Acceptance and Practical Use of Assistive Technologies for Frail Seniors and Caregivers: Interview Surveys on Nursing Homes

Akihiko Kamesawa[1(✉)], Reina Yoshizaki[2], Shiho Hirose[3], Nana Shinozaki[4], Ren Komatsu[2], Satomi Kitamura[4], Ou Fu[5], Ningjia Yang[2], Ayako Ishii[4], Yuka Sumikawa[4], Taiyu Okatani[5], Kazuki Kaneko[2], Yoshiyuki Nakagawa[2], Taichi Goto[4], Takahiro Miura[6], Taketoshi Mori[4], Tohru Ifukube[6], and Junichiro Okata[2,6]

[1] Graduate School of Arts and Sciences, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
akky6126@yahoo.co.jp
[2] Graduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
[3] Graduate School of Frontier Sciences, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
[4] Graduate School of Medicine, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
[5] Graduate School of Information Science and Technology, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan
[6] Institute of Gerontology, The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan

Abstract. Nowadays, with population aging, shortage of care workers is becoming a serious problem in Japan. Therefore, the introduction of assistive technologies at nursing care sites is a measure expected to reduce the work burden of caregivers. However, there is not much knowledge of assistive technologies required for a smooth introduction yet. Thus, especially regarding monitoring sensors, our study clarified the factors of technology acceptance and their influence on nursing care sites by interview surveys to the caregivers in nursing homes. In addition, based on the findings obtained from the survey, we presented several policies for future surveys about the introduction of assistive technologies in nursing care sites.

Keywords: Adaptation · Assistive technology · Monitoring system · Seniors Caregivers

1 Introduction

Population aging is progressing globally. This demographic movement is an almost irreversible phenomenon, and each country needs to take appropriate measures, such as an increase in social security and medical expenses. In particular, the trend is remarkable

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in Japan. It is estimated that the aging rate will exceed 30% in 2025, and the number of elderly people is estimated to increase by more than seven million people [7]. In addition to the aging rapidly proceeding in this way, the declining birthrate is also a factor that is spurring the population decline. The declining production-age population due to the declining birthrate is pressing the review of fundamental reforms of the conventional social security system that has supported the life of the elderly after retirement.

Along with the aging society, one of the areas where measures are most needed is the care field. Elderly people who need medical care and nursing care also are expected to continue to increase, but there is a decisive seriousness of lack of caregivers. The Japanese Ministry of Health, Labor, and Welfare (MHLW) calculates that nearly 400,000 caregivers will run short by 2025 [8]. In fact, among nursing care workers, dissatisfaction is raised not only in terms of work volume, wages, and working hours, but also, because of the physical and mental burden. A survey on long-term care work in Japan, conducted in 2016, reports that as for dissatisfaction concerning the burden of working conditions and work, 53.2% said that "labor is insufficient" and "wages are low for job content" at 41.5%, "paid vacation is difficult" at 34.9%, and "the physical burden is large" at 29.9% [6]. One common background to these reasons is that work productivity is poor. Care workers must provide suitable care for each elderly person. Therefore, it is difficult for them to work efficiently, and the working environment has not been improved at nursing care sites.

One of the effective breakthroughs in this situation is the introduction of assistive technologies at nursing care sites. It is expected that these technologies will help reduce or eliminate the workload of care workers and improve productivity by helping with or substituting for care. At the same time, even for elderly people, the burden on the mind and body is reduced by reducing unnecessary care and the possibility of achieving sustainable care. The Japanese Government actively encouraged the dissemination of medical devices, including assistive devices, by revising the law in 2014.

However, the introduction of assistive technologies is still stagnant at Japanese nursing care sites. Assistive technologies are not actively used by nursing care workers. According to a questionnaire survey conducted by the MHLW, about half of the subjects did not recognize the care robot [7]. However, about a 40% "expectation for reduction of nursing-care burden by introduction" was confirmed, and it is known that there is sufficient need for assistive technologies. Under such circumstances, MHLW notes that there is a mismatch between the nursing care site and the development side. There may be a lack of knowledge for advanced assistive technologies and some prejudice in the care field. Since nursing care has been done by the hands of people than before, care workers may feel resistance to lack of physical contact. Meanwhile, as to the development side of assistive technologies, it is pointed out that the practical needs of nursing care sites are not sufficiently drawn [7]. Certainly, unless it has enough usefulness to be used in care practice, it may rather cause some danger and productivity decline. In order to improve the situation, to revitalize their communication will be necessary for the nursing care workplace and the technology development side. However, there are not many studies focusing on needs research and technology acceptance in assistive technologies. We need to advance such a study from the aspect of both quantitative and qualitative researches.

Therefore, the purpose of our research is to clarify a part of technology acceptance and user evaluation of assistive technologies at nursing care sites. For this reason, we conducted interview surveys at a nursing home that introduced specific assistive devices (targeting monitoring systems in this research) and another that have not been introduced, and compared the results. We can define a monitoring system as a device intended to prevent or detect falling of an elderly in advance, such as when getting up from bed or walking in a living room. A monitoring system having such a function is expected not only to ensure the safety of the elderly but also to contribute to the reduction of the frequent patrol in a nursing home of nursing workers. However, its introduction is not progressing. For this reason, examining cases of introducing monitoring sensors will lead to improvement of the relationship between elderly people and nursing care workers.

The main questions explored in this study are as follows:

Q1. What are the factors that achieve the acceptance of a monitoring system?
Q2. By introducing a monitoring system, how has the nursing care changed?

2 Related Work

This chapter reviews previous studies related to this research. Section 1 introduces some well-established technology acceptance models as a model for analyzing factors for accepting technology. This section especially reviews a technology acceptance model for elderly people. Section 2 reviews several user studies related to assistive technologies for elderly people. These studies focus on the usefulness and impact of assistive technologies rather than individuals using assistive technologies. Taking into account both viewpoints, this study examines a monitoring system.

2.1 Technology Acceptance Models

The technology acceptance model (TAM) [1, 2] shown in Fig. 1 is one of the basic models for explaining and predicting the factors determining user attitude towards accepting new technology. Better measures explaining the factors that influence an individual's intention to technology can encourage technology acceptance by manipulating or changing the factors. Therefore, TAM proposes essentials among these factors and shows mutual relationship among the essential factors. TAM incorporates six factors listed as follows [20]:

- External variables (EV), such as demographic variables, the influence of perceived usefulness (PU), and perceived ease of use (PEU).
- Perceived usefulness (PU) is defined as 'the extent to which a person believes that using the system will enhance his or her job performance.'
- Perceived ease of use (PEU) is 'the extent to which a person believes that using the system will be free of effort'.

- Attitudes toward use (A) is defined as 'the user's desirability of his or her using the system'. Perceived usefulness (PU) and perceived ease of use (PEU) are the sole determinants of attitude toward the technology system.
- Behavioural intention (BI) is predicted by attitude toward use (A) combined with perceived usefulness (PU).
- Actual use (AU) is predicted by behavioural intention (BI).

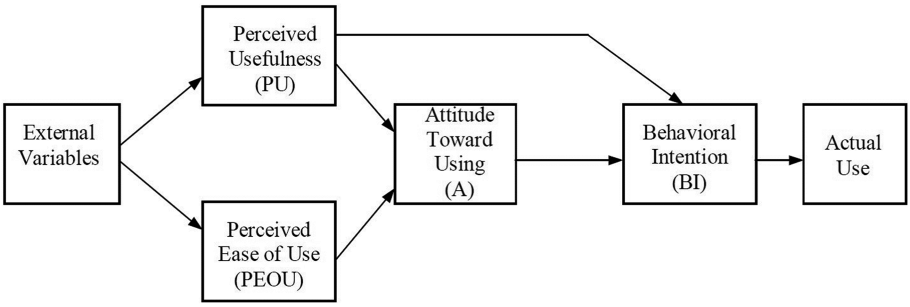

Fig. 1. Technology acceptance model (TAM) (Malhotra and Galletta 1999 [14])

It can be said that this diagram has served as a basic explanation model of technical acceptance [10, 26, 27], but some problems remain on the other hand. One of the aspects of the TAM of individuals that is not taken into consideration, is a lack of social factors in the model. Therefore, when considering such social aspects, Venkatesh et al. extended the TAM and proposed the Unified Theory of Acceptance and Use of Technology (UTAUT), which attempts to explain the behavioral intention to use technology and technology usage behavior [29].

Factors constituting the properties of UTAUT are divided into two types. The first type are the determining factors of the acceptance of technology, such as the expected performance, the expected lifespan, the social impact and the facilitating conditions. These factors directly affect the acceptance of technology and are the independent variables in the model. The second type are the individual factors, such as gender, age, experience and autonomy of use, which are the intermediary factors that affect technology acceptance. These variables are not presented as the direct factors of technology acceptance, but as the variables that indirectly influence technology acceptance through changing the former four factors as the medium. Using UTAUT that is configured in this way, Venkatesh et al. reported that it was able to explain 70% of the individual's intention to use information technology [29].

The fact that UTAUT not only included factors of social influence, but also personal factors, indicates that it is also effective in explaining the technology acceptance of specific users, who have been narrowed down in advance. This viewpoint gives the possibility of explaining the technology acceptance of seniors in particular. Various developmental models for technology acceptance by seniors have been proposed. The next section reviews such technology acceptance models for seniors.

Seniors are said to be different in personal and social aspects from others. Indeed, aging has been found to have a remarkable influence on the acceptance of technology.

For example, previous studies have reported that technology acceptance [17] and usage of new technologies [19] decrease with increasing age. While a decrease in technology interest has been reported, there are also studies reporting the importance of experience with technologies. Künemund and Tanschus report that experiences involving technology have a greater influence on technology interest than a simple age effect [12]. It has also been reported that the technical acceptance of seniors changes in each property characterizing seniors, such as physical aspects [4, 22, 24], cognitive aspects [4, 24], social aspects [13, 22], and psychological aspects [21, 32]. It has been clarified by previous studies that it is difficult to explain or predict the specificity of technology acceptance of seniors in general technology acceptance models.

Based on this background, Renaud and Biljon proposed the Senior Technology Acceptance & Adoption model for Mobile technology (STAM) shown in Fig. 2 [20]. STAM modeled the acceptance process as driven by the factors that influence mobile phone adoption in the context of elderly mobile phone users.

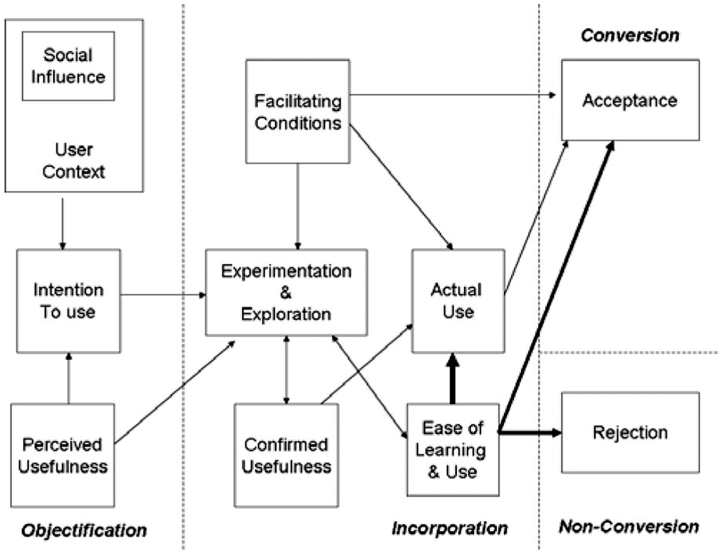

Fig. 2. Senior technology acceptance model (STAM) (Renaud and Biljon 2009) [20]

The model emphasizes the distinction between acceptance and adoption of technology. Acceptance is attitude to technology determined by various factors while adoption is a process starting with the technology and ending with the user embracing the technology and making full use of it. Based on the adoption process [13], they proposed a model that can analyze key factors that influence acceptance in each stage. In explaining technology acceptance, it is extremely important to capture adoption as another aspect. In technology engagement, people are involved whether they accept it or not in how they use it. Therefore, taking adoption into account seems to enable capturing even more practical use of technology.

For the adoption process, Renaud and Biljon rely on the technology adoption process proposed by Silverstone and Haddon [23]. Silverstone and Haddon argued that domestication is important for technology to be used in practice, and that the process leading to domestication can be analyzed in four stages. The four processes are appropriation, objectification, incorporation, and conversion, respectively, as shown in Table 1.

Table 1. Domestication adoption process dimension (Lee 2007) [13]

Dimension	Description	Examples of potential themes relevant in user experience research
Appropriation	Process of possession or ownership of the artifact	– Motivation to buy a product – Route to acquire information about a product – Experience when purchasing a product
Objectification	Process of determining roles product will play	– Meaning of a technology – What function will be used in users' life? – Where is it placed? How is it earned?
Incorporation	Process of interacting with a product	– Difficulties in using a product (usability problems) – Learning process (use of instructional manual)
Conversion	Process of converting technology to intended feature use or interaction	– Unintended use of product features – Unintended way of user interaction – Wish lists for future products

Based on this viewpoint, this study investigates acceptance and adoption of assistive technology for seniors in nursing care sites. The nursing care site is a practical site where people are in contact and interact every day. Therefore, as suggested by STAM, deepening consideration is important not only for acceptance but also for adoption at the same time.

2.2 User Study

Assistive technologies for seniors are technologies used to help the elderly with their daily problems [30]. For example, cognitive assistive equipment, the movement supporting equipment, communication robot, and so on, have been developed in addition to the monitoring system. Nelson and Dannefer reported that heterogeneity increases with age and the needs and capacity of elderly people for technology are diverse [18]. It is also known that aging causes changes in physiological and cognitive abilities and affects the ability of older people to use technology [4, 24]. These studies claim the need to appropriately know the characteristics of the relationship between the elderly and the technology.

For example, important findings have been obtained regarding communication robots. Wu et al. reported that barriers to the introduction of robots specialized in communication functions are unfamiliarity with computer technology and concern for lack of communication with people [33]. In addition, some studies have proposed concrete practical policies and development guidelines for communication robots. Wada

has conducted experiments using the therapeutic robot and has developed the manual of the robot therapy for seniors [31]. Miura et al. explains the impression of the seniors' communication robot based on the difference in physical weakness through the scores on the systems' usability scale (SUS) and the interview survey [16].

In addition, equipment for seniors is also studied from the viewpoint of technology design. Kobayashi et al. show guidelines on design about the target size and the method of the initial setting of the user interface by conducting experiments on the seniors' use of touch panel devices [11].

On monitoring systems, there have been some previous research. Veer et al. revealed that adequate coaching and training are necessary for introducing technology by a questionnaire survey targeting nurses in the Netherlands [28]. Iio et al. clarified the relationship between the range of fall detection and feeling of security and the difference of intention to use between seniors living in nursing homes and other seniors from an interview survey on seniors and caregivers who actually use a fall detection monitoring system [9]. Dolničar et al. reported that monitoring sensors were accepted positively, particularly by caregivers while both the caregivers and the elderly showed a concern that the monitoring system would reduce the opportunities for visits through interview surveys conducted by actually introducing equipment in Slovenia [3].

3 Research Design

The findings of this study were obtained by comparing the results of two interview surveys. The first interview survey was conducted with the staff of Nursing Home 1 (NH1), which did not use a monitoring system, and the second interview was conducted with the staff of Nursing Home 2 (NH2), which actively used a monitoring system. The surveys for both nursing homes lasted several hours and were conducted between February and August 2017, respectively. Semi-structured interviews were adopted for the surveys.

3.1 Interview to NH1

The survey was conducted in NH1 by interviewing three caregivers. The main question of this survey was either why the monitoring sensors had not been installed in the facility, or why they had ceased to use the monitoring sensors once they had been introduced. Although there was a range of sensors, we chose to listen mainly to the functions that were common to each sensor.

NH1, which was the subject of the survey, was a relatively small facility, with almost 30 private rooms and 36 employees. Twenty-nine elderly people were present, and the average age was about 87 years old.

3.2 Interview to NH2

The survey was conducted in NH2, by interviewing one caregiver and two managers. The main question of this survey was the background of the introduction of the

monitoring system, the opinion on the function of the monitoring system after introduction, and the change from the introduction to the present. The monitoring system introduced in the NH2 is a silhouette image sensor by an infrared camera that mainly aims at motion detection. The state of the care receiver is determined by a computer, which sends a silhouette image of the surroundings of the care receiver's bed at all times, from the image sensor through the wireless connection. When an action for alarm is detected from the determined state, the alarm is sent to the mobile device of the caregivers and the silhouette movie is saved before and after 10 s. The silhouette movie being taken constantly can be seen in real time from the mobile device of the caregiver.

NH2 had 120 private rooms and 45 employees, which was a relatively bigger facility than NH1. There were 41 elderly people who were present, and the average age was 87 years old.

The transition on use of the monitoring system in NH2 from the introduction was as follows. Through several adjustments, NH2 was able to fix the practical use of the monitoring system. Figure 3 shows the approach in chronological order.

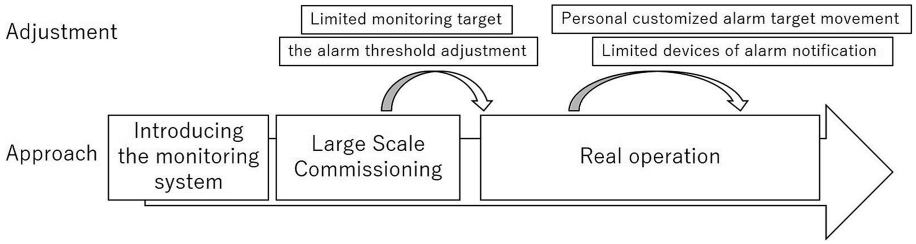

Fig. 3. The transition from the introduction of the monitoring system

4 Findings

In this chapter, we show the results of interview surveys to Nursing Home 1 (NH1), where monitoring systems have not been installed, and Nursing Home 2 (NH2), where monitoring systems have already been installed. Each interviewee had a lot of various answers, but we show the difference between NH1 and NH2 based on three major points: correspondence to alarm notification, difference in the concept of privacy, and visualization of life rhythm as an unexpected effect.

4.1 Settings of Alarm Notification

When a monitoring sensor detects the elderly person falling and getting up, the system will alarm the caregiver. The caregiver will receive the notification through the tablet at hand and can check the situation of the elderly person. The interview surveys found that notification through an alarm created difficulties common to both sides.

In the survey for NH1, we found some negative opinions about the monitoring system. One of their concerns was stress caused by the alarm. NH1 had installed a monitoring system before, but there were many false alarms due to slight body

movements by the elderly. Thus, the NH1 staff had to go to the elderly's room every time the alarm sent notification. Such a situation increased the number of visits and their psychological stress. It confirmed the paradox that the technology that should originally have reduced the work of caregivers would rather increase it.

Such a situation was confirmed in NH2. NH2 also originally installed monitoring systems in order to reduce the number of patrols at night, but the staff said that the installation caused confusion due to too many alerts. In the case of NH2, however, they could successfully solve such problems by dealing with them. NH2 collaborated with the developer side and could successfully renovate the system.

One of their ideas was to limit the target. The necessity of assistive technologies changes greatly depending on the bodily abilities of the elderly. In other words, measures such as introducing them collectively for all rooms of the nursing home will not only increase the amount of work but also cause unnecessary expenses. Initially, NH2 introduced monitoring sensors for all rooms on a trial basis, but now, only the room for the elderly suffering from dementia is equipped with the sensors. This may reduce the risk of injury.

Furthermore, NH2 changed the detecting system based on each target. They could change the function of the monitoring system according to the elderly by limiting the target. It enabled the sensor to detect each stage such as when the elderly sit up in bed, sits at the end of the bed and stands up. This contrivance can decrease the staff's workload greatly.

These results suggest that the personal adaptation of technology is needed. In nursing care, each resident has a different degree of bodily function. Therefore, it should be needed to change functional settings according to each person. In this case, uniformity of functions may lead to increase the risk of injury and workload.

4.2 Privacy

As to the installation of the monitoring sensor, we should consider about the privacy [15, 34]. Its function of monitoring the target may hinder his/her privacy, so the elderly do not have a good impression on the system. Even in the field of nursing care, the behavior of residents is always detected by the camera and thus the elderly cannot escape from the camera as long as they are in the room. These ethical resistances to the system have been shared among people.

The same situation was also confirmed in NH1 where monitoring systems have not been installed. NH1 staff said they wanted to minimize the use of monitoring systems basically because they thought that the use of them was a deterrence to residents. They also suggested that installing monitoring sensors might indirectly narrow the possibility of residents' behavior. As Townsend, Knoefel, and Goubran report [25], they also have a concept of a trade-off between safety and privacy given by the monitoring sensor.

On the other hand, in NH2, we did not find such trade-off scheme at all. Surprisingly, NH2 staff said that the privacy of residents was reversely secured when they introduced monitoring sensors. Since they could control the monitoring system, NH2 staff successfully reduced the number of patrol. The staff said that this ingenuity increased the private time for residents. Nursing care leads to some mental diseases not only for caregivers,

but also, for the elderly. The installation of the monitoring systems reduced caregiver's unnecessary assistance, so the elderly might have a sense of rest. This result is partially consistent with the survey conducted by Dolničarr et al. [3], but NH2 staff have no fear of decreasing the number of visits.

Considering the answers by NH2, the problem is not a trade-off between safety and privacy, but a trade-off between gaze and contact on privacy inhibition. The monitoring sensor might cause a hindrance of privacy, but at the same time, it contributes to reducing direct interpersonal contact. NH2 staff found positive aspects of monitoring sensors.

It seems that the way of thinking about privacy and the unexpected effect of the monitoring systems are found in the consistent use of them by NH2 staff. It should be noted that this fact was not found at the interview with NH1 staff. They did not notice the positive effect of monitoring sensors, which brought not only unnecessary work but also invasion of the elderly's privacy. NH2 staffs said that reducing staff's work volume is the result of securing residents' privacy. The function of the monitoring sensor is not only to detect dangerous behaviors of residents.

As we use certain technology constantly, sometimes, we can find it has some unexpected functions. Of course, we cannot find whether the function will have a positive or a negative effect, but these results suggest that it is important for technology acceptance in practical situations. Nursing care also has many practical and interactive scenes. Caregivers and the elderly keep in touch with each other on a daily basis; thus, assistive technologies that mediate between them might have an unexpected result. Considering this situation, we should take these side effects into consideration when we develop a new device.

4.3 Visualization of Life Rhythm

As another unexpected effect, one more thing can be mentioned. According to NH2 staff, they are currently using the image of the room recorded by the monitoring sensors to accurately grasp residents' lifestyles and ADL. The monitoring sensor introduced in NH2 has the function of recording for 10 s before and after a specific operation is detected. Initially, this function was incorporated in order to examine the cause of the fall afterward. However, in addition to that, the NH2 staff saw this video from another perspective and helped to objectively grasp the behaviors of residents. By virtue of the accurate understanding of the life rhythm and physical ability of the residents, which they could only know subjectively until now, it has become possible to provide more appropriate personal assistance.

NH2 staff pointed out that they were able to improve the excretion QOL of residents by carefully grasping their life rhythm. When the elderly excrete by themselves, they must do such movements as sitting up and rising, and the monitoring sensor detects the situation. As intended usage, it would have been within the extent that caregivers remotely confirm the appearance on the tablet. However, the NH2 staff became aware of the timing of the overall excretion of the day through the alarm and the appearance of an image. As a result, it became possible to go to the room when the residents were needing to excrete, and safe and efficient assistance became possible.

On the other hand, the motion pictures of the monitoring sensors also proved to contribute to the proper grasp of ADL or physical ability of the residents. The NH2 staff said that there are occasions when they assisted the elderly more than was necessary, and that it is difficult to assist them appropriately. Unnecessary nursing care interferes with the elderly exerting their own physical functions, and this may result in them becoming weaker. The monitoring system solved such dilemmas. By viewing the motion pictures of residents' movements, it became possible for caregivers to understand their appropriate need for assistance. NH2 staffs said that there were some residents who took an active action that they would not have expected at all. In other words, the monitoring system has the potential to lead to an improvement in the physical functions of the elderly.

The practice of daily care by caregivers included these potential functions. It may be difficult for technology developers to anticipate multiple functions that the monitoring system can have in the development stage. The interview survey conducted by this research suggests that technology should be developed in collaboration with caregivers and that technology acceptance will be completed when the communication is successful.

5 Discussion

In this chapter, we would like to add some implications in the context of technology acceptance from findings mentioned above. Due to the nature of the survey, this research was not carried out based on the series of TAMs mentioned in Sect. 2. It was found that the application of these models was not successful because of the specificity of the nursing care. These facts seem to lead to the improvement of TAMs and a contribution to user study.

5.1 Correlation Between Caregivers and Elderly People in Technology Acceptance

One of the factors of difficulty in applying TAMs is that in the nursing care field, technology acceptance is never done by one person but can be accomplished in the interaction between caregivers and elderly people. As assistive technologies are used by humans and for humans, uncertainty increases, and further flexibility is required of them. Even if they are accepted by caregivers, if incompatibilities arise due to the physical or mental attributes of the elderly people who are cared for, practical use does not go well. Sometimes it can also cause fatal danger. In nursing care sites where safety is required, assistive technologies must be designed for each elderly person. At the same time, assistive technologies must also contribute to the efficiency of the caregiver's work. Instead, even though it is optimized for the elderly, if it increases the workload of nursing care workers, problems such as shortage of personnel and job separation can be caused.

The problem concerning the setting of the alarm indicated by our research reflects such a correlation. Our study revealed that technology acceptance was achieved through personal adaptation of alarm detection and decrease of work volume. Even in previous studies, both aspects have been pointed out separately. The survey of the fall detection monitoring sensors for the elderly in the nursing home by Iio revealed the relationship

between accuracy of the detection and safety in nursing care [9]. A survey of nurses who work at a medical and welfare center in the Netherlands conducted by Veer et al. [28] pointed out that proper coaching and training on the use of technology is necessary. Thus, these studies suggest that technology acceptance should be considered from both sides of the subject and object simultaneously.

The previous models, such as TAM, targeted individuals exclusively. Attributes of others who interact with him or her are merely considered as social aspects of him or her or factors on the usefulness of technology. However, at nursing care sites, the attributes of both caregivers and the elderly are equally important, and the usefulness of technology and technology acceptance are closely linked in the correlation. Therefore, to construct a model that predicts the introduction of assistive technologies at a nursing care site, it is necessary to think about schemes that put these two attributes and relationships in range.

5.2 Finding Potential Usages by Users

Second, the findings of our study suggest that continued practice may result in discovery of new functions of technology. The interview survey revealed that the monitoring system contributes to securing privacy in another way and that it is also helping to improve QOL and ADL by grasping appropriate life rhythm and physical abilities, which is the function and effect discovered in daily practical use by caregivers. This aspect has affinity with cases indicated by Forlizzi and DiSalvo [5]. They pointed out that practical use of the cleaning robot changed user and family behavior and emphasized the importance of grasping how human interaction with robot has changed. Our study makes the same conclusion. Particularly in nursing care sites, the relationship between caregivers and the elderly is so close that it seems that the long-term impact of assistive technologies on them cannot be missed.

These points are not related to technology acceptance, but technology adoption emphasized by Renaud and Biljon [20]. In proposing STAM, they presume stepwise changes in how to engage with technology. In the process of Objectification to Incorporation and (Non-)Conversion, a notion that technology acceptance is not only understood by mere attitude, but decided in the practical use of technology is assumed. As mentioned above, the interview survey conducted by our study also confirmed the gradual change of technology adoption.

However, the potential use of monitoring systems by caregivers revealed by our study cannot be described as Conversion. NH2 staff keep using the primary usage at the development stage while using another method at the same time. Such a fact can be said to be Diversification rather than Conversion. Diversification of usage shows that the Adoption Process is never a single track; it may be a multi-track structure. Based on these findings, the technology adoption process may need to be refreshed.

It seems that further research is necessary to determine if the suggestions described above only remain in the specificity of nursing care facilities subject to this interview survey. From now on, an investigation into such viewpoints will also be required in other areas.

6 Limitation

In our study, interviews were only conducted with caregivers, and not with the elderly. Although it is difficult to conduct interviews with the elderly, because of their physical or mental weakness, it is necessary to collect their direct opinions on assistive technologies. It is our intention to change the nature of the interviewees in our future research.

7 Conclusion

This study investigated the possibility of introducing assistive technologies in nursing homes. Through the interview surveys, we established what the barriers are to introduction of monitoring systems, as well as the actual practical effects of doing so. The main contribution of our research was to clarify the specificity of technology acceptance and technology adoption at the nursing care sites. The discovery of the correlation between the caregiver and the elderly in terms of technology acceptance may lead to the further improvement of TAM for assistive technologies. In addition, the potential usage found in nursing care sites explains the phase of conversion to the technology adoption process, in detail. The results suggest that the construction of more appropriate models is required in the future.

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References

1. Davis, F.D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. **13**(3), 319–340 (1989). http://www.jstor.org/stable/249008
2. Davis, F.D., Bagozzi, R.P., Warshaw, P.R.: User acceptance of computer technology: a comparison of two theoretical models. Manag. Sci. **35**(8), 982–1003 (1989). https://doi.org/10.1287/mnsc.35.8.982
3. Dolničar, V., Petrovčič, A., Šetinc, M., Košir, I., Kavčič, M.: Understanding acceptance factors for using e-care systems and devices: insights from a mixed-method intervention study in Slovenia. In: Zhou, J., Salvendy, G. (eds.) ITAP 2017. LNCS, vol. 10298, pp. 362–377. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-58536-9_29
4. Farage, M.A., Miller, K.W.: Design principles to accommodate older adults. Glob. J. Health Sci. **4**(2), 2–25 (2012)
5. Forlizzi, J., DiSalvo, C.: Service robots in the domestic environment: a study of the roomba vacuum in the home. In: Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction, HRI 2006, pp. 258–265. ACM, New York (2006) http://doi.acm.org/10.1145/1121241.1121286
6. Foundation, C.W.: Heisei 28 nend "kaigo roudou jittai chousa" no kekka (results of 2017's survey of nursing care labor survey) (4th Aug 2017), 18 February 2018. http://www.kaigo-center.or.jp/report/pdf/h28_chousa_kekka.pdf

7. The Japanese Ministry of Health, Labour and Welfare: Fukushi yougu kaigo robotto kaihatsu no tebiki (guideline for development of welfare equipment and nursing care robot) (2014)
8. The Japanese Ministry of Health, Labour and Welfare: 2025 nen ni muketa kaigo jinzai ni kakaru jukyuu suikei (kakutei chi) ni tsuite (on supply demand estimate (fixed value) for care workers for 2025) (24th June 2015), 18 February 2018. http://www.mhlw.go.jp/file/04-Houdouhappyou-12004000-Shakaiengokyoku-Shakai-Fukushikibanka/270624houdou.pdf_2.pdf
9. Iio, T., Shiomi, M., Kamei, K., Sharma, C., Hagita, N.: Social acceptance by senior citizens and caregivers of a fall detection system using range sensors in a nursing home. Adv. Robot. **30**(3), 190–205 (2016). https://doi.org/10.1080/01691864.2015.1120241
10. King, W.R., He, J.: A meta-analysis of the technology acceptance model. Inf. Manag. **43**(6), 740–755 (2006). http://www.sciencedirect.com/science/article/pii/S0378720606000528
11. Kobayashi, M., Hiyama, A., Miura, T., Asakawa, C., Hirose, M., Ifukube, T.: Elderly user evaluation of mobile touchscreen interactions. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (eds.) INTERACT 2011. LNCS, vol. 6946, pp. 83–99. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-23774-4_9
12. Künemund, H., Tanschus, N.M.: The technology acceptance puzzle. Zeitschrift für Gerontologie und Geriatrie **47**(8), 641–647 (2014). https://doi.org/10.1007/s00391-014-0830-7
13. Lee, Y.S.: Older adults' user experience with mobile phones: identification of user clusters and user requirements. Ph.D. thesis, Virginia Polytechnic Institute and State University (2007)
14. Malhotra, Y., Galletta, D.F.: Extending the technology acceptance model to account for social influence: theoretical bases and empirical validation. In: 1999 Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences, HICSS-32. Abstracts and CD-ROM of Full Papers, vol. 1, 14 p., January 1999
15. Mittelstadt, B., Fairweather, N.B., Mcbride, N., Shaw, M.: Ethical issues of personal health monitoring: a literature review, pp. 313–321, January 2011
16. Miura, T., Goto, T., Kaneko, K., Sumikawa, Y., Ishii, A., Doke, M., Suzuki, K., Okatani, T., Kubota, A., Zhang, M., Kinoshita, Y., Yoshinaga, H., Tsuruta, M., Kominami, Y., Nihei, M., Inoue, T., Kamata, M., Okata, J.: Need and impressions of communication robots for seniors with slight physical and cognitive disabilities: evaluation using system usability scale. In: 2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC), pp. 004088–004092, October 2016
17. Morris, M.G., Venkatesh, V.: Age differences in technology adoption decisions: implications for a changing work force. Pers. Psychol. **53**(2), 375–403 (2000). https://doi.org/10.1111/j.1744-6570.2000.tb00206.x
18. Nelson, E.A., Dannefer, D.: Aged heterogeneity: fact or fiction? The fate of diversity in gerontological research. Gerontologist **32**(1), 17–23 (1992). https://doi.org/10.1093/geront/32.1.17
19. Peacock, S.E., Künemund, H.: Senior citizens and internet technology. Eur. J. Ageing **4**(4), 191–200 (2007). https://doi.org/10.1007/s10433-007-0067-z
20. Renaud, K., van Biljon, J.: Predicting technology acceptance and adoption by the elderly: a qualitative study. In: Proceedings of the 2008 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on IT Research in Developing Countries: Riding the Wave of Technology, SAICSIT 2008, pp. 210–219. ACM, New York (2008). http://doi.acm.org/10.1145/1456659.1456684
21. Ryu, M.H., Kim, S., Lee, E.: Understanding the factors affecting online elderly user's participation in video UCC services. Comput. Hum. Behav. **25**(3), 619–632 (2009). http://www.sciencedirect.com/science/article/pii/S0747563208001696, including the Special Issue: Enabling elderly users to create and share self authored multimedia content

22. Mallenius, S., Rossi, R., Tuunainen, V.K.: Factors affecting the adoption and use of mobile devices and services by elderly people-results from a pilot study. Ann. Glob. Mobility Roundtable **31**, 12 (2007)
23. Silverstone, R., Haddon, L.: Design and the domestication of information and communication technologies: technical change and everyday life. In: Communication by Design: The Politics of Information and Communication Technologies, pp. 44–74. Oxford University Press (1996)
24. Tenneti, R., Johnson, D., Goldenberg, L., Parker, R.A., Huppert, F.A.: Towards a capabilities database to inform inclusive design: Experimental investigation of effective survey-based predictors of human-product interaction. Appl. Ergon. **43**(4), 713–726 (2012). http://www.sciencedirect.com/science/article/pii/S0003687011001700
25. Townsend, D., Knoefel, F., Goubran, R.: Privacy versus autonomy: a tradeoff model for smart home monitoring technologies. In: 2011 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, pp. 4749–4752, August 2011
26. Turner, M., Kitchenham, B., Brereton, P., Charters, S., Budgen, D.: Does the technology acceptance model predict actual use? A systematic literature review. Inf. Softw. Technol. **52**(5), 463–479 (2010). http://www.sciencedirect.com/science/article/pii/S0950584909002055. TAIC-PART 2008
27. Šumak, B., Heričko, M., Pušnik, M.: A meta-analysis of e-learning technology acceptance: the role of user types and e-learning technology types. Comput. Hum. Behav. **27**(6), 2067–2077 (2011). http://www.sciencedirect.com/science/article/pii/S0747563211001609
28. de Veer, A.J., Fleuren, M.A., Bekkema, N., Francke, A.L.: Successful implementation of new technologies in nursing care: a questionnaire survey of nurse-users. BMC Med. Inf. Dec. Making **11**(1), 67 (2011). https://doi.org/10.1186/1472-6947-11-67
29. Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D.: User acceptance of information technology: toward a unified view. MIS Q. **27**(3), 425–478 (2003). http://www.jstor.org/stable/30036540
30. Vichitvanichphong, S., Talaei-Khoei, A., Kerr, D., Ghapanchi, A.H.: Adoption of assistive technologies for aged care: a realist review of recent studies. In: 2014 47th Hawaii International Conference on System Sciences, pp. 2706–2715, January 2014
31. Wada, K., Ikeda, Y., Inoue, K., Uehara, R.: Development and preliminary evaluation of a caregiver's manual for robot therapy using the therapeutic seal robot Paro. In: 19th International Symposium in Robot and Human Interactive Communication, pp. 533–538, September 2010
32. Werner, J.M., Carlson, M., Jordan-Marsh, M., Clark, F.: Predictors of computer use in community-dwelling, ethnically diverse older adults. Hum. Factors **53**(5), 431–447 (2011). https://doi.org/10.1177/0018720811420840. PMID: 22046718
33. Wu, Y.H., Wrobel, J., Cornuet, M., Kerhervé, H., Damnée, S., Rigaud, A.S.: Acceptance of an assistive robot in older adults : a mixed-method study of human-robot interaction over a 1-month period in the Living Lab setting. Clin. Interv. Aging **9**, 801–811 (2014)
34. Yusif, S., Soar, J., Hafeez-Baig, A.: Older people, assistive technologies, and the barriers to adoption: a systematic review. Int. J. Med. Inf. **94**, 112–116 (2016). http://www.sciencedirect.com/science/article/pii/S1386505616301551