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Social Capital Mediates the Association between the ICT Usage and Well-Being of Older People in Japan: Implication for a New Design Paradigm

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Abstract: As the population ages, the question of how to prevent isolation among older people and increase their well-being becomes a social issue. It has often been argued that Information and Communication Technology (ICT) usage can be a solution to these challenges, but empirical studies have not shown consistent results. Moreover, there are even fewer studies targeting older people in Japan, which is the most aging country in the world. Therefore, using the psychological comprehensive data of Japanese people aged 60 and over recorded in World Values Survey Wave 7, we conducted a study to clarify the relationship between the ICT usage, social capital, and well-being of older people to make a meaningful contribution to policymakers and the scientific community. As a result of the analysis, it was shown that ICT usage indirectly enhances well-being by increasing social capital. This indicates that for older people, ICT usage does not have a large effect on enhancing well-being, but becomes sufficiently large only through the improvement of social capital. The pros and cons of such modern communication means should be utilized as a reference when considering the development of future communication means and a human coach—a person who supports the use of communication means by older people. In other words, to think about the spread of communication means to community-dwelling older people in the future, it is always necessary to think about technology usage emphasizing the relationship between older people and society.

Keywords: well-being; ICT usage; social capital; older people; Japan

1. Introduction

As the world's population is growing older, our societies need to find ways to support older people's capabilities to age well. Specifically, studies have shown that isolation reduces the well-being of older people [1–3]. However, even isolated older people can interact with people by participating in online activities, such as social networking services (SNS). The rapid development of mobile internet networks combined with modern communication means allows older people to easily contact and share information with people via various digital means, such as text, photo, voice, and video [4]. Digital technology development has the potential to help older people to gain more social support and feelings of social connectedness, especially for older people with mobility impairment and

for those who live alone, away from family and acquaintances [5,6], as digital technology may help them to maintain social connections [7–10]. These arguments indicate that ICT usage may increase the "social capital" of older people. Social capital is defined as the "features of social organizations such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefits" [11]. indeed, many studies have shown that ICT usage can help prevent isolation and improve social capital in older people [12–20]. In particular, informal relationships with family and friends are more important than formal relationships with members of an organization in the formation of social capital for older people [11,17,21]. Therefore, the promotion of ICT usage is considered to lead to the improvement of well-being in older people through the increase of social capital based on relationships with close people.

Even though it has been suggested that ICT usage leads to an improvement of the well-being of older people [12–20], some studies have shown that there is no direct relationship between ICT usage and well-being [22–26]. Relatedly, there was not only an optimistic argument emphasizing that widespread ICT usage would increase the ease of connection between older people and others [27,28] but also a pessimistic argument that it encourages the isolation of older people [29,30]. Such inconsistency suggests that social capital is a variable that mediates the relationship between ICT usage and well-being. However, little empirical evidence establishes the mediating effect of social capital between the use of modern communication means and the well-being of older people [31–38]. Moreover, many of these studies include middle-aged people under the age of 60 and do not use comprehensive measures for ICT or well-being. Furthermore, there has been no comprehensive empirical study on the relationship between ICT usage, social capital, and the well-being of older people in Japan. Japan is the most aging country, and the percentage of older people aged 65 and over in the total population has risen to 29.1% (as of 15 September 2021), which is higher than other aging countries, including Italy at 23.6%, Germany at 22.0%, and France at 21.1% [39].

Accordingly, this study aims to assess the association between ICT usage, social capital, and well-being among older people in Japan using more comprehensive variables than previous studies. Such research is also useful for expanding the consideration of how to use newer technologies, such as communication robots, that connect older people and society [40–45], and how important a human coach, a person who supports the use of communication means by older people, is for that purpose. The target of this research is to clarify the relationship between the ICT usage, social capital, and well-being of the elderly to consider the development and popularization of communication means in the future, helping various stakeholders, such as governments, communities, and health care sectors to approach matters of ICT, and contributing to the development of related academic fields. To that end, the variables used in the analysis are the ones that reflect modern ICT and elderly well-being comprehensively. However, it should be noted that the current study is about older people in Japan and may not be directly applicable to older people in other countries.

2. Literature Review and Hypothesis

2.1. ICT Usage and Well-Being

ICT usage by the elderly improves their well-being and quality of life through a variety of channels [46]. For example, regular internet use may relate to health behaviors because there is various information about health on the internet [47]. Therefore, previous works have reported that internet use relates to better self-reported health and a lessened risk of depression and functional impairment [48–52]. Relatedly, other works have reported associations between internet use and greater social support, decreased loneliness, better life satisfaction, better psychological well-being, and better overall mental health [33,34,53,54]. Moreover, it has been shown that the usage of various ICT means, not limited to the Internet, is related to the well-being of older people [12–20]. However, some other studies have shown that there is no direct relationship between ICT usage and well-being [22–26]. For instance, previous studies found no significant association between SNS use and emotional well-being

and related variables in older adults [23,24]. Relatedly, some research indicates no association between SNS use and loneliness [22,25,26]. These contradictory results suggest that there is a variable that mediates the relationship between ICT usage and well-being.

2.2. Social Capital as a Mediator

It has been found that being part of a digital community in the internet-based media allows older people to feel socially more involved with others [52], prevents their isolation in the society [19,20], and improves their social capital [22,55–57]. For instance, Tsai et al. [20] found that videoconferencing chats between older people at nursing homes and family members significantly increased emotional and appraisal social support from family members and decreased the loneliness of older people. Social capital, in turn, has been shown to be associated with better self-rated health [58–63] and well-being [12–18]. These indicate that social capital has a mediating role between ICT usage and well-being.

2.3. Previous Studies and Hypothesis

Indeed, as is shown in Table 1, previous studies suggested that ICT usage enhances social capital (and related variables) and thereby enhances well-being (and related variables). Of the eight studies, four were for western [31–34], and four were for eastern [35–38] countries. Furthermore, of these, three studies are limited to the elderly aged 60 and over [31,34,35], and the rest include those in their 50s. Of these, the study by Sum et al. is based on data from an online survey conducted in the United States. It shows that those who use the Internet for communication and information seeking tend to have higher social capital, and those with higher social capital tend to have higher well-being [32]. Meanwhile, an intervention study by Szabo et al. in New Zealand showed that the ICT usage aimed at connecting with friends and family enhances social engagement and indirectly enhances well-being [31]. Besides them, the bridging function of social capital has been shown in several studies, if not limited to older people [23,64]. For example, there is a study by Chan et al. showing that ICT usage enhances social capital and indirectly enhances well-being for a wide range of age groups in Hong Kong [23]. Therefore, we are led to the following hypothesis:

Hypothesis. *Social capital mediates the association between ICT usage and well-being.*

This hypothesis is to test how the formation of social capital is necessary to enhance the well-being of older people who use modern communication means. The importance of social capital may in turn provide meaningful implications for the development of future ICT systems and human coaches to involve more older people in the local community, and respective policies for overall society by a socio-technical system that takes this relationship always into account.

2.4. Covariates

Previous studies have shown that sex [65–68], age [69,70], family structure [5–10,38,71], educational background [65,66,72–75], work [76], and income level [72], etc., influence ICT usage. There is also evidence that separated or divorced people, people of lower socioeconomic status, and younger persons report more often a lower level of trust [77]; lower-income and psychosocial factors are associated with inferior health [58,78]; and social activity participation has a positive impact on older adults' physical and mental health [16,79–85]. Therefore, a series of these demographic variables will be used as control variables in the following analysis.

Table 1. Previous research on the mediation effect of social capital and related variables.

Country	Age	N	Method	Independent Variable	Mediator	Dependent Variable	Result	Article
New Zealand	60–77	1165	Path analysis (longitudinal)	Frequency of online activities	Loneliness and social involvement	Well-being (control, autonomy, self-realization, and pleasure)	The use of the Internet indirectly affected well-being through reduced loneliness and increased social involvement.	[31]
Australia	55 and above	222	Multiple regression analysis (cross-sectional)	The length of Internet usage	Social capital (feelings of trust and values of life)	Well-being (satisfaction with health, relationships, feeling of safety, the standard of living, achieving in life, feeling part of the community, and future security)	The use of the Internet for communication and information exploration had a positive effect on well-being through the improvement of social capital.	[32]
United States	50 and above	591	Path analysis (cross-sectional)	Whether they used ICT (e-mail, social networking sites, online video/phone calls, online chatting/instant messaging, smartphone)	Loneliness	Well-being (life satisfaction) and other mental health benefits	Using social technologies was associated with better subjective well-being and other mental health benefits, and the associations were mediated through reduced loneliness.	[33]
United States	65 and above	5203	Structural equation modeling (cross-sectional)	Frequency of Internet use	Social support and loneliness	Life satisfaction and psychological well-being	Internet use predicted higher social support, leading to lower levels of loneliness and higher levels of psychological well-being and life satisfaction.	[34]
China	60 and above	6323	Multiple regression analysis (cross-sectional)	Whether they used the Internet during the past month	Social capital (frequency of interaction with friends)	Physical and mental health	Social capital acts as a partial mediator between internet use and the physical health of the elderly.	[35]

Table 1. *Cont.*

Country	Age	N	Method	Independent Variable	Mediator	Dependent Variable	Result	Article
China	50 and above	4083	Structural equation modeling (cross-sectional)	Frequency of Internet use	Loneliness and volunteering	Happiness	Internet use is indirectly associated with a high level of happiness, which is mediated by a decrease in loneliness and an increase in volunteer activity.	[36]
South Korea	55 and above	1661	Multiple regression analysis (cross-sectional)	Internet usage, diversity, value creation	Social capital (on–offline relationship)	Life satisfaction	Social capital acts as an intermediary between the level of digital information usage and life satisfaction.	[37]
South Korea	50 and above	6306	Generalized estimating equation (cross-sectional)	Whether they used the Internet in a year	Social relationship satisfaction	Depression	Internet use was related to increased satisfaction with social relationships, which, in turn, was associated with decreased levels of depression symptoms.	[38]

3. Methods

We conducted structural equation modeling (SEM), a powerful multivariate analysis technique widely used in the social sciences [86], to identify the factors that determine well-being. SEM is used to analyze complex relationships among multiple variables, including observed and latent variables, to test the validity of theory using empirical models [87]. The foremost advantage of using SEM over ordinary least-squares regression is that the scores on the variables are measured without error because SEM permits the incorporation of measurement errors into the analyses [88–90]. For that purpose, we discuss the source and nature of the data in this section.

3.1. Samples and Data Collection

We used the responses to a survey included in the database below to investigate the association of well-being with ICT usage and social capital.

World Values Survey Wave 7 [91]: https://www.worldvaluessurvey.org/WVSContents.jsp, accessed on 24 June 2021.

We used all 32 related items recorded under the dataset above. Answers to the questionnaire were mainly through face-to-face interviews, but some were by mail, online, or by phone. The survey was conducted in the major languages of each country, targeting people aged 18 and over living in 80 countries around the world. The survey in Japan was conducted in 2019 and was attended by 1353 people. Here, we use the complete-answer data of Japan's 397 older people (male 190, female 207) aged 60–94 years old (mean 71.3, SD 7.3). Figure 1 is a histogram showing the frequency of the participants by age.

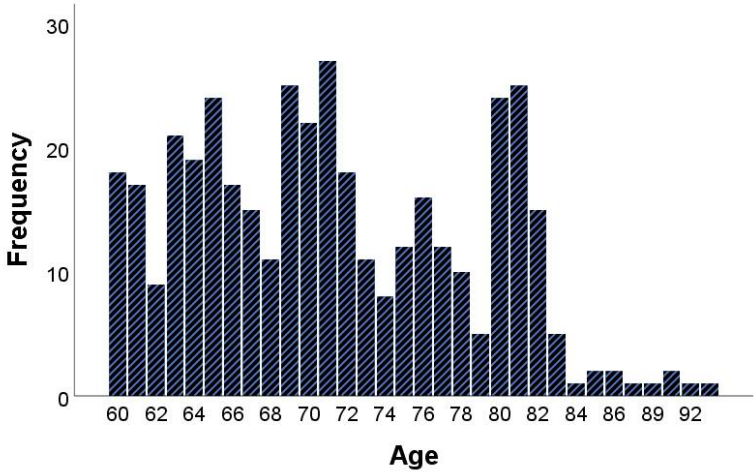

Figure 1. Frequency of the participants by age.

3.2. Measures

This research used the following variables. Considering the difference in scale, each item was converted to a z score and summed up to calculate a variable score. Following the items, the questionnaire sentences are written in italic in parentheses.

3.2.1. Well-Being

As shown in Table 1, in the previous studies, in addition to studies using comprehensive well-being, including the condition of health [31–33,35], as dependent variables, there are studies using variables that indicate a particular psychological area, including happiness [36], life satisfaction [34,37], and depression [38]. In previous research, well-being has included various elements such as emotions, financial and health conditions, and freedom of choice [12–20]. The authors are also targeting healthy aging and independent living for the elderly by improving well-being based on these diverse factors through the research and development of communication robots and human coaches [92]. Therefore, a five-item scale composed of divergent elements including satisfaction with life, satisfaction with the

financial situation of household, happiness, and freedom of choice and control measured well-being in the current research. "Satisfaction with your life (*All things considered, how satisfied are you with your life as a whole these days?*)" as the well-being 1 (WB1) and "satisfaction with the financial situation of household (*How satisfied are you with the financial situation of your household?*)" as the well-being 2 (WB2) are measured on a ten-point scale from 1 (completely dissatisfied) to 10 (completely satisfied). "Happiness (*Taking all things together, would you say you are*)" as the well-being 3 (WB3) is measured on a four-point scale from 1 (not at all happy) to 4 (very happy). The original scale was from 1 (very happy) to 4 (not at all happy), but we reversed it so that the positive answers became higher. "Freedom of choice and control (*Indicate how much freedom of choice and control you feel you have over the way your life turns out*)" as the well-being 4 (WB4) is measured on a ten-point scale from 1 (no choice at all) to 10 (a great deal of choice). "State of health (*All in all, how would you describe your state of health these days?*)" as the well-being 5 (WB5) is measured on a five-point scale from 1 (very poor) to 5 (very good). The original scale was from 1 (very good) to 5 (very poor), but we reversed it so that the positive answers became higher. The reliability coefficient was 0.782. In general, the reliability coefficient is acceptable if it is 0.6 or more [93].

3.2.2. ICT Usage

Seven of the eight previous studies listed in Table 1 limit the independent variable to the Internet. On the other hand, only Chopik et al. used an independent variable composed of various ICTs, such as e-mail, social networks, and smartphones [33]. Furthermore, there are studies that use not only frequency [31,34,36] but also experience [33,35,37,38] and length [32] of usage as independent variables. The purpose of this study is to clarify the effect of the spread of modern ICT as a whole and to obtain hints for considering related policy issues. Therefore, as an independent variable, comprehensive ones including various modern communication means such as mobile phones, email, Internet, and social media are used. These are related with social capital and well-being of older people in previous research [12–20]. Further, it is considered that not only the experience but also the continuous use of ICT is required for changes in the consciousness and behavior of the elderly. Indeed, previous research indicated that the frequency of ICT usage was related to lower loneliness and isolation [94], depression [48,49], and higher interaction with other people [94]. Therefore, it is rational to use the frequency of usage as the scale of the independent variable. A four-item scale measured the ICT usage "mobile phone" as the information and communication 1 (IC1), "Email" as the information and communication 2 (IC2), "Internet" as the information and communication 3 (IC3), and "social media (Facebook, Twitter, etc.)" as the information and communication 4 (IC4) ("*For each of the following sources, please indicate whether you use it to obtain information daily, weekly, monthly, less than monthly, or never*") are measured on a five-point scale from 1 (never) to 5 (daily). The original scale was from 1 (daily) to 5 (never), but we reversed it so that the positive answers became higher. The reliability coefficient was 0.698.

3.2.3. Social Capital

As is shown in Table 1, the contents of social capital and related variables are not consistent, including relationships of trust [32], on–offline relationship [37], relationship satisfaction [38], interaction frequency [35], social support [34], and loneliness [31,33,34,36]. In this research, a three-item scale measured social capital based on an argument that family, friends, and neighborhood are the key factors of social capital in older people [11,17,21]. Further, the significance of trust is used as the scale of social capital because trust and trustworthiness are commonly mentioned as the most essential element of social capital [95–101]. "Your family" as the social capital 1 (SC1), "your neighborhood" as the social capital 2 (SC2), and "people you know personally" as the social capital 3 (SC3) ("*Could you tell me for each whether you trust people from this group completely, somewhat, not very much, or not at all?*") are measured on a four-point scale from 1 (do not trust at all) to 4 (trust completely). The original scale was from

1 (trust completely) to 4 (do not trust at all), but we reversed it so that the positive answers became higher. The reliability coefficient was 0.640.

3.2.4. Control Variables

To control the individual differences, several demographic variables were included. The highest educational level is on a nine-point scale from 0 (early childhood education/no education) to 8 (doctoral or equivalent).

The scale of incomes is on a ten-point scale from 1 (lowest group) to 10 (highest group).

Working in active duty is an eight-point scale originally, but was converted to a two-point dummy scale from 0 (no paid employment: retired/pensioned; housewife not otherwise employed; student; unemployed; other) to 1 (has paid employment: full-time employee; part-time employee; self-employed).

Living with spouse is on a six-point scale originally, but was converted to a two-point dummy scale from 0 (divorced; separated; widowed; single) to 1 (married; living together as married).

Unconverted response data were used for age, the number of people in a household, and the number of children. We also used sex dummy, 1 (male) and 0 (female), which was converted from the original scale 1 (male) and 2 (female).

Social activity participation was measured by the average of the following twelve-item scores: "church or religious organization", "sport or recreational organization, football/baseball/rugby team", "art, music or educational organization", "labor union", "political party", "environmental organization", "professional association", "humanitarian or charitable organization", "consumer organization", "self-help group, mutual aid group", "women's group", and "other organization" (the questionnaire was "*For each organization, could you tell me whether you are an active member, an inactive member, or not a member of that type of organization?*"). Each item was measured on a three-point scale from 0 (don't belong), 1 (inactive member), and 2 (active member).

Table 2 indicates the mean, standard deviation (SD), and correlations between the main and control variables.

3.3. Analytical Method

We performed the SEM using the latent variables of well-being, social capital, and ICT usage to analyze the factors influencing well-being. Variables composing individual latent variables and other demographic variables were treated as manifest variables. The significance level was determined at $p < 0.05$. All statistical analyses were performed using IBM SPSS Statistics and AMOS Version 26 (IBM Corp., New York, NY, USA).

Table 2. Descriptive statistics and correlations for all the variables.

		Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1	Well-being	0.000	0.732											
2	Social capital	0.000	0.766	−0.193 ***										
3	ICT usage	0.000	0.724	−0.082	0.079									
4	Sex	0.479	0.500	−0.050	0.054	−0.127 *								
5	Age	71.280	7.266	0.042	0.021	0.253 ***	−0.003							
6	Living with spouse	0.786	0.411	0.055	−0.162 **	−0.108 *	0.217 ***	−0.207 ***						
7	Highest educational level	4.200	1.493	0.124 *	−0.140 **	−0.256 ***	0.232 ***	−0.207 ***	0.081					
8	Working in active duty	0.375	0.485	0.060	0.026	−0.232 ***	0.143 **	−0.433 ***	0.024	0.146 **				
9	Number of people in household	2.440	1.392	0.062	−0.129 *	0.091	0.005	−0.035	0.271 ***	−0.013	−0.025			
10	Number of children	2.080	1.045	0.140 **	−0.153 **	0.035	−0.033	−0.029	0.159 **	0.024	0.048	0.202 ***		
11	Scale of incomes	3.310	2.383	0.208 ***	−0.150 **	−0.104 *	0.142 **	−0.179 ***	0.244 ***	0.160 **	0.129 *	0.375 ***	0.097	
12	Social activity participation	0.134	0.185	0.237 ***	−0.094	−0.117 *	−0.051	0.061	−0.024	0.031	0.041	−0.016	−0.017	0.067

Notes: $n = 397$. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. The values are the correlation coefficients. The variables 1 to 3 are of the average values of component items.

4. Analysis and Results

Before proceeding to the main analyses, the confirmatory factor analysis (CFA) was used to test if the factors were related to the measures. The model fit was evaluated by examining the indices recommended by Hu and Bentler [102]. These were the ratio of Chi-square to the degree of freedom (χ^2:df ratio: acceptable if 3.0 or less; [103]), the comparative fit index (CFI: good if 0.90 or more; [104]), the root mean square error approximation (RMSEA; good if 0.06 or less), and the standardized root mean square residual (SRMR; good if 0.08 or less; [105]). To begin, a 3-factor model was tested with the variables of well-being, social capital, and ICT usage, each loading on a single factor. The results indicated a good fit between the data and the model. Next, 2- and 1-factor models were tested, where all the variables were combined into one or two factors. Results show that the 3-factor model is better than the 2- and 1-factor models for all the indicators presented in Table 3. Therefore, in the following analysis, we treat these latent variables separately. Table 4 is the estimates from CFA.

Table 3. Results of CFA.

Model	DF	*p*-Value	χ^2/DF	CFI	RMSEA	SRMR
3-Factor model	51	0.000	2.116	0.951	0.053	0.053
2-Factor model (a)	53	0.000	4.964	0.819	0.100	0.087
2-Factor model (b)	53	0.000	7.258	0.714	0.126	0.112
1-Factor model	54	0.000	10.106	0.576	0.152	0.134

Notes: 3-factor model (1 = well-being, 2 = social capital, 3 = ICT usage); 2-factor model (a) (1 = well-being and social capital, 2 = ICT usage); 2-factor model (b) (1 = well-being, 2 = social capital and ICT usage); 1-factor model (all factors combined).

Table 4. Estimates from CFA.

	Well-Being	Social Capital	ICT Usage
WB1. Satisfaction with your life	0.926		
WB2. Satisfaction with the financial situation of household	0.791		
WB3. Happiness	0.615		
WB4. Freedom of choice and control	0.532		
WB5. State of health	0.390		
SC1. Your family		0.470	
SC2. Your neighborhood		0.766	
SC3. People you know personally		0.643	
IC1. Mobile phone			0.548
IC2. Email			0.891
IC3. Internet			0.526
IC4. Social media (Facebook, Twitter, etc.)			0.464

Notes: Figures are standardization coefficients.

Figure 2 shows the results of SEM using 12 variables. Details of the coefficients and correlations are listed in Table 5. In the analysis, modification indices were used to improve the model fit. First, we were able to confirm the significant paths from the ICT usage to social capital ($\beta = 0.403$, $p < 0.01$) and from social capital to well-being ($\beta = 0.741$, $p < 0.001$). Further, no significant correlation was shown between ICT usage and well-being at a 5% level. These indicate that social capital mediates the association between ICT usage and well-being, supporting our hypothesis.

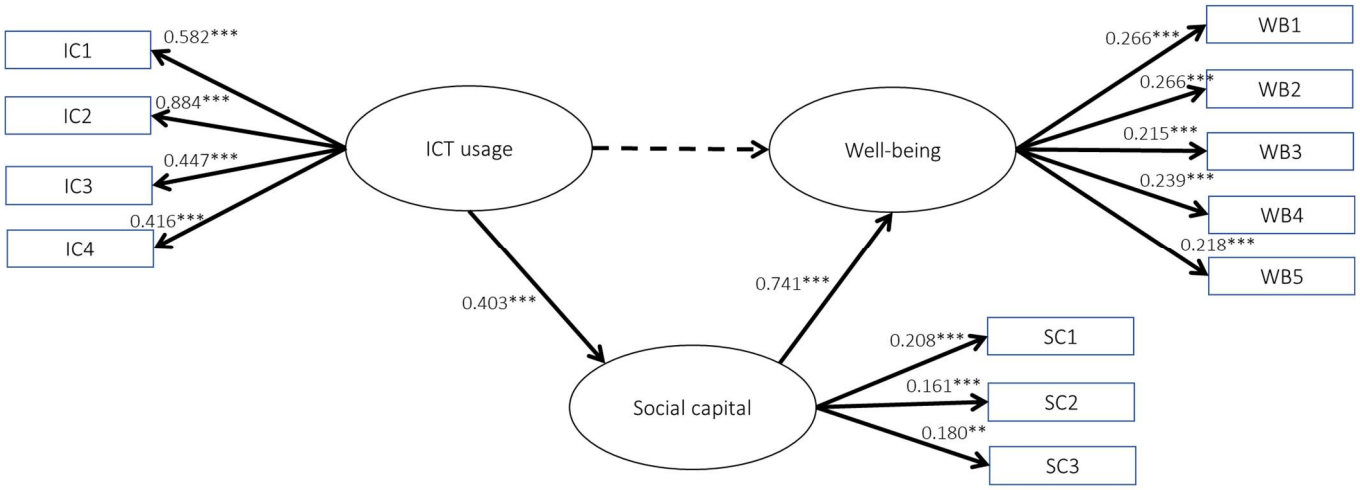

Figure 2. Results of SEM. Figures are standardized coefficients. n = 397. ** $p < 0.01$; *** $p < 0.001$. All straight-line paths are significant at the 5% level but a dashed-line path is not. Goodness-of-fit indices: χ^2 = 166.577, df = 123, root mean square error of approximation (RMSEA) = 0.030, probability of close fit (PCLOSE) = 0.999, goodness-of-fit index (GFI) = 0.958, adjusted goodness-of-fit index (AGFI) = 0.935, normed fit index (NFI) = 0.902, comparative fit index (CFI) = 0.971. Covariances (sex; age; living with spouse; highest educational level; working in active duty; number of people in household; number of children; scale of incomes; and social activity participation) and error terms are omitted in the figure (available upon request).

Table 5. Estimates from SEM.

Path			β
Social capital	<—	Highest educational level	0.313 *
Social capital	<—	Scale of incomes	0.571 **
Social capital	<—	Number of children	0.553 **
Social capital	<—	ICT usage	0.403 *
Well-being	<—	Social activity participation	0.671 ***
Well-being	<—	Social capital	0.741 **
WB1. Satisfaction with your life	<—	Well-being	0.266 ***
WB2. Satisfaction with the financial situation of household	<—	Well-being	0.266 ***
WB3. Happiness	<—	Well-being	0.215 ***
WB4. Freedom of choice and control	<—	Well-being	0.239 ***
WB5. State of health	<—	Well-being	0.218 ***
SC1. Your family	<—	Social capital	0.208 ***
SC2. Your neighborhood	<—	Social capital	0.161 **
SC3. People you know personally	<—	Social capital	0.180 ***
IC1. Mobile phone	<—	ICT usage	0.582 ***
IC2. Email	<—	ICT usage	0.884 ***
IC3. Internet	<—	ICT usage	0.447 ***
IC4. Social media	<—	ICT usage	0.416 ***
IC3. Internet	<—	Age	−0.305 ***
IC4. Social media	<—	Age	−0.157 **
IC4. Social media	<—	Working in active duty	0.123 *
IC1. Mobile phone	<—	Highest educational level	−0.176 ***
IC4. Social media	<—	Social activity participation	0.125 **
IC1. Mobile phone	<—	Working in active duty	0.146 **
IC3. Internet	<—	Highest educational level	0.162 ***
IC2. Email	<—	Age	−0.109 *

Table 5. *Cont.*

Path			β
Covariance			r
Scale of incomes	<–>	Working in active duty	0.138 **
Highest educational level	<–>	Age	−0.204 ***
Scale of incomes	<–>	Age	−0.164 ***
Scale of incomes	<–>	Number of people in the household	0.372 ***
Number of people in the household	<–>	Number of children	0.157 ***
Scale of incomes	<–>	Highest educational level	0.149 **
Working in active duty	<–>	Highest educational level	0.135 **
Working in active duty	<–>	Age	−0.433 ***
Highest educational level	<–>	ICT usage	0.217 ***
Number of people in the household	<–>	ICT usage	−0.113 *

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Figures are standardized coefficients. Error terms are omitted in the table (available upon request).

The result in Figure 2 that there is no significant correlation between ICT usage and well-being is the same as the result in Table 2. However, the correlation between ICT usage and social capital in Figure 2 contradicts the result in Table 2. This is because the correlation was controlled by demographic variables and measurement errors were incorporated into the analyses [88–90] in Figure 2.

Among the covariates, the highest educational level (β = 0.313, $p < 0.05$), number of children (β = 0.553, $p < 0.01$), and scale of incomes (β = 0.571, $p < 0.01$) had a positive correlation with social capital. On the other hand, social activity participation (β = 0.671, $p < 0.001$) had a positive correlation with well-being.

5. Discussion

In order to clarify the relationship between ICT usage, social capital, and well-being, we conducted an SEM analysis using data from Japanese older people. This was to test how important the formation of social capital is to enhance the well-being of older people who use modern communication means, and at the same time, to obtain meaningful implications for the development of future new communication means and for human coaches to involve more older people in the society. The results show that those who use more modern communication means have better social capital, and those who have better social capital have a higher sense of well-being. To summarize, social capital mediates the relationship between ICT usage and well-being. The effect of social capital mediating the relationship between modern communication means and well-being is consistent with our hypothesis and supports the results of previous studies [31–38].

There are three main contributions of the current research presented here. One is that we used more comprehensive measures than previous studies. That is, as an independent variable, ICT usage included multiple modern communication means, including mobile phones, emails, the Internet, and social media. On the other hand, as a dependent variable, well-being included happiness, life satisfaction, health, financial affluence, and freedom of choice. The use of such indicators is important for comprehensively understanding modern ICT and its effects, and for considering future technologies and measures. Second, as a mediator, we used social capital based on the relationships of trust that surround the elderly, including family, friends, and acquaintances. The choice of such a variable may lead to important implications for social capital-centered policies in light of many arguments that relationships of trust with close people, such as families and friends, is a key element of social capital [11,17,21,95–101]. The third is that we used the data of older people aged 60 and over in Japan, who are the most aging in the world but on whom we have not fully studied the relationship between ICT, social capital, and the well-being.

Previous studies have not consistently shown that ICT usage enhances well-being. That is, in addition to the research that shows modern communication means enhance well-being [33,34,48–54], there is also the research that there is no direct relationship between modern communication means and well-being [22–26]. Relatedly, there is a disagreement between researchers who see the modern communication means as a new basis for social inclusion, social capital, and community [27,28] and others who see it as a threat, leading to new forms of exclusion and a decline in face-to-face contacts [29,30]. However, the results of the current study show that ICT usage leads to increased well-being through the rise of social capital. Therefore, the inconsistency of previous studies on the relationship between ICT usage and well-being is thought to be due to social capital mediating the relationship between the two. This, on the flip side, shows that if social capital does not increase even with modern communication means, there is no hope of improving the sense of well-being. In turn, this should also become a strong design paradigm while developing ICT systems for older adults.

Therefore, when the goal is the well-being of older people, it is necessary to disseminate modern communication means in a way that enhances social capital. So, how can we increase the social capital of older people? In previous studies, using the Internet for communication and information seeking was more likely to have positive effects on older people's social capital, loneliness, and well-being, while using the Internet to find new people and for entertainment was a direct predictor of lower well-being [32]. In other words, it can be said that ICT usage does not automatically lead to the improvement of social capital, and if it is used incorrectly, it can have harmful consequences in the form of diminished well-being. For reference, the score of the item used in this study is based on the answer to the question including the words "to obtain information", which is close to the "information seeking" used by Sum et al. [32]. Therefore, it is considered that ICT usage was likely to lead to the improvement of social capital due to the composition of variables (i.e., if the question used different words such as "for entertainment", we might not obtain the same result). If so, it is impossible to draw optimistic conclusions from the results of the current study that modern communication means automatically increase social capital. Rather, the results of the study should be interpreted as that ICT devices that are disseminated with proper use may enhance the social capital and thereby the well-being of older people. Therefore, it can be said that the results of the current research provide important implications for the spread of new communication means in the future and the ideal way for a human coach to contribute. For example, for the elderly to use ICT as a tool for acquiring more information, ICT developers must listen to the opinions and dissatisfaction of the elderly and utilize them for the design and development of user-friendly ICT. By this, social capital could become a new paradigm for designing ICT-based support systems for older adults.

The finding of this research is that social capital works to connect ICT usage and well-being, and thus has important implications for connecting the elderly and society in various fields. For instance, previous studies have shown that the support of family and friends plays a major role in helping older people overcome age discrimination and adapt to the workplace [106,107]. The ability of the elderly to adapt to the workplace and work longer means compensating for the labor shortage in many developed countries, including Japan, where the birthrate is declining and the population is aging [108]. Therefore, in light of the results of this treatise, it can be said that the improvement of social capital through the spread of ICT has great significance in helping the elderly to participate in society as workers for a long time while increasing their well-being. If the elderly can continue to work, it may be possible to reduce medical and long-term care costs and divert national finances to the development of an ICT society for the elderly. By doing so, the social capital and well-being of the elderly will be further enhanced, and a positive spiral can be expected to occur. By linking these discussions to more feasible and concrete policies, it will be possible to develop support systems for the elderly living in the community based on ICT and social capital.

6. Implication

From the above, it was shown that ICT usage has encouraged older people to build social capital and enhance well-being. In other words, if there is no increase in social capital, it is not possible to fully increase the well-being of older people even if there is ICT usage. Therefore, to encourage more people who use modern communication means to build social capital, two effective methods can be considered. One is to change the way modern communication means are used so that they can contribute to improving the relationship of trust with close people. This includes new means of communication, such as communication robots, to replace modern communication means. The other is to enlarge the role of the human coach so that he/she could play a bridging role between the ICT usage and the trust with surrounding people for the users. For example, it would be nice if a human coach could teach the users how to use communication means that would make them want to keep in touch with people close to them.

The current study shows that the spread of comprehensive ICT, including mobile phones, emails, the Internet, and social media, will bring about comprehensive well-being, including improved life and financial satisfaction, happiness, freedom of choice and control, and state of health, through the improvement of social capital. The results of previous studies that have shown the effect of some particular ICT (e.g., Internet) were somewhat difficult to utilize in the policy to popularize ICT for the elderly, which many countries are aiming for. This is because when policymakers take up ICT as a policy issue, it is difficult to distinguish which ICT is good and which is bad. The results of this study, which show that the use of ICT as a whole has a positive impact on the elderly from the perspective of social capital and well-being, will help various stakeholders such as governments, communities, and health care sectors to face ICT constructively. Furthermore, the results of this study, which showed that social capital mediates the relationship between ICT usage and well-being, indicates that the national policies of spreading ICT to older people and improving the relationship of trust between generations should be considered in an integrated manner. This supports previous studies showing the effectiveness of urban planning utilizing ICT and social capital [109,110], while adding the feasibility of including older people as the main characters.

Knowing the overall effect of existing ICT can also be used as a reference when considering future new communication means. It should be noted here that the current study has shown that even modern communication means enhance the social capital and well-being of older people. In other words, there is no point in spreading new communication means unless they should surpass modern communication means in terms of their effects on the elderly. Candidates include communication robots that can extract information in conversation without having to manually operate the devices. Indeed, previous studies have shown that the use of robots promotes interaction in older people [40–42]. In addition, some studies have shown that the use of robots improves the mental health of older people [43,44]. However, in an intervention study conducted by Čaić et al. [45], in evaluating the hedonic and utilitarian value perceptions of exergames (i.e., video games integrating physical activity), human coaches score higher on perceived warmth and competence relative to robotic coaches. The reason given was that the user noticed that the words of encouragement such as "excellent!" from the robot were thoughtless words programmed into the machine. Additionally, when a conversation with a user does not go well, a human coach tries to express it more easily with gestures, whereas a robot coach just repeats the same words from the beginning to the end [45]. The problems of these robots indicate the technical improvements that should be addressed. At the same time, it can be said to show how the human coach should supplement the robot before the robot completely catches up with the human functionally in the future.

The idea of collaboration between humans and means of communication is considered to be particularly necessary for countries such as Japan. For example, it has been shown that Japanese students are less likely to consult with others when depressed than American students [111]. Moreover, in Japan, people living alone have a lower sense of well-being,

which is a tendency not seen in other countries [112]. This suggests that showing one's weaknesses disrupts harmony, so there is a greater need for familiar people to consult in a collectivistic country such as Japan. While applying these discussions, it is worth considering that older people are in a vulnerable position and even if they are in trouble they do not want to consult with their surroundings, and if they are left alone, they are more likely to fall into a vicious cycle of deepening isolation in Japan. However, if the other person is a robot coach rather than a human, it would be easier for these reluctant Japanese elderly people to seek help. In this case, the human coach should play a supporting role rather than a leading role, watching from a distance and promoting interaction between older people and the robot.

As this study shows, modern communication means have made a certain contribution to increasing the social capital and well-being of older people when used correctly. We should keep these facts in mind and aim to contribute to the improvement of older people's social interaction and relationships of trust from the users' rather than the developers' perspective. In other words, social capital should be emphasized as an important variable for designing new ICT-based systems (e.g., communication robots) to support older adults living at home.

7. Limitation

There are four limitations to this paper. First, this study is aimed at older people in Japan and may not be directly applicable to older people in other countries. In the future, generalizability should be verified by applying data from other countries to the analytical model of this study.

Second, this study used data over the age of 60. However, there are various definitions of older people, and many of them are 65 years old or older. This study used data over the age of 60 because of the short life expectancy in many countries, and therefore the broader definition of older people makes the study results more applicable. Indeed, UN reports also list people over the age of 60 as older people (e.g., reference [113]). However, future studies should focus more on the age differences of older people.

Third, the current study is quantitative and omits qualitative information. It is important to clarify how the quantitative information revealed in this study is related to the qualitative information. Future research should pay attention to the content of communication, as well as the quality of the relationship among older people.

Finally, it should be noted that this study is a cross-sectional analysis and does not show a causal relationship. Future studies are expected to reveal in longitudinal intervention studies how older people given modern communication tools and robots change their behavior.

Based on the above, it is possible to verify and add new findings in future research by (1) conducting a more comprehensive analysis using qualitative and longitudinal data and (2) targeting older elderly people in various countries and societies.

8. Conclusions

In this study, we conducted an SEM analysis using the psychological data of Japanese older people aged 60 and over recorded in World Values Survey Wave 7 to analyze the relationship between ICT usage and social capital and well-being. We used more comprehensive measures than previous studies for understanding modern ICT and its effects, and for considering future technologies and measures practically. That is, the independent variable, ICT usage, included multiple modern communication means, such as mobile phones, emails, the Internet, and social media. The dependent variable, well-being, included happiness, life satisfaction, health, financial affluence, and freedom of choice. Furthermore, as a mediator, we used social capital based on the relationships of trust with family, friends, and acquaintances. As a result, it was shown that ICT usage indirectly enhances well-being by increasing social capital. This indicates the development of future communication means for community-dwelling older people should be considered together with the improvement of their social relationships. Such an understanding could become a new design paradigm for

developing ICT-based support systems for this target group in the future, and also serves well for policymakers to frame the legal and ethical environment for the development and dissemination of the ICT-based support systems to community-dwelling older adults in eastern and western countries facing the current and future demographic change.

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