

# A Study on Smart Home Design Incorporating Ubiquitous Healthcare Services

Ji-Eun Lee, Young-Ho Yoon and Dong-Suk Yang

*Department of Architecture, Land and Housing Institute, Daejeon, Korea*

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**Abstract:** The smart home using ubiquitous technology can effectively provide services to the elderly and the physically impaired. However, such services are accompanied by high initial cost of installation and the operating inefficiency due to the absence of design guidelines. To solve these, the integrated management of the process by supplying the public service like voucher schemes to the dwelling is needed. This paper mainly proposes a research about the healthcare service in a residential environment, which includes medical service and safety service and so on, by surveying the voucher program and the in-house infra status. Finally, the house planning elements for healthcare-based smart home are drawn and the planning directions through expert survey are suggested. Therefore, this study surveyed on voucher program and in-house infra status, and drew the house planning elements for health-based care smart home. In addition, this study suggested the planning direction through expert survey. This study can be used as a guideline for constructing a smart home, which supplies healthcare service.

**Key words:** Smart home, ubiquitous healthcare services, voucher program.

## 1. Introduction

The world population is showing a trend toward aging, and domestic circumstances are in more rapid progress, so it is predicted that Korea would enter the super-aged society, in which in 2026, the population aged over 65 will exceed 20% of the whole population of Korea. A senior citizen falls short of independence due to physical aging, and in case of a patient with a chronic disease, a long-term management and psychological stability are required. It is advisable to serve those people at home where they can manage their healthy living with family, which can lessen the economic burden and help those people not to feel a sense of loss due to the separation from family rather than a nursing home or hospital. According to the 2010 Seniors Partners Survey, 54.7% of the residents wanted to cure their health at home. This shows the paradigm

shift of the health management which occurs from hospital to housing facilities and from focusing on the ailment to preventing disease. Thus, construction of smart home based health care system is required.

Smart home enhances an occupant's comfort using telecommunication and web technology. A smart home user can operate house devices from outside; it is also possible to compose sensors as a part of environment so that they can behave suited to circumstances by recognizing them even without a user's direct manipulation. Particularly, looking into the progress of healthcare technology and industry to the present, it mostly ends with a single-shot pilot project after all because it only focused on developing relevant devices. From this aspect, to construct a smart home, which effectively provides health care service, will play a vital role in solving such a problem as using the above IT-technologies. Thus, the purpose of constructing a smart home to provide healthcare service can be suggested as follows: The first purpose is to improve quality of life for senior citizens and reducing social

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**Corresponding author:** Ji-Eun Lee, associate research fellow, research fields: architectural design incorporating environmental performance and health services. E-mail: jee@lh.or.kr.

cost as a way to prepare for entering aging society. The increased proportion of elderly makes medical expenses increase dramatically. Thus, to reinforce the healthcare function is needed in cost cutting of residential space.

Second, it aims for an occupant, which guaranteed to the sustainable residential space for realizing “aging in place”. This expedites the management a self-supporting village and the senior citizens’ active participation in social activities. This study is aimed at suggesting the design elements and methods, which should definitely be reflected in at a time of planning a smart home by looking into the cases of health care service, which was applied to the interior of an apartment house. In addition, this study is intended to improve the role of housing in aging society and to set the foundation on which healthcare service can be effectively operated in an apartment house.

This paper is organized as follows: first, this study considered the previous research and description related to healthcare service system and smart home. Second, this study surveyed on the health care service model applying the voucher program as the typical case of u-health service type in progress of the nation. It also surveyed whether the foundation of housing complex is constructed or not. Finally, this study suggested healthcare service items that should be supplied to a house and their application plan.

## 2. The Review Procedure

### 2.1 Method in Smart Home Technology

Smart home can be defined as a human-centered intelligent residential space which can automatically recognize an occupant’s behavior and function by itself in ubiquitous computing environment applying digital technologies. The integral part of smart home is as follows: (1) network: wired, wireless and hybrid; (2) intelligent manipulation technology: the gateway for managing the system; (3) home automation: integrating electrical devices in a house with each other, tying in outer services such as caregivers or

institutional care. In addition, smart home has to supply comfort, safety service and additionally health care service for occupants with these. First, smart house recognizes an occupant’s activity and automatically control. It is due to the fact that occupant’s comfort and safety can be guaranteed at a time of an accident, such as a fire and a gas leak, etc.. In addition, smart house supplies the service that can control internal devices by connecting them remotely from outside. Second, health care service checks an occupant’s health condition and takes measures using the medical devices supplied to each family. Moreover, a check-up and medical action makes it possible to notify the relevant information to a medical institution using an automatic patient-monitoring system.

Such services as these will be developed into a true sense of smart home as a part of housing as adequately as a user can not recognize the motion of the relevant system. For this purpose, many research works for making an optimized model to meet the needs of a user, and the launching of the application model should be entailed.

### 2.2 Theoretical Approaches for Public Healthcare System

According to the development of network technologies, the concept of service is being expanded with the existing medical service integrated with information and communication technology to transcend time-space. U-healthcare is defined as a system or environment that can be provided with health and medical service for prevention, diagnosis, and follow-up management by integrating medical industry with IT by the definition of Telecommunications Technology Associations. Healthcare service suggests type-division different by each institution. CHA (Continua Health Alliance)<sup>1</sup> classifies the health care service into disease management, obesity management, and the

<sup>1</sup> CHA: [www.continuaalliance.org](http://www.continuaalliance.org), the organization of healthcare and technology companies.

elderly-monitoring system [1]. The Korea Health Industry Development Institute does depend on the target person: high-risk patients as u-medical, the elderly as u-silver, and ordinary people as u-wellness. The health care service, which is conducted by the domestic voucher program, is a kind of the treatment and management of metabolic syndrome<sup>2</sup>. That belongs to u-wellness for ordinary people, and it is necessary to expand its scope to u-silver in order to respond to aging society.

The government implemented u-health pilot project after 2006. Its service scope has included medically vulnerable region like island areas and penitentiary, etc. for chronic diseases requiring continuous monitoring, such as a lung disease, and high blood pressure. Song (2011) [2] divided the u-health pilot project into six service types and suggested the treatment and management of metabolic syndrome as a type having an active political support. This service is provided through the process in which u-health center measures a user's biometric data, which are delivered to an affiliated sports curer and nutritionist for continuous monitoring and counseling [2]. This service has promoted the metabolic syndrome management service through preventive health services based on regional-development voucher program led by the Ministry of Health & Welfare since 2010.

Such a health care service will be a major planning element in housing plan like prevention of safety accident. According to the 2011 statistics, in case of the elderly, they have the tendency to think of their health condition as bad, and 88.5% of the age-old population aged over 65 was found to have chronic diseases. Among those elderly people, the rate of having more than three chronic disease accounts for 54.7%. Therefore, the service is useful for a national level reduction in medical expenses as well.

<sup>2</sup> By the definition of Wikipedia, metabolic syndrome is a combination of medical disorders to increase the risk of developing cardiovascular disease and diabetes.

### 3. Review of Projects

#### 3.1 Voucher Program for Social Service

Regarding the voucher program, the healthcare service supply model can be explained roughly by two sorts according to device management methods as shown in Table 1 [3]. The first method is to install a device at a specific space for users to visit for their health measurement at any time. This measurement is available as a dwelling unit as well. The measuring result is stored on the Website and linked to u-health zone which is installed at the space for the common use. In addition, the result can be confirmed at different location. The next method is to supply service while the exclusive manpower is traveling with health devices. However, the weak point of this method is that it is available only on fixed days. Through the temporary rental of mostly the welfare center or the public facilities for residents, this service is provided for common use, together with telephone counseling for motivation and feedback.

#### 3.2 Actual Services and Utilities in Apartments

This study conducted the actual condition survey on the present housing environment for service construction targeting silver towns and apartments designated for the elderly. First, the subsequent differentiated management system and service should definitely be arranged for silver towns. The reason is that the facilities target the elderly who have a lot of difficulties to get around and have many constraints in daily life. The 2010 survey by Kyobo Insurance and Seniors Partners indicated that there was the highest demand for medical service [4]. However, according to

**Table 1** Cases of existing voucher programs.

Installation at a public space at all times	Health consultation and measurement by periods	Visiting service by periods
		

results, the actual condition of nine silver towns in Korea was that emergency pager, motion-detecting sensor, and location system are adequately provided, whereas the monitoring system for healthcare was installed in only three places, being exposed to shortages. Next, when apartments supplied the health care system into a dwelling, the lack of the Internet and power supply unit is considered. According to the previous result, surveying four places out of five rental-housing complexes designated for the elderly, only the emergency pager was applied to three complexes [5]. In addition, there was not enough space and infra to install and store health devices for common use as shown in Table 2. Therefore, the space and equipment for the service should be considered, when new apartment complex was planned.

As shown above, the present situation for implementation of health care service is insufficient and the infra is also inadequate for service construction. Thus, it is urgent to arrange the foundation for supplying sustainable healthcare service through physical infra-construction and effective program management which back up a healthcare service policy.



#### 4. Design Methods for U-healthcare System

In supplying health care service, presently various sorts of prescribers and controllers should be involved, but a helping hand will be less required soon. In other words, smart home will gradually recognize and understand a human's behavior. However, big problems may arise in storing a user's pile of information outside. Accordingly, it is important to construct the safety of information and enhance credibility for the information supplied and stored by smart home.

##### 4.1 Smart Home Services

The health care service supplied to smart home can be roughly divided into four as follows: First, wellness

**Table 2 Implementation of health-service in the existing housing condition.**

Independent senior status	Dependent senior status
	

monitoring is to provide the visual analysis results and its typical service type is to trace activities including outside control. Second, "aging in place" is offering comfort and safety for the elderly, and it includes the service of supporting activity disorder and luminance-adjusting services for elderly activity. Third, the telemedicine is the supporting service of showing and managing a person's health condition. Finally, supporting a patient is the service for doing healthcare of a specific disorder in case of disability like dementia.

In order to construct such services in residential housing, it is required to install a system which can recognize occupant behavior by using a sensor. This information is transmitted to home gateway and the outside of housing through home automation. The method of settling such services in housing should be applied to the form of smart home [6]. In addition, it could be an effective method for supplying the telemedicine service for the elderly and people with physical disabilities to lead independent and successful lives.

The method of attaching them to housing can be divided into simple attachment type and package type. According to questionnaire survey<sup>3</sup>, the package type was preferred by around 68% of the respondents. This study drew an important requirement that such a package devices for supplying health care service

<sup>3</sup> Questionnaire survey: Target 32 experts (architects 7, public officers 1, researchers 15, professors 5, the others 4), period: Oct. 2 15, 2012.

should be installed together with the monitor, which makes it possible for a user to measure in a comfortable posture, and to confirm the health information. In addition, the installation flexibility should be applied with importance: composition of multi-purpose space form that can be used for other function not doing health measurement, variable mobile-type planning.

#### 4.2 Design Factors in Health Care Services

Design factors based on such three sorts of division can be listed as shown in Table 3. These planning elements can be applied to planning roughly in three methods. The first method is to make the recognized occupant behavior through a sensor into information and to support the safety by connecting it to the outside. It is attached to the wall, ceiling, and floor, and it does not visually stand out. In addition, appliance monitoring and controlling from distance

location is useful for this purpose, and web-based solutions and mobile device are available. The second method is to predict an occupant's behavior through the sensor and support convenience. It is operated mostly by lighting and supported by the change of illumination; generally, that is paired with the manual operation. Moreover, there is the equipment attached for a specific service like an emergency pager and interphone. The third method is to measure the health condition and to get information. This method makes it possible for a user to get information support through measurement at any time and any place they choose. Its related equipment varies depending on the sorts of service. It is advisable to install it in a removable form rather than composing it as a part of the housing interior for its efficient maintenance. However, these services belong to the planning matters in which visually unexposed information management and service supply system construction

**Table 3 Smart home design factors**

Classification of design factors	Space character	
	Private	Public
<b>1. Wellness monitoring &amp; remote access</b>		
·Audio-visual supporting device + emergency escape	•	•
·Installation of CCTV for preventing emergencies		•
·Health-condition-verification system	•	
·Notifying system for personal schedule	•	
·RFID-based access location verification system	•	•
·Appliance control via mobile devices from outside (gas, boiler, home appliances, etc.)	•	
·Controlling system for convenient life (lights-out in a lump/gas block-switch, elevator call)	•	•
·Voice-operated appliance control	•	•
<b>2. Aging in place</b>		
·Automatic ventilation system for room air quality	•	
·Motion-detecting sensor in response to emergencies	•	
·Water temperature-visually recognizable bath-tub and faucet	•	
·Video-telephony apparatus for relieving loneliness	•	
·Lighting available for luminance changes according to activity	•	
·Sensor-based indirect lighting(stair, front, door, the floor adjacent to a bathroom)	•	•
·Notifying system for location of frequently used belongings	•	
·Emergency pager with easily accessible form	•	•
<b>3. Telemedicine</b>		
·Space layout for health measurement depending on the occupant behavior	•	
·Installation of precision measurement healthcare apparatus and its infra		•
·Installation of health notification system (checking of dosage, management of medicine-taking history, checkup period)	•	

should be decided as a top priority. Therefore, the quality of social service in home would be determined by the proper infrastructure outside of housing.

## 5. Conclusions

The model of the future housing is the housing form supporting automation through smart home. It supplies diverse services from the outside, among which healthcare service can play a vital role in improving the quality of life for the elderly and disabled people. The previous researches were mostly related on the system in the smart home or the health service supply model; whereas, there has not been the research on the foundation for supplying services to residential space. This study suggested the design factors and methods for supplying healthcare service to housing. First, healthcare smart home should support convenient and safe in daily life and the elderly independent life for “aging in place”. In addition, there should be a planning of the service supply system which expands and connects the disease prevention and health condition management function in hospital’s charge to the family. Second, it is imperative that the sensor for constructing service infra is reflected. In addition, the device and space, which complete the process of linking information to spaces outside the dwelling by transmitting information to the gateway, should be arranged. Third, this study suggested the package-type installation and simple-attachment-type installation for health care equipment. In addition, in case of the highly preferred package type, equipment model can be supplied

differently according to service types. There should be definitely arranged the criteria for service standardization through all research works for smart home construction. The reason is that service quality degradation and personal information leakage caused by the equipment gap should be controlled. In accordance with the development of healthcare equipment and ubiquitous technologies, it will be possible to build a smart home, which can provide high-quality healthcare service.

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