Knowledge Creation in Technology Evaluation of 4-Wheel Electric Power Assisted Bicycle for Frail Elderly Persons

A Case Study of a Salutogenic Device in Healthcare Facilities in Japan

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Abstract: As societies age, it is anticipated that we will see a sudden increase in the number of frail elderly persons. New assisted-technology (AT) devices to facilitate the activities of daily life (ADL), especially of walking, are essential for the healthy life of these people. However, frail elderly people suffer a variety of physical and mental weaknesses that tend to hinder their ability to make use of AT devices in the intended manner. Because of this, it is important that new AT devices undergo technology evaluation within the context in which they are to be used, but there is very little research in this area. In this study, frail elderly people in Japanese daycare centers and rehabilitation facilities were given a 4-wheel, power-assisted bicycle, called a "Life Walker" (LW), to ride, and technology evaluations were carried out based on functionality, usability, and experience as perceived by the frail elderly riders. The LW is considered to be best suited for those age 75 and older assessed at level 1 to 3 under Japan's long-term care insurance program, but the data for the 61 people at the rehabilitation facility who tried out the bicycle under the supervision of a resident physical therapist (PT), indicated that there was considerable individual deviation on the continued use of the AT device. The LW is also meant to enable frail elderly users who have difficulty walking to go outside and enjoy themselves more. It was found, however, that this effect was achieved only when the physical therapist intervened, gave encouragement, adjusted the bicycle settings as needed for the user, and otherwise created new knowledge. It was also found that in order for this kind of knowledge creation to take place, the bicycle must be used in an appropriate setting, the user needs to have a proactive attitude, and organizational support to ensure that therapists are appropriately assigned is necessary.

1 INTRODUCTION

Between 2000 and 2050, the proportion of the world's population over 60 years will double from around 11% to 22%. The absolute number of people aged 60 years and over is expected to increase from 605 million to 2 billion over the same period (WHO, 2014). Japan is aging rapidly also. The population of people 75 years or older will double over the next two decades (Fukutomi et al, 2013), and the national cost for medical care for those 70 years or older will account for 45% (MHLW, 2011) of all medical cost. Health promotion for this large cohort of aging population is indispensable for building a sustainable society.

Our perception of health has gradually changed from a dichotomous to a salutogenic perspective. In the former, health and disease are treated separately and health is defined as being "low on risk factors". The latter, however, focuses on "keeping people well". From this perspective, health is viewed as an ease/dis-ease continuum (Antonovsky, 1996). The 1986 Ottawa Charter for Health Promotion marks one of the starting points of this change. Before the

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charter was drafted, it was considered the individual's responsibility to maintain a healthy lifestyle, but under the Ottawa Charter, health is something to be achieved through a collaboration of environment, community, personal skills, and public policies. The Ottawa Charter initiated a redefining and repositioning of institutions, epistemic communities and actors within the disease-health continuum (Kickbusch, 2003).

Frail elderly persons, especially those aged over 75 years, who tend to be the main users of aged care services live in a dis-ease condition. Frailty is highly prevalent in old age and poses a high risk of falls, disability, hospitalization, and mortality (Fried et al, 2001). Falls are common and often devastating among older people (Rubenstein, 2006). Walking is a risk factor for falling, and yet walking is a basic salutary factor in an individual's life. Therefore, in order to promote health among frail elderly persons, optimal approaches involving interdisciplinary and inter-agency collaboration are required to build an environment in which such people can go out without worry about falling.

While some people may have difficulty in walking, they may still be able to ride a bicycle. Already there are electric power-assisted bicycles on the market that will allow the rider to climb steep hills with ease, even if they do not have much foot power. The power-assisted bicycles were originally developed by the Yamaha Motor Company. The 4-wheel assisted bicycle is a newly developed vehicle which is safer than walking for frail elderly persons, and is actually allowed on public roads as a wheelchair. Its controls are set so that it will not exceed a speed of 6 km per hour when going downhill. With this vehicle, a person who cannot walk can climb a hillside at the same pace as someone walking at normal speed. Though technically it is already available, this vehicle is not yet on the market because there remain concerns of its safety for frail elderly users.

In order to find salutogenic benefits in lifestyles of the frail elderly, we undertook action research on frail elderly people's use of this 4-wheel electric power assisted bicycle in a rehabilitation hospital in the city of Kakegawa, Japan. As Antonovsky (1996) said, we must start with the question, "How can this person be helped to move toward greater health?" This kind of effort must relate to all aspects of the person, and the frail elderly adult is no exception. We tackled this question through interdisciplinary and inter-agency collaboration among manufacturer, hospital, municipal government, and university.

2 LITEATURE REVIEW

2.1 Assessing Frailty in Elderly Persons

In order to provide appropriate care for frail elderly persons covered by long-term care insurance (LTCI) the Japanese Ministry of Health, Labour and Welfare (MHLW) drew up a *Kihon Checklist*, a basic health checklist, for those aged 65 and older, to be used as a frailty index to predict the risk of requiring care under LTCI. The checklist consists of a 25-item, self-reported questionnaire, covering seven categories including physical strength, nutritional status, and oral function, as well as houseboundness, mobility, cognitive function, and depression risk (Fukutomi et al, 2013). Using this checklist, municipal governments classify the frail elderly persons in their communities according to their need for preventive care. Kakegawa City covers all 25 items on the questionnaire as well as medical certificates to identify the frail elderly. Figure 1 is a partial view of the checklist and its screening criteria.

Municipal governments use the basic checklist as a guide to decide their own criteria and procedures for preventive care and care services, the dispatch of helpers, the lending of wheelchairs, and the need to provide rehabilitation. Care services are provided in accordance with the degree to which acitivities of daily life (ADL) have deteriorated. Table 2 shows the assesement levels for LTCI. Persons classfied as Support Level 1 and Support Level 2 are eligible for preventive care. Table 2 was drawn up by the first author as a simplified illustration of Japanese LTCI assessment levels.

A few researchers have evaluated the validity of this checklist to predict the risk of requiring care (Fukutomi et al, 2013; Tomata et al, 2011). Fukutomi, 2013, in particular, has suggested that physical strength and cognitive function are more useful indices for detecting the risk of future deterioration of ADL. However, there is no consideration of intervention to prevent future risk. Frailty is defined as a clinical syndrome in which three or more of the following criteria are present: unintentional weight loss, self-reported exhaustion, weakness (grip strength), slow walking speed, and low physical activity (Fried, 2001). Geriatric interventions have been developed to improve clinical outcomes for frail older persons (Applegate et al, 1990; Rubenstein, 2006). Maki et al, 2012, also evaluated the efficacy of intervention by examining a municipality-led walking program for the prevention of mental decline in the elderly aged

72.0±4.0, in a randomized controlled trial. This study introduced a 90-minute intervention program consisting of 30 minutes of exercise and 60 minutes of group work, and concluded that this intervention program may provide benefits for some aspects of cognition. Though their research target was not the frail elderly, from the criteria in Table 1 and the assessment level of LTCI we can easily surmise that the frail elderly requiring LTCI are unable to participate in this kind of walking intervention.

In these studies, some interventions were implemented to evaluate the efficacy for improving clinical outcome through randomized controlled trials (RCT). Though RCT is a traditional evidence-based methodology to examine the efficacy of medical treatments or interventions in medicine, it does not address the fact that frailty involves multiple deteriorations, or that an elderly person's ability to take part in an intervention will vary according to the context in which they live.

We need other methodologies to assess the frailty of the elderly and to mitigate the inconveniences in their daily life.

Table 1: Screening criteria for providing preventive care (partial view of MHLW check list).

Mobility (those with top score of 3 points are candidates for preventive care)	**0 point**	**1 point**
Q6. Can you climb stairs without holding onto a handrail or wall?	Yes	No
Q7. Can you stand up from a sitting position without holding on to anything?	Yes	No
Q8. Can you walk continuously for 15 minutes?	Yes	No
Q9.Have you fallen within this one year?	No	Yes
Q10. Do you worry about falling down?	No	Yes
Cognitive functions (1 point or more required)	**0 point**	**1 point**
Q18. Do people around you say you repeat the same thing and have become forgetful?	No	Yes
Q19. Do you make phone calls by yourself?	Yes	No
Q20. Do you find yourself not knowing today's date?	No	Yes
Depression (2 points or more required)	**0 point**	**1 point**
Q21. I do not feel any fulfillment in my daily life during the last two weeks.	No	Yes
Q22. I cannot enjoy things I used to enjoy during the last two weeks.	No	Yes
Q23. During the last two weeks, I am not willing to do what I could do easily before.	No	Yes
Q24. During the last two weeks, I do not feel I am useful to anyone.	No	Yes
Q25. During the last two weeks, I feel I am exhausted without any reason.	No	Yes

Table 2: Japan's long-term care insurance assessment levels (○Yes, △Partial, ×No).

	Level	**Self-sufficient**	**Body care**	**Comprehension**	**Behavior control**	**Mobile**
Support	**Level 1**	○	△	○	○	○
	Level 2	○ △	△	○	○	○
LTC	**Level 1**	△	△	○	○	○
	Level 2	△	△	○	○	△
	Level 3	×	×	△	△	△
	Level 4	×	×	×	×	△
	Level 5	×	×	×	×	×

2.2 Health Care in Tacit Knowledge

Since the 1970s, people have been given more room to take the initiative in roles where they provide expertise and participate in informing, ideating, and conceptualizing activities in the early design phases (Sanders and Stappers, 2008). This movement is called user-centered design. For frail elderly people, there are various assisted-technology (AT) devices such as canes, walkers, and bath benches, as well as wheelchairs, that could be considered to be user-centered designs. As Mann et al (1999) notes, many elderly persons rely on these devices.

NHS (the UK department of health) advocates patient-led care and urges health care teams to move from a service that does things to and for its patients to one which is patient-led and which works with patients to support them with their health needs (Pickles, J., Hide, E., and Maher, L., 2008). AT devices are provided to frail elderly people on the assumption that the devices will promote their independence and lower costs (Mann et al, 1999), but there is little research on how much and what kinds of frailty are mitigated by AT devices and what kind of support is needed to make full use of such devices. As some of the studies have pointed out, an important part of health care consists of tacit knowledge.

A significant part of health-care knowledge exists in tacit form, for instance the working knowledge of health care experts (Abidi, Cheah, Curran, 2005). Abidi, Cheah, Curran, 2005, classify tacit knowledge into 1) basic tacit knowledge or routine experiential knowledge, and 2) complex tacit knowledge or intuitive experiential knowledge. The latter is "progressively accumulated as the expert responds to atypical and high acuity clinical problems–it is deeply embedded and, hence, not easily articulated, yet manifests as the expert's intuitive judgment in challenging clinical situations." According to this classification, a health care professional's judgment of the usability of an AT device for the frail user is inherent in the professional's tacit knowledge. The question is: How can we extract this individual knowledge and create new knowledge for patient-led care?

2.3 Knowledge Creation and Technology Evaluation of AT Devices

Knowledge creation starts with socialization, which is the process of converting new tacit knowledge through shared experiences in day-to-day social interaction (Nonaka and Toyama, 2003). Nonaka and Toyama also state that "knowledge creation is a synthesizing process through which an organization interacts with individuals, transcending emerging contradictions that the organization faces", and "one can share the tacit knowledge of others through shared experience" (Nonaka and Toyama, 2003). In order to transform tacit knowledge to shared new knowledge, socialization and efforts to transcend

contradictions are needed. In professional health care work places, medical doctors, nurses, physiotherapists, and occupational therapists work together. In this sense their routines consist of an inter-agency, interdisciplinary collaborative experience (Saijo et al, 2013). Also the main contradictions in elderly health care are inherent in the care itself. All human beings must eventually die, but the care professional's work is to challenge this destiny. The need to transcend emerging contradictions and shared experience are embedded in their routines. The problem is how to elucidate their tacit knowledge and reconstruct it to create new knowledge. In this study, we describe this process through a technology evaluation of a newly developed 4-wheel electric power-assisted bicycle, called a Life Walker or LW vehicle, for frail elderly persons. This requires, however, that the health care professional collaborate with outsiders, engineers and researchers, to undertake the technology assessment of the newly developed AT device. Collaboration with outsiders requires socialization of their mind or manners. We assume that this shared new experience will extract their tacit knowledge to create new knowledge in the methodology of caring for frail elderly persons.

Technological evaluations of manual and powered wheelchairs have already been made in the field of anthropometry, the measurement of physical characteristics and abilities of people (Paquet and Feathers, 2004; Das and Kozey, 1999), with the objective of acquiring information that is essential for the appropriate design of a wheelchair. There is little study, however, of the usability of a wheelchair, or how it is actually used in real-world health care circumstances. And there is no user-centered technology evaluation of newly developed AT devices for supporting the frail elderly on outings in real-life circumstances with inter-agency and interdisciplinary cooperation.

McNamara and Kirakowski (2005, 2006) propose three aspects that need to be considered from the viewpoint of user-centered technology evaluation, namely, functionality, usability, and experience. They state that these are unique but independent aspects of usage. Functionality focuses on the product and is evaluated by answering the question, "What will the product do?" Usability is defined by the ISO 9241-11 definition of usability as, "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241). Experience is the individual's personal experience of using the device. The question asked here should perhaps be, "How do I relate to this product?"

In this study of the Life Walker (LW), we apply these aspects of technology evaluation to the framework of knowledge creation. The aim of this study is to elucidate the process of knowledge creation among inter-agency and interdisciplinary health care professionals, engineers, and researchers in evaluating AT technology meant to promote patient-led care among frail elderly persons.

3 RESEARCH METHODOLOGY

3.1 Research questions

In introducing the Life Walker (LW), a microcomputer-controlled, 4-wheel, electric power-assisted bicycle, to frail elderly persons certified as requiring care in a rehabilitation hospital and a daycare center for the elderly, we began with two questions: (1) What conditions are necessary to have an LW used in a hospital or daycare setting in such a way that there will be knowledge creation, and (2) How can the functionality, usability, and experience of the LW be measured quantitatively and qualitatively? The three categories in the second question were further broken down into additional questions as follows:

Functionality: What are the distinguishing characteristics of the LW and what kind of elderly person is it best suited for?

Usability: What kind of elderly person will ride the vehicle and for how long?

Experience: What do the elderly persons and care professionals experience through riding the LW?

3.2 Case Study Method

We loaned the LW for two months to a rehabilitation hospital and a daycare center for the elderly. Figure 1 shows the flow of data collection for this study.

- *Period:* Nov 5, 2012 to Jan 30, 2013
- *Targets:* 1) Frail elderly people (hereafter "facility users") in the Kakegawa Kita Hospital and the Kakegawa City Sayanoie daycare facility for the elderly. Facility users were rated at Support Level 1 through LTC 4 level ; and
  2) Hospital and daycare care professionals: physiotherapists (PT), occupational therapists (OT), care managers (CM), care workers (CW), and social workers (SW)

- *Methods:* Questionnaire survey, test riding of LW, and interviews of care professionals

The questionnaire for this study included the following kinds of information. The authors prepared a form that was filled out by the care professionals (as it turned out, only PTs in the rehabilitation hospital filled out the form). Also we interviewed care professionals at both hospital and daycare center.

Personal portfolio: Age, sex, care rating, dates at facility, experience riding LW, type of rehabilitation, continuing or interruption of LW experience: PT's predictions of whether each facility user will become a continuing rider or not.
Riding report: Rider's basic checklist (if there were multiple test rides, only changes from the first ride were recorded), reason for test rides, evaluation of driving skills
Recording of interview: The authors carried out focus group interviews (FGI) of the care professionals just before or after the loan of the LWs and during the loan period.

The sub-categories of the research questions were handled as follows.

3.2.1 Functionality

Functionality is a concept related to the technical aspects of a product, and involves answering the question, "What does the product do?" (McNamara and Kirakowski, 2005, 2006)
The specifications of the LW vehicle used in this study are as follows.

- Overall length x Overall width x Overall height: 1.190 mm x 655 mm x 990 mm
- Dry weight (with battery): 36 kg (38 kg)
- Tires: Sponge-type; do not blow out
- Drive system: dual electric-assisted run and full-electric run
- Control system: Microcomputer control with motor controlled automatic brake
- Max forward speed: 6.0 km/h
- Max reverse speed: 0.5 km/h

When the rider is a healthy adult, the functions of the vehicle are dependent on its specifications; while there may be small divergences, the functions of the vehicle do not change drastically among different riders. The functionality of this vehicle as judged by its specifications would be described thus:

With the electric-assist function, the vehicle can be made to move forward with just light pressure on the pedals. The vehicle can be stopped with handbrakes or by simply removing one's feet from the pedals. Reversing is also possible. The vehicle is pre-set so that it cannot go forward at a speed greater than 6 km/h or reverse any faster than 0.5 km/h.

However, the users who are the subjects of this study are all certified as requiring some level of nursing care in their ADLs, as shown in Table 2, and the functionality of the LW in the case of a facility user greatly depends on the physical and mental condition of the rider. Therefore, the question needs to be revised to, "What kind of rider can move this vehicle?" It must also be pointed out that since the LW is not yet available on the commercial market, facility users have no analogy with their past experiences to refer to.

In FGIs carried out prior to the test riding of the LW, we asked the health care professionals routinely caring for the facility users what kind of person they felt was suitable for this vehicle. During the loan period of LW vehicles, we asked for volunteers among the care professionals who would be willing to encourage facility users to ride the LW. We then asked them to predict whether each rider would continue to ride the LW or not. Later, we included these predictions in the personal portfolio.

3.2.2 Usability

Usability, according to ISO is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." In this study, we created a histogram and accumulated data chart comparing the riding rates of continuous riders and those who discontinued riding, a histogram of riding rates (number of rides / days at facility) by attributes (sex, age cohort, care level) to clarify what kind of people rode the LW at what frequency. The effectiveness of the rides should also be measured in terms of physical and mental effects, but that is not within the scope of this study.

3.2.3 Experience

According to McNamara and Kirakowski (2005, 2006), judging experience requires answering the question, "How do I relate to this product?" The facility users who tried out the LW required assistance in their ADLs, but they nevertheless made the decision to ride the LW, tried it out several times, and then decided to either continue or discontinue riding during the period in which the vehicle was on

loan to the facility. By keeping a record of their reasons (for deciding to continue or discontinue use), it was possible to learn what they found appealing, or conversely, what they found to be a problem, about the LW. Likewise, it was possible to find out how they were influenced to try out the experience of riding the LW. This data was collected by the authors from the riding survey tables and through interviews carried out after the vehicle loan period.

This study was carried out only after it had been reviewed and approved by the ********** research ethics committee. (authorization NBR: 2012021)

4 RESULTS

4.1 Circumstances which Elucidate Knowledge Creation

In this experiment, not one facility user at the daycare center attempted to ride the LW. At the rehabilitation hospital, there were 61 users who rode the vehicle. This result indicates that, without exception, there was no knowledge creation generated by the loan of the new AT device to the daycare center. The following is an excerpt from an interview related to this.

(D: Daycare Center Director; 1st: First Author; 2nd: Second Author; Ci: City Hall staff; En: LW Engineer)

PT: When the vehicle was demonstrated, there were two people who expressed interest, but they never tried to ride the vehicle themselves.
D: They were told it was OK to ride the vehicle, but the one person who we thought might be a good candidate to try it out became sick and that made a trial difficult.
1st: Yes, it may be difficult without an atmosphere that this might become popular within the facility.
PT: There was no word-of-mouth encouragement.
1st: If at least one person had tried it out, and said it was fun....
PT: Yes, if that sort of thing had happened we might have seen different results. But it didn't turn out that way, I'm sorry.
D: Persons who are undergoing rehabilitation are working hard to resume their normal life, so for someone like that a vehicle that they can pedal on their own is appealing. There is a difference between simply wanting to maintain your current lifestyle such that, for example, even if you can't drive a car yourself, you can use a wheelchair or your family will drive you, or you can have groceries delivered, and being motivated to go

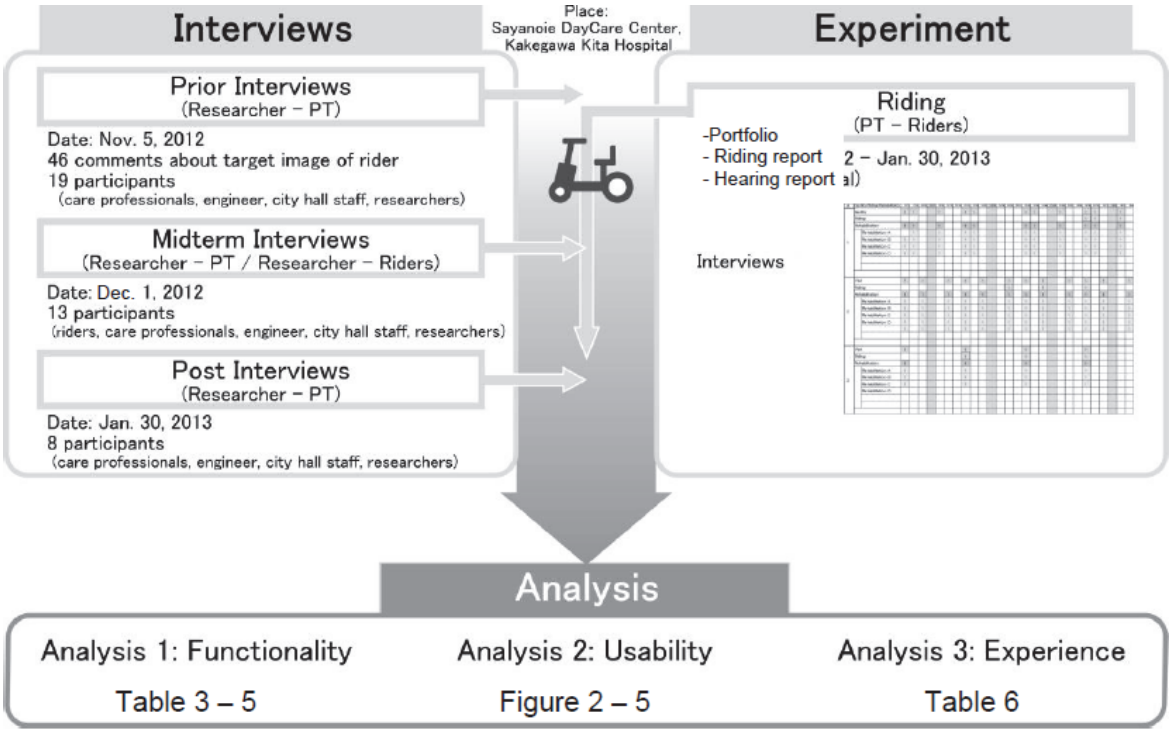

Figure 1: Flow of Data and Analyses.

out on your own to do something. There is a difference of drive and energy between the two. ...
2nd: Apparently, people were reluctant to try out the vehicle because they were told they could not ride it outside. But even though they were allowed to use it within the facility, no one tried, so we were not able to find out how they might have used the vehicle.
D: Given the size of the vehicle, it is not surprising that people were reluctant to ride it inside the facility. It is hard to imagine riding on the LW through the same hallways in which people are in wheelchairs, or walking, or even just standing because they can't walk. It doesn't seem reasonable to expect people to ride smoothly inside a hospital.
Ci: I think it would be embarrassing, too. You would have to have courage.
1st: You would stand out and you would feel constrained to have to sweep by the other people.
D: A wheelchair would feel more natural. Two-wheelers and 3-wheelers are what feel out of place.
Ci: But if you get used to it, it wouldn't be so bad.
En: In America, people ride mobility scooters [called "senior cars" in Japan] inside hospitals.
Ci: [It would be nice] if everyone could get used to it that way.
(2013 Jan 30, Post interview FGI: Sayanoie Daycare Center)

The daycare center is a place where elderly persons certified as requiring care can spend time during the day. They do not come to the center with a specific purpose in mind, such as those who go to the rehabilitation hospital, and there are no specified activities for each individual. Still, just like at the rehabilitation hospital, the daycare center PTs and OTs did demonstrate the vehicle, riding the LW themselves and inviting the facility users to do the same. No one took them up on the invitation, however. This indicates how important it is to have someone try out the vehicle first in order to disseminate use of the new AT device. Also, as indicated in the interview excerpt above, the conditions for health care knowledge creation in this particular case are that facility users are highly motivated to go outside, are proactive in their lifestyles, and are not embarrassed to use the vehicle inside the facility.

4.2 Functionality

4.2.1 The Type of Frail, Elderly Person for Whom the LW Is Best Suited

Table 3 shows the characteristics that emerged from the prior interview that best describe the type of elderly person who would be able to make use of the LW. As was shown in Figure 1, we collected 46 comments from interviews with care professionals. Comments that were basically the same were combined into one.

Table 3: Target image of frail elderly persons who are best suited to use the LW vehicle.

Occupation	ID	Target image
CM	S	Forward-looking person
CM	S	Candidate for secondary preventive care
CM	S	Person requiring preventive care or support as opposed to a regular daycare user
CM	S	Person who is being taken care of by a general support center (preventive care)
CM	S	Person who wants to undergo rehabilitation
CM	S	Person who can walk using a cane
CM	S	Person who thinks they can still ride a bicycle or who uses a bicycle like a cane, but who others do not believe is actually capable of riding a bicycle
CM	S	A relatively healthy elderly person who still farms (such as in mountain valley areas or in tea fields)
CM	S	Person who has not yet ridden a mobility scooter
CM	T	Person with relatively strong legs who can pedal (including those with dementia)
PT	A	Person who is mobile near the home using a cane or walker but who has difficulty going further afield
PT	SW	Person who uses machines or bicycles for physical training and rehabilitation
PT	A	Person who thinks they will be able to go outside if they have this kind of vehicle
CW	M	Anyone who shows interest; anyone who likes vehicles
SW	N	Person who is still riding bicycles but is losing confidence in their ability to do so
Facility director	IN	Person who doesn't want to depend totally on a mobility scooter

While no quantitative analysis has been made, the comments shown in Table 3 contrast the target image held by PTs and care managers. The PTs speak of the facility user's behavior and psychological factors while the care managers tend to base their target image on external markers such as the facility user's level of care, AT device, and even occupation. Nevertheless, as will be demonstrated in the next section on usability, these kinds of external markers are not effective measures of a user's suitability for riding the LW.

4.2.2 PT's Predictions of Whether a User Will Continue or Discontinue Riding

Table 4 shows the PT's predictions and actual results of facility users' continuity of riding. The rate of accuracy of the PT's predictions was around 50%.

In Table 4, the "Neither" category indicates those who rode only sporadically and for whom the PT had difficulty deciding which category (continue or discontinue) they belonged to.

Table 5 indicates the reasons for the PT's predictions. The numbers above the double line are the PT's predictions and the numbers below, the actual results. The figure under "Prompt" indicates the number of users the PT believed would respond to or not respond to prompting. The criteria "Prompt", "Proactive", and "Initiative" proved to be effective measures for deciding whether a user was likely to continue using the LW or not, but it was found that the other criteria, "Willingness" (willingness to try anything new), "Interest" (interest in the LW vehicle), "Medical/physical condition" (today's condition), were not very effective measures for judging a person's reaction to the LW vehicle. The reasons were recorded in the personal portfolios, with each reason categorized in the 8 categories shown in Table 5. The PT sometimes gave several reasons for a prediction, so the total number of reasons is not the same as the total number of riders.

Table 4: Rate of accuracy of PT's prediction.

	Result		
Prediction	Continued	Discontinued	Total
Continue	31.1%	19.7%	50.8%
Neither	9.8%	14.8%	24.6%
Discontinue	6.6%	18.0%	24.6%
Total	47.5%	52.5%	100.0%

Table 5: Reasons for prediction by category.

Category	Prompt	Willingness	Proactive	initiative	Interest	Fear	Bicycle	Medical / Physical condition
All	10	11	12	7	19	3	5	9
Continue	7	6	8	5	5	0	1	2
Neither	3	1	2	1	7	0	2	1
Discontinue	0	4	2	1	7	3	2	6

4.3 Usability

The breakdown of the users who tried out the LW vehicle in the rehabilitation hospital is as follows: Age: 65-74: 22; 75-above: 39. Men: 36; Women: 25. Care level: Support Level 1– LTC Level 4.

The number of days that a user came to the facility varied according to the individual's care level and medical condition. In order to determine what kind of persons rode the LW vehicle and to what extent, it was necessary to calculate the rate of riding by dividing the number of rides by the number of days at the facility. Figure 2 compares the riding rates and accumulated riding rates of those who continued to ride against those who discontinued. Those who continued where persons who may have taken several breaks, but who nevertheless continued to ride the LW vehicle throughout the period it was on loan to the rehabilitation hospital. Those who discontinued were persons who tried out the vehicle a few times but then stopped riding. There were only 4 riders in the "Neither" category so we traced their record of riding and re-categorized them in "continued" or "discontinued".

Looking at Figure 2, you can see that most of those who discontinued riding generally did so after they had reached a riding rate of around 20% (4 times). This indicates that the users were able to judge by their fourth ride whether or not the LW vehicle suited them. Those who continued to ride are distributed between 20% to 90%, and half exceeded a riding rate of 50%, indicating that they rode the LW vehicle at least half of the days that they came to the hospital.

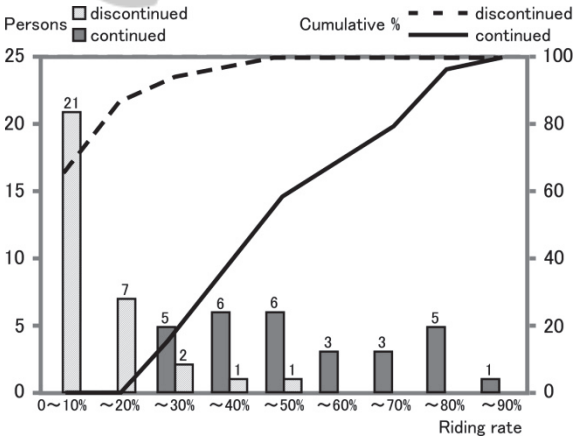

Figure 2: LW riding rate and accumulated riding rate by continued / discontinued category.

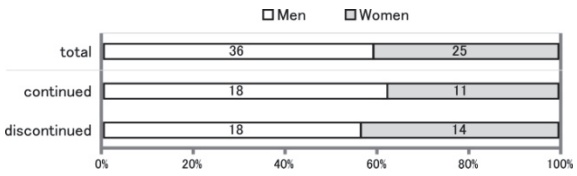

Figure 3: Rates by sex.

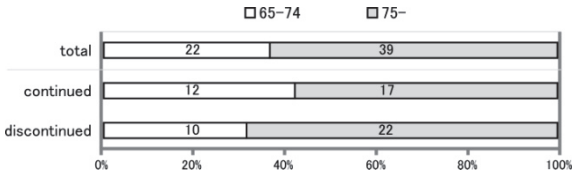

Figure 4: Rates by age cohort.

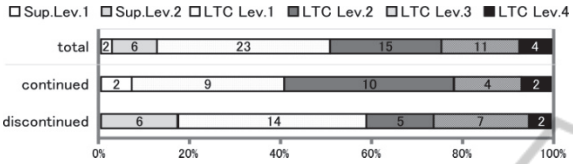

Figure 5: Rates by care level.

Figures 3 through 5 indicate that more men than women, and those older than 75 as compared to those age 65 to 75, were likely to continue riding. In terms of care levels, the greatest number of continuing riders spans LTC Levels 1, 2 and 3, while most of those at the less demanding care levels of Support Levels 1 and 2 did not attempt to ride the vehicle.

4.4 Experience

The most common reasons cited by users in their personal portfolios for riding the LW vehicle were: because I was encouraged to do so by the PT, because it looked like fun, because I want to build up some muscle, because I saw or heard about someone riding, and because I want to be able to ride a bicycle. Those who continued riding gave as their reasons for doing so: able to go outside, fun, encouraged to do so, condition was good, etc. Those who discontinued riding gave as their reasons: hard to ride, tiring, too slow, condition was poor, etc. As was noted earlier, almost all of the 61 riders at the rehabilitation hospital rode the LW vehicle at least four times, suggesting that the PT's encouragement was a major factor in securing so many riders. Below are some of the comments made in an FGI of the rehabilitation hospital PTs during the experiment.

What these comments tell us is that the rehabilitation hospital assigned staff specifically to help with the trial rides, repeatedly encouraged users to try out the vehicle, made adjustments as necessary to ensure a smoother ride, called out a beat to give the rider a rhythm by which to pedal, and otherwise made proactive efforts to act as an interface between the rider and the LW vehicle.

Table 6: PTs' comments in midterm interview.

Topics	Comments
Trial rides	Start by gathering everyone together, saying "Would you like to ride it? Let's try it." Have a person get on the vehicle, show them how to operate it and walk by them as they go a few rounds. On the first ride, the rider goes a few turns and tries out all the vehicle's functions. Each individual is asked if they want to give it a try, and a staff person accompanies each person who decides to try riding. Once one person is done, the next person is brought forward.
	Those who want to try a second ride are contacted by the facility staff.
	Those who ride two or three times tend to continue riding.
	A common characteristic of those who continue riding is that they are self-sufficient at home but have difficulty going out on their own.
	These were mostly persons at support level 1 and nursing care level 2.
	There were some care level 3 people who tried out the vehicle, but they generally needed assistance in controlling the vehicle, and some had to have help to keep their feet on the pedals.
	Those who had disabilities of their hands or feet had difficulty controlling the vehicle.
Encouragement from hospital staff during the trial ride	Progress is uneven during the trial rides, but we tried to encourage the rider by helping them with rhythm, for example, calling out, "One, two, one, two" each time they stopped pedalling. The usual staff worked with the riders [so they had people they were familiar with helping them out]
	After the rider got on the vehicle, the seat was adjusted (height, etc.) to ensure a comfortable ride. It was slightly different from adjusting a bicycle seat, but the staff kept communicating with the rider, asking "How does it feel?" and so on, and making minor changes as needed.

(2012 Dec 1, Midterm FGI interview, Kakegawa Kita Hospital)

5 CONCLUSIONS

As a new AT device, we found that the LW vehicle could be fun and highly satisfactory to frail elderly users who had difficulty walking on their own or going outside. But this was an experience that could not have been achieved without the interaction between the PTs and the users. The PTs provided encouragement, helped in adjusting the vehicle settings, made judgments as to who might be suited to ride the vehicle, and otherwise created new knowledge to guide frail elderly persons to using the

vehicle. In order for this kind of knowledge creation to take place, it is imperative that the organization provide an environment suitable for the use of the device, that the user be proactive, and that dedicated staff be appropriately assigned to assist as necessary.

In the setting of the rehabilitation hospital where PT supervision was available, it was found that the LW vehicle was best suited to users at LTC Levels 1 to 3 who were over the age of 75. At the same time, there was considerable discrepancy among individuals as to whether they would continue or discontinue use of the vehicle. It was also found that it was difficult for PTs to predict who would or would not continue riding, and in this regard there is a need for new knowledge creation.

The primary focus of the salutogenic perspective on health is the individual's ability, right up to the time of death, to adapt to his or her own condition as necessary to stay in good health. Today, there are a variety of devices that support this ability. The more devices that are made available to frail elderly persons, the easier it will be to realize the kind of health that is the focus of this perspective. Unfortunately, major manufacturers are reluctant to develop new products for the over-75 market because of the fear of accidents and the probability of being sued as a result. Still, the market for devices for the over-75 age cohort is certain to expand and there is ample room for innovation based on new knowledge creation. As this study has shown, having a new device evaluated within the context of a care facility serves as an impetus to transform the tacit knowledge of professional caregivers to explicit knowledge. This requires, however, close collaboration among the device maker, researchers, and caregivers. In the current study, the city hall staff also played an important role as intermediaries bringing together diverse professionals and the staff of the care facilities.

There are three topics that this study must undertake in the future.

(1) Accurate measurement of effectiveness which is a critical index for judging usability. We need to elucidate the psychological and physical effects of continuous use of the LW vehicle.
(2) We need to provide a method, such as a rehabilitation menu, by which care managers, who are not as knowledgeable as PTs about nursing care, can judge who is best suited to use the LW vehicle.
(3) We need to consider what kind of knowledge creation is needed to enable users to ride the LW vehicle outside of the facilities.

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