Examining the Factors Affecting Elderly Adopt Gerontechnology

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***Abstract*—Due to the advancement of medical technology and the improvement of living standards, Taiwan has seen a continuous decrease in its mortality rate, while the proportion of elderly individuals in the population has been steadily increasing. Gerontechnology has created opportunities for certain industries to improve the quality of life for the elderly. Gerontechnology empowers the elderly to lead fulfilling lives that are healthy, safe, and comfortable, while also offering families and healthcare service providers with more convenient and efficient care tools. Gerontechnology is a rapidly evolving field that encompasses a range of products and services designed to meet the unique needs of older adults. Encouraging elderly individuals to embrace and use these technologies will be a significant challenge for healthcare service providers. Overcoming this hurdle will be crucial to realizing the potential benefits that gerontechnology can offer in improving the health, independence, and overall well-being of older individuals. Via our empirical research and the analysis of 10 studies from Taiwan Theses and Dissertations Knowledge Value-Added System, the meta-analytic structural equation modeling technique with Technology Acceptance Model (TAM), self-efficacy, and anxiety are applied in this study. Based on the results of this study, it has been found that first, attitude has a positive effect on behavioral intentions, perceived usefulness has positive effects on attitude and behavioral intentions, and perceived ease of use has a positive effect on behavioral intentions. Second, self-efficacy has positive effects on perceived usefulness and perceived ease of use. Third, technology anxiety has negative effects on perceived ease of use. This study proposed an integration model of an extended TAM with self-efficacy and anxiety as the research model. It may be a modest contribution to find out factors influencing the acceptance of telecare systems.**

***Keywords*—mobile health, gerontechnology, computer self-efficacy, computer anxiety**

I. Introduction

Meeting the demand for life support and healthcare services arising from the rapidly growing elderly population cannot be accomplished solely by increasing the number of caregivers and care resources. In the last few years, there has been a significant transformation in our lives due to the rapid advancement and widespread use of science and technology, particularly computers, the Internet, and wireless communication technologies. Utilizing scientific and technological advancements to develop products, systems, services, and living environments for the elderly is a critical concern in the field of technology. Simultaneously, providing family and professional healthcare workers with convenient and efficient tools is crucial to address the challenges of life support and healthcare in an aging society (Martel *et al.*, 2018).

Gerontechnology is an interdisciplinary field that has emerged in response to the challenges presented by an aging population. The term "gerontechnology" is derived from the combination of "geron," meaning "old age," and "technology." The International Society of Gerontechnology (ISG) defines gerontechnology as the design of technology and environments that enable older individuals to maintain good health, comfort, safety, independence, and social engagement. Gerontechnology products aim to address the specific needs of older adults in terms of independent living and social participation.

In recent years, there has been a significant investment in research and development related to gerontechnology worldwide (Martel *et al.*, 2018). Gerontechnology integrates a range of technologies, including internet connectivity, automation control, and sensors (Buck, 2017). Modern systems typically consist of switches and sensors connected to a central hub, commonly referred to as a "gateway." The user interface for controlling the system can be accessed through a wall-mounted terminal, mobile phone software, tablet computer, or web interface, often with the use of cloud services (Fiorini *et al.*, 2017). One of the key objectives of gerontechnology is to enable older adults to age happily and comfortably in their own homes or familiar communities, as most prefer to do.

It has been observed that older adults may not fully embrace modern technology, and as a result, the adoption rates of technological innovations such as mobile phones and computers tend to be lower for this demographic than for younger age groups. This raises doubts about the effectiveness and value of newly-developed technologies such as gerontechnology. Investing significant resources into these technologies without ensuring their acceptance and utilization by older adults may lead to a waste of time and resources.

Older adults have distinct experiences when using technology products, often resulting from physical factors such as visual and cognitive impairments, as well as fatigue (Zhu, 2018). The use of gerontechnology products is heavily influenced by the health status, physical functioning, and cognitive abilities of older adults. Many older adults are skeptical about the benefits of information technology and its ability to enhance their quality of life (Heart *et al.*, 2013). In addition, they may struggle with remembering how to operate technology devices and fear damaging them if not used correctly, which can lead to a cautious or even exclusionary attitude towards digital products (Chiu *et al.*, 2019). Based on these findings, it can be inferred that self-efficacy and anxiety levels towards gerontechnology significantly impact older adults' intentions to use these

products. Moreover, the usage of technology products among the elderly is generally lower compared to other age groups.

Gerontechnology refers to technological tools and services designed to enhance the independence, health, comfort, safety, and social engagement of older adults (Lauzé *et al*., 2018). As there is currently no research focused on exploring the acceptance of gerontechnology among the elderly in Taiwan, this study aims to identify the factors that influence their willingness to adopt technology. Specifically, this study will examine perceived usefulness, perceived ease of use, intention to use, computer self-efficacy, and computer anxiety as factors that may affect the acceptance of technology among elderly Taiwanese adults.

II. Inserting Content Elements

According to previous studies, a concept model (Fig. 1) for telecare systems acceptance is proposed in this current study. This model is an adaptation of Davis' TAM (Davis *et al.*, 1989), behavioral intentions to use telecare systems (BI), perceived usefulness (PU), perceived ease of use (PEOU), telecare systems self-efficacy (CSE), and telecare systems anxiety (ANX). Fig. 1 is the graphical depiction of this telecare systems acceptance model.

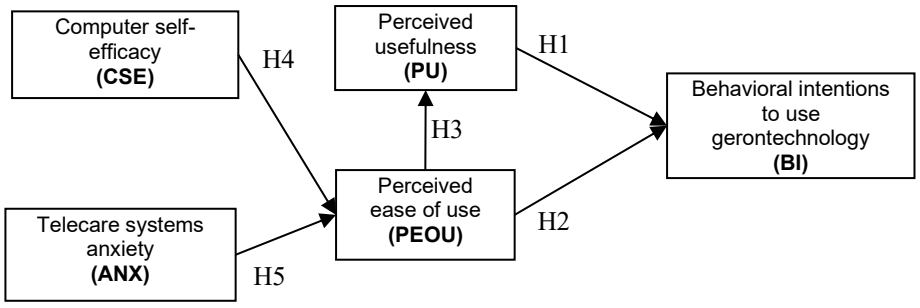

Fig. 1. Ecological model of behavioral intentions to use telecare systems.

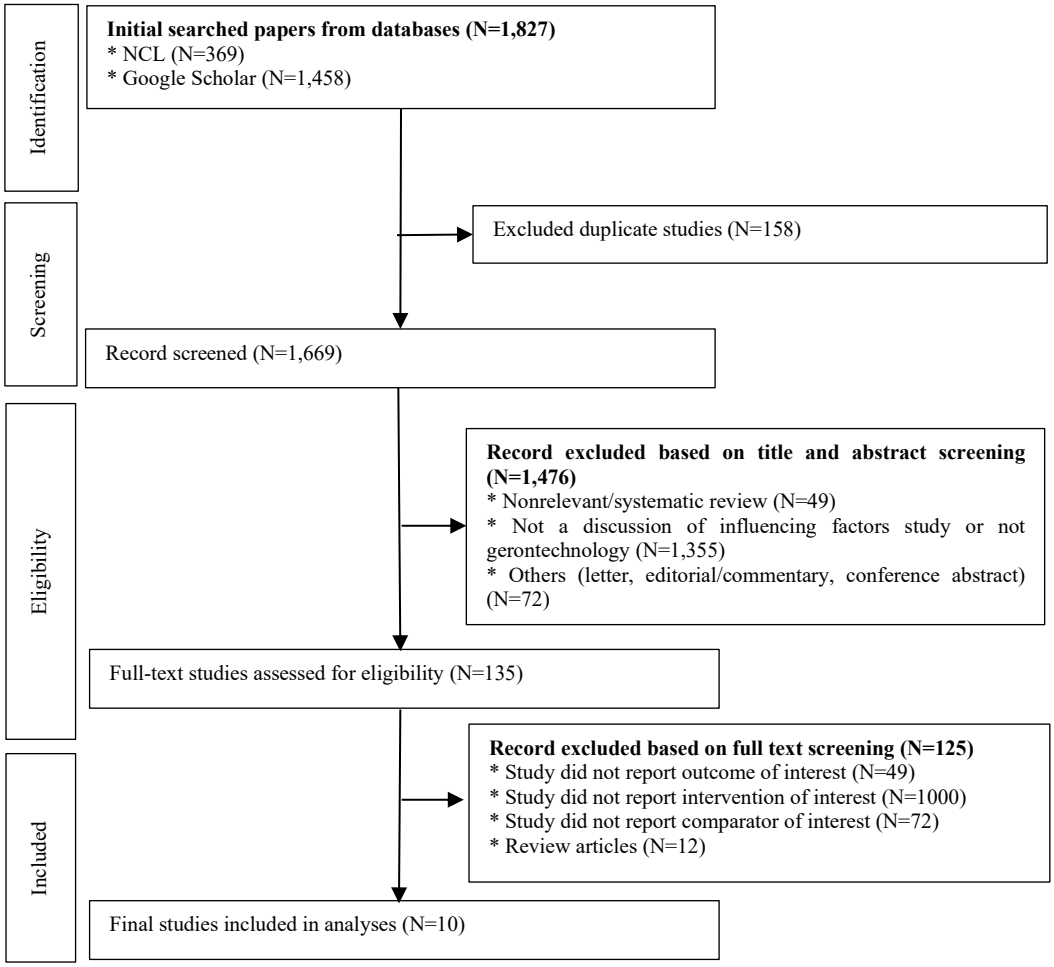

Fig. 2. Diagram illustrating the process of selecting studies.

A. Data Source and Search Strategy

In order to obtain detailed information (such as covariance matrix, observed variables, and questionnaires) for Meta-Analytic SEM, this study only used data from master theses and doctoral dissertations which were selected from Taiwan Theses and Dissertations Knowledge Value-Added System (Taiwanese National Central Library, 2024). We did not set

limitations on the year of publication or language. The search keywords were: "telecare" OR "tele-care" OR "Telemedicine" OR "telehealth". This review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines as a reference.

Following the completion of the eligibility evaluation, fifteen further studies were eligible to be included for analysis (Fig. 2). The process included identification of studies from literature search, screening of the title and the abstract, eligibility screen for full-text review, and included studies in the analysis. Reasons for exclusion and the number of studies excluded during the process were also recorded.

Table 1. The research data in this study

	Author	The year of publish	n
1	Huang, C.H.	2009	100
2	Chen, C.	2010	221
3	Lin, Y.L.	2011	22
4	Lai, C.H.	2011	179
5	Lin, M.H.	2013	49
6	Chang, C.P.	2013	48
7	Chen, Y.L.	2013	281
8	Hsieh, C.W.	2015	284
9	Cheng, J.C.	2016	222
10	Szu, W.W.	2019	398

This study picked out studies that focus on user behavior towards the telecare system. To make sure the quality of the chosen study, the Critical Appraisal Checklist by Joanna Briggs Institute (JBI) was used by two independent reviewers (Jak, 2015).

A total of 10 studies were selected from Taiwan Theses and Dissertations Knowledge Value-Added System. They all investigated the correlates of the use of the telecare system (Table 1).

B. Data Analysis Method

Meta-analytic SEM is an extension of the classical individual structural equation modeling. It aims to solve the important scientific problem of integrating, combining and comparing research findings. The meta-analysis is a statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings (Glass, 1976). It can generalize findings across studies, identify potential moderators in the model structure and obtain the appropriate estimates given a larger sample size. Structural equation modeling is a powerful statistical method for estimating multivariate regression models with latent variables that combines regression analysis with confirmatory factor analysis.

III. Results

This study integrated the 10 studies that used TAM models (Davis *et al.*, 1989) with Meta-analytic SEM. The estimations were calculated using SAS 9.4. In our study, we only used the 1st generation TAM (Davis *et al.*, 1989), which includes BI, PEOU, PU, CSE, and ANX (Fig. 1).

A. Description of the Literature

Of all the 10 studies, 30.0% were published in 2013, and 40% had a sample size of 0~100 and 201~300 (Table 2). They provide information on correlation coefficients relating to behavioral intentions to use telecare systems and their correlations with five distinct factors.

Table 2. General characteristics of the studies

Characteristic	Number of studies (k)	%
Year of publication		
2009	1	10.0
2010	1	10.0
2011	2	20.0
2013	3	30.0
2015	1	10.0
2016	1	10.0
2019	1	10.0
Sample size		
0~100	4	40.0
101~200	1	10.0
201~300	4	40.0
301~400	1	10.0
Total	10	100.0

B. Meta-analysis of the Literature

The correlation coefficients provided by the 10 independent studies were combined into mean effect sizes representing correlations among Behavioral intentions to use telecare systems and five other factors. Z-transform tests and 95% confidence intervals indicated that 15 weighted mean effect sizes were significantly different from zero. Table 3 shows the estimates of correlation coefficients, their standard errors, Z values and p-levels. The forest plot of the 9 hypotheses in this study is shown in Fig. 1.

Table 3. Estimated pooled correlation coefficients (Random-effect parameters)

	k	N	r	S.E.	Z-value
BI-PU	10	1804	0.526*	0.017	30.849
BI-PEOU	10	1804	0.370*	0.020	18.179
BI-CSE	3	681	0.273*	0.035	7.698
BI-ANX	2	502	−0.311*	0.040	−7.712
PU-PEOU	10	1804	0.525*	0.017	30.711
PU-SE	3	681	0.567*	0.026	21.788
PU-ANX	2	502	−0.408*	0.037	−10.944
PEOU-CSE	3	681	0.600*	0.024	24.449
PEOU-ANX	2	502	−0.452*	0.035	−12.734
CSE-ANX	2	502	−0.450*	0.035	−12.643

Note: *: p-value<0.05; k: total number of effect sizes; N: total sample size; r: correlation; *S.E.*: standard error; Z: Fisher's Z transformed correlatio

Table 4. Summary of combined effect sizes

	r	fail-safe Ns	Q-value
BI-PU	0.526*	3,337	205.191*
BI-PEOU	0.370*	1,149	138.628*
BI-CSE	0.273*	56	24.221*
BI-ANX	−0.311*	41	2.672
PU-PEOU	0.525*	2,766	139.044*
PU-CSE	0.567*	514	12.216*
PU-ANX	−0.408*	86	0.443*
PEOU-CSE	0.600*	652	0.499*
PEOU-ANX	−0.452*	121	6.889
CSE-ANX	−0.450*	118	2.565

Note: *: p-value<0.05; r: correlation

All of the 10 studies examined the relationship between BI and PU. The total sample size was 1,804. The overall mean weighted effect size was 0.526 ($p<0.001$, 95% CI=0.493~0.559), which is significantly different from zero. This suggests that BI is positively associated with PU (Table 3). Applying Cohen's standard (Cohen, 1988), the overall mean effect size was rated "large", and the fail-safe Ns is 3,337 (Table 4).

All of the 10 studies examined the relationship between PU and PEOU. The total sample size was 1804. The overall mean weighted effect size was 0.525 (p<0.001, 95% CI=0.491~0.558), which is significantly different from zero. This suggests that PU is positively associated with PEOU (Table 3). Applying Cohen's standard (Cohen, 1988), the overall mean effect size was rated "middle", and the fail-safe Ns is 2,766 (Table 4).

There were 3 studies that examined the relationship between PU and CSE. The total sample size was 681. The overall mean weighted effect size was 0.567 (p<0.001, 95% CI=0.516~0.618), which is significantly different from zero. This suggests that PU is positively associated with CSE (Table 3). Applying Cohen's standard (Cohen, 1988), the overall mean effect size was rated "large", and the fail-safe Ns is 514 (Table 4).

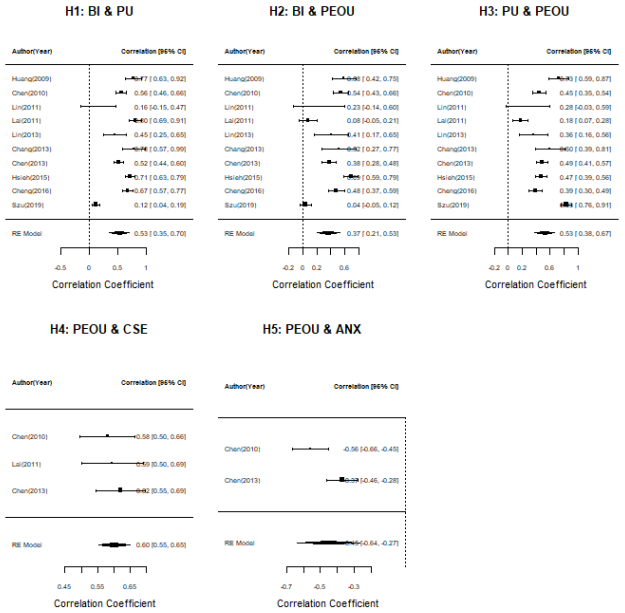

Fig. 3. Forest plots of the 5 hypotheses in this study.

There were 2 studies that examined the relationship between PU and ANX. The total sample size was 502. The overall mean weighted effect size was −0.408 (p<0.001, 95% CI=−0.481~−0.334), which is significantly different from zero. This suggests that PU is negatively associated with ANX (Table 3). Applying Cohen's standard (Cohen, 1988), the overall mean effect size was rated "middle", and the fail-safe Ns is 86 (Table 4).

There were 3 studies that examined the relationship between PEOU and CSE. The total sample size was 681. The overall mean weighted effect size was 0.600 (p<0.001, 95% CI=0.552~0.648), which is significantly different from zero. This suggests that PEOU is positively associated with CSE (Table 3). Applying Cohen's standard (Cohen, 1988), the overall mean effect size was rated "middle", and the fail-safe Ns is 652 (Table 4).

There were 2 studies that examined the relationship between PEOU and ANX. The total sample size was 502. The overall mean weighted effect size was −0.452 (p<0.001, 95% CI=−0.522~−0.383), which is significantly different from zero. This suggests that PEOU is positively associated with ANX (Table 3). Applying Cohen's standard (Cohen, 1988), the overall mean effect size was rated "middle", and the fail-safe Ns is 121 (Table 4).

C. Analysis of the Ecological Model

Based on the result of the meta-analysis in this study, a correlation matrix was built. Table 5 shows the pairwise correlations among 6 variables, along with the number of independent studies and the total sample size contributing to each effect size estimate. 15 sample-weighted mean effect size estimates were significantly different from zero (p-value<0.05). The sample sizes used to estimate each correlation ranged from 22 to 398 and the number of studies ranged from 2 to 10.

The result of Meta-Analytic SEM is displayed in Fig. 3. The chi-square test for this model was not significant – x2(df=5)=5.163 (p-value=0.396), and most of fit indices did indicate a good model fit (RMSEA =0.016, CFI =0.999, GFI=0.987, NNFI=0.998). The overall variance in behavioral intentions to use telecare systems (R2) explained by the revised model was 43.7%.

Table 5. Summary of meta-analysis results for weighted mean correlation effect sizes

	BI	PU	PEOU	CSE	ANX
BI	0.885				
PU	0.526	0.887			
PEOU	0.370	0.525	0.867		
CSE	0.273	0.567	0.600	0.893	
ANX	−0.311	−0.408	−0.452	−0.450	0.830

Note: The numbers in the diagonal row were Cronbach's alpha

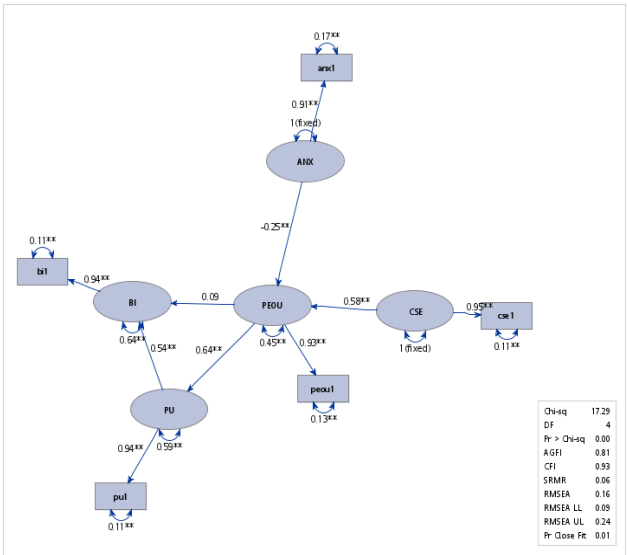

Fig. 4. The ecological model of behavioral intentions to use telecare systems with standardized path coefficients.

The aggregate sample size is 130.598. The correlation between the six variables based on the meta-analysis is shown in Table 3. Chi-square of the target model is 5.163 with df=3 and p-value=0.396. The goodness of model fit is acceptable. Fig. 4 and Table 4 show that the effects of PU on BI 0.563 (p-value<0.001); the effects of PEOU on PU are 0.274 (p-value=0.026), the effects of CSE on PU and PEOU are 0.363 (p-value=0.002) and 0.550 (p-value<0.001); and the effects of ANX on PU and PEOU are −0.148 (p-value=0.154) and −0.249 (p-value=0.012). Most of these effects are statistically significant except the effect of PEOU on BI.

Based on the results of the study presented in Table 6, it

has been found that first, PU has a positive effect on BI (H1); PEOU has positive effects on BI and PU (H2 and H3). Second, CSE has positive effects on PEOU (H4). ANX has negative effects on PEOU (H5).

Table 6. The results of this study

	Hypothesis	Estimate	Std. Err	P(>|z|)
H1	PU->BI	0.535	0.108	<0.001
H2	PEOU->BI	0.090	0.117	0.441
H3	PEOU->PU	0.639	0.063	<0.001
H4	CSE->PEOU	0.575	0.082	<0.001
H5	ANX->PEOU	−0.253	0.093	0.006

IV. Conclusion

The findings of this study can offer some suggestions for the field of health care, provide concrete and specific guide for both hospital managers and public health policymakers. The results of this study indicate that PU, PEOU, CSE, and ANX played an almost equal role in behavior intention in using telecare systems.

Based on the findings of this study, users would adopt a telecare system if they have positive opinions about it. The direct positive relationship that PU has on BI indicates that if the government wants to popularize a telecare system, it should come up with methods to emphasize its usefulness to patients, such as placing advertisements. There are two indirect influences that PU has on BI; one is PEOU, and the other is CSE. PEOU directly influences PU and then indirectly affects BI.

Contrary to prior studies in other fields, PEOU does not have a significant effect on PU. Since healthcare is a matter of life and death, workers of the healthcare field wouldn't try out a new telecare system only because the system is easy to use. For a telecare system to be adopted by healthcare workers, it also has to be proven to be helpful for health management. This finding might imply that people tend to be more conservative in the use of technology in the healthcare field than in other fields. And we believe this finding is reasonable because a conservative environment or mindset would lead to a different decision process when adopting a new technology.

This study used an integration of an extended TAM with CSE and ANX as the research model (Fig. 1). The findings of this study indicate that if we want to investigate people's interest in using new information technology, we should consider both the technology aspects and the human behavior aspects. This extended methodology can have a more accurate prediction because of a comprehensive view of the adoption behavior. Incorporating human-computer interaction factors (such as CSE and ANX) can broaden a study's viewpoint and then increase the predictive power more than solely considering the technology factors or the human behavior factors. This study has found out that first, attitude has a positive effect on behavioral intentions; perceived usefulness has positive effects on attitude and behavioral intentions; and perceived ease of use has a positive effect on behavioral intentions. Second, self-efficacy has positive effects on perceived usefulness and perceived ease of use. Third, technology anxiety has negative effects on perceived ease of use. Based on these results, this paper is a modest contribution to unveil factors influencing the acceptance of telecare systems.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

YHL designed the study and wrote the study protocol; YHL, and FFH were involved in the conception, design, analysis, and interpretation of the data, as well as the drafting and revision of the paper; YHL is the guarantor of this work; both authors had approved the final version.

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