Title: Enhancing Care Homes with Assistive Video Technology for Distributed Caregiving

Taro Sugihara
Graduate School of Natural Science and Technology, Okayama University,
3-1-1, Tsushima-Naka, Kita-ku, Okayama 700-8530, Japan
t-sugihara@okayama-u.ac.jp
Phone: +81-86-251-8228 Fax: none

Tsutomu Fujinami
School of Knowledge Science, Japan Advanced Institute of Science and Technology

Rachel Jones
Instrata Limited

Kozo Kadowaki
School of Science and Technology, Meiji University

Masaya Ando
Faculty of Engineering, Chiba Institute of Technology

ABSTRACT

Dementia care is becoming increasingly important in Japan as the elderly population grows. Care homes are designed so that caregivers can easily observe and subsequently respond to the needs of people with dementia. However, the layout of care homes can become overly restrictive for residents, for example, by not providing intermediate spaces where people can spontaneously interact and initiate conversations. We present a case study that explores the implementation of video monitoring in two purpose-built care homes in which we were asked to help overcome the blind spots presented by the layout. We collected data both before and after the implementation of the video monitoring in order to understand its effect. The balance between people's sense of security and the concerns about loss of privacy through video monitoring is well established. However, we found that video monitoring had a beneficial effect on both the caregivers and the residents if implemented sensitively. Furthermore, the implementation of video monitoring could support the design of more beneficial care home layouts. In conclusion, we propose that the sensitive implementation of video monitoring be considered alongside design of the physical layout of care homes.

Keywords:

People with dementia, caregivers, care homes, spatial layouts, video monitoring, qualitative research

1 INTRODUCTION

Dementia care is becoming increasingly important in Japan as the elderly population grows (United Nations Population Division 2008; World Health Organization and Alzheimer's Disease International 2012). Elderly people with dementia require special attention because they are vulnerable to changes and events in their environment, and become uncomfortable when they do not recognize their surroundings. Thus, caregivers must create a peaceful environment. Caregivers must be well trained and experienced, and they need to pay special attention to the particular needs of people with dementia. Person-centered care (Kitwood and Bredin 1992; Kitwood 1997) is an approach to dementia care in which the client is central to the activities; essentially, the caregiver observes and communicates with that person to determine what he/she wants to do and why.

Previous studies have not paid particular attention to the spatial layout of care homes in relation to caregiving and assistive technologies. Among the literature reviews published so far, Topo (2009) focused on the relationship between assistive technologies and the needs of people with dementia. In addition to these factors, we look to the environment for caregiving. Another systematic review described monitoring technologies for people with dementia in residential care (Niemeijer et al. 2010); looking at 79 papers, they found a conflict of interest between residents, managers, and/or owners. Privacy is one of the issues in this context, which may be seen in a new light when we consider factors involved in the living environment (Niemeijer et al. 2010).

Care homes are being designed so that caregivers can easily observe and therefore respond to the needs of people with dementia. However, the layout of care homes can subsequently become overly restrictive for residents. For example, the care home can lack intermediate spaces in which people can spontaneously interact and initiate conversations. This paper explores the relationship between the spatial layout of a care home and the use of a video monitoring system in the environment to enhance collaborative care. Three research questions (RQ) were posed to investigate the relationship:

RQ1 How does a video monitoring system affect collaboration among caregivers?

RQ2 How do the spatial layouts in conventional care houses affect care management?

RQ3 How does a video monitoring system enable people with dementia and their caregivers to identify opportunities to change the spatial layout to strengthen care?

To answer these RQs, we conducted case studies of a video monitoring system implemented in two care home and analyzed the spatial layout. The results addressing these RQs have been briefly reported elsewhere (Sugihara et al. 2013). This article was written as a follow-up to our prior results. This study employed qualitative research design to compare two kinds care houses, a renovated care house and a purpose-built care house, with descriptive analysis.

In the next section, we briefly explain the related work in architecture and assistive technologies, and then present the findings from our case studies. The paper concludes with a broader discussion.

2. LITERATURE REVIEW

A *smart home* is one in which a sensor network is installed. The goal of a smart home is to provide an assistive environment, such as being able to sense the locations of caregivers and residents in order to enact

mappings between the physical world,remote monitoring and intervention services (Demiris et al. 2004; Helal et al. 2005). When the concept is applied to a care home, the result is a smart home that enables caregivers to monitor residents' whereabouts. When a smart home is inhabited by people with dementia, it helps caregivers to be more aware of the risks associated with residents' unusual behaviors, such as wandering and agitation.

Arcelus et al. (2007) describe sensors integrated into a home as a "health monitoring system," which can communicate to health care providers any abnormalities found in patients living in that home. A previous study reported on a smart home containing infrared sensors, which could detect the abnormal behaviors of elderly people with Alzheimer's disease (Campo and Chan 2002). A framework called the Open Service Gateway Initiative was proposed and adopted to develop a system that integrated the Mobile Patient Care-Giving Assistant, General Reminder System, and Augmented Awareness System (Helal et al. 2003). A bedside monitoring system was developed to predict when staff should perform each form of therapy by highlighting specific areas for attention (Hope and Waterman 1997). A sensor network was developed to localize users via signal strength measurements, which consisted of user badge nodes, several image sensor nodes, a node with a modem, and additional optional wireless nodes (Tabar, Keshavarz, and Aghajan 2006). Another study developed a decision support system using a machine learning technique relating to daily behavioral patterns of patients with Alzheimer's disease (Zhang et al. 2008).

Regarding the issue of spatial layouts for caregivers and residents, we must find complementary solutions that can improve the effectiveness of layouts, rather than relying on them solely. This is because the conflicts between the physical safety and personhood needs will never be solved by merely focusing on the layout of the house. What follows is a proposal to separate the flow of information and the spatial relationship between caregivers and residents by deploying assistive technologies in care homes. By separating the information flow and spatial relationship we are able to load different functions onto them, attributing the former to caregivers and the latter to residents. The relationship between privacy issues, assistive technologies, and person-centered care warrants attention (Niemeijer et al. 2010).

3 CASE STUDY1: The Video Monitoring System

We focus on a small type of care home called a group home. Group homes in Japan are categorized from an architectural standpoint into two types. One type is converted from an old house built originally for a family, meaning that it was not intended initially for use as a care home. This type of home tends to have many blind spots. The other type of home is purpose-built to accommodate the elderly with dementia. This type of home is built to eliminate as many blind spots as possible on the grounds of safety.

An overview of the case studies is shown in Table 1.

We investigated two group homes, which we refer to as GH-C and GH–D, via interviews and video observations. We implemented a video monitoring system in both group homes. In the following section, we describe and analyze the effect of the systems, which prompted us to raise some architectural issues.

Our purpose was to investigate how the spatial layouts of care houses affect caregiving, and, more specifically, how they affect the communication between caregivers and residents. We compared the caregiving at GH-D, a care home renovated from a traditional Japanese-style house, with the caregiving at GH-C, a new purpose-built care home, to examine the effects of spatial layouts. We also investigated the effects of a video monitoring system through a comparison of the caregiving methods before and after implementation of this system in GH-C and GH-D.

3.1 Research method

We designed the system to be as simple as possible because the caregivers in the group homes were not familiar with computers. The system consisted of wireless cameras, a portable monitor, and a laptop functioning as a server. Visual data from the cameras were gathered on the server and displayed on a web browser. A down-scan converter was employed to turn the information displayed on the web browser into television signals, which were transmitted to a portable monitor. This eliminated possible malfunctions due to mishandling by the caregivers or residents because it was impossible for them to operate the system through the monitor.

A preliminary investigation was undertaken to identify the blind spots in the group homes and to identify the system's requirements. The manager and caregivers were concerned with invasion of privacy and were especially keen to avoid any unwanted effects that might be caused by video recording, so we paid considerable

Table 1. Overview of Case Studies

		GH-C	GH-D
Type of buildings		Purpose-built and newly established	Renovated
Number of residents		Nine	Nine
Number of informants		Five caregivers and two managers	Nine caregivers and one manager
Caregivers during daytime		Two or three	Two or three
Caregivers during nighttime		One	One
Residential areas		First floor	First floor
Start of system operation		March 2008	September 2010
Time of interview	Before	November and December 2007	August and September 2009
	After	May 2008	August 2010
Time of video observation	Before	March 2008	December 2010
	After	December 2008	September 2010

attention to preserving residents' privacy. We decided to establish cameras in common spaces only, such as the entrance hall, the corridor, and the living room. In our discussion with the manager of GH-C, we discovered that five areas in the home were often difficult to observe. Furthermore, we decided not to include any video recording functionality in the system. The GH-D system was implemented in a similar manner.

A series of semi-structured interviews was undertaken before and after the system was implemented in GH-C and GH-D. We interviewed fourteen caregivers and three managers, asking them their opinions of the system and which aspects they regarded as the most valuable in terms of dementia care.

All of the interviews were recorded with an IC recorder and fully transcribed for ease of reference. The constant comparison method (Glaser and Strauss 1967) was used to analyze the transcriptions. The transcriptions were repeatedly read as many times as possible to identify any commonalities and differences among the data, and similar data were classified into categories. In this process, categories were integrated when one was recognized that had similarities with another. This analysis process was repeated until new categories no longer emerged.

We also recorded and observed the caregivers' and residents' behaviors. The caregivers and managers allowed us to record their images with two extra video cameras in GH-C as shown in Fig 1 (V1 and V2), which were not part of the main camera system.

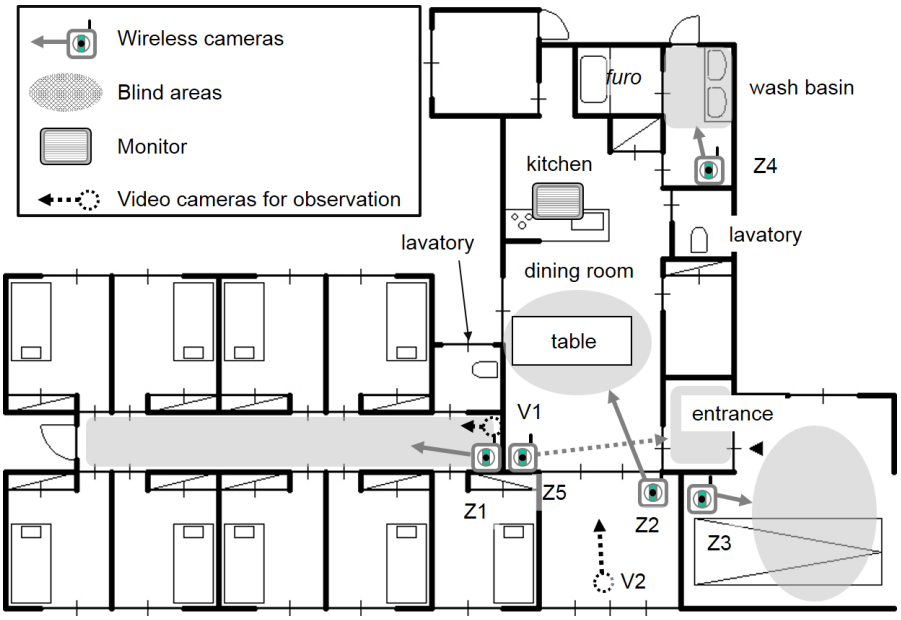

Fig 1. GH-C plan and arrangement for cameras and a monitor

After obtaining informed consent, we connected four video cameras (V3 to V6 in Fig 2) into the GH-D home for the investigation.

We collected data one day before installation and one day after system installation. The total recording amount in GH-C was four nights (nineteen hours for each); the recording for GH-D was conducted over four nights (52 hours) pre-system implementation and six nights (78 hours) post-implementation. It was difficult to compare before and after system installation in the case of GH-C due to a serious affair that occurred during this investigation, although video recording was conducted in the same way as in GH-D. This study mainly focuses on the results from GH-D. We analyzed the caregivers' and residents' behaviors as observed in the corridor, living rooms, and dining rooms to concentrate our investigation on the events closely related to daily activities, such as restroom assistance, at GH-D. When residents or caregivers took actions, their behaviors on the video were annotated. The annotations were categorized in response to similarities and the number of actions was counted. Furthermore, we recorded the place where the actions took place and the actions involved when a caregiver took a responsive action.

In this study, we strictly observed informed consent guidelines when asking individual caregivers and group home managers for data. Likewise, a letter of consent was obtained from the residents' families. To maintain privacy, video cameras were never connected in private residential areas such as inside a resident's room, the

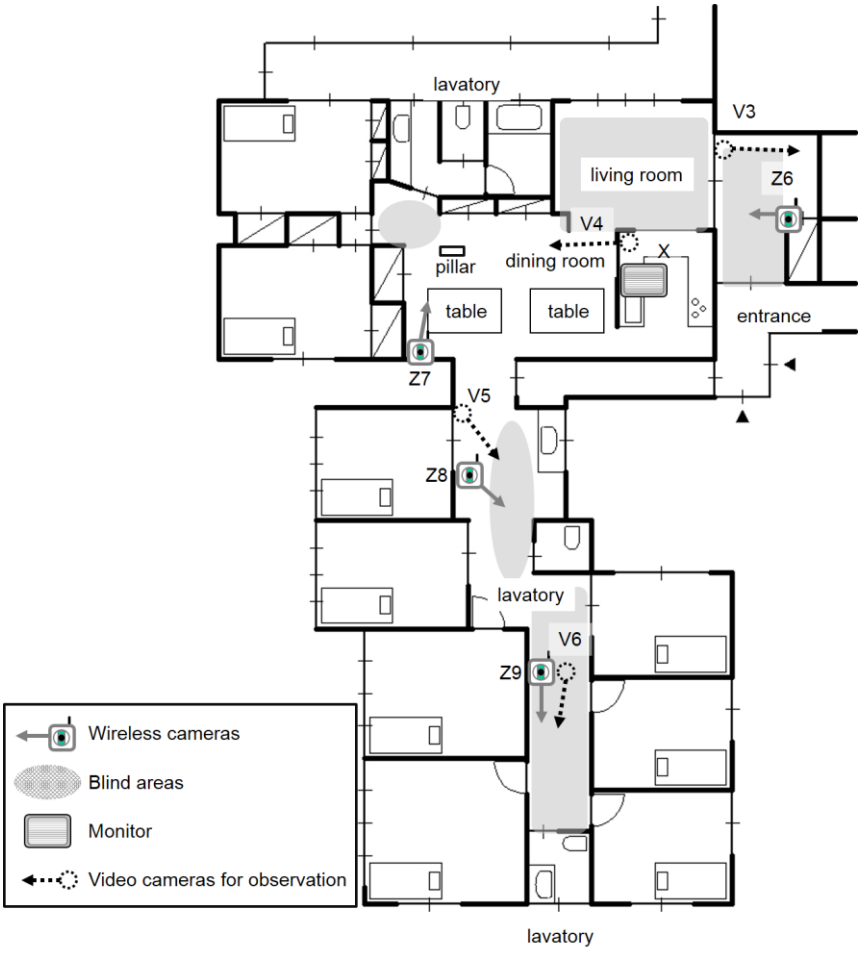

Fig 2. GH-D plan and arrangement for cameras and a monitor

Table 2. Results of the interview

Categories	GH-C	GH-D
Adopting technological aid for comprehension of situations in the care house	○	○
Confirming signs/actions of wandering	○	○
Confirming signs/actions of fall-down	○	
Confirming the residents' behaviors with care work at hand	○	○
Establishing the role of care work	○	
Alleviating physical burdens	○	○
Alleviating mental burdens	○	○
Eliminating blind areas	○	○

washroom, or the *furo* (Japanese-style bathroom). This study was approved by an ethical committee at the Japan Advanced Institute of Science and Technology.

3.2 Findings

From the analysis, interview data were divided into two major categories: ways of system use and effects on care work. The categories of system use were adopting technological aid for comprehension of situations in the care home, confirming signs/actions of wandering, confirming signs/actions of falling down, and confirming the residents' behaviors with care work at hand. The category of the effects of care work consisted of establishing the role of care work, alleviating physical burdens, alleviating mental burdens, and eliminating blind areas. Comments from the informants and their categories are shown in Table 2; circles refer to the comments in terms of individual categories. According to the results of the interviews and video observations, we found two behavioral changes.

3.2.1 Establishing the roles of watcher and doer

It was found that the monitoring system made caregivers' roles clearer to them. After the system implementation, a caregiver who was working in the kitchen where one of the video monitors was placed, took the role of watcher while other caregivers were involved in household chores. The caregivers outside the kitchen were helped by the caregiver in the kitchen in that they could control situations even if there were several areas that they could not directly see. Caregivers in both group homes felt that the system had improved their work styles significantly because it enabled them to focus on the tasks at hand, such as helping another resident use the washroom.

The role of watching residents from the kitchen in GH-C indicates that the caregivers could carry out specific tasks more easily than before. Before, care workers had to move to places to see what was happening when they noticed something unusual. Now, the video monitoring system enables them to see those areas without physically moving to them, allowing them to remotely observe an incident. There is no need for coordination as long as the caregiver receives immediate information and reacts to a resident-related incident. It is worth noting that there was no ability for a caregiver to view an incident without physically being at the location of the incident before the introduction of the video monitoring system.

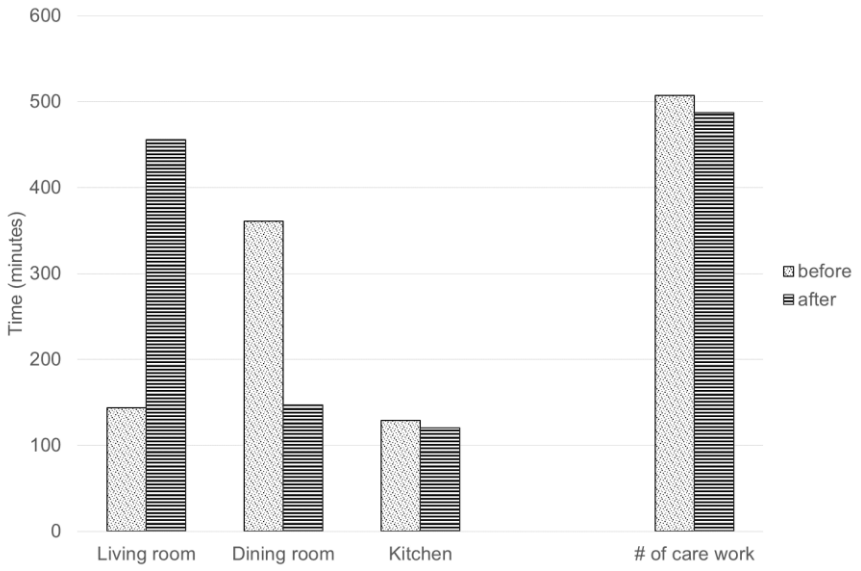

Fig 3. Caregiver's location and total amount of care work at GH-D

The results from the interviews and video observations at GH-D were similar to the results in GH-C, although the environment was slightly more difficult for observation. GH-D had three large blind spots (the three washrooms), although the number of caregivers did not differ from GH-C. The caregivers were highly concerned that they could not assist residents needing to use the toilet when they were assisting other residents in another washroom. The bottom washroom in Fig 2 is separate from the living room, where some residents undertake pastimes such as watching television and where caregivers rest; and from the dining room, where residents undertake pastimes and caregivers complete required tasks such as writing care records. In addition, the sliding door near the dining room opens and closes smoothly and silently, making it difficult to hear. Therefore, the washroom became the largest blind spot for caregivers before the system's implementation, with all of the caregivers paying considerable attention to the washroom at all times.

One of the difficulties when assisting the elderly with dementia is that they may unexpectedly perform unusual activities. Thus, caregivers must pay attention to the residents at all times. However, they cannot always watch them. For example, they must take residents to the washroom and may not be able to watch others while being engaged in that task.

Results from the video observations support the results of the interviews. Fig 3 shows caregivers' whereabouts and total amount of care work that they performed at GH-D.

Caregivers had to be in dining room prior to the system's implementation because the dining room, especially near the table, was the best place to observe the residents' bedroom doors and the washroom doors. Although they usually wrote care records on the table in the dining room, this caused them considerable stress because the room was more difficult to relax in than the living room. Consequently, their workspace was shifted from the dining room to the living room after the system's implementation for easier relaxation timeat night.

There is no evidence that caregivers were careless with residents. The results of the excretion assistance analysis indicated that the caregivers concentrated their resources on the residents who required assistance. As shown in Fig 4, the video monitoring system enabled relaxation in the living room because of the enhanced viewing capabilities that room allowed, owing to the monitoring system being set up there.

After the system implementation, back-and-forth walking to confirm situations in the washrooms and care time for walking assistance, such as opening and shutting the door, were reduced. However, care for residents in the washrooms did not change.

The results indicated that the video monitoring system enabled coordination of the role changed between watchers and doers by enhancing their field of vision. Although it was difficult for caregivers to be good watchers before the system was implemented because of residents' actions in blind spots, they could nonetheless be responsive doers. Post-implementation, watchers could take more responsive actions.

3.2.2 Alleviating stress

The series of interviews revealed that the system reduced caregivers' physical and mental stress, as previously reported (Sugihara et al. 2008; Sugihara and Fujinami 2011), comparing the situation before and after system deployment. Caregivers reported that some areas became blind spots at night because fewer caregivers were available to work overnight. The video monitoring system was most effective during nighttime and, specifically, from midnight to early morning. Caregivers who worked during the night were very anxious about blind spots. They were afraid that some residents might be seriously injured (e.g., bone fracture) if they fell down. Such accidents are

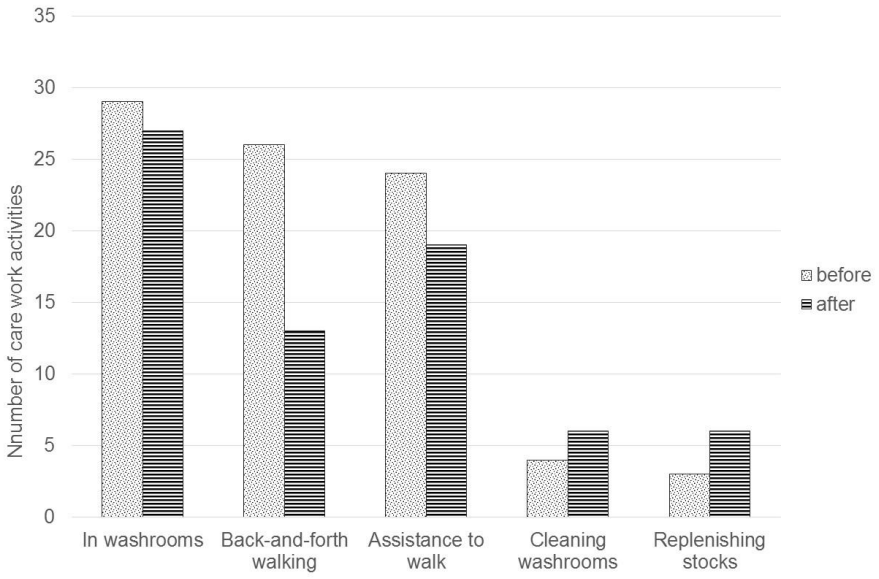

Fig 4. Classification of excretion assistance at GH-D

always a possibility, but they must be avoided because being injured and confined to a bed may further cognitively impair the individual. Caregivers were so concerned about accidents that their anxiety would increase in the evenings.

During both the daytime and nighttime shifts, caregivers reported that the camera system assisted them in making decisions. For instance, when a resident appeared from his/her room and walked toward the washroom at night, caregivers in the kitchen in GH-C or dining room in GH-D may not have been aware of the event. If they noticed that a resident was heading toward the washroom, they left their work and took any necessary action. Such redundant back-and-forth walking and extraordinary precautionary attention led to high caregiver stress. Two caregivers and a manager in GH-C said that, post-implementation, it was easy for them to observe residents entering or exiting the washroom, both day and night.

Before the introduction of the monitoring system, residents' activities were limited in order to ensure their physical safety. On the other hand, while the system was in place, both residents and caregivers had fewer restrictions. A veteran caregiver reported that the elderly residents' peace of mind improved in response to the increased level of caregiver attention.

4 CASE STUDY2: Comparison of Renovated and Purpose-Built Care Homes

4.1 Analysis of Spatial Layouts of Group Homes

The architectural plans of the new purpose-built care house, GH-C (Fig 1), and a renovated care house, GH-D (Fig 2), were analyzed using space syntax (Hiller 1985). The analysis was conducted by an architecture researcher, the fourth author, who is a professional architect and a university-based assistant professor.

Space syntax is a combination of theory and technique designed to analyze the spatial configuration of spaces such as urban areas and hospitals. It is a useful method to grasp the spatial functions of group homes.

First, the two group homes were separated along with the design compartments. Individual compartments were categorized into four groups: space for personal use (e.g., residents' rooms), space for access by the general public and multi-purpose uses (e.g., living room, dining room), space for access by the general public and specified purposes (e.g., lavatory, kitchen, *furo*), and space for moving (e.g., corridor, entrance).

Second, the relationships between the categories were described in order to understand their nature. Each compartments' functions were then rendered in detail from the standpoint of how residents and caregivers usually used the spaces, how connecting points (e.g., doors) worked to link other compartments, and the functions each compartment had for visual and auditory purposes.

4.2 Results

GH-C consists of two components, one of which extends from north to south and the other of which from east to west. These two components are adjacent to each other and the former includes common facilities such as the kitchen and dining room, while the latter includes individual rooms.

The GH-C plan (Fig 1) shows that the central corridor joins the common facilities and individual rooms, which are arranged on both sides of the corridor. The width of the corridor is set for a person in a wheelchair to pass

through and no activity is expected to occur there except for a resident's movement through the area. The architectural planning only exhibits two types of spaces: private or public. There is no gray area, such as an alcove. Therefore, the residents have few options concerning their whereabouts and are rarely persuaded to undertake small group activities such as chatting between themselves.

GH-D is a renovated care house converted from a family house (Fig 2). The house consists of common facilities and individual rooms, which are connected by a crooked corridor. The reason that the corridor is not straight is that the house was not designed with the purposes of care in mind, but rather for a family: thus, while the crooked corridor produces blind areas making it not ideal for caregiving, it also produces places for communication among small numbers of people who encounter each other. This type of space allows residents to exhibit a greater variety of behaviors, but is not preferred by caregivers because it is difficult for them to monitor residents. GH-D's common facilities are also a problem because caregivers cannot look through the corners if they are in either the living room or the common room. From a caregivers' perspective, it is difficult to coordinate their activities and the space includes many blind areas. As the result, each caregiver tends to deal with residents independently, which leads to restricting residents' behaviors so that they are near the caregiver.

The interviews showed that caregivers often bring residents into the dining room or living room. The dining room allowed caregivers to easily observe residents' recreational activities from the kitchen. The living room, specifically the television, was used to prevent wandering. However, it was difficult to watch their actions from the kitchen because of the wall. Finally, part of the wall was removed (as shown as Point X in Fig 2) to eliminate the blind areas in the living room. A dining room door was removed as well.

5 DISCUSSION

Human resources establishments are designed to prioritize the maintenance of operations and management in the building. All users must obey the building's purpose. In particular, it becomes clear that the building's design requires both the operator and receiver to behave according to the building's purpose. For instance, jails are designed to fulfill the purpose of easily monitoring prisoners. Accordingly, the corridors in the jails are usually straight, jail room doors are usually transparent, and walls separating the inmates from the outside are usually higher. Schools, libraries, hospitals, and care homes can be classified in the same category.

If administrators' resources are inadequate to operate the building, they will overwork themselves to continue operation. Additionally, the building's functions, such as spatial layouts and/or facilities, are then used beyond their capabilities to cope with the administrative resources. In this study, caregivers repeatedly walked back and forth to confirm conditions in the washroom. The GH-C purpose-built group home has more straight corridors, wider rooms, and more open spaces, in a similar way to ordinary schools, jails, libraries, and hospitals. This type of facility can be considered a precaution for the risk of inadequate resources. The wall and door removal in GH-D can be considered in this case, especially in terms of its spatial layout. Our previous study showed that caregivers may lock doors that directly leading to the outside if caregivers and managers do not have the skills and leeway to maneuver dementia-related issues such as aimless wandering (Sugihara et al. 2008; Sugihara and Fujinami 2011). The informants in these studies appealed the anxiety of serious injuries or missing caused by wandering before

similar monitoring system deployed. The video monitoring system decreases the number of moments in which no caregiver is able to see the residents by providing caregivers with a wider area of visibility, thus increasing the chances that caregivers will be able to respond to residents' sudden unusual behaviors.

Such coping methods are used because indispensable information for care in care houses is collected merely from the physical environment. Information from sight, sound, and scent can be propagated or shut out by facilities and partitions. The methods of acquiring information are entrusted to the caregivers' motivations and the policy of the care home. In other words, it is likely that this is an issue of personal commitment to the residents' wellbeing. Consequently, it means that conventional care houses do not often have the ability to manage information effectively. This makes it necessary to introduce assistive technologies into care houses to enhance caregiving potential.

Brand (1994) highlighted that buildings consist of six layers: site, structure, skin, services, space plan, and stuff. Each layer differs in terms of longevity. Site, which signifies the geographical settings, the urban location and the legally defined lot, is the most long-lasting layer. People do not expect to change the structure layer to reduce the risk of deterioration and because of the costs. Skin (i.e., exterior surface) changes every twenty years due to updatesin fashion and/or technological trends. Services involve all of the building's facilities such as electrical wiring and plumbing, which are replaced every seven to fifteen years in Japan. Space plan is the layer for interior layouts: space plans change approximately every three years. Stuff refers to the objects contained within, such as chairs, pictures, and books; these are often changed daily. The space plan can take into consideration the spatial layout rearrangements. Assistive technologies belong to the stuff layer and their connecting components such as wires and plugs, are part of the services layer.

The introduction of the monitoring system adds a new layer, which we call *the information layer*. This exists in addition to the physical layer, which is the building itself. Before the introduction of the system, the physical layer defined the information layer; that is, the structure of the building determined the information layer. Caregivers must grasp all of the information regarding the residents' physical and mental conditions, and detect signs of unexpected behavior from their line of sight. They must also coordinate their tasks on the basis of this restricted sight. Therefore, they changed the structure layer to enhance their sight and to coordinate more easily.

The information layer enabled caregivers to coordinate themselves when dealing with the residents. A caregiver in the kitchen could determine not only the residents' actions but also those of their companions without changing the structure layer. From the standpoint of the owners of care homes, introducing such assistive technologies can cut change-related costs. Implementing assistive technology means changing the services layer and the space plan, which is far less expensive than changing the house structure.

The addition of the information layer also helped caregivers to clarify their roles, resulting in a division of labor: the watcher and the doer. The clarification decreased caregiver work stress (Kahn et al. 1964) because their responsibilities were specified. Role stress, especially role ambiguity and role conflict, is a well-known predictor of burnout (Rizzo, House and Lirtzman 1970). In healthcare settings, several studies show that role ambiguity and role conflict are causally related to emotional exhaustion (e.g.. Barber and Iwai 1996; Shaefer and Moos 1996; Moniz-Cook et al. 1997).

Role ambiguity and role conflict arose adjacent to the blind spots in these case studies. The blind spots increased caregiver confusion about whether they needed to give residents assistance, how to prioritize the order of their tasks, and how to collaborate with their companions. In other words, they did not have any role alternatives to choose from other than who was the watcher and the doer. Post-system implementation, the caregivers had the means to accomplish delineated goals, easing their work stress.

The addition of the information layer also benefits the residents in that the care homes can be designed with more flexibility. That is, the structure does not determine caregivers' line of sight; the areas that are not observable by the eye can be seen via the video monitoring system. Given this flexibility, the house can be physically designed to suit residents' needs. The house may also include gray areas, which are those that are partly public and partly private. The enriched structure of the houses contributes to increasing the overall comfort of the residents' lives.

It is essential to consider privacy issues regarding the information layer as there are important relationships between privacy, assistive technologies, and person-centered care (Niemeijer et al. 2010). Much more work will need to be undertaken to integrate privacy controls into the information layer.

6 CONCLUSION

We presented an exploration of the architecture and information of care homes and explained the results of our case studies undertaken at two group homes to investigate the effects of the information layer added to one of them. The explicit introduction of an information layer to the home enabled caregivers to monitor residents remotely, leading them to clarify their roles (i.e., the watcher and the doer). The clarification contributed to decreasing their stress levels due to the disambiguation of task assignments.

Our concept of separating the information layer from the physical layer will assist caregivers in coordinating their care of elderly people with dementia. Therefore, the answers for the RQs are:

Answer for RQ1: The video monitoring system enables caregivers to clarify their role (i.e., the watcher and the doer) and to facilitate the coordination of their work. It also alleviates their stress.

Answer for RQ2: Either caregivers overwork themselves to maintain operations, or the building's functions, such as spatial layouts and/or facilities, are used beyond their capabilities in order to cope with administrative resource shortages.

Answer for RQ3: The video monitoring system shows that by not changing the physical layout and deploying the information layer, the quality of care is sustained, if not improved.

There are two noteworthy limitations of this study: data collection and external validity. Although we mainly collected data using semi-structured interviews and short-term video observations, it would have increased the validity if we had also undertaken follow-up observational studies. We must also consider the different architectural contexts. Houses in Japan are usually made from wood, soil, paper, and ceramic, whereas European houses are made of wood, brick, or stone. We would need to undertake comparative studies in the future to understand the implications of using different materials and different spatial layout styles in order to extend the scope of this study's findings.

ACKNOWLEDGMENTS

Our research was partly supported by the Grant-in-Aid for Scientific Research (22615017, 23500646 and 24616004) from the Japan Society for the Promotion of Science (JSPS) and the Service Science, Solutions and Foundation Integrated Research Program (S3FIRE) from the Japan Science and Technology Agency (JST).

REFERENCES

Arcelus A, Jones M, Goubran R, Knoefel F (2007) Integration of smart home technologies in a health monitoring system for the elderly. Proc. of the 21st International Conference on Advanced Information Networking and Applications Workshops (AINAW '07) vol 2, pp 820-825.

Barber CE, Iwai M (1996) Role conflict and role ambiguity as predictors of burnout among staff caring for elderly dementia patients. J Gerontological Soc Work 26(1-2):101-116.

Brand S (1994) How buildings learn: What happens after they're built. Penguin Books, London.

Campo E, Chan M (2002) Detecting abnormal behaviour by real-time monitoring of patients. Proc. of the AAAI '02 Workshop, pp 8-12.

Demiris G, Rantz MJ, Aud MA, Marek KD, Tyrer HW, Skubic M, Hussam AA (2004) Older adults' attitudes towards and perceptions of 'smart home' technologies: A pilot study. Inform Health Soc Care 29(2):87-94.

Glaser, B. G. & Strauss, A. L. (1967) The Discovery of Grounded Theory: Strategies for Qualitative Research. Chicago: Aldine.

Helal S, Giraldo C, Kaddoura Y, Lee C, El Zabadani H, Mann W (2003) Smart phone based cognitive assistant. Proc. of the 2nd International Workshop on Ubiquitous Computing for Pervasive Healthcare Applications (UbiHealth 2003).

Helal S, Mann W, El-Zabadani H, King J, Kaddoura Y, Jansen E (2005) The Gator Tech Smart House: A programmable pervasive space. Comput 38(3):50-60.

Hope K, Waterman, H (1997) Using multi-sensory environments with older people with dementia. J Adv Nurs 25(4):780-785.

Kahn RL, Wolfe DM, Quinn RP, Snoek JD, Rosenthal RA (1964) Organizational stress: Studies in role conflict and ambiguity. Wiley, New York.

Kitwood T (1997) Dementia reconsidered. Open University Press, Buckingham, UK.

Kitwood T, Bredin K (1992) Towards a theory of dementia care: Personhood and well-being. Ageing Soc 12:269-287.

Niemeijer AR, Frederiks BJM, Riphagen II, Legemaate J, Eefsting JA, Hertogh CMPM (2010) Ethical and practical concerns of surveillance technologies in residential care for people with dementia or intellectual disabilities: An overview of the literature. Int Psychogeriatr 22(7):1129-1142.

Moniz-Cook E, Clin D, Millington D, Silver M (1997) Residential care for older people: Job satisfaction and psychological health in care staff. Health Soc Care Comm 5(2):124-133.

Rizzo JR, House RJ, Lirtzman SI (1970) Role conflict and ambiguity in complex organizations. Adm Sci Q 15(2):150-163.

Schaefer JA, Moos RH (1996) Effects of work stressors and work climate on long-term care staff's job morale and functioning. Res Nurs Health 19(1):63-73.

Sugihara T, Fujinami T (2011). Emerging triage support environment of care with camera system for persons with dementia. Lect Notes Comput Sci 6779:149-58.

Sugihara T, Fujinami T, Jones R, Kadowaki K, Ando M (2013) Enhancing layers of care house with assistive technology for distributed caregiving, Proc. of AAAI 2013 Spring Symposia Series, pp 83-88.

Sugihara T, Nakagawa K, Fujinami T, Takatsuka R (2008) Evaluation of a prototype of the Mimamori-care system for persons with dementia. Lect Notes Comput Sci 5178:839-846.

Tabar AM, Keshavarz A, Aghajan H (2006) Smart home care network using sensor fusion and distributed vision-based reasoning. Proc. of the 4th ACM International Workshop on Video Surveillance and Sensor Networks (VSSN ’06), pp 145-154.

United Nations Population Division (2008) World population prospects: The 2008 revision population database. http://esa.un.org/unpp/index.asp?panel=2. Accessed 30 April 2011.

World Health Organization and Alzheimer’s Disease International (2012) Dementia: A public health priority. World Health Organization.

Zhang S, McClean S, Scotney B, Hong X, Nugent C, Mulvenna M (2008) Decision support for Alzheimer’s patients in smart homes. Proc. of the 21st IEEE International Symposium on Computer-Based Medical Systems (CBMS ’08), pp 236-241.