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RESEARCH ARTICLE

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Associations between depressive symptom clusters and care utilization and costs among community-dwelling older adults

Shiyu Lu[1,3] | Yan Zhang[2] | Tianyin Liu[2] | Dara K. Y. Leung[2] | Wai-Wai Kwok[2] | Hao Luo[2] | Jennifer Tang[1] | Gloria H. Y. Wong[1,2] | Terry Y. S. Lum[1,2]

[1]Sau Po Centre on Ageing, The University of Hong Kong, Hong Kong, China

[2]Department of Social Work and Social Administration, The University of Hong Kong, Hong Kong, China

[3]Department of Social and Behavioural Sciences, City University of Hong Kong, Hong Kong, China

Correspondence

Terry Y. S. Lum, Department of Social Work and Social Administration, The University of Hong Kong, Pok Fu Lam, Hong Kong, China.
Email: tlum@hku.hk

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Abstract

Objectives: Whether and how symptom clusters are associated with care utilization remains understudied. This study aims to investigate the economic impact of symptom clusters.

Methods: We conducted cross-sectional analyses of data collected from 3255 older adults aged 60 years and over in Hong Kong using the Patient Health Questionnaire-9 and the Client Service Receipt Inventory to measure depressive symptoms and service utilization to calculate 1-year care expenditure. Based on Research Domain Criteria framework, we categorized depressive symptoms into four clusters: Negative Valance Systems and Externalizing (NVSE; anhedonia and depression), Negative Valance Systems and Internalizing (guilt and self-harm), Arousal and Regulatory Systems (sleep, fatigue, and appetite), and Cognitive and Sensorimotor Systems (CSS; concentration and psychomotor). Two-part models were used with four symptom clusters to estimate economic impacts on care utilization.

Results: Core affective symptoms had the largest economic impact on non-psychiatric care expenditure; a one-point increase in NVSE was associated with USD$ 571 additional non-psychiatric care expenditure. The economic impacts of CSS on non-psychiatric care expenditure was attenuated when the severity level of NVSE was higher.

Conclusions: Our findings highlight the importance of understanding economic impacts on care utilization based on symptom profiles with a particular emphasis on symptom combinations. Policymakers should optimize care allocation based on older adults' depressive symptom profiles rather than simply considering their depression sum-score or the severity defined by cut-off points.

KEYWORDS

depression, health economics, health service research, mental health

Key points

- Whether and how symptom clusters are associated with care utilization remains understudied

- We found that the economic impact of four depressive symptom clusters and their interactions were heterogeneous across the health, social, and rehabilitation care sectors
- Core affective symptoms had the largest economic impact on non-psychiatric care expenditure
- Policymakers should optimize care allocation, taking account of older adults' depressive symptom profiles

1 | INTRODUCTION

Depression is a heterogeneous mental health issue rather than a single condition.[1,2] The DSM-5 identifies nine symptoms of major depressive disorder: (1) depressed mood, (2) anhedonia, (3) change in weight/appetite, (4) insomnia/hypersomnia, (5) psychomotor agitation, (6) fatigue, (7) feelings of worthlessness, (8) concentration difficulty, and (9) recurrent suicidal ideation.[3] Depressed mood and anhedonia are core symptoms and diagnostic criteria for major depressive disorder. Recent studies have found that these nine symptoms differ from each other in their relations with biological markers, risk factors,[4] and even their response to prevention and treatment approaches.[5]

Depressive symptoms can be categorized into different symptom clusters, such as somatic, cognitive, and affective symptoms.[6] Given the heterogeneity of depression, most rating assessment tools, such as the Patient Health Questionnaire (PHQ-9), are multifactorial and do not measure one underlying construct.[6] Recently, there has been an emerging effort to map nine items in the PHQ into the Research Domain Criteria (RDoC) model,[2] a research initative developed by the National Institute of Mental Health in the United States to conceptualize mental disorder symptoms and diagnoses as dysfunctions of brain circuitry that can be further linked to observable impairment.[7] The RDoC has been considered a transformative initative to facilitate health practitioners to better understand mechanisms underlying mental disorders and optimize mental health interventions and care resource allocation in public health.[8] Under the RDoC, depressive symptoms includes Negative Valence Systems and Externalizing (NVSE; anhedonia and depressed mood), Negative Valence Systems and Internalizing (NVSI; guilt and self-harm), Arousal and Regulatory Systems (ARS; sleep, fatigue, and appetite), and Cognitive and Sensorimotor Systems (CSS; concentration and psychomotor).[2]

Older adults with different symptom clusters may display various care utilization patterns because different symptom clusters signal different types of functional impairment. A previous study found that individual depressive symptoms were differently associated with different domains of psychosocial functioning (e.g., home management, social activities) and that depressed mood and concentration problems had the largest associations with functioning impairment.[9] Furthermore, a recent study from Komulainen and colleagues found that individual depressive symptoms were differently associated with healthcare utilization[10]: people reporting more sleep problems and fatigue had more frequent contacts with a medical doctor while depressed mood was associated with psychiatric inpatient admission. However, Komulainen et al.'s study was limited by its exclusive focus on healthcare and ignoring interaction effects of different symptoms.[10]

So far, no study has attempted to examine economic impacts of depressive symptom clusters and their interactions on healthcare/social care utilization. Understanding of the associations between symptom clusters and care utilization can provide an untapped source of economic evidence and refine information for resource allocation. Previous studies have found that depression is associated with higher total health costs, even after controlling other comorbid conditions.[11–13] Most existing economic research has estimated economic impacts of depression on healthcare utilization using dimensional instruments (e.g., PHQ).[11,12] The majority added up severity scores for individual symptoms to create a sum-score and classified individuals as depressed or not depressed or experiencing different levels of severity based on cut-off values.[11,14] This economic evaluation practice assumes that depression is a single condition, yielding equivalent economic impact on care utilization.

More than 10% of older adults in primary care settings in Hong Kong show signs of clinically significant depression.[15] Older adults in Hong Kong are inclined to express depressive symptoms in somatic illnesses,[16] a phenomenon commonly observed in East Asian populations.[17] The current study investigated the heterogeneous economic impact of depressive symptom clusters and their interaction on healthcare/social care utilization/expenditure in Hong Kong. We proposed following two research questions. First, how are depressive symptom clusters based on the RDoC model (NVSE, NVSI, ARS, and CSS) associated with healthcare, rehabilitation, and social care utilization/expenditure? Second, since depressive mood and anhedonia (NVSE) are core symptoms and correlated with other three symptom clusters, how does the interaction between NVSE and other symptom clusters (NVSI, ARS, and CSS) impact care expenditure?

2 | MATERIALS AND METHODS

2.1 | Sample

This study adopted a cross-sectional design in Hong Kong. Study data were derived from 3430 community-dwelling Chinese older adults collected between 2016 and 2019. Respondents were eligible if they were (1) aged 60 years or older; and (2) having a score of ≥5 on the PHQ-9, mild depression,[18] or a PHQ-9 score lower than 5 *and* at least one of the following self-reported (presence or absence) risk factors for depression: loneliness, lack of social interaction, lack of

meaningful/enjoyable activities, chronic pain, more than four chronic diseases, or bereavement in past 2 years. The exclusion criteria included a known history of autism, intellectual disability, schizophrenia-spectrum disorder, bipolar disorder, Parkinson's disease, or dementia. We used the Hong Kong Chinese version of Montreal Cognitive Assessment 5-minute protocol (MoCA 5-min) to assess potential respondents' cognition and excluded those who scored below the cut-off scores for dementia.[19] Trained social workers collected all data through face-to-face interviews.

2.2 | Measurement

2.2.1 | Service utilization

We focused on service utilization in three care settings: (1) healthcare, including psychiatric healthcare (inpatient and outpatient psychiatric care, and community-based psychiatrists/psychiatric nurses) and non-psychiatric healthcare (inpatient and outpatient general care, and community-based general practitioners and nurses), (2) rehabilitation (day-hospital and occupational therapist consultation), and (3) social care (professional social work, clinical psychology services, and non-professional community support services). Since clinical psychologists are members of multi-disciplinary professional teams in mental health-related social services in Hong Kong,[20] clinical psychology services were categorized into the social care sector.

Respondents' self-reported care utilization in the previous 3 months were measured using the Client Service Receipt Inventory (CSRI).[21] A team of experienced researchers in health services research and health economics fields adapted the CSRI for use in Hong Kong that was piloted with a small sample of older persons in Hong Kong before data collection. The annual care expenditure was calculated by multiplying the volume of service usage and unit cost of these services obtained from the government (2017/2018 prices) and the major local private hospitals (Table S1). For instance, we calculated annual inpatient psychiatric expenditure by multiplying total inpatient psychiatric days and this unit cost. All costs were converted to US dollars using the official exchange rate.[22]

2.2.2 | Depression and four depressive symptom clusters

Depression was assessed using the validated Chinese version of the PHQ-9.[23,24] Respondents specified the frequency they had experienced the nine DSM-5 depressive symptoms (anhedonia, depressed mood, sleep problems, fatigue, appetite change, low self-esteem, concentration difficulties, psychomotor agitation, and suicidal ideation) in the previous two weeks. Possible responses included 0 (not at all), 1 (several days), 2 (more than half the days), and 3 (nearly every day). PHQ-9 scores range from 0 to 27, with conventional cut-off points of 5, 10, and 15 suggesting at-risk (PHQ-9 = 0–4), mild depression (PHQ-9 = 5–9), clinically significant depressive symptoms (PHQ-9 ≥ 10), respectively.[25,26] Cronbach's alpha in our sample was 0.71.

Based on the RDoC framework, we mapped nine items of the PHQ-9 into four clusters, with anhedonia and depressed mood categorized to NVSE (range = 0–6), low self-esteem and suicidal ideation to NVSI (range = 0–6), sleep problems, fatigue, and appetite change to ARS (range = 0–9), and concentration difficulties, psychomotor agitation to CSS (range = 0–6). A higher score indicates higher severity on the corresponding symptom cluster. This categorization has been tested in Confirmatory Factor Analysis (Table S2).

2.2.3 | Covariates

Control variables included sex, age, marital status, years of education, poverty status (being a recipient of a means-tested welfare payment vs. not), chronic conditions (with vs. without more than four conditions), and cognitive function, measured using the Hong Kong Chinese version of MoCA 5-min.[19] Chronic conditions were assessed by a single question about whether respondents had more than four common chronic conditions (yes vs. no). We also controlled for a previous diagnosis of depression/anxiety (yes vs. no), measured using a single question about whether respondents had a previous diagnosis of depression/anxiety.

2.3 | Data analyses

Descriptive analysis was conducted to summarize respondents' characteristics and calculate their care utilization/expenditure. To examine the association between four symptom clusters and care expenditure, we used logistic regression to examine the effects of four symptom clusters on the probability of utilization and then used the generalized linear model (GLM) with the log link and the gamma distribution to estimate effects on expenditure among those who used services,[27] with all symptom clusters and covariates included in models. The two-part model (TPM) was preferred because some respondents did not use any health/rehabilitation/social care during the previous three months and expenditure data were highly skewed.[28] Aligned with Manning and Mullahy's recommendations,[29] we examined the appropriateness of the error distribution assumption using Park's test; the gamma distribution for the GLM was found to be appropriate for this study. We included four symptom clusters in TPMs to estimate the independent economic impacts of four symptom clusters and controlled for sex, age, marital status, education, chronic diseases, cognitive function, poverty status, and any previous diagnosis of depression/anxiety. We then calculated the average marginal effects (AMEs) of four symptom clusters on care expenditure. AME estimates the change in care expenditure after changing one point in a symptom cluster while holding all other variables constant.[30] This approach has been widely used in previous health economic studies.[31,32] We further included interaction terms (NVSE*NVSI, NVSE*ARS and NVSE*CSS) in TPMs to examine interaction effects of NVSE and other three symptom clusters on care expenditure.

We used the *twopm* command for running TPM analysis[28] and obtained AMEs using *margins* command in Stata V15.1.[28,33] The estimates of AMEs were bootstrapped 5000 times to obtain the confidence interval (CI). Because symptoms clusters are correlated with each other, we performed multicollinearity diagnostics for both regression analyses. The variance inflation factor did not exceed 2, indicating no substantial multicollinearity. We used listwise deletion to handle missing values (5.1%), resulting in a final sample of 3255 respondents.

2.4 | Sensitivity analysis

A previous diagnosis of depression/anxiety may relate to depressive symptoms and cognitive functions, and inclusion of a previous diagnosis of depression/anxiety in the regression could underestimate of the economic impacts of depressive symptom clusters. Thus, we re-estimated the TPMs to check the robustness of the results without controlling for the previous diagnosis of depression/anxiety.

3 | RESULTS

Table 1 presents respondents' demographic and socio-economic characteristics. Most were women (78.7%), and 41.1% were married. Their mean age was 76.8 years (SD = 8.2), and the average length of education was 5.2 years (SD = 4.6). Slightly fewer than a third received means-tested welfare benefits. The mean MoCA score was 21.2 (SD = 4.6). Only 9.9% had more than four chronic diseases, and 8.4% had a previous history of depression/anxiety. The average PHQ-9 total score was 6.3 (SD = 4.0). There were 1006 respondents (31%) at risk for depression, 1695 (52%) with mild depressive symptoms, and 554 (17%) with clinically significant depressive symptoms. Sleep problems, fatigue, depressed mood and anhedonia were reported the most. ARS and NVSE were more reported among the four symptom clusters, while NVSI and CSS were less reported.

Table 2 shows care utilization/expenditure; 86.0% had used any care. In particular, 84.1% used healthcare, 10.8% used psychiatric care, 82.4% used non-psychiatric healthcare, 6.6% used rehabilitation, and 14.4% used social care. The average unadjusted annual total care expenditure among all respondents was US$4408 (95%CI: 3898–4918). Average psychiatric care expenditure was US$196 (95%CI: 149–244), compared with US$3812 (95%CI: 3321–4302) for non-psychiatric healthcare. The average rehabilitation expenditure was US$262 (95%CI: 187–336), and the average social care expenditure was US$139 (95%CI: 113–165).

Table 3 shows results of the logit regression on service utilization, GLM analyses on care expenditure among those who used services, and the AMEs based on the results in TPMs after controlling for covariates. The economic impacts of four depressive symptom clusters were heterogeneous. Respondents scoring high on NVSE incurred a greater amount of non-psychiatric care expenditure ($\beta = 0.16$, $p < 0.001$), leading to a greater amount of healthcare ($\beta = 0.15$, $p < 0.001$) and overcall expenditure ($\beta = 0.13$, $p < 0.001$). Respondents scoring high on NVSE also had a greater likelihood of psychiatric care use (odds ratio [OR] = 1.15, $p < 0.01$). Respondents scoring high on NVSI were more likely to use psychiatric (OR = 1.32, $p < 0.001$) and social care (OR = 1.24, $p < 0.001$). Those with high scores on ARS were more likely to use non-psychiatric (OR = 1.13, $p < 0.001$) and social care (OR = 1.06, $p < 0.05$). CSS symptoms were associated with a greater likelihood of rehabilitation (OR = 1.28, $p < 0.001$) and non-psychiatric care (OR = 1.13, $p < 0.05$), but a lower likelihood of social care use (OR = 0.88, $p < 0.05$). No associations were found between care expenditure and NVSI/ARS/CSS symptoms.

Table 3 also shows the AMEs of four depressive symptom clusters. A one-point increase in NVSE was associated with USD$ 571 (95%CI: 220–922) additional non-psychiatric care expenditure. Similar patterns were also found in the healthcare and total care expenditure. A one-point increase in NVSI was associated with USD$ 52 additional psychiatric care expenditure, and a one-point increase in ARS was associated with USD$ 15 additional social care expenditure. Also, a one-point increase in CSS is associated with an increase of USD$ 75 in rehabilitation expenditure, but a reduction in social care expenditure (USD$ −29).

Based on findings from Table 3, we added interaction terms (NVSE*NVSI, NVSE*ARS, and NVSE*CSS) into the TMP for overall care, healthcare, social and rehabilitation care, respectively. Only significant interaction effects between NVSE and CSS on non-psychiatric care were found. The association between CSS and non-psychiatric care was positive when NVSE ranged from 0–3, but the association became negative when NVSE ranged from 4–6 (Figure 1).

We re-examined the TPMs without controlling for a previous diagnosis of depression/anxiety, and no substantial difference in results was found, compared to those controlling for a previous diagnosis of depression/anxiety.

4 | DISCUSSION

This is the first study to investigate association between depressive symptom clusters, based on the RDoC model, and care utilization/expenditure across a range of care settings. Our findings highlight the heterogeneous economic impact of four depressive symptom clusters and the combination of different depression symptom clusters.

Our study found that economic impacts of four depressive symptom clusters was heterogeneous across health, social, and rehabilitation care sectors.

First, we found that a one-point increase in NVSE was associated with USD$ 571 (95% CI: 220–922) additional non-psychiatric care expenditure, the largest increase among four symptom clusters. Previous studies found that older adults with higher severity of anhedonia and depressed mood had more non-psychiatric hospital admissions and re-admissions than those with lower severity.[34,35] Older adults are more likely to associate NVSE with physical pain because bodily experience is regularly coupled with the expression and experience of anhedonia and depressed mood, especially in Asian

TABLE 1 Sample description ($N = 3255$)

Variables		
Sociodemographic		
Sex, *N* (%)		
Female		2560 (78.65)
Male		695 (21.35)
Marital status, *N* (%)		
Married		1339 (41.14)
Single/Widowed/Separated/Divorced		1916 (58.86)
Age (years; range = 60–99), mean (SD)		76.80 (8.20)
Education years (range = 0–21), mean (SD)		5.22 (4.60)
Poverty status, *N* (%)		
Welfare recipients		975 (29.95)
Non-welfare recipients		2280 (70.05)
MoCA (range = 9.5–30), mean (SD)		21.19 (4.62)
Chronic diseases, *N* (%)		
With four and more chronic diseases		323 (9.92)
With less than four chronic diseases		2932 (90.08)
A previous history of depression/anxiety, *N* (%)		
Yes		272 (8.36)
No		2983 (91.64)
PHQ-9 (range 0–27), mean (SD)		6.34 (4.01)
At-risk (0–4)		1006 (31.00)
Mild depressive symptoms (5–9)		1695 (52.00)
Clinically significant depressive symptoms (≥10)		554 (17.00)
Specific symptoms, mean (SD)	1. Anhedonia	0.86 (0.91)
	2. Depressed mood	1.05 (0.91)
	3. Sleep problems	1.40 (1.04)
	4. Low energy	1.21 (0.94)
	5. Appetite change	0.26 (0.61)
	6. Low self-esteem	0.52 (0.8)
	7. Concentration difficulties	0.63 (0.77)
	8. Psychomotor	0.26 (0.56)
	9. Suicidal ideation	0.21 (0.51)
Symptom clusters based on RDoC, mean (SD)	Negative valence systems and externalizing (0–6)	1.91 (1.56)
	Negative valence systems and internalizing (0–6)	0.73 (1.11)
	Arousal and regulatory systems (0–9)	2.87 (1.82)
	Cognitive and sensorimotor systems (0–6)	0.89 (1.05)

Note: MoCA, The Montreal Cognitive Assessment; PHQ-9, Patient Health Questionnaire-9; RDoC, Research Domain Criteria; SD, standard deviation.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

culture.[36] Therefore, higher severity of NVSE symptoms contributed to the increase in non-psychiatric care expenditure. Another possible explanation is that even though Asian older populations may be aware of their depressed mood and anhedonia, they may stigmatize or lack knowledge of mental illness,[37] leading them to seek help mainly from the non-psychiatric care sector.

TABLE 2 Care utilization and expenditures (N = 3255)

	Utilization (counts), N (%) All	Expenditure (USD$), mean (95% CI) All
Health care (A)	2738 (84.12)	4008 (3516, 4500)
Non-psychiatric care	2682 (82.4)	3812 (3321, 4302)
Psychiatric care	350 (10.75)	196 (149, 244)
Rehabilitation (B)	216 (6.64)	262 (187, 336)
Social care (C)	470 (14.44)	139 (113, 165)
Total (A + B + C)	2798 (85.96)	4408 (3898, 4918)

Note: CI, confident interval.

Second, we found that higher scores on NVSI resulted in greater psychiatric care expenditure only. NVSI symptoms (e.g., suicidal ideation) are an acute symptom cluster and mainly signal severe depression, often requiring immediate clinical attention.[38] Thus, older adults with higher scores on NVSI symptoms may be immediately identified and referred for psychiatric care.

Third, our study found that higher scores on ARS resulted in a greater amount of social care expenditures only. Previous research has linked somatic symptoms to poor physical health and a high frequency of medical doctor consultations.[10] Although our study found that somatic symptoms were linked to a greater likelihood of non-psychiatric care use, we found no significant association with non-psychiatric care expenditure/marginal effects. Perhaps NVSE explained away the association between somatic symptoms and non-psychiatric care expenditure as we included all four symptom clusters in models, and previous studies have shown that somatic symptoms intensified depressed mood/anhedonia.[39] The association of somatic symptoms with health concerns may be reflected in a higher frequency of contacts with social workers in community care centers providing community support services (e.g., health promotion, leisure, and exercises) that enable older people to lead a healthy life. The association of somatic symptoms with physical discomfort may also be reflected in a higher frequency to seek help for home management (e.g., meal delivery and housecleaning).[40]

Fourth, our study found that the severity of CSS symptoms was positively associated with rehabilitation care expenditure but negatively linked with social care expenditure. Previous research has shown that cognitive dysfunction is a key predictor of functional limitation.[41] Older adults who score high on CSS may be referred to rehabilitation services because the Hong Kong Hospital Authority provides care for older adults with cognitive impairment and their carers, including day rehabilitation training and day rehabilitation services.[42] In contrast, the association between a higher severity of concentration and psychomotor problems with reduced social care utilization may be reflected as respondents' withdrawal from social activities and interaction.

We further found that effects of CSS on care expenditure depended on the severity of core affective symptoms (NVSE) of depression. High severity of both cognitive symptoms and NVSE was linked to a smaller amount of non-psychiatric care expenditure than low severity of both cognitive symptoms and NVSE. Perhaps older adults who scored high on CSS may have lower insight into their conditions and low self-care capacity.[43] Because they also scored high on NVSE, they may have low motivation to do anything, including help-seeking.[44] Presentation of cognitive symptoms can lead to the assumption of dementia; in Hong Kong, diagnostic services are limited, thus people might not have reached the healthcare system yet (e.g., waiting) and family may delay help-seeking.[45] Since a small percentage of older adults (less than 4%) scored 4 and above on CSS, caution should be taken regarding findings related to interactions between NVSE and CSS, and further study is needed.

Our study's strengths include a large sample, data collection by professionally trained social workers, service use data from three settings, adjustment for a comprehensive array of covariates, cost estimation using TPM, categorizing nine depressive symptoms into four clusters based on the RDoC research framework and examining their interaction effects.

Our findings should be interpreted with caution due to several limitations. First, the sample was not chosen randomly and thus not generalizable to other populations. Second, we estimated direct care costs only. Therefore, we may underestimate the overall economic impact. Third, healthcare utilization data were self-reported and subject to recall bias. We used CSRI to collect data over a 3-month retrospective period while PHQ-9 and other covariates were collected on the last date of that period. Fourth, we used a cross-sectional design which limited our ability to explore causal relationships between depressive symptoms and costs. Fifth, we did not include the supply side of care resources, which may confound our conclusions. Sixth, our sample covered older people with a wild range of PHQ-9 scores, including those who did not have clinically significant depressive symptoms. Future studies can replicate our study with a sample with higher severity of depressive symptoms. Last, the CSRI only records health care utilization and not the reasons for the visit. Therefore, we did not know why respondents sought care, and thus it is possible that the care utilization was unrelated to depressive symptoms.

Nevertheless, our findings have important policy implications. We advanced existing literature in mental health economics by linking four symptom clusters to healthcare and social care expenditure based on the RDoC research framework and documenting how

TABLE 3 Results of the two-part model analysis on care utilization, by *depressive symptom clusters* ($N = 3255$)

	Healthcare (Non-psychiatric and psychiatric care)			Rehabilitation			Social care			Overall care		
	Logit OR (SE)	GLM β (SE)	AME USD$ (95% CI)	Logit OR (SE)	GLM β (SE)	AME USD$ (95% CI)	Logit OR (SE)	GLM β (SE)	AME USD$ (95% CI)	Logit OR (SE)	GLM β (SE)	AME USD$ (95% CI)
NVSE	0.97 (0.04)	0.15*** (0.04)	570** (219, 920)	1.04 (0.05)	−0.06 (0.10)	−8 (−69, 52)	1.01 (0.04)	−0.11 (0.07)	−13 (−33, 7)	0.98 (0.04)	0.13*** (0.04)	576** (203, 948)
NVSI	1.16* (0.07)	0.03 (0.06)	182 (−298, 662)	1.03 (0.06)	0.20 (0.14)	62 (−28, 153)	1.24*** (0.06)	−0.08 (0.08)	14 (−11, 39)	1.20** (0.08)	0.03 (0.06)	231 (−279, 741)
ARS	1.16*** (0.04)	0.00 (0.03)	89 (−174, 353)	1.06 (0.05)	−0.11 (0.06)	−16 (−59, 27)	1.06* (0.03)	0.06 (0.05)	15* (1, 30)	1.12*** (0.04)	0.00 (0.03)	72 (−206, 351)
CSS	1.12* (0.06)	0.05 (0.05)	280 (−99, 658)	1.28*** (0.08)	0.04 (0.10)	75* (5, 144)	0.88* (0.05)	−0.10 (0.08)	−29* (−55, −2)	1.12 (0.06)	0.07 (0.05)	359 (−53, 771)
Constant	1.92 (0.42)	7.03*** (0.74)		0.08* (0.10)	8.89*** (1.66)		0.12** (0.10)	5.82*** (1.10)		2.18 (1.73)	7.33*** (0.72)	

	Non-psychiatric care			Psychiatric care		
	Logit OR (SE)	GLM β (SE)	AME USD$ (95% CI)	Logit OR (SE)	GLM β (SE)	AME USD$ (95% CI)
NVSE	0.95 (0.03)	0.16*** (0.04)	571** (220, 922)	1.15** (0.05)	−0.05 (0.05)	11 (−13, 34)
NVSI	1.09 (0.06)	0.01 (0.06)	89 (−394, 571)	1.32*** (0.08)	0.05 (0.06)	52** (20, 84)
ARS	1.13*** (0.03)	0.01 (0.03)	127 (−135, 389)	1.01 (0.04)	−0.07 (0.04)	−12 (−30, 7)
CSS	1.13* (0.06)	0.05 (0.05)	254 (−126, 634)	1.14* (0.07)	0.00 (0.06)	19 (−8, 47)
Constant	0.81 (0.58)	6.72*** (0.78)		6.1 (6.26)	7.72*** (1.01)	-

Note: The results were controlled for age, gender, marital status, years of education, poverty status, cognitive function, chronic diseases, a history of depression/anxiety in two-part model analyses. Multicollinearity measured by VIFs and tolerance was checked, and no substantial multicollinearity was found (VIF < 2).

Abbreviations: AMEs, average marginal effects; ARS, Arousal and Regulatory Systems, including sleep problems, fatigue, and appetite change; CI, confident interval; CSS, Cognitive and Sensorimotor Systems, including concentration difficulties and psychomotor agitation; GLM, generalized linear model; NVSE, Negative Valence Systems and Externalizing, including anhedonia and depressed mood; NVSI, Negative Valence Systems and Internalizing, including low self-esteem and suicidal ideation; OR, odds ratio; SE, standard error; VIF, variance inflation factor; β, coefficient.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

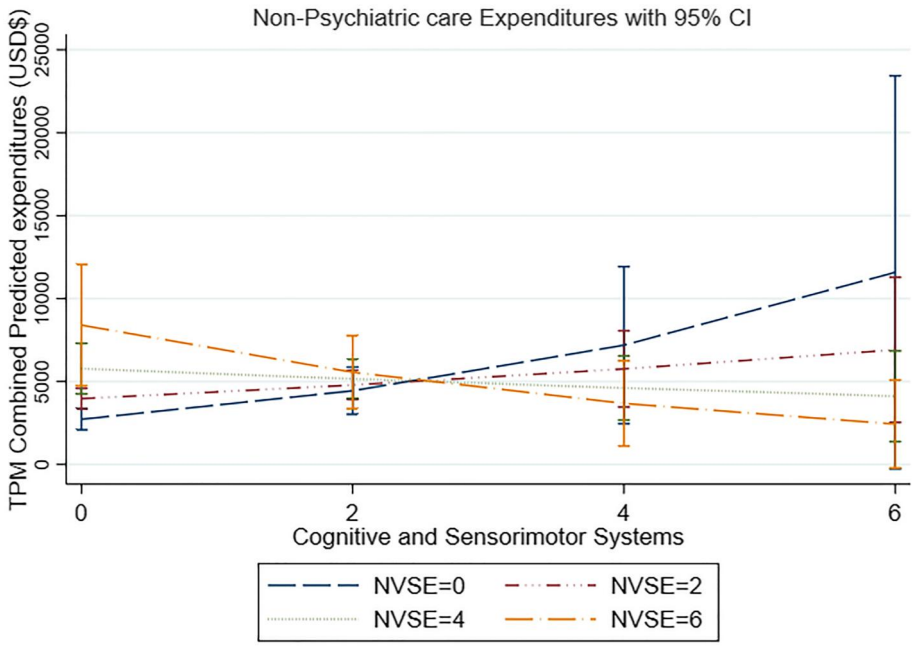

FIGURE 1 Interaction effects of symptom clusters on care utilization. For the straightforward presentation, we only plotted lines using selecting scores of NVSE (0, 2, 4, 6). CI, confident interval; NVSE, Negative Valence Systems and Externalizing. Only significant interactional effects were shown. Other results are available upon request

different combinations of symptom clusters were associated with care utilization. Our findings highlight the importance of understanding the economic impact based on symptom profiles, with a particular emphasis on symptom combinations, going beyond existing literature focusing only on the sum-score of symptoms/severity defined by cut-off points. Special attention should be paid to preventing older adults from developing NVSE.

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CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

ETHICAL APPROVAL

This study was approved by the Human Research Ethics Committee (HREC) of the University of Hong Kong (reference number: EA1709021). Each respondent provided written informed consent before participating in the study.

DATA AVAILABILITY STATEMENT

The data are not available to the public. The data from this study are under certain restrictions, according to the Human Research Ethics Committee (HREC) of the University of Hong Kong.

ORCID

Shiyu Lu https://orcid.org/0000-0002-9355-4883
Tianyin Liu https://orcid.org/0000-0002-8194-5342
Dara K. Y. Leung https://orcid.org/0000-0002-7255-2790
Gloria H. Y. Wong https://orcid.org/0000-0002-1331-942X
Terry Y. S. Lum https://orcid.org/0000-0003-1196-5345

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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