



Smart senior care cognition and health among Chinese elderly: A moderated mediation model featuring parent-child relationship and internet use

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Abstract

In the context of digital transformation, smart senior care (SSC) cognition among elderly individuals has become an important contributor to their health. Using a sample of 345 older adults derived from the cross-sectional data of a questionnaire survey on the application of home-based SSC services and products among elderly individuals, this study explored how the parent–child relationship mediated the linkage between SSC cognition and elderly health. To examine the moderating role of internet use, we applied the multigroup structural equation modeling (SEM) approach to test whether significant disparities exist between older adults who use the internet and those who do not on the pathways in the mediation model. After controlling for gender, age, *hukou* (household registration permit), ethnicity, income, marital status, and education level, we found that SSC cognition exerted significant positive effects on elderly health, in which the parent–child relationship exerted a mediating effect. As for differences between the elderly with internet use and those without, on the three pathways connecting SSC cognition and health, SSC cognition and parent–child relationship, and parent–child relationship and health among elderly individuals, older adults who used the internet were more susceptible than those who did not. The findings are helpful for improving the policy-making on elderly health and may serve as a practical guide and theoretical reference for the promotion of active aging.

Keywords Smart senior care cognition · Parent–child relationship · Health status · Internet use · Older adults

Introduction

Due to the lengthening life expectancy and decline in fertility, population aging has become a common phenomenon across the globe. It is particularly severe in China, with the

characteristics of considerable scope, depth and speed (Bai & Lei, 2020). Data from the seventh National Census show that China has approximately 260 million people aged 60 and above, representing 18.70% of its total population (Tu et al., 2022). At the 20th National Congress of the Communist Party of China (CPC), General Secretary of the CPC Xi Jinping proposed the construction of a healthy China and included this concept as a national strategy to actively deal with the aging of the population by developing old-age services and industry (Yang et al., 2022). Due to declines in physiological function, socioeconomic status and social capacity, the elderly health is deteriorating, and their health prospects are not optimistic (Li et al., 2022). In the context of digital transformation, elderly individuals, as the main group subject to “information poverty”, face a series of practical challenges in daily travel, shopping, medical treatment and other aspects, which produce a negative impact on their wellbeing in later years and aggravating their health vulnerability (Hong et al., 2017). Therefore, society has

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focused attention on bettering the health and quality of life of elderly individuals.

Generally, socioeconomic status, social adaptation, and social support are regarded as key social contributors to the health of elderly individuals (Ge & Jin, 2021). Nevertheless, as digital technology penetrates in daily life and elderly care, smart senior care (SSC) products and services emerge to meet the diverse needs of elderly individuals. The greater elderly people's recognition of the SSC concept and willingness to use SSC products and services (i.e., a higher cognitive level of SSC), the better their health condition is (Kania-Lundholm & Torres, 2018; Walsh & Callan, 2011). Scholars reason that the higher elderly people's cognitive level of SSC is, the more often they use SSC products and services such as home security and health monitoring, whose features provide health protection to elderly people in the information society (Zhou et al., 2022). In reality, where empty nesters abound and intergenerational conflicts erupt frequently (Isengard & Szydlik, 2012), the SSC cognition of older adults can serve as a shared parent-child identity to increase the frequency of interaction, narrow social distance, and improve the relationship between parents and children (Kildare & Middlemiss, 2017). The effect of the parent-child relationship on elderly health has been confirmed in a slew of studies. A close parent-child relationship provides extensive intergenerational support for elderly individuals (Reczek & Zhang, 2016), which ensures their conditions for a healthy life, improves their subjective well-being, and enhances their physical and mental health (Katz, 2009). Elderly people's SSC cognition reflects their recognition of the SSC concept. High levels of SSC cognition encourage elderly people to learn and use SSC products and services; this strengthens parent-child interaction and reciprocity and further improves the health status of elderly people (Tsertsidis et al., 2019). Therefore, SSC cognition affects the parent-child relationship, which in turn exerts influence on elderly health. Therefore, it is possible that the parent-child relationship mediates the linkage between SSC cognition and elderly health status.

A large number of elderly people in China have yet to access or use the internet (Yuan & Jia, 2021). A growing body of evidence shows that significant gaps exist between older adults who use the internet and those who do not in terms of SSC cognition, parent-child relationships and health (Gordon & Crouch, 2019; Hong & Cho, 2017; König & Seifert, 2020). The digital literacy of elderly internet users improves their recognition of the SSC concept and their willingness to use SSC, the "virtual contact" produced by social media improves parent-child relationships, and internet use advances their health and wellbeing (Kim & Kim, 2017; Antunes et al., 2022).

This study further explored the interplay between SSC cognition, the parent-child relationship and health among elderly people by examining how parent-child relationship mediated the SSC cognition acting on the health of elderly individuals. Furthermore, this study tested differences in relation to the use of the internet by means of multigroup structural equation modeling (SEM) to provide a theoretical reference and practical guidance for policy-making aimed at better health and welfare for elderly people.

Literature review

SSC cognition and health

Positive SSC cognition among the elderly entails their high willingness to use smart products (Quinn, 2018). The use of SSC products and services not only brings convenience to the daily life of the elderly but also effectively ensures their safety and improves their health status (Y. Zhou, 2022). Some scholars point out from the perspective of resource acquisition that a high level of SSC cognition helps elderly people access and use the latest health care information and services, thus improving their physical health (De Aguilera & Casero-Ripollés, 2018; Liddle et al., 2020). Proponents believe that SSC cognition instills digital concepts into elderly individuals, inspires them to learn operation with digital tools, and fosters their integration into the digital society, thus elevating their mental health (Nguyen et al., 2022). Some contend that due to the lack of digital literacy or children's assistance, obstacles that elderly people may encounter in the process of accessing SSC products and services strain their health (Arar et al., 2021). Moreover, affected by perceived behavioral control, older women are more likely than older men to embrace information about SSC products and services and thus obtain health benefits from them (Zhang, 2021).

SSC cognition and parent-child relationships

The formation of SSC cognition is also a process of accelerating the digital integration of elderly individuals, during which the generation gap between parents and children is filled (Wu & Chiou, 2020). A large number of empirical studies have revealed that the SSC cognition positively affects parent-child relationships. Some take the perspective of identity sharing, arguing that SSC cognition has a promoting effect on the parent-child relationship. Elderly individuals with a higher level of SSC cognition are more likely to increase social contact with their offspring and form a shared identity bond through intergenerational learning, thus contributing to a closer parent-child relationship (Li

& Zhou, 2021). From the perspective of intergenerational interaction, elderly individuals who recognize the SSC concept and are willing to learn to use SSC products and services tend to demand assistance and support from their children, thus increasing the frequency of social interaction and reciprocity between parents and children and strengthening the parent–child bond (Bousfield & Hutchison, 2010; Drury et al., 2016). In addition, compared with older men, older women are more willing to strengthen parent–child communication via voice or video enabled by SSC products (Weiser, 2000).

Parent–child relationships and health

Parent–child relationships are interpersonal connection formed by the interaction between parents and children based on consanguinity. Compared with estranged parent–child relationships, close parent–child relationships bring positive emotional experiences to older adults (Carstensen, 1992; Shaw et al., 2007). Previous studies have concluded that parent–child harmony is positively correlated with the health status of elderly people (Gualano et al., 2018; Tosi & Grundy, 2019; Zhou et al., 2018). Based on social support theory, some scholars have discussed the promoting effect of a sound parent–child relationship on the physical health of elderly individuals. The more harmonious the relationship elderly people have with their adult children, the more material and informational support they receive from their children and the lower their likelihood of suffering from diseases or environmental hazards (Peng et al., 2019). Silverstein & Bengtson (1991) put forward that children improve the physical health of their elderly parents by providing them with health care knowledge, encouraging them to adopt a healthy lifestyle (e.g., appropriate diet), and guiding them in the early prevention of geriatric diseases. Based on the stress process model, other scholars have discussed the positive action of the parent–child relationship on elderly health, suggesting that the stress caused by physiological decline can be alleviated by maintaining a harmonious parent–child relationship or engaging in “meaningful contact” with children to reduce the risk of depression (Cassel, 1974; Zhai et al., 2015). This mechanism of action works better on older women than older men (Li et al., 2021).

Internet use as moderator

Differences in internet use are widely found in studies on elderly individuals’ SSC cognition, parent–child relationships and health. Relevant studies have confirmed that the use of the internet enhances the cognition of SSC in elderly individuals and plays a positive role in their health (Llorente-Barroso et al., 2021). Some studies based on

self-efficacy theory (Blank & Groselj, 2014; Livingstone & Helsper, 2007) have proposed that elderly individuals with internet use experience have a high e-learning conviction (Torkzadeh & Van Dyke, 2002) and can easily establish positive SSC cognition. They use SSC products to obtain information and resources to effectively prevent diseases, thereby improving their health (Shishehgar et al., 2018). In the context of a postmetaphorical culture, the use of the internet helps elderly people break the information barrier, embrace modern network civilization, and learn new concepts, new technologies, new ideas and new methods from their offspring. This not only improves the SSC cognition of elderly people but also enhances intergenerational communication and exchange (Apriceno et al., 2019; Yu et al., 2016). Others have shown that older adults with internet use experience can overcome the limitations of physical space, enhance online connection with their children, and establish a closer parent–child relationship, thereby amplifying the positive impact of the parent–child relationship on health (König & Seifert, 2020).

Limitations of the current literature and the establishment of hypotheses

Most current studies have explored the direct impact of SSC cognition and the parent–child relationship on elderly health or have explained how SSC cognition affects elderly people’s parent–child relationships (Kildare & Middlemiss, 2017). However, there is a lack of a complete and definitive explanation for the interplay between SSC cognition, the parent–child relationship and the health status of elderly individuals (Chan, 2018; Bruggencate et al., 2019). Moreover, whether the aforementioned interplay differs between elderly individuals who use the internet and those who do not has yet to be sufficiently investigated (Lu & Kandilov, 2021). To this end, we established a holistic theoretical framework to reveal the relationships between SSC cognition, the parent–child relationship and health status and to examine the differences among Chinese elderly people along the line of whether one uses the internet (see Fig. 1). The following three hypotheses are proposed.

H1: The higher elderly individuals’ level of SSC cognition is, the better their health status.

H2: Improved SSC cognition promotes parent–child relationships for elderly individuals, thus elevating their health status.

H3: The extent to which SSC cognition affects the health of elderly individuals through the parent–child relationship differs depending on whether they use the internet.

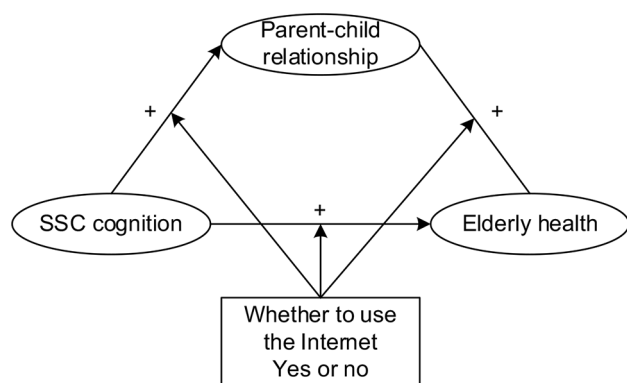


Fig. 1 Conceptual framework

Methods

Study design and participants

The promotion and application of SSC is in line with the development of the urban economy. This survey adopted a cross-sectional quantitative design with Jiangning District in Nanjing, Jiangsu Province as the survey area. Jiangsu is an economically developed province in the eastern coastal region of China. Its per capita GDP and regional development and life index (DLI) top all other provinces in China, indicating good prospects for the development of SSC (Liu et al., 2021). Nanjing, the capital of Jiangsu, faces a grim picture of aging. In particular, in its Jiangning District, the epitome of the economic and social development of Jiangsu, a government-sponsored home SSC service with the brand name “Xiaojiang Home Care” has completed a total of 1.556 million orders. The service was selected into the “first batch of demonstration cases of using intelligent technology to serve the elderly” by the National Development and Reform Commission of China. Therefore, Jiangning District is a typical area for studying how SSC cognition acts on elderly health. The survey was conducted by the proportional quota sampling method, and the baseline sample size was determined to be 450 households. First, three streets were extracted from Jiangning District. Second, in each street, three neighborhoods rated good, medium, and poor in terms of socioeconomic conditions were selected. Third, 50 households were investigated in each neighborhood for a final sample size of $50 \times 9 = 450$. This sampling method applies when recruiting participants of diverse genders and ages (Rababah et al., 2020). Elderly individuals aged 60–74 in Jiangning District were invited to participate. In total, 448 elderly people completed the questionnaire, and copies with incomplete or conflicting answers were removed. Ultimately, a total of 103 invalid copies were removed, and 345 valid copies were retained. The final sample included

170 males (49.28%) and 175 females (50.72%) with the mean age of 67.42 years old. Among them, 189 held agricultural hukou (54.78%) and 156 held non-agricultural hukou (45.22%); the majority was Han Chinese (98.84%), junior high school or below-educated (80.58%), and married (92.46%); individual annual incomes were concentrated in the range of RMB35,000 or less (74.49%). The data were collected in June 2022.

Measures

Dependent variable. The health of elderly people consists of two parts: physical health and mental health. For physical health, a total of 13 questions were asked about the following functional abilities: “dress” “bath”, “eat”, “get up and out of bed”, “go to toilet”, “walk”, “do chores”, “cook”, “go shopping”, “make a call”, “take medicine”, “manage money”, and “use vehicles”. The options were 1 = unable to complete, 2 = having difficulty and needing help, 3 = having difficulty but still able to complete, and 4 = no difficulty, with higher scores indicating better physical health. Ten questions were asked about mental health with regard to how often the respondent had the following feelings: “feeling bothered by trifles”, “feeling it difficult to concentrate when doing things”, “depression”, “feeling it hard to do anything”, “filled with hope about the future”, “feeling scared”, “not sleeping well”, “feeling happy”, “feeling lonely”, and “feeling unable to go on with my life”. Options for these questions, with the exception of how often one feels happy and how often one feels hopeful about the future, were 1 = never/seldom (< 1 day); 2 = not often (1 ~ 2 days); 3 = sometimes/half the time (3 ~ 4 days); and 4 = most of the time (5 ~ 7 days). These options were rated in reverse order for questions regarding “feeling hopeful about the future” and “feeling happy”, so that the higher the scores, the better the respondent’s mental health.

Independent variable. The measurement of SSC cognition should not only reflect objective conditions such as the extent to which the SSC concept is popularized and the extent to which SSC products and services are promoted but also subjective criteria such as elderly people’s views on SSC products and services and their willingness to use them (Van Soest et al., 2011). With reference to the Unified Theory of Acceptance and Use of Technology (UTAUT) model, 26 indicators were presented in the questionnaire, including performance expectancy, effort expectancy, social influence, facilitating circumstances, behavioral intention, perceived trust, perceived security, and degree of adaptation. to measure elderly people’s SSC cognition (Zuo et al., 2022). Questions such as “Do you think that SSC services and products bring convenience to your daily life and health

management?" were asked. The options were scored on a five-point scale (1 = totally disagree; 2 = disagree; 3 = somewhat; 4 = agree; 5 = totally agree); a higher score suggested a higher cognitive level of SSC.

Mediating variable. Regarding the parent–child relationship, the question "Are you satisfied with your relationship with your children?" was asked. The options were 1 = very dissatisfied; 2 = dissatisfied; 3 = somewhat; 4 = satisfied; 5 = very satisfied. A higher value indicated a better parent–child relationship.

Moderating variable. Whether the respondent used the internet was a dichotomous variable represented by the question "Do you use the internet?" The options were 0 = no, 1 = yes.

Covariates. Seven variables were chosen to represent demographics: age, gender (0 = male, 1 = female), *hukou* (0 = agricultural, 1 = nonagricultural), ethnicity (0 = minorities, 1 = Han Chinese), education (1 = illiterate, 2 = elementary school, 3 = junior high school, 4 = high school/technical school, 5 = associate degree, 6 = bachelor's degree, 7 = master's degree, 8 = other), marital status (0 = unmarried, 1 = married), and individual annual income (1 = less than RMB20,000, 2 = RMB20,000–35,000, 3 = RMB35,000–50,000, 4 = RMB50,000–65,000, 5 = RMB65,000–120,000, 6 = more than RMB120,000).

Analytical approach

We employed SPSS 22.0 to examine the data and conduct descriptive statistics and correlation analysis and Amos 24.0 to establish the measurement and structural models among the variables for analysis. The following indices were used to evaluate the fit of the models: chi-square (χ^2), comparative fit index (CFI), the Tucker–Lewis index (TLI), and the root mean square error of approximation (RMSEA). The nonsignificant chi-square value ($p > 0.05$) suggested a sound fit of the hypothesized models. That the CFI and TLI were higher than 0.90 and the RMSEA was lower than 0.08 indicated adequate model-data fit. Bootstrapping was conducted to test for the mediating effect (resampled 5,000 times), which would be considered significant if the 95% confidence interval (CI) excluded 0. Multigroup SEM was adopted to assess whether the overall model differed depending on whether the respondent used the internet. Moreover, to compare the structural path coefficients between groups, we used the critical ratio of difference (CRD), as the absolute value of which higher than 1.965 would indicate a difference between groups at the level of $p < 0.05$.

Results

Descriptive statistics and correlation analysis

The descriptive statistics of key sociodemographic variables herein are shown in Table 1. In the sample of 345 elderly people, the number of females was slightly higher than that of males, indicating an overall balance; the participants had an average age of 67.42 years; the number of people with agricultural *hukou* was slightly higher than that of the non-agricultural population (45.22%); most were Han Chinese; the participants' education level was mainly junior high school or below (80.58%); more than 90% were married; and their personal annual income was mostly RMB35,000 yuan or less (74.49%). In the sample along the line of gender, the average age of women was higher than that of men; more women than men held non-agricultural *hukou*; the males were mainly primary school to high school-educated, while the education levels of females were mainly below primary school, thus the males were better educated than the females on average; the annual individual incomes of men fell between RMB20,000 and RMB50,000, while that of the majority of women was below RMB35,000, thus the men were better paid than women on average, and those with an annual income above RMB50,000 were mainly male. Table 2 shows descriptive statistics for the key variables, in which men, on average, were at a higher level than women on the key variables. As shown in Table 3, physical health, mental health, SSC cognition and parent–child relationships were positively and significantly correlated with one another; that is, there were significant correlations among key variables herein, meeting the prerequisite for the mediation test.

Measurement model

The test of the physical and mental health measurement scales resulted in the Cronbach's alpha coefficients of the physical and mental health items being 0.979 and 0.889, respectively; both were greater than 0.7, indicating the robust reliability of these scales. We used the confirmatory factor analysis (CFA) to evaluate the fit of the measurement model that contained one latent variable: the health of elderly individuals. As a result, the model fit was good, with chi-square = 2.392, $p > 0.05$; $df = 1$, CFI = 0.995, TLI = 0.969, and RMSEA = 0.064. The factor loadings of elderly physical and mental health were 0.805 and 0.705, respectively, significant at the $p < 0.001$ level. The CR value of the latent variable was 0.727, greater than 0.6, and the AVE value was 0.573, greater than 0.5, suggesting that the convergent validity of the model was up to standard. In addition, the multigroup analysis showed that the model

Table 1 Descriptive statistics of variables (N = 345)

	Full		Male		Female	
	Frequency(n) or Mean	Percentage(%) or SD*	Frequency(n) or Mean	Percentage(%) or SD*	Frequency(n) or Mean	Percentage(%) or SD*
Age	67.42	4.56	66.52	4.59	68.29	4.38
Hukou						
Agricultural	189	54.78%	96	56.47%	93	53.14%
Non-agricultural	156	45.22%	74	43.53%	82	46.86%
Ethnicity						
Minorities	4	1.16%	3	1.76%	1	0.57%
Han Chinese	341	98.84%	167	98.24%	174	99.43%
Education						
Illiterate	87	25.22%	15	8.82%	72	41.14%
Elementary	112	32.46%	57	33.53%	55	31.43%
Junior high	79	22.90%	48	28.24%	31	17.71%
High/technical school	61	17.68%	46	27.06%	15	8.57%
Associate	2	0.58%	1	0.59%	1	0.57%
Bachelor	4	1.16%	3	1.76%	1	0.57%
Marital status						
Unmarried	26	7.54%	14	8.24%	12	6.86%
Married	319	92.46%	156	91.76%	163	93.14%
Personal annual income						
Less than RMB20,000	132	38.26%	42	24.71%	90	51.43%
RMB20,000–35,000	125	36.23%	65	38.24%	60	34.29%
RMB3,5000–50,000	65	18.84%	44	25.88%	21	12%
RMB50,000–65,000	11	3.19%	9	5.29%	2	1.14%
RMB6,5000 – 120,000	10	2.90%	8	4.71%	2	1.14%
More than RMB120,000	2	0.58%	2	1.18%	—	—

*SD = standard deviation

Table 2 Descriptive statistics of key variables (N = 45)

	Full		Male		Female	
	Mean	SD	Mean	SD	Mean	SD
Physical health	3.711	0.645	3.852	0.500	3.711	0.645
Mental health	3.465	0.586	3.669	0.527	3.465	0.586
SSC cognition	2.977	0.760	3.192	0.660	2.977	0.760
Parent-child relationship	4.131	0.953	4.371	0.687	4.131	0.953
Whether to use the Internet	0.509	0.501	0.724	0.449	0.509	0.501

Table 3 Correlation analysis among key variables

	1	2	3	4	5
1. Physical health	1				
2. Mental health	0.568***	1			
3. SSC cognition	0.371***	0.282***	1		
4. Parent-child relationship	0.357***	0.351***	0.401***	1	
5. Whether to use the Internet	0.154***	0.114**	0.372***	0.129**	1

*** $p < 0.001$, ** $p < 0.01$; SSC denotes smart senior care

was invariant depending on whether the respondents used the internet at the configurational, metric, and scalar levels.

Structural model

The fitting indices of the structural model overall were chi-square = 29.153, $df = 15$, $p < 0.05$, CFI = 0.974, TLI = 0.904, and RMSEA = 0.052, showing that the model fit the sample data well. As can be seen from Fig. 2; Table 4, in the full-sample model, the effect of SSC cognition on elderly health was positive in a significant way ($\beta = 0.390$, $p < 0.001$), i.e., the higher the cognitive level of SSC, the better the health status of elderly individuals. H1 was thus verified. The parent-child relationship mediated in an important manner the connection between SSC cognition and elderly health.

Fig. 2 Standardized structural model (full sample)
 *** $p < 0.001$; SSC denotes smart senior care

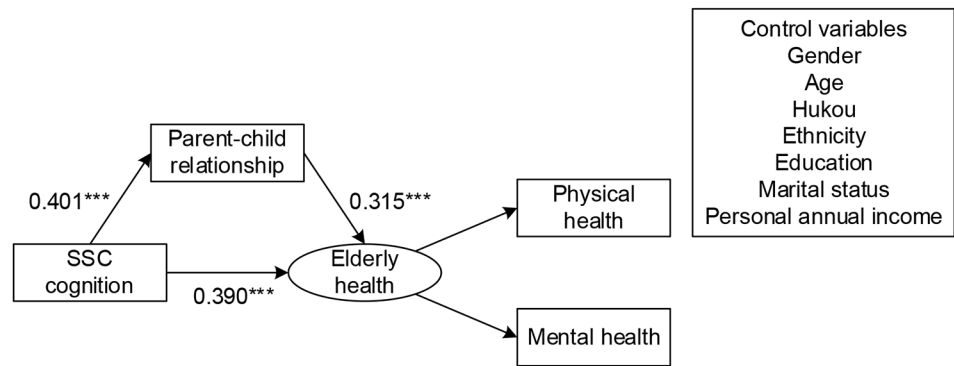


Table 4 Results of the structural model for the full sample and subsamples

Model Paths	Full sample				With internet use				Without internet use			
	B	β	SE	CR	B	β	SE	CR	B	β	SE	CR
Elderly health ← SSC cognition	0.241***	0.390	0.042	5.800	0.273***	0.400	0.043	6.345	0.020	0.059	0.029	0.712
Parent-child relationship ← SSC cognition	0.468***	0.401	0.058	8.112	0.603***	0.476	0.077	7.859	0.291**	0.240	0.103	2.837
Elderly health ← Parent-child relationship	0.167***	0.315	0.033	5.135	0.272***	0.505	0.032	8.567	-0.003	-0.010	0.020	-0.149
Elderly health ← Gender	-0.137*	-0.154	0.054	-2.517	-0.131*	-0.144	0.051	-2.584	-0.060	-0.123	0.060	-1.010
Elderly health ← Age	0.009	0.096	0.006	1.613	0.012*	0.112	0.006	2.076	0.009	0.153	0.008	1.112
Elderly health ← Hukou	-0.080	-0.09	0.051	-1.578	-0.090	-0.100	0.049	-1.822	0.018	0.038	0.035	0.508
Elderly health ← Ethnicity	0.039	0.009	0.228	0.170	-0.139	-0.03	0.241	-0.576	0.099	0.052	0.152	0.656
Elderly health ← Education	-0.056*	-0.141	0.026	-2.145	-0.050*	-0.125	0.023	-2.148	-0.029	-0.109	0.031	-0.943
Elderly health ← Personal annual income	0.021	0.048	0.027	0.773	-0.003	-0.009	0.023	-0.149	-0.021	-0.065	0.027	-0.760
Elderly health ← Marital status	0.318***	0.189	0.095	3.357	0.293***	0.207	0.074	3.968	0.412	0.213	0.343	1.199

B=unstandardized coefficient; β =standardized coefficient; SE=standard error; CR=critical ratio; SSC=smart senior care; *** $p < 0.001$, ** $p < 0.01$, and * $p < 0.05$

Table 5 Direct and indirect effects and 95% confidence intervals (CI)

	Full		With internet use				Without internet use					
	β	95% CI		β	95% CI		β	95% CI				
		Lower	Upper		Lower	Upper		Lower	Upper			
Total effect												
SSC cognition → Elderly health	0.516	0.298	0.681	0.640	0.440	0.782	0.057	-0.136	0.168			
Direct effect												
SSC cognition → Elderly health	0.390	0.200	0.555	0.400	0.230	0.545	0.059	-0.150	0.151			
Indirect effect												
SSC cognition → Parent-child relationship → Elderly health	0.126	0.059	0.199	0.240	0.148	0.325	-0.002	-0.003	0.036			

β =standardized coefficient

Specifically, the improvement of SSC cognition helped to establish a closer relationship between elderly people and their offspring ($\beta = 0.401$, $p < 0.001$), contributing to the elderly’s mental health ($\beta = 0.315$, $p < 0.001$). H2 was thus verified.

Among the covariates, the health status of males was better than that of females ($\beta = -0.154$, $p < 0.05$); a higher education level corresponded to a worse health status ($\beta = -0.141$, $p < 0.05$); and compared with the unmarried, married older adults had better health status ($\beta = 0.189$, $p < 0.001$), while other demographic variables had no significant effects

on elderly health. Overall, the full-sample model revealed 16.1% of the variance in the parent-child relationship and 36.5% of the variance in the elderly health. The results of bootstrapping are laid out in Table 5. The parent-child relationship mediated the influence of SSC cognition on elderly health ($\beta = 0.126$, 95% bootstrap CI[0.059, 0.199]), representing 24.4% of the total effect ($\beta = 0.516$, 95% bootstrap CI[0.298, 0.681]). Furthermore, the bootstrap 95% confidence interval of the indirect effect did not include 0, indicating that the indirect effect reached a significant level.

Fig. 3 Standardized structural model (subsample with internet use)
*** $p < 0.001$.

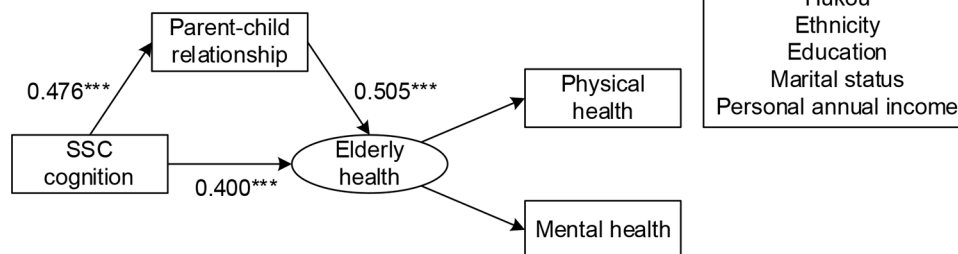
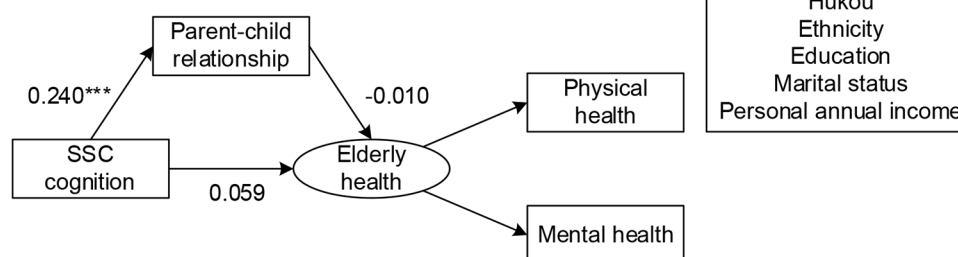


Fig. 4 Standardized structural model (subsample without internet use)
** $p < 0.01$.



Tests of intergroup differences

Multigroup analysis in the SEM was conducted to test whether path coefficients differed significantly depending on whether the respondents used the internet. First, we tested the invariance of the measurement model. The results showed that the model was invariant ($p > 0.05$) with the factor loadings equal along the line of whether the respondent used the internet. Second, we contrasted the unconstrained structural model, in which the structural paths changed depending on whether the respondent used the internet, with the constrained structural model, in which factor loadings, covariances, weights, and residuals were set equal along the line of whether the respondent used the internet. The results indicated significant differences between the unconstrained model ($\chi^2 = 40.512$, $df = 30$) and the constrained model ($\chi^2 = 81.699$, $df = 41$) ($p < 0.001$).

The CRD test showed significant differences depending on whether the respondents used the internet on all three paths. Specifically, there were significant differences in the path coefficients of SSC cognition on the health of elderly people ($CRD = 1.985$, $p < 0.05$), of SSC cognition on the parent–child relationship ($CRD = 2.428$, $p < 0.01$), and of the parent–child relationship on the health of elderly people ($CRD = 4.535$, $p < 0.001$). As shown in Fig. 3, Fig. 4, and Table 4, on the path from SSC cognition to elderly health, respondents who used the internet ($\beta = 0.400$, $p < 0.001$)

were affected more than those who did not use the internet ($\beta = 0.059$, $p > 0.05$). On the path from SSC cognition to parent–child relationship, respondents who used the internet ($\beta = 0.476$, $p < 0.001$) were more impressionable than those who did not use the internet ($\beta = 0.240$, $p < 0.01$). On the path from the parent–child relationship to elderly health, respondents who used the internet ($\beta = 0.505$, $p < 0.001$) were once again more susceptible than those who did not use the internet ($\beta = -0.003$, $p > 0.05$).

Discussion

This study discussed the interplay between SSC cognition, the parent–child relationship, and elderly health. It revealed the mechanism of action of SSC cognition on elderly health through the parent–child relationship and further verified the significant differences between elderly individuals who used the internet and those who did not in the influence of their SSC cognition on health through the parent–child relationship.

The finding that the improvement of SSC cognition effectively enhanced the health of elderly people supported H1 in this study. The full-sample model showed the effect of SSC cognition on elderly health as significantly positive; that is, the higher the cognitive level of SSC, the better the health status, which is largely consistent with previous research

results (Jeng et al., 2022). For elderly individuals, on the one hand, high recognition of the SSC concept encourages them to actively integrate into the digital society, which positively affects their health status (Vulpe & Crăciun, 2020). On the other hand, based on the technology acceptance model (TAM), the higher the willingness of elderly individuals to use SSC products and services, the higher their perceived usefulness and ease of use with SSC products and services, thus increasing their use (Hong et al., 2006). The utilization of SSC products and services facilitates elderly access to medical care resources, and their personal health-related quality of life improves with the elevation of SSC cognition (Rantanen et al., 2017). In the process of learning the use of SSC products, older women are more likely than their male counterparts to accept the help of family members in access to health information and resources that improve their health level (Muscanell & Guadagno, 2012). In this study, elderly people with high levels of SSC cognition had closer parent–child relationships, thus improving their health status. This finding supported H2 and can be considered a fresh insight based on a new framework that explains the relationship between SSC cognition, parent–child relationships and the health of elderly individuals. In light of cognitive-behavioral theory, elderly individuals' cognition of SSC directly affects their SSC use behavior, and a higher cognitive level of SSC leads to a higher demand for SSC use (Dura-Perez et al., 2022). Elderly people learning to use SSC services and products is an intergenerational interaction process through which elderly people keep up with the latest concepts, technology and knowledge. This improves tolerance, understanding and respect between the generations, contributing to more harmonious parent–child relationships (Correa, 2014). For instance, messaging via video services establishes online links between parents and children, which helps the offspring's emotional expression when they are “not present” and fosters a harmonious parent–child relationship (Reis et al., 2021). Because the cognition of SSC improves the closeness of the parent–child relationship, a harmonious parent–child relationship is beneficial to the health of elderly individuals (Chen & Jordan, 2018), which echoes previous research results. A close parent–child relationship gives elderly people more advantages in obtaining daily care and material and spiritual support from their children and improves their physical and mental health and their life satisfaction (Tosi & Grundy, 2019). Furthermore, attention and care from children strengthen the emotional expression of elderly people and help them prevent and resolve psychological crises (De Donder et al., 2012; Litwin, 2011). Compared with older men, older women see their happiness more effectively enhanced by the family cohesion fostered by informal social activities,

such as discussing SSC products with family members (Kimbrough et al., 2013).

In addition, the multigroup analysis in relation to difference in internet use led to valuable findings that the effect of SSC cognition on elderly health through the parent–child relationship differed along the line of whether one used the internet, which supports H3 in this study. On the three paths by which SSC cognition affects health, SSC cognition affects the parent–child relationship, and the parent–child relationship affects health, elderly individuals with internet use were affected more than those without internet use. Based on self-efficacy theory, elderly individuals with internet use have higher efficacy expectations and outcome expectations for SSC products and services through personal experience, which effectively elevates their cognitive level of SSC (Zhang et al., 2022). With a higher cognitive level of SSC, the digital literacy accumulated by internet use enables elderly people to better utilize SSC products and services, thereby providing them with health benefits. However, elderly individuals who lack experience in using the internet tend to feel the discomfort of being “marginalized” when faced with shifting interfaces filled with icons in SSC products and services (Cheng & Sabran, 2021). In the process of adapting to SSC products and services, elderly individuals who use the internet for online instant messaging with their children can seek technical assistance from them, thus strengthening the emotional link between parents and children and effectively improving the parent–child relationship (Antonucci et al., 2017). More than that, life-course studies have shown the “connected” lives of parents and their children improve the health status of parents through the social support and stress buffer provided by a close parent–child relationship (Merz et al., 2009; Thomas, 2010). Therefore, compared with elderly individuals who do not use the internet, the elderly with internet use are more likely to have their health status affected by SSC cognition and parent–child relationships.

Limitations and Implications

This study offers practical guidance for all walks of life to improve the elderly health. On the one hand, in light of the development status and trend of SSC, the government should establish an integrated network that enlists elderly individuals, neighborhoods and enterprises to offer, support and maintain SSC services to strengthen elderly sense of identity and trust in the SSC concept. The government should also strengthen cooperation with social organizations and media institutions to promote the benefits of using SSC products and services to the elderly in a targeted manner and provide basic training and guidance (Ghorayeb et al., 2021). At the same time, the role of family members should

be considered when cultivating the digital literacy of elderly individuals. Moreover, the culture of filial piety should be further promoted to encourage children and community workers to help elderly people adapt to SSC products and services (Zhou, 2022). In this way, not only is a harmonious intergenerational relationship built but the “technology anxiety” of elderly people when facing high-tech products alone is alleviated, thereby improving their physical and mental condition and promoting digital feedback (Rosales & Blanche-T, 2022).

Objectively speaking, some limitations exist herein that need to be addressed in subsequent research. First, combined with theories and multigroup SEM, we explored the mechanism of interaction between SSC, parent–child relationship and elderly health. However, the use of cross-sectional data restricted the robustness of causal links, which may be reinforced by including experimental operations and longitudinal designs (Kivi et al., 2021). Second, the sample’s health status was measured without consideration of objective physical indicators due to data limitations. Both self-rated and objective health indicators may be collected in future research to ensure a holistic view of the study data (Seifert et al., 2021). Thirdly, many epidemic prevention measures during the period of COVID-19 relied on digital information technology, which produced a profound impact on elderly people’s SSC cognition, parent–child relationship and health (Seifert et al., 2021). Follow-up research may scrutinize the influence of COVID-19 on elderly SSC cognition, parent–child relationships, and physical and mental health (Brugiavini et al., 2022; Dura-Perez et al., 2022). Finally, many existing studies have presented the role of gender in the influence of SSC cognition on health. Future studies may examine whether the impact of SSC cognition on health is gender-specific amongst older adults (Saarinen et al., 2022).

Author Contribution Jingjing Zhou and Qian Zhao designed the model and the research frame work, and wrote the manuscript. Jianfang Zhou contributed to the data preparation.

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Data Availability The data was derived from the “Home-based Smart Senior Care Service and Application Survey (2022)” of Jiangsu Research Institute for Smart Elderly Care: Off-campus Research Base on Humanities and Social Sciences for Universities in Jiangsu, the availability of which is subject to a confidentiality agreement.

Declarations

Ethics approval and consent to participate The Ethics Review Committee, School of Sociology and Population, Nanjing University of Posts and Telecommunications has approved the protocol of the study (Ethical Code: NJUPT-DOS-IRB-001029-22,010). An informed consent was obtained from all of the participants at the beginning.

Consent for publication Not applicable.

Competing interests The authors declare none.

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