challenging to find independent users, offline interviews were primarily conducted through chatting in the health hut to create a relaxed atmosphere. In contrast, online interviews aimed to uncover the needs of potential users of such services

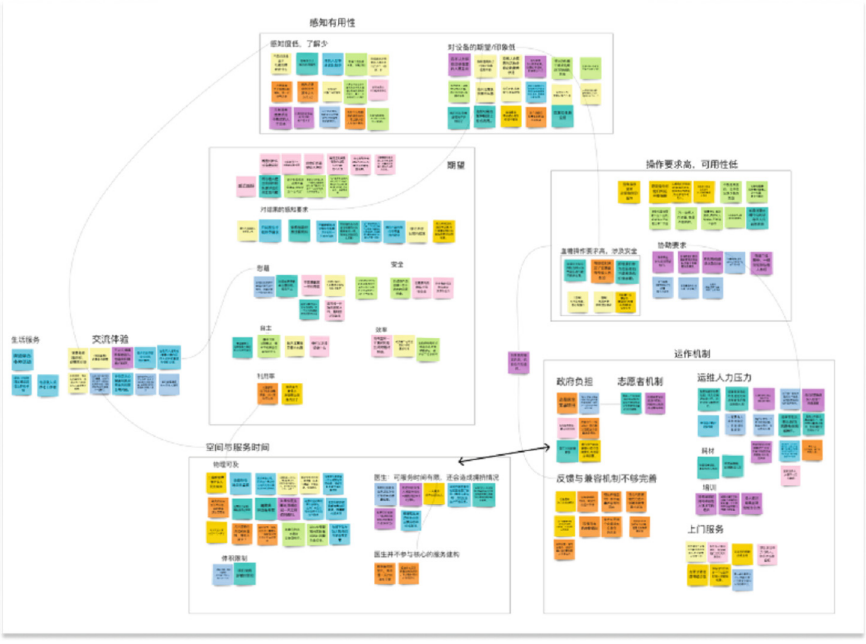

Fig. 5. Affinity map stage 2: Information clustering (intercepting the valid part).

by asking participants to imagine what an efficient community health screening service would look like. Subsequently, the value provided in the value-set stage was used as the initial theme for subsequent analysis interviews, and the content of the interviews was summarized and organized. The data were visualized and presented in the form of an affinity chart (Fig. 5).

4 Findings and Analysis

Data analysis employs analytical usability assessment and affinity diagrams to evaluate the usability of existing aging technology equipment and extract key insights from complex data. In the third phase, technical research translates important values into actual designs through literature research and desktop research. It defines the feasible scope of the design and outlines new service and product landscapes. Finally, in the fourth phase, service and product positioning, a new service picture is established based on the transition design perspective, and the business model of the new service system is visualized via business canvas analysis. A design backtracking approach is used to create a transformation path and identify current feasible options. The focus group further investigates users' views on solutions to value tension in retrospective design and explores user preferences and reasons in depth. This study aims to comprehensively explore different dilemmas and value-sensitive design issues in the design of aging technology products through these four stages, providing strong support for related product design. Several major value conflicts are derived from interviews and demand and focus groups: conflicts of kinglyness, privacy and personal needs.

The current service model is based on community or street settings, where each community is equipped with self-service physical sign detection equipment. However, there is a significant problem with the current service model, which is the underutilization of equipment. Upon analysis, it is clear that the current service model fails to meet the value needs of users, especially in terms of accessibility. Additionally, the scarcity of resources and the difficulty in training professionals contribute to the service provider's need for cost-effectiveness, making it challenging for the current service model to expand its role. Currently, only doctors who visit once or twice a week take the initiative to gather the surrounding residents for testing. Limited contact scenarios further restrict the ability of the equipment to be fully utilized (Fig. 6).

This paragraph discusses the concept of value and the resolution of value conflicts in design. The essay mentions the use of mechanism appeals and the identification and classification of value in empirical research. The paragraph also introduces dilemma-driven design theory, which suggests to using personal dilemmas as opportunities for design innovation. This study highlights the importance of understanding the value demands and conflicts of stakeholders and how value-sensitive methods can guide the conceptual design process. The paragraph further emphasizes the significance of interviews and focus groups in identifying needs and value retrospectives in experience design. Additionally, the analysis and iteration of technical pain points in aging technology products

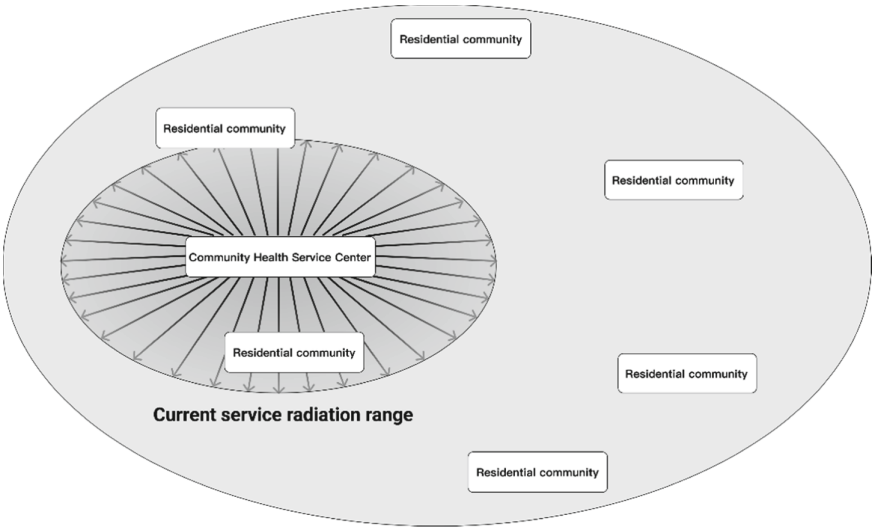

Fig. 6. Current physical radiation situation of self-service testing service.

are mentioned to obtain a final value description model. This model can be used to analyze and identify values and conflicts in the design process, providing better guidance for designers (Fig. 7).

This study uses dilemma-driven design theory as a breakthrough to identify value conflicts in the design practice stage. The observations and interviews in the empirical research look at the generation of multiple values from micro, meso and macro perspectives and make full use of the theoretical basis to excavate and identify value demands. Based on the value description model, future aging technology products were designed, and a prototype of a self-service health screening device was produced.

The positioning is designed according to the theoretical model, and the design prototype is produced. The whole set of equipment consists of a blood pressure detector; a comprehensive detector that can measure blood sugar, blood oxygen, pulse, blood lipids and heart rate; an interactive touch screen; a wireless charging base with a thermal paper printer; and a packaging box (Figs. 8 and 9).

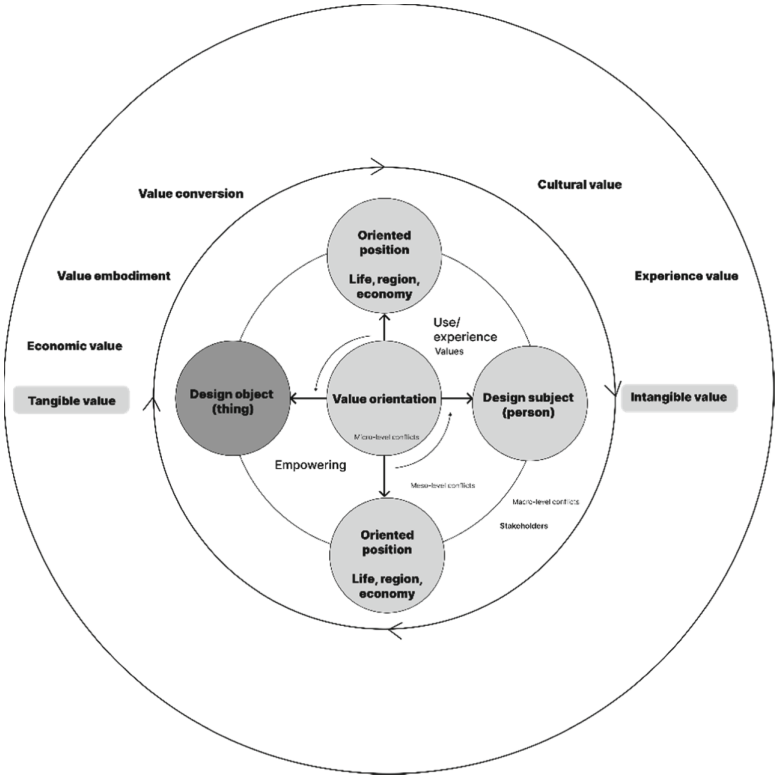

Fig. 7. Value description model.

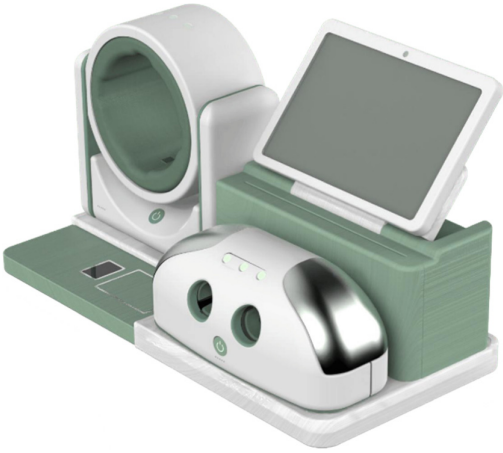

Fig. 8. Product prototype design draft.

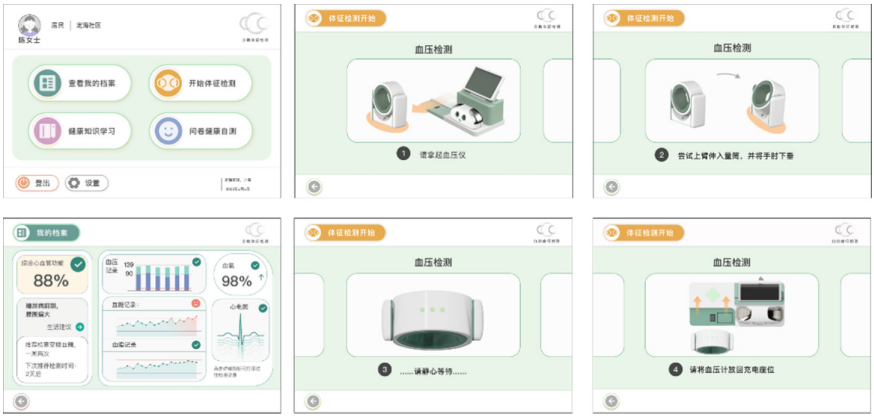

Fig. 9. Service system interface design.

5 Discussion

In the field of geriatric technology product design, this study focuses on a dilemma-driven design theoretical model combined with value-sensitive design methods. The aim is to explore in depth the value conflicts that arise when elderly people use self-service health monitoring devices. By examining individual dilemmas at the microlevel, this approach provides a comprehensive understanding of the challenges and dilemmas that older adults face when using these devices, as well as potential value conflicts. This study emphasizes the importance of using dilemma-driven theoretical approaches and value-sensitive design methods in geriatric technology design to address value conflicts related to self-service health monitoring for older adults. This study highlights the need to balance microlevel dilemmas, such as usability, privacy, and personalization, with the needs of stakeholders at the meso level, such as performance and interoperability. Additionally, macrolevel considerations, which are currently underexplored, are crucial for building a holistic technology ecosystem. Future research should focus on addressing conflicts at multiple levels to achieve inclusive gerontech designs.

Acknowledgments. We would like to express our sincere gratitude to all the elderly participants, community volunteers, and professionals who generously contributed to this study for their valuable insights and feedback.

Ethical. Considerations Ethical approval will be obtained from relevant committees to ensure that the research conforms to the highest ethical standards. Participants will be informed of the research purpose, and consent will be obtained before the interviews. Data privacy and confidentiality will be maintained throughout the research process.

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