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Cross-lagged panel insights into health, social, and economic in life satisfaction

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ABSTRACT

This study examines life satisfaction in older Thai adults as shaped by dynamic interactions among health, social, and economic factors. Most prior research—both globally and in Thailand—has relied on cross-sectional designs, limiting understanding of cross-lagged relationships. Closing this gap led to the following research objectives: i) assess the stability of health, social, and economic factors and life satisfaction, ii) examine reciprocal and temporal relationships among these domains, and iii) explore age-related variations. Data were drawn from Wave III and IV of the Health, Aging, and Retirement in Thailand (HART) survey (n = 561) and analyzed using cross-lagged structural equation modeling. The findings demonstrated stability in social activity, physical health, mental health, and life satisfaction in both waves. Cross-lagged effects revealed reciprocal and temporal relationships, where mental health influenced future physical health, and life satisfaction impacted subsequent mental well-being. Age-specific differences emerged, with stronger effects in middle-aged adults, where life satisfaction had a greater effect on future mental health, and mental health more strongly influenced physical health over time. Among those aged 60 and older, physical health exhibited the highest stability, while life satisfaction and mental health effects weakened, suggesting age-related shifts in well-being.

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1. INTRODUCTION

Mental health is increasingly recognized as a critical component of overall well-being, particularly among older adults. Globally, a systematic review and meta-analysis reported that the prevalence of depression among the elderly was approximately 19.2%, anxiety 16.5%, and stress 13.9%, underscoring the widespread nature of psychological distress in aging populations [1]. In Thailand, recent data from the Department of Mental Health revealed that between 2020 and 2024, nearly 10% of the population was at risk of depression, while more than 8% experienced high levels of stress [2]. Although these issues are more prevalent among youth, older adults remain highly vulnerable due to factors such as social isolation and deteriorating health. The World Health Organization emphasized that loneliness and social isolation were serious health risks, comparable to poor nutrition and physical inactivity. It was estimated that one in four older adults globally experienced social isolation, which could significantly affect mental health and, in turn, life satisfaction [2]. While mental health is not the sole focus of this study, it is regarded as a reflective factor

contributing to life satisfaction outcomes. Addressing mental health in aging populations is essential, as it influences emotional resilience, social engagement, and perceptions of quality of life.

Thailand's population aged 60 years and older reached 13,358,751 in recent years, accounting for 19.6% of the total population. This demographic included approximately 5.97 million males and 7.38 million females [3], with percentages exceeding 10%, signaling Thailand's transition into a full-fledged aging society. This demographic shift was not unique to Thailand; it was part of a broader global trend toward aging populations. Such demographic changes attracted considerable interest from scholars and policymakers alike due to their wide-ranging social and economic implications. As the number of older adults continues to grow, there is an urgent need for society and government agencies to adapt services and infrastructure to meet their evolving needs, emphasizing the importance of informed and forward-looking policy development. Factors such as living conditions, social welfare provision, and access to healthcare play a central role in shaping older adults' quality of life. This broader perspective underscores the need for thorough studies and strategic policy initiatives to address the challenges and opportunities presented by population aging.

Within this context, life satisfaction emerges as a multidimensional and vital aspect of well-being in later life. It reflects a personal evaluation of various life domains, including physical health, mental and emotional well-being, social connections, and the achievement of personal goals. Enhancing life satisfaction among older adults is crucial, as it is directly linked to overall quality of life and successful aging. The determinants of life satisfaction in this demographic are multifaceted, encompassing health status, financial security, social participation, and a sense of purpose. Tailored support systems, healthcare interventions, and social programs targeting these determinants can significantly contribute to sustaining high levels of life satisfaction.

Previous research demonstrated that life satisfaction among older adults was influenced by a complex interplay of interconnected factors. Household socio-economic status—including income, wealth, and assets, played a significant role, with studies revealing positive associations between socio-economic factors and life satisfaction [4]. Physical and mental health also represented crucial dimensions, with age-related declines in physical functioning negatively impacting overall satisfaction [4], [5]. Moreover, the reciprocal relationship between socio-economic status and health was well-documented, as economic resources influenced health outcomes [6], [7]. Active participation in social activities further emerged as a key driver of mental health and life satisfaction, fostering social connectedness and a sense of purpose [8], [9].

Although prior studies offered valuable insights into the determinants of life satisfaction in later life, several limitations remained. Most research—both globally and in Thailand—relied on cross-sectional designs, limiting the ability to assess temporal dynamics or causal relationships. Many focused on single domains, such as health or economic status, without accounting for their combined effects with social engagement. Moreover, longitudinal studies in the Thai context were scarce, and none applied cross-lagged structural equation modeling to examine the reciprocal relationships among health, social, and economic factors and life satisfaction. This study addresses these gaps by integrating multiple domains using high-quality longitudinal data to explore the stability and cross-lagged effects of key determinants of life satisfaction among older Thai adults.

The intricate interrelationships among these factors highlight the necessity of a comprehensive approach to studying life satisfaction in older adults. This study seeked to assess and explore the factors influencing life satisfaction among older adults in Thailand, focusing on the interplay between physical health, mental health, social engagement, and socio-economic conditions. Given the complexity of aging-related changes, a longitudinal approach is essential to capture how life satisfaction, health, and socio-economic factors evolve over time. To address this need, the present study employed a cross-lagged structural equation model to examine reciprocal and temporal relationships across two time points. By leveraging high-quality longitudinal data, the study aimed to generate deeper insights into the dynamic interactions among these variables, thereby contributing to a more comprehensive understanding of the aging process in Thailand. These findings were expected to be valuable for policymakers and relevant organizations in developing effective strategies and interventions to support the well-being of older adults in the years to come.

2. METHOD

This section describes the study's theoretical foundation, hypotheses, data source, and analytical approach, focusing on the use of cross-lagged structural equation modeling to assess stability and reciprocal relationships among key variables over time.

2.1. Theoretical framework

The exploration of life satisfaction among older adults was of paramount importance in informing national policymakers. This study focused on four key dimensions that were anticipated to impact life satisfaction, both directly and indirectly. These dimensions included socio-economic factors, participation in social activity, and the influence of physical and mental health. To gain a deeper understanding of the dynamics of these variables over time, this study employed a cross-lagged panel model, which allowed for the examination of reciprocal and temporal relationships between variables across multiple time points from the longitudinal data. A comprehensive understanding of these aspects, including their stability and cross-lagged effects, was reflected in the proposed model as shown in Figure 1, providing valuable insights into the long-term factors influencing life satisfaction among older adults.

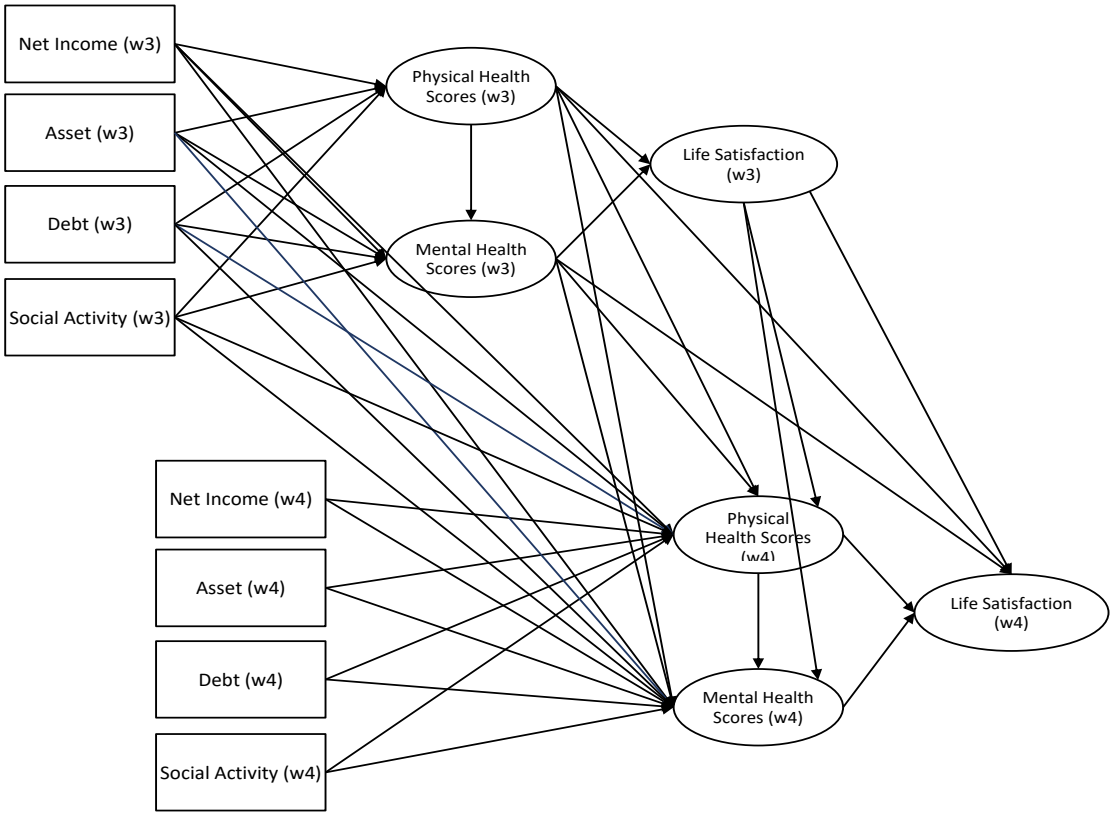

Figure 1. Proposed model

2.2. Hypotheses

2.2.1. Physical and mental health affect life satisfaction

Life satisfaction was shaped by life events [10], [11] and fluctuated during transitional phases [12]. It followed an inverted U-shape across the lifespan, remaining low before age 60, peaking temporarily, and declining in later years due to health deterioration [13]. Research showed that declining physical health was associated with aging, negatively affecting life satisfaction [4], [5]. Studies in China and Vietnam found a positive relationship between health and life satisfaction [14], [15]. Research in India identified strong associations between self-rated health, functional health, mental well-being, and life satisfaction [13]. However, findings from Finland, Poland, and Spain suggested that health had an indirect effect on life satisfaction [16].

Recent studies have employed cross-lagged panel models to examine the reciprocal and temporal relationships between life satisfaction, physical health, and mental health over time. For instance, research has demonstrated that while health and life satisfaction can impact each other longitudinally, the effect of life satisfaction on health becomes negligible when within-person stability is accounted for, suggesting that health may have a more substantial impact on life satisfaction than vice versa [17]. Additionally, studies have found bidirectional associations between depressive symptoms and life satisfaction, indicating that changes

in mental health can influence life satisfaction and vice versa [18]. By employing a cross-lagged panel approach, we aimed to assess the reciprocal and temporal relationships between health and life satisfaction across two waves. Thus, we proposed hypothesis 1: Health influenced life satisfaction over time, while life satisfaction also played a role in shaping future health outcomes, demonstrating a dynamic and bidirectional association.

2.2.2. Household socio-economic affect health

Healthy aging was influenced by socio-economic status [SES] throughout life [6]. Lower SES was associated with poorer health, higher morbidity, and premature mortality [19]. It was also related to poor self-rated health, chronic disease [20], lower quality of life [21], cardiovascular diseases, reduced muscle strength, low respiratory function [22], higher mortality [23], and disability [24]. Low household SES contributed to unhealthy behaviors and poor health outcomes [25]. Higher income improved nutrition, housing, and healthcare [26]. Structural equation modeling [SEM] showed SES significantly affected physical but not psychological health [7]. Social participation helped mitigate the negative effects of low SES [26]. Meanwhile, higher SES enabled better healthcare access, quality care, and health awareness, fostering positive health behaviors and improved self-perception [27]-[29].

Through previous studies, we found that socio-economic status was positively associated with health and had significant effects on both physical and mental well-being in older adults. However, these effects may evolve over time, influencing health outcomes at different life stages. To examine this temporal dimension, we propose hypothesis 2: Socio-economic status positively impacts older adults' health and contributes to long-term changes in physical and mental well-being.

2.2.3. Social activity participation affects mental health and life satisfaction

Older adults who participated in social activity experienced slower cognitive decline and better mental health [8]. Social engagement was associated with fewer depressive symptoms, though its impact varied by activity type [30]. Active participation improved mental well-being, reduced depression, and enhanced life satisfaction [31]. Maintaining an active lifestyle supported self-esteem and a positive self-concept, contributing to mental health in later life. Based on activity and role accumulation theories, both participation and the number of activities were crucial to mental well-being [32].

Studies found that involvement in religious groups, clubs, political organizations, and volunteering had positive effects on mental health [30], [33], [34]. Social activity included hobby clubs, gatherings, religious events, volunteering, and senior community centers [35]. Life satisfaction increased when older adults engaged in social activity, as these provided purpose and resilience. Informal activities with friends or family enhanced well-being [36].

Research consistently showed that active participation improved life satisfaction. Older adults in South Korea with better economic conditions, physical activity, and social connections reported higher satisfaction [37]. Among those aged 65–74, meeting children and volunteering significantly enhanced life satisfaction, while for those 75 and older, talking with friends, using senior centers, and hobby clubs had a greater impact [35]. European and Israeli spouse caregivers who engaged in social activity reported higher life satisfaction than those who did not, as well as non-caregivers [38]. We propose hypothesis 3: Social activity factor positively impacts older adults' health and contributes to long-term changes in physical and mental well-being.

2.3. Research methodology

This study utilized panel data from the Health, Aging, and Retirement in Thailand (HART) Project [https://hart.nida.ac.th/], specifically Wave III (2021) and Wave IV (June 2022 – July 2023). HART provides high-quality longitudinal data that enable researchers to explore dynamic changes in the aging population over time. The combined dataset included 561 Thai participants aged 45 and older who completed both waves and provided complete and valid responses for all key variables. Participants were divided into two age groups: 101 individuals aged 45–59 years and 460 individuals aged 60 years and older. The analysis was restricted to cases with full-rank data, retaining only participants who provided complete responses.

The analysis employed a cross-lagged structural equation modeling approach to examine the stability and reciprocal relationships of key variables across two time points. These variables included health (physical and mental), social engagement, economic status (income, assets, debt), and life satisfaction. Model estimation and fit assessment were conducted using software AMOS, with standard fit indices such as GFI, CFI, and RMSEA used to evaluate model adequacy.

Definitions and measurement details of all observed and constructed variables used in the analysis are presented in Table 1. Observed variables included net income, asset value, debt, and social activity participation. Constructed variables included physical health (based on impairment scores), mental health (based on depression indicators), and life satisfaction (based on subjective ratings of physical, mental, and economic satisfaction).

Table 1. Definition of observed and constructed variables used in the analysis

Variable		Meaning	Value
Observed variable	Net income	Value of personal cash earned per year, e.g., income, compensation, pension, reward, heritance.	Log of net income
	Asset	Value of personal asset at time of observation, e.g., real estate, vehicle, cash saving, deposit, stock & share, life insurance.	Log of asset
	Debt	Value of personal debt at time of observation, including all kind of loan.	Log of debt
	Social activity	Numbers of non-online participated activities.	
Constructed variable	Physical health	Total score of physical impairment in mobility, vision, hearing, speech, and memory.	Physical impairment: 1 = Yes and 0 = No [Total score: 0 – 5]
	Mental health	Total score of depression: boring, lack of concentration, sadness, anxiety, insomnia, loneliness, dissatisfaction, and worthless.	Score of depression: Score 1 = None, Score 2 = 1 – 2 days/week Score 3 = 3 – 4 days/week Score 4 = 5 – 6 days/week Score 5 = every day [Total score: 8 – 40]
	Life satisfaction	Total subjective score of satisfaction in physical health, mental health and self-economic status.	Score of satisfaction: [1 – 10] Score 1 = very bad Score 2 = very good [Total score: 3 – 30]

2.4. Statistical model-based theory

This study employed a multi-wave, multi-domain cross-lagged panel structural equation model (SEM) to examine the reciprocal and temporal relationships among economic, social, health, and well-being factors. The analysis utilized data from two measurement points—Wave 3 (w3) and Wave 4 (w4)—covering four key domains: economic (net income, asset, debt), social (social activity), health (physical health, mental health), and well-being (life satisfaction). The model simultaneously estimated three types of effects. First, stability (autoregressive) effects measured the extent to which each variable remained consistent over time. These effects were modeled as autoregressive paths in which a variable at Wave 4 was predicted by its own value at Wave 3, expressed as: $X_4 = \alpha_X + \beta_{XX}X_3 + \epsilon_X$ where X_t is the value of variable X at wave t, β_{XX} represents the autoregressive coefficient reflecting temporal stability, and ϵ_X is the disturbance term. Higher values of β_{XX} indicate stronger persistence of the construct over time.

Second, cross-lagged effects captured the directional influences between different constructs across waves, allowing for the examination of reciprocal causation. These were modeled as: $Y_4 = \alpha_Y + \beta_{YY}Y_3 + \beta_{XY}X_3 + \epsilon_Y$, where β_{XY} represents the cross-lag coefficient from X_3 to Y_4 and $X_4 = \alpha_X + \beta_{XX}X_3 + \beta_{YX}Y_3 + \epsilon_X,$, where β_{YX} represents the cross − lag coefficient from Y_3 to X_4. Significant values for both β_{XY} and β_{YX} provide evidence for reciprocal relationships.

$$\text{For example: } LS_4 = \alpha_{LS} + \beta_{LS,LS}LS_3 + \beta_{PH,LS}PH_3 + \beta_{MH,LS}MH_3 + \epsilon_{LS}$$
$$PH_4 = \alpha_{PH} + \beta_{PH,PH}PH_3 + \beta_{LS,PH}LS_3 + \epsilon_{PH}$$

Where *LS* represents life satisfaction, *PH* and *MH* denote physical and mental health scores at wave t, t = 3, and 4. If both $\beta_{PH,LS}$ and $\beta_{LS,PH}$. These are significant; this indicates dynamic reciprocity between physical health and life satisfaction.

Third, synchronous correlations measured the associations between variables within the same wave, capturing contemporaneous relationships beyond the longitudinal pathways. In SEM matrix notation, the model can be expressed as: $Y_4 = \alpha + BY_3 + \epsilon$, where $Y_t = [NI_t, AS_t, DE_t, SA_t, PH_t, MH_t, LS_t]^T$, B is a coefficient matrix containing both stability coefficients (β_{ii}) and cross-lagged coefficients (βij, i≠j), and ϵ is the residual error vector. Diagonal elements of B represent stability paths, whereas off-diagonal elements represent cross-lagged paths. The theoretical foundation of this model integrates several perspectives. Cross-lagged panel theory [39] provides the framework for assessing reciprocal and directional influences between constructs over time. The stability–continuity perspective [40] posits that psychological and behavioral constructs exhibit moderate to high rank-order stability across the life course. The life course perspective emphasizes the dynamic interdependence of economic, social, health, and well-being trajectories over time. Finally, dynamic systems theory offers a conceptual approach for interpreting the interplay between stability (as reflected in autoregressive effects) and change (as reflected in cross-lagged effects), thereby informing the analysis of both persistent and evolving influences on life satisfaction.

3. RESULTS AND DISCUSSION

This section presents the findings of the cross-lagged panel model, examining the relationships between socio-economic factors, health variables, social activity, and life satisfaction across Wave III and Wave IV. The analysis explored both direct and indirect effects, identifying reciprocal and temporal relationships as well as cross-wave influences over time. This approach provided a comprehensive understanding of stability, bidirectional effects, and dynamic interplay among health, well-being, and socio-economic factors.

3.1. Measurement invariance

The results pertaining to the related fit statistics of measurement invariance, as well as the fitness indices of the alternative model [final model] and age group models, were examined. To assess the moderating role of the variable 'age group' in older adults' life satisfaction, it is essential to initially compare the fitness indices between the alternative model and the age group model. The model fitness indices used in the current study were goodness of fit index (GFI), adjusted goodness of fit index (AGFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA). As shown in Table 2, the fitness indices of the alternative model and the age group model were different, implying that the age of older adults could be moderated by their life satisfaction.

3.2. Model fitness indices

The proposed model included three constructed variables: physical health, mental health, and life satisfaction, alongside four observed variables: net income, assets, debt, and social activity. However, after investigating the significant factors, it was found that life satisfaction was unaffected by certain predictors. As a result, an alternative model was developed, along with an age group model, to examine how the relationships among all factors vary by age group. These models, incorporating cross-lagged panel analysis to assess reciprocal and temporal relationships over time, were depicted in Figures 2 and 3.

Table 2 presents the model fitness indices, providing a comprehensive evaluation of how well the models align with the observed data. For the alternative model, the indices were GFI = 0.961, AGFI = 0.928, CFI = 0.911, and RMSEA = 0.062. For the age group model, the fitness indices were GFI = 0.944, AGFI = 0.901, CFI = 0.902, and RMSEA = 0.048, with notable improvements in CFI [ΔCFI = 0.009] and RMSEA [ΔRMSEA = 0.014]. These results indicated that both the alternative model and the age group model fit well with the empirical data. These results demonstrated that both the alternative model and the age group model fitted well with the empirical data. Another important point to note was that the Chi-square value, referred to as CMIN, was highly significant, as evidenced in Table 2 [p<0.001].

Table 2. Model invariance test

Model	χ^2	*df*	CMIN/DF	GFI	AGFI	CFI	RMSEA	Δ CFI	Δ RMSEA
Alternative	139.659	44	3.174	0.961	0.928	0.911	0.062	-	-
Age group	200.179	88	2.275	0.944	0.901	0.902	0.048	0.009	0.014

3.3. Exploring cross-lagged associations in the alternative model influencing life satisfaction

This study investigated cross-lagged associations within age-specific models to understand factors influencing life satisfaction. By examining the dynamic interplay of health, social, and economic variables across time, the research identifies key pathways that impact life satisfaction, as shown in Figures 2 and 3.

3.3.1. Findings within Wave III [w3]

The analysis within Wave III revealed significant relationships among key variables. Mental health emerged as the strongest effect on life satisfaction [path coefficient = 0.290, p<0.001]. This highlights the critical role of mental health in shaping subjective well-being, echoing findings by [14], [35]. Additionally, social activity significantly influenced life satisfaction [path coefficient = 0.150, p<0.001], a result supported by research highlighting the importance of social engagement in later life [36], [38]. Physical health also had a positive effect on life satisfaction [path coefficient = 0.090, p = 0.029], consistent with [13].

In terms of mental health, both assets [path coefficient = 0.089, p = 0.032] and physical health [path coefficient = 0.142, p<0.001] were positively associated with better mental well-being. Net income, however, demonstrated no significant impact on physical health [path coefficient = 0.025, p = 0.542], in line with findings from [29].

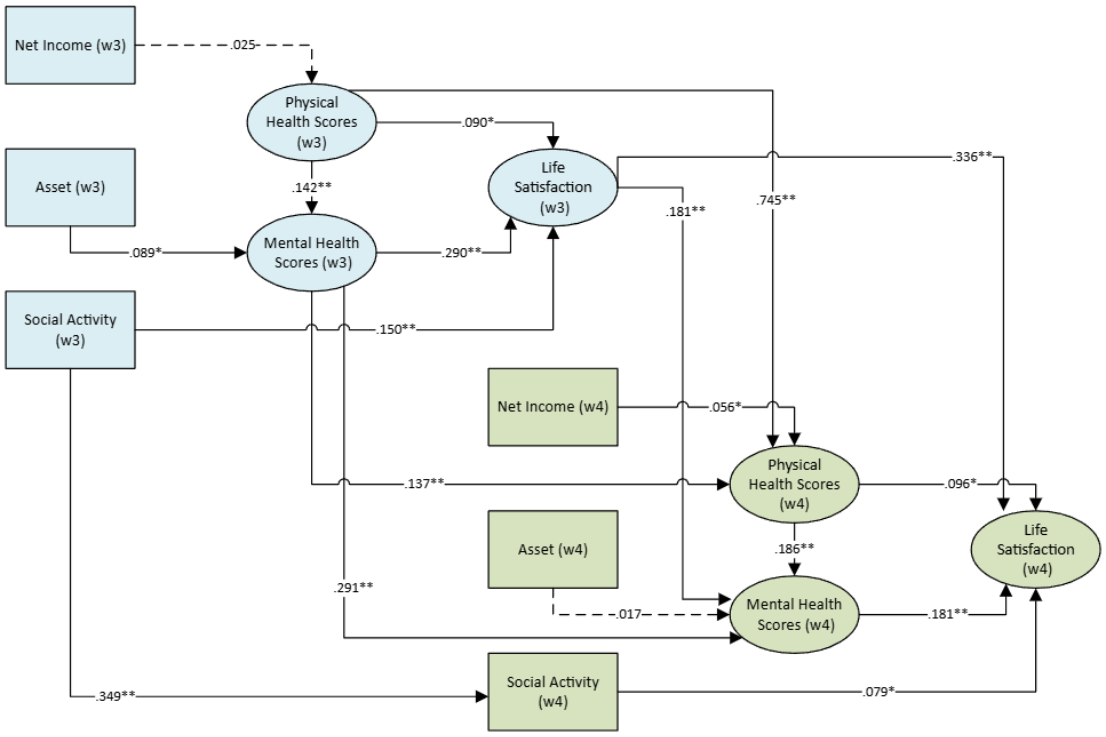

Figure 2. Standardized regression coefficients – final model: alternative model

			Alternative model				*Agegroup model: age= 45-59 (n=101)*				*Agegroup model: age= 60 and over (n=460)*			
			std.Estimate	***Estimate***	***S.E.***	**P**	***std.Estimate***	***Estimate***	***S.E.***	**P**	***std.Estimate***	***Estimate***	***S.E.***	**P**
within w3														
Physical_w3	<---	Net income_w3	0.025	0.047	0.077	0.542	0.158	0.232	0.139	0.096	-0.001	-0.003	0.089	0.978
Mental_w3	<---	Asset_w3	0.089	0.260	0.121	0.032	0.035	0.107	0.301	0.722	0.098	0.284	0.133	0.033
Mental_w3	<---	Physical_w3	0.142	0.127	0.037	0.000	0.169	0.160	0.093	0.085	0.136	0.122	0.041	0.003
LifeSat_w3	<---	SocialAct_w3	0.150	0.051	0.014	0.000	0.037	0.012	0.032	0.709	0.172	0.060	0.015	0.000
LifeSat_w3	<---	Physical_w3	0.090	0.121	0.055	0.029	-0.182	-0.312	0.172	0.069	0.144	0.185	0.057	0.001
LifeSat_w3	<---	Mental_w3	0.290	0.435	0.060	0.000	0.258	0.468	0.175	0.008	0.301	0.432	0.063	0.000
within w4														
Physical_w4	<---	Net_income_w4	0.056	0.299	0.142	0.035	0.128	0.396	0.209	0.058	0.036	0.221	0.176	0.210
Mental_w4	<---	Asset_w4	0.017	0.034	0.076	0.653	-0.194	-0.385	0.160	0.016	0.051	0.105	0.085	0.220
Mental_w4	<---	Physical_w4	0.186	0.094	0.020	0.000	0.219	0.123	0.048	0.011	0.170	0.086	0.022	0.000
LifeSat_w4	<---	SocialAct_w4	0.079	0.032	0.015	0.035	0.024	0.011	0.027	0.695	0.097	0.037	0.016	0.024
LifeSat_w4	<---	Physical_w4	0.096	0.080	0.033	0.014	-0.018	-0.023	0.086	0.785	0.154	0.118	0.034	0.000
LifeSat_w4	<---	Mental_w4	0.181	0.299	0.067	0.000	0.086	0.201	0.158	0.204	0.219	0.333	0.070	0.000
Cross wave 3-4														
SocialAct_w4	<---	SocialAct_w3	0.349	0.318	0.036	0.000	0.365	0.310	0.079	0.000	0.342	0.318	0.041	0.000
Physical_w4	<---	Physical_w3	0.745	1.276	0.046	0.000	0.654	1.000	0.105	0.000	0.757	1.308	0.050	0.000
Physical_w4	<---	Mental_w3	0.137	0.261	0.051	0.000	0.210	0.340	0.110	0.002	0.129	0.249	0.057	0.000
Mental_w4	<---	Mental_w3	0.291	0.282	0.039	0.000	0.374	0.340	0.080	0.000	0.279	0.272	0.044	0.000
Mental_w4	<---	LifeSat_w3	0.181	0.117	0.025	0.000	0.199	0.100	0.042	0.017	0.176	0.120	0.030	0.000
LifeSat_w4	<---	LifeSat_w3	0.336	0.359	0.042	0.000	0.767	0.901	0.075	0.000	0.181	0.187	0.046	0.000

Figure 3. Hypothesis testing: effects of path estimation

3.3.2. Findings within Wave IV [w4]

The results from Wave IV showed consistent patterns, with mental health continuing to play a dominant role in predicting life satisfaction [path coefficient = 0.181, p<0.001]. Physical health also had a significant positive impact on life satisfaction [path coefficient = 0.096, p = 0.014], suggesting that physical health remains relevant for well-being in later stages. In addition, social activity significantly influenced life satisfaction [path coefficient = 0.079, p = 0.035], further reinforcing its importance [30], [31]. Net income exhibiting a significant positive association with physical health [path coefficient = 0.056, p = 0.035]. However, assets at Wave IV had no significant effect on mental health [path coefficient = 0.017, p = 0.653].

3.3.3. Cross-lagged effects between Wave III and Wave IV

Stability: The analysis revealed strong stability across key variables over time. Social activity remained consistent, with Wave III having a significant effect on Wave IV [path coefficient = 0.349, p<0.001]. Likewise, mental health demonstrated continuity, as mental health at Wave III strongly influenced mental health at Wave IV [path coefficient = 0.291, p<0.001]. Physical health exhibited the highest stability, with substantial continuity between Wave III and Wave IV [path coefficient = 0.745, p<0.001], emphasizing its persistence as a critical factor over time. Life satisfaction also maintained strong stability, with Wave III significantly affecting Wave IV [path coefficient = 0.336, p<0.001], reflecting similar findings from [11], [13].

Reciprocal and temporal relationships: The analysis revealed reciprocal and temporal relationships among mental health, life satisfaction, and physical health. Within each wave, mental health had a significant effect on life satisfaction, while across waves, life satisfaction at Wave III influenced mental health at Wave IV [path coefficient = 0.181, p<0.001], confirming mutual influence [17]. Likewise, mental and physical health exhibited bidirectional effects. For Wave III, physical health contributed to mental well-being, and across waves, mental health at Wave III positively affected physical health at Wave IV [path coefficient = 0.137, p<0.001], supporting a life course perspective [20], [23]. These findings underscore the dynamic and interdependent nature of psychological and physical well-being over time. Notably, both mental health and physical health functioned as moderators in Wave III and Wave IV, bridging the relationships between socio-economic factors [assets, net income] and life satisfaction. In addition, physical health contributed indirectly to life satisfaction through its impact on mental health, a mechanism that is also noted in the work of [7].

3.4. Exploring cross-lagged associations in age group models influencing life satisfaction

This study considered age groups as a moderator, leading to an analysis that examined cross-lagged associations separately for each age group. By applying age-specific models, the research explored how health, social, and economic factors influenced life satisfaction over time.

3.4.1. The age group 45–59 years

The cross-lagged panel model for the age group 45–59 years demonstrated significant relationships among socio-economic factors, health variables, social activity, and life satisfaction within and across time points [Wave III and Wave IV] as shown in Figures 3 and 4.

– Findings within Wave III [w3]

Only mental health exerted a significant influence on life satisfaction, whereas the other factors did not demonstrate statistically significant effects. Specifically, physical health was not significantly associated with either life satisfaction or mental health. Likewise, net income and assets did not exhibit significant associations with health variables. Furthermore, social activity also failed to demonstrate a significant effect on life satisfaction.

– Findings within Wave IV [w4]

At Wave IV, it is interesting to note that within the same wave, no factors were significantly associated with life satisfaction. Instead, the explanatory variables, namely assets and physical health, had a significant impact on mental health [path coefficient = -0.194, p = 0.016 and path coefficient = 0.219, p = 0.011, respectively], suggesting complex socio-economic dynamics as described by [16]. This finding suggests that asset ownership may be related to financial or psychological stress in this age group, highlighting the need for further investigation to explore the underlying mechanisms driving this relationship. Similar to Wave III, net income continued to reflect a non-significant effect on physical health, indicating a persistent lack of association between economic resources and health outcomes. Additionally, social activity at Wave IV remained unrelated to mental health.

Stability: Social activity, physical health, and mental health maintained significant stability across waves, highlighting their lasting presence over time. Social activity demonstrated strong continuity, with Wave III having a significant effect on Wave IV [path coefficient = 0.365, p<0.001], indicating consistent levels of social engagement. Likewise, physical health exhibited substantial stability, as Wave III had a strong influence on Wave IV [path coefficient = 0.654, p<0.001]. Mental health also retained significant stability, with Wave III scores affecting Wave IV scores [path coefficient = 0.374, p<0.001], reinforcing the persistence of psychological well-being across time. Life satisfaction also demonstrated high temporal stability, with Wave III affecting Wave IV [path coefficient = 0.767, p<0.001], underscoring its role as a consistent measure of subjective well-being.

Reciprocal and temporal relationships: The findings for the age group 45–59 years affirmed the strong stability of social activity, physical health, mental health, and life satisfaction across waves, with significant cross-lag effects demonstrating their interconnected nature. Specifically, mental health not only maintained its own stability but also influenced future physical health, while life satisfaction served as a predictor of subsequent mental health. These results highlighted the dynamic relationships between

psychological, physical, and subjective well-being over time, emphasizing the long-term importance of mental health and life satisfaction as drivers of overall well-being, consistent with the findings of [41].

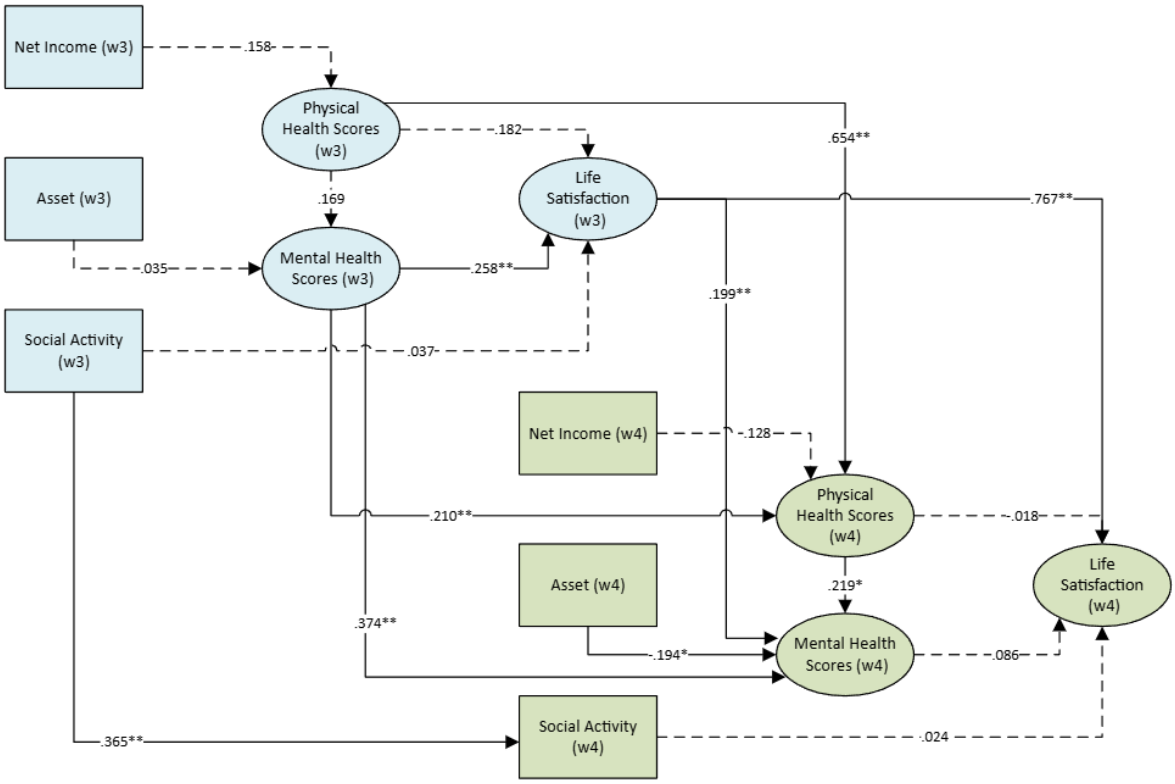

Figure 4. Standardized regression coefficients – Final model: age group model [45-59 years]

3.4.2. The age group 60 years and over

The final model for individuals aged 60 and over highlighted significant relationships among social activity, socio-economic, health, and well-being variables across Wave III and Wave IV (Figures 3 and 5). Mental health continued to serve as a crucial mediator between physical health and life satisfaction in both Wave III and Wave IV. Physical health positively influenced mental health [path coefficient = 0.136, $p<0.001$ for Wave III, and path coefficient = 0.170, $p<0.001$ for Wave IV], which in turn had a significantly strongest effect on life satisfaction [path coefficient = 0.301, $p<0.001$ for Wave III, and path coefficient = 0.219, $p<0.001$ for Wave IV], consistent with studies by [26], [34].

Social activity and physical health emerged as key contributors to life satisfaction in both waves, while financial factors played a limited role. Social engagement significantly influenced life satisfaction, with stronger effects observed at Wave III [path coefficient = 0.172, $p<0.001$] compared to Wave IV [path coefficient = 0.097, $p = 0.024$], consistent with findings from [9], [33]. Physical health demonstrated a consistent positive impact on life satisfaction, with significant effects at both Wave III [path coefficient = 0.144, $p<0.001$] and Wave IV [path coefficient = 0.154, $p<0.001$]. In contrast, financial factors had minimal influence; while assets at Wave III had a positive effect on mental health [path coefficient = 0.098, $p = 0.033$], their direct impact on future outcomes was limited. Net income, on the other hand, had no significant long-term association with either physical or mental health in this age group.

Several key variables demonstrated strong stability across waves. Physical health, mental health, life satisfaction, and social activity all retained significant continuity from Wave III to Wave IV, as indicated by their respective path coefficients [physical health = 0.757, $p<0.001$; mental health = 0.279, $p<0.001$; social activity = 0.342, $p<0.001$]. Life satisfaction at Wave III significantly affected life satisfaction at Wave IV [path coefficient = 0.181, $p<0.001$]. These findings highlight the long-term stability of these variables over time, emphasizing their foundational roles in overall well-being.

Furthermore, life satisfaction at Wave III had a positive effect on mental health at Wave IV [path coefficient = 0.176, $p<0.001$], demonstrating a reciprocal and temporal relationship in which improvements

in subjective well-being contributed to enhanced mental health over time. Additionally, mental health at Wave III significantly impacted physical health at Wave IV [path coefficient = 0.129, p<0.001], supporting the role of psychological well-being in sustaining physical health over time [5], [22].

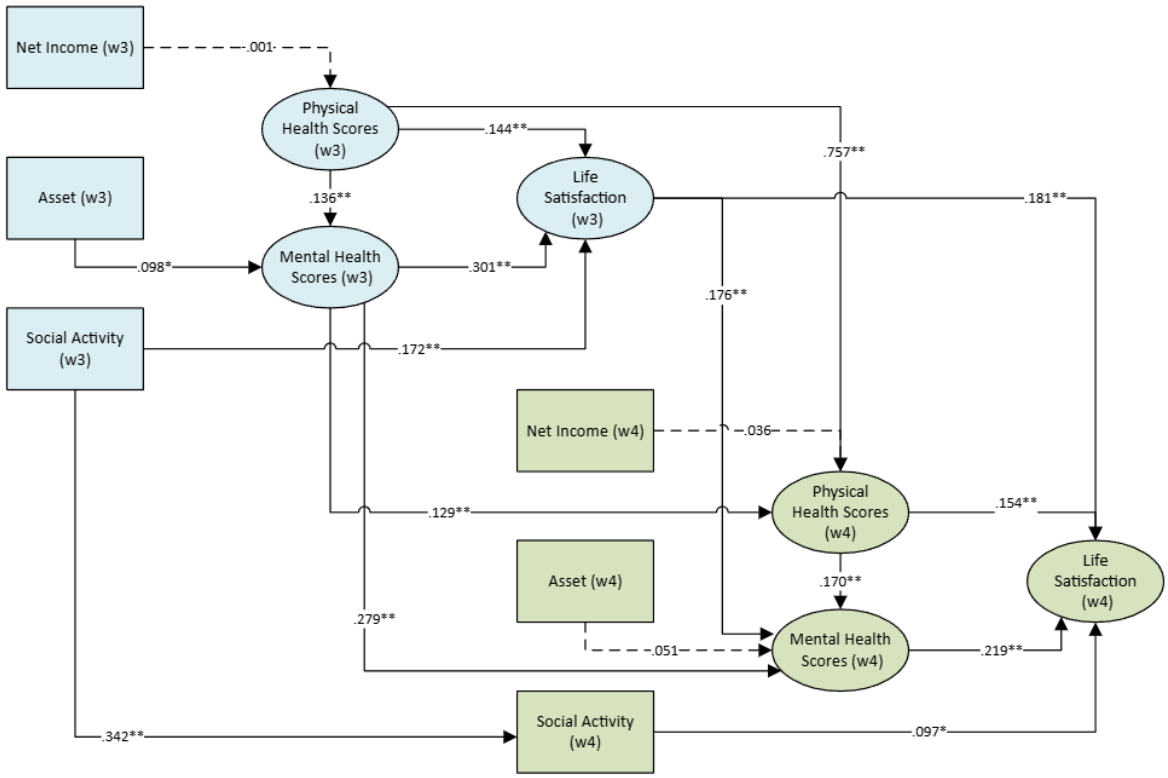

Figure 5. Standardized regression coefficients – final model: age group model [60 years and over]

The overall model results indicated that mental health was the most consistent and influential factor affecting life satisfaction across both waves, consistent with prior longitudinal studies that identified psychological well-being as a key determinant of quality of life in later adulthood [14], [35]. This highlighted the central role of psychological well-being in shaping individuals' perceptions of quality of life and their ability to adapt to health and social changes. Its strong impact may have stemmed from how positive mental states enhanced resilience, coping, and social connections—key elements of subjective well-being that had been emphasized in prior theoretical and empirical work [14], [35]. Physical health also showed a persistent contribution, reinforcing the importance of maintaining functional ability and independence for daily engagement and mental stability, in line with earlier findings that functional limitations strongly predicted declines in well-being [13], [34]. Social activity, though with a smaller effect size, supported life satisfaction by reducing isolation and fostering emotional support and belonging, which echoed previous studies highlighting social engagement as a protective factor against loneliness and psychological distress in older populations [30], [36]. In contrast, socio-economic indicators such as assets and income had weaker or inconsistent direct effects, a finding consistent with research suggesting that, beyond meeting basic needs, financial resources often influenced well-being indirectly through health and social pathways rather than direct effects [29].

Age-stratified analysis revealed distinct patterns, broadly aligning with evidence that the salience of different life satisfaction determinants shifted with age [37], [38]. Among adults aged 45–59, mental health was the key driver of life satisfaction, possibly due to midlife stressors like work and family obligations that overshadowed the benefits of income or social activity, a phenomenon observed in other midlife well-being studies [14], [37], [38]. The negative link between assets and mental health in Wave IV may have reflected financial strain or debt-related stress, paralleling findings that asset ownership could be associated with financial anxiety under certain economic conditions [29]. For adults aged 60 and older, both physical and mental health remained strong predictors of life satisfaction, consistent with prior research showing that health-related capacities became more critical for maintaining quality of life in later life [26], [34]. Mental

health also mediated the link between physical functioning and well-being, in agreement with studies highlighting psychological well-being as a pathway through which physical health affected subjective life evaluations [26], [34]. Social activity also played a significant role, helping to reduce loneliness and enhance emotional support, which supported earlier findings on the importance of social connectedness in promoting healthy and satisfying aging [9], [33], [36]. These findings suggested that interventions should focus on mental health in midlife and on maintaining physical health and social engagement in later life, aligning with recommendations from previous gerontological and public health research.

4. CONCLUSION

This study examined the reciprocal and temporal relationships among physical health, mental health, social activity, socio-economic factors, and life satisfaction among Thai adults aged 45 and older, using a cross-lagged panel structural equation model across two survey waves. The main findings indicated that mental health consistently emerged as the strongest and most stable predictor of life satisfaction across all models, underscoring its pivotal role in shaping subjective well-being. Physical health also demonstrated substantial continuity and contributed meaningfully to life satisfaction, while social activity provided additional but smaller positive effects, particularly in reducing isolation and fostering a sense of belonging. In contrast, socio-economic indicators, such as assets and net income, exerted only limited or inconsistent direct effects, suggesting that their influence was more indirect through health and social engagement. Age-stratified results further revealed that in midlife (45–59 years), mental health and life satisfaction were more tightly related, whereas in later life (60+ years), physical health assumed greater prominence. These results were largely consistent with previous research in both global and Asian contexts, though the observed negative association between assets and mental health in the midlife group diverged from some earlier findings, warranting further investigation.

The implications of these findings are significant for both research and practice. From an academic perspective, they provide longitudinal evidence for the stability and interdependence of psychological, physical, and social dimensions of well-being in the Thai context. Practically, the results highlight the importance of mental health promotion throughout adulthood, the maintenance of physical functioning in later life, and the role of social participation in sustaining well-being. These insights are relevant for public health planning, community-based intervention design, and policy development aimed at promoting healthy and satisfying aging.

Future research should integrate geospatial and spatial-temporal analysis to explore how health, social activity, socio-economic factors, and life satisfaction vary across regions. This approach can uncover spatial disparities and localized well-being patterns, essential for place-based interventions. Linking cross-lagged panel data with GIS can highlight regional differences in stability and causal effects, identifying communities at higher risk of poor health outcomes. Spatial analysis also enables the detection of low life satisfaction clusters and the assessment of environmental, healthcare, transportation, and social infrastructure impacts. Comparing urban, peri-urban, and rural areas would yield granular insights for targeted policies. Incorporating spatial modeling into longitudinal studies enhances contextual relevance and supports geographically sensitive health and social strategies.

In terms of policy and practice, the findings support the implementation of integrated programs that address both mental and physical health, particularly targeting midlife adults to strengthen resilience and prevent later-life decline. For older adults, policies should prioritize sustaining physical functioning and facilitating opportunities for meaningful social interaction, such as community clubs, volunteer activities, and intergenerational programs. Expanding access to community-based mental health services, along with health promotion campaigns tailored to different life stages, could enhance well-being and quality of life for Thailand's rapidly aging population.

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AUTHOR CONTRIBUTIONS STATEMENT

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C : **C**onceptualization
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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors state no conflict of interest.

ETHICAL APPROVAL

This study was approved by the ethical committee of the National Institute of Development Administration [COA No. 2023/0072]. Informed consent for the data collection and use of information was obtained from all participants.

DATA AVAILABILITY

The data that support the findings of this study are openly available in the Dryad Digital Repository at the following URL: http://datadryad.org/stash/share/bi-hSVodYeC-SZ5t7_j23ikZ9ndjWyVPDfIWuPiHw2g.

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