Spatial Disparities in Elderly Health Well-Being in Taiwan: The Role of Public Healthcare Spending and Household Medical Expenditure

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Background: Taiwan’s Aging Challenge

- Taiwan officially entered the super-aged society category in 2025.
- Over 20% of its population is aged 65 or above, with rapid increases in long-term care demand.
- Rising health inequality, particularly in rural and low-income counties, poses urgent policy questions.

Gaps in the Universal Health System

- Taiwan’s NHI covers 99% of the population, but:
  - Long-term care, dental, home nursing, and assistive devices are often excluded.
  - Elderly households bear high out-of-pocket costs for essential services.
- This creates a disjunction between universal coverage and actual financial protection.

Motivation and Key Questions

- What is the real effect of household medical burden on elderly health?
- Does public health spending alleviate or exacerbate this burden?
- Are these effects localized, or do they spill over into neighboring areas?

Conceptual Framework

- This study treats **household medical spending** as a signal of both vulnerability and engagement.
- **Public healthcare** spending is conceptualized as a contextual buffer.
- We analyze how these two forces interact, directly and spatially, to shape LE65.

Hypotheses

- H1: Higher household medical burden is associated with lower LE65.
- H2: Public healthcare spending moderates this relationship positively.
- H3: There are spatial spillover effects in elderly health outcomes across counties.

Review of Literature (I): Elderly Health Indicators

- LE65 is preferred due to:
  - Its policy relevance,
  - Immunity from early-life mortality biases,
  - Consistency across regions and years.
- Compared to HALE or DALYs, LE65 is more readily interpretable in a subnational context.

Review of Literature (II): Medical Burden and Vulnerability

- Out-of-pocket medical costs are linked to:
  - Care delay and avoidance (Xu et al., 2003),
  - Lower mental well-being (Wang et al., 2024),
  - Financial distress, especially in low-income elderly households.

Review of Literature (III): Public Healthcare Spending as a Moderator

- Public healthcare improves population health, but effectiveness varies (Musgrove, 1996; Gupta et al., 2002; Bokhari et al., 2007),
- Benefits depend on access, financial literacy, and administrative capacity (Nixon & Ulmann, 2006; Cylus et al., 2022),
- Targeted spending is more effective for vulnerable groups (Ravindran & Gaitonde, 2018).
- Spending quality matters more than quantity.

Review of Literature (IV): Spatial Inequality

- Service access and health outcomes show strong regional clustering.
- Spatial dependence exists in:
  - Healthcare infrastructure,
  - Administrative capacity,
  - Health-seeking behavior.

Data and Variables

- Time Frame: 2010–2023
- Geographical Scope: 22 counties in Taiwan
- Key variables:
  - LE65 (outcome)
  - HHMedShare (% of total consumption)
  - Public health spending per capita
  - GDP per capita, physician density, elderly share, COVID dummy

Methodology: Spatial Durbin Model (CRE-SDM)

- Captures both **direct** and **spatial spillover** effects of household and public health spending.
- Uses **lagged regressors** to reduce endogeneity and reflect policy implementation delay.
- Employs **Mundlak's correlated random effects** to control for time-invariant heterogeneity.
- Estimated via **Maximum Likelihood**, with standard errors clustered at the county level.

Methodology: Model Specification

$$
\begin{aligned}
y_{i,t} = {} & \rho \sum_{j=1}^{N} w_{i,j} y_{j,t} + \alpha + \beta_1 \mathrm{HHMedShare}_{i,t-1} + \beta_2 \log(\mathrm{PubHealth}_{i,t-1}) \\
& + \beta_3 (\mathrm{HHMed} \times \mathrm{Pub})_{i,t-1} + \beta_4 \log(\mathrm{GDPPC}_{i,t-1}) \\
& + \beta_5 \mathrm{Physicians}_{i,t-1} + \beta_6 \mathrm{ElderlyRate}_{i,t-1} + \beta_7 \mathrm{COVID19}_{i,t-1} + \beta_8 \mathrm{C}_{i,t-1} \\
& + \theta_1 \sum_{j=1}^{N} w_{i,j} \mathrm{HHMedShare}_{j,t-1} + \theta_2 \sum_{j=1}^{N} w_{i,j} \log(\mathrm{PubHealth}_{j,t-1}) \\
& + \theta_3 \sum_{j=1}^{N} w_{i,j} (\mathrm{HHMed} \times \mathrm{Pub})_{j,t-1} + \theta_4 \sum_{j=1}^{N} w_{i,j} \log(\mathrm{GDPPC}_{j,t-1}) \\
& + \theta_5 \sum_{j=1}^{N} w_{i,j} (\mathrm{Physicians}_{j,t-1}) + \theta_6 \sum_{j=1}^{N} w_{i,j} (\mathrm{ElderlyRate}_{j,t-1}) \\
& + \theta_7 \sum_{j=1}^{N} w_{i,j} (\mathrm{COVID19}_{j,t-1}) + \theta_8 \sum_{j=1}^{N} w_{i,j} \mathrm{C}_{j,t-1} + \mu_i + \varepsilon_{i,t},
\end{aligned}
$$

- y_{it}: Life expectancy at age 65 in county i at time t
- w_{ij}: Spatial weight matrix
- ρ: Spatial autoregressive coefficient
- μ_i: County-specific unobserved effect (handled via CRE)
- ε_{it} : Idiosyncratic error term

Descriptive Statistics Overview

Table1. Definitions and Descriptive Statistics of Variables (N=280)

Variables	Descriptions	Mean (S.D.)	Min. (Max.)	Exp. Sign
A. Dependent variables				
$LE65_{i,t}$	Life expectancy at age 65	19.534 0.888	17.695 22.618	
B. Independent variables				
$HHMedShare_{i,t-1}$	Share of household healthcare expenditure in total consumption (%)	17.388 3.258	10.230 28.350	−
$PubHealth_{i,t-1}$	Local government public health expenditure per capita (NTD, deflated by CPI in 2010=100)	1,008.979 694.852	250.120 3,935.850	+
$GDPPC_{i,t-1}$	Average household disposable income (10,000 NTD)	90.609 18.373	56.840 142.620	+
$Physicians_{i,t-1}$	Licensed medical personnel per 10,000 people	120.321 41.779	63.240 262.740	+
$ElderlyRate_{i,t-1}$	Proportion of population aged 65 and over (%)	14.196 2.923	8.040 21.690	+/−
$COVID19_{i,t}$	Covid-19 pandemic occurrence year dummy variable, 2020-2023=1, others=0.	0.214 0.411	0.000 1.000	−

Sources: 1. Report on the Survey of Family Income and Expenditure published by the Directorate-General of Budget, Accounting and Statistics (DGBAS), Executive Yuan, Taiwan.
2. The website of DGBAS: http://www.dgbas.gov.tw.

- Large inter-county variation:
  - HHMedShare: 10% to 28%
  - PubHealth: NT$250 to NT$3,900+
- Suggests significant room for local policy leverage and comparative analysis.

Table 2. Total Effects from CRE-SDM Estimation

Variable	Coefficient	Std. Error	z-Statistic	P-value
$HHMedShare_{t-1}$	0.0061	0.058	0.12	0.907
$Log(PubHealth_{t-1})$	0.331	0.297	1.11	0.268
$HHMed*PUB_{t-1}$	0.043	0.089	0.48	0.631
$Log(GDPPC)_{t-1}$	2.520***	0.579	4.35	<0.001
$Physicians_{t-1}$	0.016	0.016	1.03	0.302
$ElderlyRate_{t-1}$	-0.007	0.011	-0.61	0.542
$COVID19_{t-1}$	-0.328**	0.135	-2.44	0.015
$mean\_HHMedShare_{t-1}$	4.070**	1.829	2.23	0.027
$mean\_log(PubHealth_{t-1})$	9.770*	5.090	1.92	0.059
$mean\_HHMed*PUB_{t-1}$	-0.740**	0.324	-2.28	0.023
$mean\_log(GDPPC_{t-1})$	-12.830*	6.729	-1.91	0.060
$mean\_Physicians_{t-1}$	0.047	0.021	2.24	0.025
$mean\_ElderlyRate_{t-1}$	-0.022	0.014	-1.57	0.114
ρ	0.59***			
σ_e^2	0.034***			
Number of Obs.	280			
Wald spatial lag test	24.39***			
Wald spatial error test	21.02***			

Note: 1. Model is estimated using a Spatial Durbin Model (SDM) with correlated random effects (CRE) and maximum likelihood estimation.
2. The model uses robust standard errors clustered at the county level.
3. All explanatory variables are lagged by one year. Unit-level means of time-varying variables are included to correct for potential correlation with unobserved heterogeneity (Mundlak, 1978).

- Short-term household spending and public spending both have no significant effect on LE65.
- Long-term household spending is positively linked to LE65.
- Long-term public spending also shows a marginal positive effect.
- Interaction term is negative and significant → substitution effect.
- Strong spatial dependence (ρ = 0.59) shows that elderly health is regionally interconnected, requiring cross-county solutions to spatial inequality.

Summary of Empirical Evidence

Aspect	Short-Term Effect	Long-Term Effect
Household Spending	Not significant	Positive
Public Spending	Not significant	Marginal positive
Interaction Term	Not significant	Negative (Substitution)
Spatial Effect (ρ)	—	Strong (ρ = 0.59)

Policy Implications

- Short-term increases in spending may not help—but long-term patterns matter.
- Recommendations:
  - Deploy early-warning systems for medical burden.
  - Target public investment where household stress is greatest.
  - Foster regional integration in healthcare planning.

Conclusion and Future Research

- Key Takeaways:
  - Health outcomes arise from interactions—not additive effects—of household and public spending.
  - Public systems may substitute, not reinforce, private behavior.
  - Spatial econometrics helps uncover hidden dynamics in regional inequality.
- Future work:
  - Use microdata to explore heterogeneity within counties.
  - Apply nonlinear interaction terms.
  - Extend the analysis to other aging East Asian systems.