An Analysis of the Impact of Cell Phone Use on Depressive Symptoms among Japanese Elders

Yuka Minagawa^a Yasuhiko Saito^b^aWaseda Institute for Advanced Study, Waseda University, Tokyo, and ^bAdvanced Research Institute for the Sciences and Humanities and School of Medicine, Nihon University, Tokyo, Japan

Key Words

Depressive symptoms · Information and communication technologies · Social engagement · Japan

Abstract

Background: There has been increasing interest in the impact of information and communication technologies, such as the computer and Internet, on physical and mental health status, but relatively little is known about the health effects of using cell phones. **Objective:** This study investigates how cell phone usage is associated with levels of depressive symptoms among Japanese men and women aged 65 years and older. We focus on social relationships, particularly intergenerational relationships between older parents and adult children, as a possible mediator in the association of cell phone use with late-life depressive symptoms. We therefore hypothesize that using cell phones contributes to the psychological well-being of older adults primarily through encouraging social relationships. **Methods:** We used 4 waves of data from the Nihon University Japanese Longitudinal Study of Aging (2001–2009) to analyze the impact of cell phone use on depressive symptoms. Results are based on ordinary least squares regression analyses. **Results:** Although the use of cell phones was related to lower levels of depressive symptoms among elderly Japanese people, controlling for sociodemographic characteristics and physical health conditions wiped out the effects for men. In contrast, the protective effects of using cell phones persisted among women,

even net of all controls. Moreover, the impact of using cell phones was not explained by filial relationship measures, suggesting that cell phone use influences the mental health of older women independently of social engagement. **Conclusions:** Among the many advantages brought about by recent technological developments, cell phones appear to be an important contributor to the psychological well-being of Japanese elders. Researchers and policy makers should prioritize access to new technologies for older adults.

© 2014 S. Karger AG, Basel

Introduction

The development of modern information and communication technologies (ICTs), such as the computer, Internet and cell phones¹, has indelibly transformed the way contemporary society exchanges information. According to the United Nations, in 2012, 36% of the world population had access to the Internet, while the cell phone penetration rate had reached 96% globally. Modern communication technology has gained popularity across every segment of society. While young generations have made heavy use of ICTs, new technologies have also become popular even among older people. Today, competence in technology usage is spreading to more and more

¹ We use the terms 'cell phones' and 'mobile phones' interchangeably throughout the article.

elderly individuals, whom researchers often refer to as 'silver surfers' [1].

The rapid proliferation of ICTs has promoted substantial interest and debate regarding the impact of technology use on physical and mental health status. While some studies find that computer and e-mail use is associated with a better quality of life [2], other evidence suggests that those who use the Internet are more likely to experience loneliness or depression [3]. Compared to the large body of research on computers and the Internet, relatively little attention has been directed toward the health consequences of cell phone usage. Moreover, those few studies that have been conducted have tended to focus on the negative effects. Extended exposure to electromagnetic fields via mobile phones, for instance, tends to cause headaches, earaches and fatigue [4]. Exposure to mobile phones can be a direct source of psychological problems. Inappropriate incoming calls, including those made at inconvenient and disruptive moments, may increase stress and cause annoyance for the receiver [5, 6]. Heavy cell phone usage is linked to anxiety, depression and insomnia, while inability to return calls often creates feelings of guilt [7].

These findings illustrate the unfavorable health consequences of exposure to cell phones, but mobile phones may also contribute positively to health. Recently, researchers have focused on cell phone devices as important tools for health interventions. Cell phones facilitate communication between patients and health professionals, allowing them to make voice calls or leave messages regardless of the time or location [8]. Also, using text messaging, health care providers can remind patients to attend appointments or take medications [9]. Some mobile phone applications even monitor users' physical health conditions, such as weight, blood pressure and calorie intake [10].

In addition to direct health interventions, cell phones may indirectly affect health through enhanced social relationships. First, mobile phones increase the level of connectedness to others, making users rapidly accessible to other people. Studies find that communication via cell phones strengthens close social ties, such as those between family members and close friends, rather than remote or weak ties, and thus cell phone usage reinforces existing interpersonal connections [11, 12]. Second, mobile communications foster more personal and intimate interactions. Unlike other communication devices, namely e-mail messages, cell phones essentially enable two-way communication in real time and foster intimacy or a sense of cooperation among individuals. In Rettie's [13] qualitative study, respondents preferred voice calls

to text messages when they felt lonely or wanted company. In summary, cell phone usage appears to contribute to interpersonal relationships in terms of both quantity and quality.

Research across disciplines finds that greater social involvement benefits health [14]. Several explanations have been put forward for mechanisms linking active social integration to better health. Involvement in social relationships provides individuals with various types of support, which mediates the detrimental effects of stressors on mental and physical health status [15]. Moreover, evidence indicates that social relationships directly influence the immune, endocrine and cardiovascular functions of the human body [16]. Additionally, supportive social ties often promote healthy behaviors, characterized by more exercise and less drinking or smoking [17]. These observations help us understand the possible link between cell phone use and health. Through cell phone use, individuals enjoy greater access to social networks that may in turn positively influence the health status of these individuals through psychological, physiological and behavioral processes. Therefore, social relationships may play a mediating role in the association between cell phone usage and health.

Older adults especially stand to benefit from technological connectedness [18–20]. Individuals often experience social withdrawal after retirement and a loss of meaningful relationships, as well as physical and cognitive impairment with age, and these life events tend to increase the risk of feeling lonely, powerless, isolated or depressed [21]. ICTs may help overcome precisely such problems. For example, new communication technologies allow older people to keep in contact with geographically distant family members or friends and to stay connected with the outside world despite impaired mobility. ICTs are indeed a key source of social engagement, support and life enhancement for older people [22]. From this standpoint, cell phones may be a particularly important contributor to elderly well-being. In contrast to computers or the Internet, access to cell phones is enjoyed by a large number of older people, and cell phones constitute a ready source of social contact among the elderly [19, 20]. Past studies have shown that more frequent contact with members in one's social network, such as family members, friends and neighbors, lessens the risk of loneliness among older adults [23].

Japan offers an excellent opportunity to examine the hypothesis linking cell phone usage with the health of older people. Japanese elders have phenomenal health status. Japan ranks first in the world in life expectancy and

healthy life expectancy at birth [24]. The nation has experienced a drastic rise in the number of centenarians over time, and an increasing number of people remain engaged well into their golden years. In addition, cell phone usage is widespread in the culture; 73.6% of the entire population used cell phones as of 2010. This number includes a growing proportion of older people; in 2010, 77.8% of people aged between 60 and 64 used cell phones, and penetration rates reached 17.2% among those who were aged 80 and older. Given that Japanese elders enjoy phenomenal health status and have higher levels of cell phone use, Japan provides a unique opportunity to assess the hypothesized relationship between cell phone use and elderly well-being.

The present study draws data from a study of Japanese people aged 65 and older and investigates how cell phone usage is related to Japanese elders' health, especially their mental health status. Mental health status is of particular importance because, for cultural reasons, elderly Japanese people, particularly women, are at greater risk of suffering from depressive symptoms. The structure of the Japanese family has undergone substantial changes over time, but gender role ideology continues to be strong within Japanese households. Consequently, despite increased female labor force participation, many Japanese women still engage in caregiving work for the senior members of their family [25]. Caring for the frail elderly often induces depressive symptoms among caregivers [26]. This is exacerbated by the tendency of Japanese people not to rely on social services because of the fear of losing face or appearing neglectful [27]. Therefore, while Japanese people have overall good health status, cultural norms associated with caregiving may pose a threat to their psychological well-being, particularly among women.

Taken together, the theoretical rationale developed for the present study leads to the following two hypotheses.

Hypothesis 1: cell phone use is associated with depressive symptoms among older men and women in Japan. Specifically, although mobile phone usage might have negative effects on mental health status [7], we focus on its positive aspects and hypothesize that those who use cell phones exhibit lower levels of depressive symptoms than those who do not.

Hypothesis 2: the relationship between cell phone use and late-life depressive symptoms is explained by the quantity and quality of interactions with the outside world. Statistically, this implies that the impact of using cell phones on depressive symptoms becomes insignificant after controlling for variables representing social relationships.

In what follows, we first describe our data, measures and statistical procedures. We then summarize the key results of our analysis. We conclude with a discussion of our major findings, study limitations and policy implications.

Materials and Methods

Data

The present study applies data from the Nihon University Japanese Longitudinal Study of Aging (NUJLSOA). NUJLSOA covered a nationally representative sample of Japanese people aged 65 and older as of the first data collection in 1999. In total, data were collected in 5 waves, i.e. in 1999 ($n = 4,997$), in 2001 ($n = 4,950$), in 2003 ($n = 4,888$), in 2006 ($n = 3,879$) and in 2009 ($n = 2,886$), with a refreshment of younger respondents in 2001 and 2003. Complete information can be found at the NUJLSOA website [28].

Since the question about cell phone usage was included in NUJLSOA only after 2001, the current study uses waves 2, 3, 4 and 5. In order to observe a change between each of the waves, we organized the data into 3 observation intervals, as follows: 2001–2003, 2003–2006 and 2006–2009. The initial year of each interval is considered the baseline and the ending year is treated as the follow-up. In the end, data from each interval were pooled for analysis. Previous studies have used interval observations of NUJLSOA data to analyze Japanese elders' physical [29] as well as psychological health status [30]. This work pursues the same analytical approach and investigates how cell phone usage is associated with late-life depressive symptoms over the 8-year period. We analyze data from community-dwelling participants who self-reported their responses. Those with missing values for variables of interest, except for household income, were dropped from the analysis, resulting in 5,164 observations (2,255 men and 2,909 women). We applied cross-sectional weights at the beginning of each observation interval to account for the complex survey design.

Methods

Dependent and Independent Variables

We measured depressive symptoms using the 11-item version of the Center for Epidemiologic Studies-Depression (CES-D) scale. The scale has been found to be a valid and reliable indicator of depressive symptoms. NUJLSOA uses the shorter version of the scale, with 11 items and 3 response categories of 'hardly ever or never', 'some of the time' and 'much or most of the time'. We used 9 negative affect items, such as 'I feel lonely', 'I feel depressed' and 'I feel sad', and 2 positive items, namely 'I feel happy' and 'I enjoy life'. Items were all coded to ensure that higher scores reflect greater levels of depressive symptoms.

The focal independent variable for the current study is the use of cell phones at baseline. NUJLSOA includes several questions regarding cell phone usage, such as 'Have you heard of cell phones?', 'Do you want to be able to use cell phones?' and 'Can you use cell phones?'. Since we were interested in the influence, if any, of actual cell phone usage on the mental health status of Japanese elders, we only focused on the question 'Can you use cell phones?'. Respondents were coded 1 if they could use cell phones. Since there is no information about the purpose for which cell phones were used, the present study does not take into account differences in

the effects between talking on the phone and sending text messages. Indeed, many studies have shown that the elderly tend to use cell phones to make phone calls rather than to send messages [31, 32].

Social Relationships

To test the hypothesis that social relationships may mediate the association between cell phone use and depressive symptoms, we included a number of variables representing the quantity and quality of social relationships, with a special focus on contacts between older parents and adult children². Although the number of children in each family has gradually decreased in recent decades, filial relationships remain a source of support for older people in Japan [25, 30, 33], and familial contacts constitute a major part of older persons' mobile phone-based interactions [32]. The quantity of intergenerational relationships was operationalized via the frequency of contact between parents and children, both face to face and by phone. Respondents were asked about the frequency of contacts with children through the questions 'How often do you get together with children?' and 'How often do you speak on the phone with children?'. There are 8 response categories: 'almost every day', 'more than once a week', 'once a week', 'once every 2 weeks', 'once a month', 'several times a year', 'once a year' and 'never'. These items were first reverse coded, such that higher scores reflected more frequent contact with children. We then assigned a number of days to each category, ranging from 0 ('never') to 365 ('almost every day'), in an attempt to capture the intensity of contacts. Note that we used a logarithmic transformation to better linearize the relationship of this variable with the dependent variable.

The quality of relationships was measured through the item regarding the transaction of support between older parents and adult children, given that modern communication technologies are an important source of support for the elderly [20]. Respondents were asked whether they received or provided support to children. If respondents answered 'yes', they were asked to specify the kinds of support, namely emotional (e.g. companionship and advice) or instrumental (e.g. help with transportation and meals). Due to high correlations among the support variables, we decided to construct a single measurement for the provision and receipt of support. There are 2 variables, namely the receipt of support from children (1 = received emotional or instrumental help from children; 0 = otherwise) and provision of support to children (1 = provided emotional or instrumental help to children; 0 = otherwise). Also, since the health consequences of family support might vary in nature, we focused on both receiving and providing assistance. For instance, providing support positively contributes to elderly well-being [34], while continually receiving help elevates the risk of psychological distress [21].

² Respondents were asked about intergenerational relationships only if they had at least one adult child living separately. We conducted additional analyses excluding those who did not have any children living separately (e.g. those who co-reside with their only child), but we found that the substantive conclusions of this study remained unchanged. Given that a larger sample size improves the power of the analysis, we used the models including older parents with no children living separately, and they were coded zero in the intergenerational relationship variables.

Control Variables

There are a number of factors associated with depressive symptoms at advanced ages. Increasing age is a major risk factor for depressive symptoms, while higher socioeconomic status offers protection against that health outcome. Among Japanese elders, poor self-rated health or functional limitations are also predictive of higher levels of depressive symptoms [34]. Based on these research findings, the following variables at baseline were included in the analysis as controls: (1) sociodemographic characteristics, namely age (continuous in years), marital status (1 = currently married), educational attainment (1 = more than high school education) and high annual income (1 = higher than the 50th percentile), and (2) physical health status, namely self-rated health ('very poor', 'poor', 'fair', 'good' and 'very good' as the reference category) and functional limitations (1 = any difficulty in activities of daily living or instrumental activities of daily living). Due to higher levels of missing values for annual income (11.3% of the entire sample), we used a mean imputation approach for this variable and included a dichotomous variable representing an absence of income data (1 = annual income missing; 0 = otherwise). Further, since the distribution of this variable is highly skewed, we converted the original categories of annual income (ranging from JPY 500,000 to 15 million) to a dichotomous variable of higher income. Our cutoff point corresponds to the average annual income for the elderly population in Japan. We also conducted analyses with the original categories, but the substantive conclusion of the present study remained unchanged.

Analytical Design

Ordinary least squares regression analyses were performed to investigate how cell phone usage among Japanese elders at baseline was associated with the CES-D scale at follow-up. Three sequential models were used to examine the relative impacts of covariates on the focal association. The first model included only the use of cell phones, the second model added sociodemographic characteristics and physical health status, and the final model adjusted for social relationship measures. We controlled for the CES-D scale at baseline in all models. Finally, since the interval between 2001 and 2003 was 2 years, as opposed to 3 years in the later waves, a dummy variable indicating whether data belonged to the 2-year interval was included. We analyzed data for men and women separately.

Results

Table 1 summarizes the variables used for analysis. The last column presents results from two-sample tests detecting statistical differences between men and women. Consistent with previous studies [21], females reported significantly higher levels of depressive symptoms than their male counterparts both at baseline and follow-up. Cell phone use was more prevalent among men than among women; 21% of male respondents in this sample used cell phones, whereas only 10% of women did. Men had higher levels of educational attainment as well as higher annual income, while women had worse physical

Table 1. Descriptions of variables used in the analysis

	Range/category	Men	Women	p value
<i>CES-D scale</i>				
Continuous				
Baseline	0–22	3.99	4.13	***
Follow-up	0–22	4.01	4.29	***
Dichotomous				
Baseline	1 = higher than 7.0, 0 = otherwise	10.71	14.58	***
Follow-up		13.04	17.74	***
<i>Technology use</i>				
Cell phone	1 = yes, 0 = no	20.80	9.91	***
<i>Sociodemographic factors</i>				
Age, years	men: 65–98; women: 65–103	76.20	77.21	***
Married	1 = yes, 0 = no	83.90	42.77	***
High school education	1 = yes, 0 = no	44.30	38.88	***
Higher income	1 = yes, 0 = no	53.66	35.79	***
Self-rated health	1–5	2.81	2.68	***
ADLs/IADLs	1 = yes, 0 = no	8.25	15.98	***
<i>Intergenerational relationships</i>				
Days of seeing children	0–365	68.91	69.98	–
Days of calling children	0–365	57.91	58.34	–
Receives support from children	1 = yes, 0 = no	30.69	48.20	***
Provides support to children	1 = yes, 0 = no	34.87	35.08	–

Values represent percentages for categorical variables and means for continuous variables. *** $p < 0.001$ for differences between men and women. ADLs = Activities of daily living; IADLs = instrumental activities of daily living.

health conditions, characterized by poorer self-rated health status and a larger number of functional limitations. There were no significant gender differences in terms of filial relationships, except for receiving support from children. Next, we tested our study hypotheses in table 2.

Is Cell Phone Use Associated with Depressive Symptoms among Japanese Elders?

Table 2 presents the results from a series of ordinary least squares regression models estimating the net effects of cell phone use and covariates on the levels of late-life depressive symptoms. We first focused on the results for men. As shown in model 1, cell phone usage was strongly related to depressive symptoms. Controlling only for the CES-D scale at baseline and the wave variable in model 1, men who used cell phones had a lower CES-D score by 0.32 compared to those who did not ($p < 0.001$). However, the protective impact of cell phone usage goes away with adjustment for control variables in model 2. The relationship between using cell phones and depressive symptoms,

which was negative and significant in model 1, decreased and became insignificant with adjustment for sociodemographic and physical health status variables in model 2; therefore, the original effect of cell phone usage on depressive symptoms among older men (recognized in model 1) is explained by these background characteristics.

What about women, then? Is cell phone use only weakly associated with levels of depressive symptoms in their case as well? What table 2 shows most clearly is the strong effect of cell phone usage in mediating the risk of experiencing depressive symptoms among women. Using cell phones was associated with decreases in the CES-D scale by 0.60, net of the depressive symptoms at baseline and the interval variable (model 1). Importantly, although the association between using cell phones and depressive symptoms was attenuated by the inclusion of sociodemographic characteristics and physical health conditions (model 2), the result remained statistically significant at the 0.05 level. These findings stand in contrast to the analysis for men, in which statistical controls for sociodemographic characteristics and physical health conditions reduced es-

Table 2. Ordinary least squares regression models assessing cell phone use and depressive symptoms at follow-up

	Men (n = 2,255)			Women (n = 2,909)		
	model 1	model 2	model 3	model 1	model 2	model 3
<i>Technology use</i>						
Cell phone use	−0.32***	−0.20	−0.19	−0.60***	−0.47**	−0.45**
<i>Sociodemographic factors</i>						
Age		0.01	0.01		0.01	0.01
Married		−0.38**	−0.36*		0.19*	0.21*
High school education		−0.04	−0.04		−0.22**	−0.22**
Higher income		−0.24*	−0.23*		−0.20	−0.19
Income missing		0.02	0.02		0.01	0.01
Self-rated health						
Very good		ref.	ref.		ref.	ref.
Good		0.32**	0.32**		0.27*	0.30*
Fair		0.41**	0.40**		0.52***	0.53***
Poor		0.84***	0.83***		1.27***	1.27***
Very poor		1.88***	1.87***		1.66***	1.67***
ADLs/IADLs		0.25	0.25		0.49**	0.49**
<i>Intergenerational relationships</i>						
Days of seeing children			−0.03			−0.02
Days of calling children			−0.04			−0.02
Receives support from children			0.02			−1.0
Provides support to children			−0.14			−0.26**
<i>Depression scale (baseline)</i>	0.44***	0.38***	0.38***	0.42***	0.35***	0.35***
<i>Interval between waves 2 and 3</i>	−0.34***	−0.30**	−0.30**	−0.01	0.01	0.01
R2	0.17	0.19	0.20	0.16	0.19	0.20

* p < 0.01, ** p < 0.05, *** p < 0.001. ADLs = Activities of daily living; IADLs = instrumental activities of daily living.

timated net effects of cell phone use to insignificant. Thus, briefly summarized, we find that cell phone use is consistently associated with lower levels of depressive symptoms among older Japanese women, whereas there is no significant relationship for men, net of all controls.

Are Effects of Cell Phone Use Explained by Interpersonal Relationships?

Next, we tested the mediating hypothesis by adding measures for the quantity and quality of relationships with children. Here, we focus only on the results for women, because among men the initially significant association between cell phone usage and the depression scale became insignificant with adjustment for control variables. The results, presented in model 3 in table 2, show that social relationships do not mediate the relationship between cell phone usage and the CES-D score. The coefficient for cell phone use in predicting the depression scale remained virtually unchanged, even after controlling for intergenerational relationship variables in model 3 (from −0.47 to −0.45). The direction of

change in the CES-D scale suggests that the quantity and quality of contacts with children may explain some of the effect of cell phone use on the dependent variable, but the results continue to be significant at the 0.05 level. In fact, among intergenerational relationship factors, providing support to children is the only variable significantly associated with depressive symptoms ($p < 0.05$). However, the inclusion of this factor does little to affect the focal association between cell phone use and the CES-D score. Overall, these results run directly counter to hypothesis 2.

We also performed logistic regression analyses, using the dichotomous measurement of depression as the dependent variable. Prior research confirmed 7.0 as an adequate value for the cutoff point on the 11-item CES-D scale [35]. Using a cutoff point of 7.0, we estimated the odds of reporting depression (i.e. higher than 7.0 on the CES-D depression scale). Consistent with the results in table 2, cell phone use was not associated with the odds of suffering from depression among men, net of controls, whereas it continued to be a significant predictor of late-

life depression among women. Additionally, statistical controls for filial relationships had no impact on the odds of experiencing depression in this sample. The full results are presented in the Appendix.

Finally, we briefly looked at the effects of sociodemographic and physical health variables on depressive symptoms (models 3 in table 2). Consistent with prior research [36], the effect of marriage varied greatly according to gender. Further, the results clearly demonstrate that physical health status, notably self-rated poor health, is a significant predictor of depressive symptoms among Japanese elders. The levels of depressive symptoms are distributed in a graded fashion; that is, the worse the self-rated health status, the greater the risk of experiencing depressive symptoms. Functional limitation is associated with depressive symptoms only among women.

Discussion

In this paper, we have used nationally representative data to assess the impacts of cell phone use on depressive symptoms among Japanese elders. Two hypotheses were tested in the present study. First, it was expected that cell phone usage would be associated with lower levels of depressive symptoms. Some support was garnered for this hypothesis. Cell phone use is consistently and significantly related to lower levels of depressive symptoms among women, but this pattern is not shared by men. Among men, controlling for sociodemographic factors and physical health status wipes out the initially significant associations of cell phone use with the CES-D scale, whereas the protective effects remain strong among women, net of all controls. These findings suggest that the impact of cell phone use on the psychological well-being of Japanese elders differs greatly according to gender. Overall, our first hypothesis received support only for women.

Second, we hypothesized that the relationship between cell phone use and depressive symptoms is explained by the levels of involvement with social relationships. However, this assumption was not supported. Among women, the protective effects of cell phone use against depressive symptoms are not mediated by the quantity or quality of intergenerational relationships. The frequency of seeing or calling children and the transaction of various types of support do not explain away the effects of cell phone use on the CES-D scale. Thus, cell phone use seemingly influences depressive symptoms independently of one's contact with children.

To summarize, cell phone use protects against the risk of depressive symptoms, but the impact is observed only among women. Our findings that cell phone use may help reduce the risk of depressive symptoms among elderly Japanese women may be influenced by the fact that women are much more likely to suffer from depression than men [21]. Alternately, it may be related to the fact that only a small proportion of female respondents reported cell phone use, as shown in table 1. However, the present findings suggest that women benefit from engaging in mobile communications. Nevertheless, the mechanism by which cell phones produce better health remains to be explored. Cell phones may in fact directly enhance the psychological well-being of the elderly, providing older people with a sense of comfort and safety; by carrying cell phones, elders feel safer going out alone, are less afraid of getting lost and feel confident that there is someone to call in case of trouble [37]. Self-efficacy, defined as the degree of confidence that persons have in their ability to perform specific tasks, is related to a range of health outcomes, including psychological distress [38]. Therefore, cell phones may be a valuable life tool that bolsters a sense of confidence in everyday life and supports independent living for older adults, thereby positively contributing to their mental health status.

The present study has several strengths, including the use of a large national sample of Japanese elders and attention to mechanisms linking cell phone usage to mental health outcomes. However, appropriate caution must be exercised in interpreting results from this study. First, our measurement of cell phone use is limited. Lu et al. [39] found that the health consequences of mobile communication among the Japanese depended largely on the level of usage. However, the present study only considered whether or not respondents used cell phones, because NUJLSOA does not include information about the frequency of usage. Furthermore, although mobile phones can lead to psychological problems [7], the negative health effects of cell phone use remain to be addressed. In addition, we cannot determine whether and to what extent health consequences might vary by function, such as making phone calls and sending messages. Overall, future work should extend the present findings to investigate how the mental health status of Japanese elders is influenced by the level, function and purpose of mobile communications.

Second, our social relationship measures are relatively crude, which might explain why we found only limited effects of these variables on depressive symptoms. We also controlled for the influence of relationship satisfaction (1 = satisfied with relationship with children; 0 = otherwise). The focal association between cell phone use and

the CES-D scale, however, remained almost unchanged with or without adjustment for this variable. Indeed, the present study focuses only on parent-children relationships, while interactions with members from broader social networks, namely siblings, friends, neighbors and former co-workers, might also be important for elderly well-being [23]. To address this point, we conducted supplemental analyses including group affiliation as controls, but the results remained the same. Taken as a whole, future studies might incorporate variables that account for the more precise structure and dynamics of individuals' social networks and analyze how these are related to mental health outcomes.

The present study has important implications for social policy in Japan. Typing on a computer keyboard is challenging to older people, because a Japanese-style typewriter was developed only in the late 20th century [40]. In contrast, cell phones are relatively easy to engage with; they require no special skills, techniques or knowledge. However, older individuals are still faced with a range of

barriers, including the complex details of cell phone contracts, the limited size of the display and buttons that are too small and easy to misdial [32, 33]. Older adults should therefore be considered in the design of cell phone devices and services, and it is important to redesign technologies to address the needs and situations of older users [19, 20, 41]. In Japan, for instance, there are mobile devices specially designed for older people called *raku raku phone*, or handy phones, with larger displays and a function of audio feedback when pressed. In the face of the rapidly aging population, more research and policy attention should be devoted to making accommodation for older people in society, through, among other things, ICTs.

Acknowledgments

Support for this research was provided by the Japan Society for the Promotion of Science (Grant-in-Aid for Scientific Research 25293121). We are grateful to the editor and the reviewers of Gerontology for their very helpful comments.

Appendix

Logistic Regression Models Assessing Cell Phone Use and Odds of Reporting Depression at Follow-Up

	Men (n = 2,255)			Women (n = 2,909)		
	model 1	model 2	model 3	model 1	model 2	model 3
<i>Technology use</i>						
Cell phone use	0.67**	0.79	0.80	0.56***	0.64**	0.64**
<i>Sociodemographic factors</i>						
Age		0.99	0.99		1.00	1.00
Married		0.76	0.78		1.19	1.20
High school education		0.89	0.90		0.86	0.85
Higher income		0.78	0.78		0.81	0.81
Income missing		1.01	1.01		1.01	1.00
Self-rated health						
Very good		ref.	ref.		ref.	ref.
Good		1.31*	1.13*		2.21**	2.23**
Fair		1.32*	1.31*		2.98***	3.00***
Poor		2.54***	2.51***		5.69***	5.69***
Very poor		3.84***	3.77***		9.23***	9.30***
ADLs/IADLs		1.31	1.31		1.41**	1.43**
<i>Intergenerational relationships</i>						
Days of seeing children			0.96			1.00
Days of calling children			0.96			0.98
Receives support from children			0.92			0.93
Provides support to children			0.78			0.94
<i>Depression scale (baseline)</i>	7.48***	5.40***	5.39***	4.72***	3.13***	3.12***
<i>Interval between waves 2 and 3</i>	0.75*	0.78	0.78	0.96	1.01	1.00

* p < 0.01, ** p < 0.05, *** p < 0.001. ADLs = Activities of daily living; IADLs = instrumental activities of daily living.

References

- 1 Cody MJ, Dunn D, Hoppin S, Wendt P: Silver surfers: training and evaluating internet use among older adult learners. *Commun Educ* 1999;48:269–286.
- 2 Vanderwerker LC, Prigerson HG: Social support and technological connectedness as protective factors in bereavement. *J Loss Trauma* 2004;9:45–57.
- 3 Kraut R, Patterson M, Lundmark V, Kiesler S, Mukopadhyay T, Sherilis W: Internet paradox. A social technology that reduces social involvement and psychological well-being? *Am Psychol* 1998;53:1017–1031.
- 4 Johansson A, Nordin S, Heiden M, Sandström M: Symptoms, personality traits, and stress in people with mobile phone-related symptoms and electromagnetic hypersensitivity. *J Psychosom Res* 2010;68:37–45.
- 5 Eyrolle H, Cellier J: The effects of interruptions in work activity: field and laboratory results. *Appl Ergon* 2000;31:537–543.
- 6 Wei R, Leung L: Blurring public and private behaviors in public space: policy challenges in the use and improper use of the cell phone. *Telemat Inf* 1999;16:11–26.
- 7 Thomee S, Harenstam A, Hagberg M: Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults – a prospective cohort study. *BMC Public Health* 2011;11:66.
- 8 Patrick K, Griswold WG, Raab F, Intille SS: Health and the mobile phone. *Am J Prev Med* 2008;35:177–181.
- 9 Leong KC, Chen WS, Leong KW, Mastura I, Mimi O, Sheikh MA, Zailinawati AH, Ng CJ, Phua KL, Teng CL: The use of text messaging to improve attendance in primary care: a randomized controlled trial. *Fam Pract* 2006;23:699–705.
- 10 Logan AG, McIsaac WJ, Tisler A, Irvine MJ, Saunders A, Dunai A, Rizo CA, Feig DS, Hamill M, Trudel M, Cafazzo JA: Mobile phone-based remote patient monitoring system for management of hypertension in diabetic patients. *Am J Hypertens* 2007;20:942–948.
- 11 Ito M: Personal, Portable, Pedestrian: Mobile Phones in Japanese Life. Cambridge, MIT Press, 2005.
- 12 Ling, RS: New Tech, New Ties: How Mobile Communications Is Reshaping Social Cohesion. Cambridge, MIT Press, 2008.
- 13 Rettie R: Mobile phone communication: extending Goffman to mediated interaction. *Sociology* 2009;43:421–438.
- 14 Umberson D, Montez JK: Social relationships and health: a flashpoint for health policy. *J Health Soc Behav* 2010;51:S54–S66.
- 15 Cohen S: Social relationships and health. *Am Psychol* 2004;59:676–84.
- 16 Uchino B: Social support and health: a review of physiological processes potentially underlying links to disease outcomes. *J Behav Med* 2006;29:377–387.
- 17 Umberson D, Crosnoe R, Reczek C: Social relationships and health behavior across the life course. *Annu Rev Sociol* 2010;36:139–157.
- 18 Olphert W, Damodaran L: Older people and digital disengagement: a fourth digital divide? *Gerontology* 2013;59:564–570.
- 19 Selwyn N: The information aged: a qualitative study of older adults' use of information and communications technology. *J Aging Stud* 2004;18:369–384.
- 20 Selwyn N, Gorard S, Furlong J, Madden L: Older adults' use of information and communications technology in everyday life. *Ageing Soc* 2003;23:561–582.
- 21 Mirowsky J, Ross CE: Education, Social Status, and Health. New York, Aldine de Gruyter, 2003.
- 22 White H, McConnell E, Clipp E, Bynum L, Teague C, Navas L, Craven S, Halbrecht H: Surfing the net in later life: a review of the literature and pilot study of computer use and quality of life. *J Appl Gerontol* 1999;18:358–378.
- 23 de Jong Gierveld J, Broese van Groenou M, Hoogendoorn AW, Smit JH: Quality of marriages in later life and emotional and social loneliness. *J Gerontol B Psychol Sci Soc Sci* 2009;64:497–506.
- 24 Salomon JA, Wang H, Freeman MK, Vos T, Flaxman AD, Lopez AD, Murray CJL: Healthy life expectancy for 187 countries, 1990–2010: a systematic analysis for the Global Burden Disease Study 2010. *Lancet* 2012;380:2144–2162.
- 25 Izuhara M: Care and inheritance: Japanese and English perspectives on the 'generational contract'. *Ageing Soc* 2002;22:61–77.
- 26 Barnes CL, Given BA, Given CW: Caregivers of elderly relatives: spouses and adult children. *Health Soc Work* 1992;17:282–289.
- 27 Oura A, Washio M, Wada J, Arai Y, Mori M: Factors related to institutionalization among the frail elderly with home-visiting nursing service in Japan. *Gerontology* 2006;52:66–68.
- 28 Nihon University Japanese Longitudinal Study of Aging. <http://gero.usc.edu/CBPH/nujlsoa/>.
- 29 Chang A, Zimmer Z, Saito Y: Gender differences in disability and mortality transitions: the case of older adults in Japan. *J Aging Health* 2011;23:1285–1308.
- 30 Takagi E, Saito Y: A longitudinal analysis of the impact of family support on the morale of older parents in Japan: does the parent's normative belief in filial responsibilities make a difference? *Ageing Soc* 2013;33:1053–1076.
- 31 Kurniawan S: Older people and mobile phones: a multi-method investigation. *Int J Hum Comput Stud* 2008;66:889–901.
- 32 Ling R: Should we be concerned that the elderly don't text? *Inf Soc* 2008;24:334–341.
- 33 Tiedt A: The gender gap in depressive symptoms among Japanese elders: evaluating social support and health as mediating factors. *J Cross Cult Gerontol* 2010;25:239–256.
- 34 Thomas PA: Is it better to give or to receive? Social support and the well-being of older adults. *J Gerontol B Psychol Sci Soc Sci* 2010;65B:351–357.
- 35 Yokoyama E, Kaneita Y, Saito Y, Uchiyama M, Matsuzaki Y, Tamaki T, Munezawa T, Ohida T: Cut-off point for the 11-item shorter form of the CES-D depression scale. *Nihon Univ J Med* 2008;50:123–132.
- 36 Kiecolt-Glaser JK, Newton TL: Marriage and health: his and hers. *Psychol Bull* 2001;127:472–503.
- 37 Nasir MHN, Hassan H, Jomhari N: The use of mobile phones by elderly: a study in Malaysia perspectives. *J Soc Sci* 2008;4:123–127.
- 38 Seeman T: Social ties and health: the benefits of social integration. *Ann Epidemiol* 1996;6:442–451.
- 39 Lu X, Watanabe J, Liu Q, Uji M, Shono M, Kitamura T: Internet and mobile phone text-messaging dependency: factor structure and correlation with dysphoric mood among Japanese adults. *Comput Human Behav* 2011;27:1702–1709.
- 40 Umesao T: Chiteki seisan no gijutsu. Tokyo, Iwanami shoten, 1969.
- 41 Wandke H, Sengpiel M, Sönksen M: Myths about older people's use of information and communication technology. *Gerontology* 2012;58:564–570.