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Original Article

Factors Associated with Multiple Geriatric Conditions in Community-Dwelling Older Adults in Taiwan

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SUMMARY

Background: Geriatric conditions (GCs) commonly result from cumulative insults in older adults' aging, disease, and inactivity. However, the interrelations between GCs in the older population are not well understood. Hence, this study investigated the coexistence of GCs and the factors associated with increased numbers of GCs in older adults.
Methods: Data were collected from the Taiwan Survey of Health and Living Status of Older Adults. Demographic factors, comorbidities, health behaviors, perceived health status, and GCs, namely falls, functional impairment, depressive condition, cognitive impairment, urinary incontinence, and underweight, were collected using questionnaires. Logistic regression was used to explore factors associated with increased numbers of GCs. Multiple correspondence analysis (MCA) models were employed to determine the mutual associations among GCs.
Results: In total, 2,742 participants were enrolled (women: 48%), with 53.3%, 27.1%, and 11.1% having 0, 1, and 2 GCs, respectively. Generalized logistic regression revealed that older age, female sex, institutional residence, living alone, poor and very poor self-perceived health status, and histories of chronic diseases were significantly associated with higher numbers of GCs. Except for underweight, all the GCs were more likely to coexist and occurred more frequently in the participants with higher numbers of GCs (≥ 3). The MCA indicated that the ≥ 85 year age group was close to the cluster of most GCs.
Conclusions: Most GCs tend to coexist and occur more frequently in individuals with more GCs and in those aged ≥ 85 years. At-risk older adults should endeavor to avoid further occurrence of GCs.

1. Introduction

Geriatric conditions (GCs) or syndromes are as common as other chronic diseases among older adults, especially the oldest and most vulnerable adults or those with multiple comorbidities.[1,2] Previous studies showed that the cumulative effects of multiple GCs on life satisfaction and mortality occurred only among older adults with ≥ 2 GCs.[3,4] The occurrence of any GC may be a warning sign for the vicious cycle of poor outcomes, the so-called "geriatric cascade", which leads to a deterioration involving chronic diseases, poorer life satisfaction, and increased hospital admissions, healthcare use, disability, and mortality among community-dwelling older adults.[3–7]

GCs may interact with and influence each other. GCs may have a bidirectional association, such as in the case of depression and falls,[8,9] or memory and physical function.[10,11] Any GC may lead to the occurrence of another, which can aggravate the first condition or promote a third one.[8,10–15] GCs have complex interplay between age-related physiologic changes and chronic diseases in older adults.[16,17] Distinct from most chronic diseases (e.g., metabolic syndromes or cerebrovascular disorders) for which practice guidelines are available to inform realistic assessment and management of these diseases, GCs are frequently neglected by the conventional disease-oriented care among older adults. This is probably because of GCs' subtle or nonspecific presentations and some not being regarded as diseases. Moreover, GCs may occur alongside long-term chronic diseases, especially in older adults with more advanced age.[1,2] Ultimately, GCs mediate the association on the healthcare, life satisfaction, and quality of life in the older adults and their families.[4,6,12,18] Hence, clinicians must prioritize the screening of older adults when managing those adults' health.

Although occurrence of individual GCs on poor outcomes have

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been studied extensively,[12] the accumulated effects and co-occurrence of these conditions have rarely been investigated.[3,4,19–21] The aggregated effects of concurrent presence of multiple conditions on a patient's health may be larger than the sum of the impact of conditions.[22,23] By understanding characteristics of the concurrence, more actions of effective care can be taken for not only one health condition but for the clustered ones.[23] Therefore, we used the secondary data analysis from a nationwide representative survey to study the co-existence and factors with concurrence of GCs in community-dwelling older adults.

2. Materials and methods

2.1. Data and participants

Data of this study were obtained from Taiwan's Survey of Health and Living Status of Older Adults, also known as the Taiwanese Longitudinal Study on Aging, a nationwide representative survey that began in 1989, with follow-ups every 3 to 4 years. The survey was funded by Taiwan's Bureau of Health Promotion and the University of Michigan's Population Studies Center. The first round of interviews was conducted in 1989 (cohort I), and people aged ≥ 60 years were recruited.[24] In 1996 (cohort II) and 2003 (cohort III), new samples of individuals aged ≥ 50 years were interviewed. Data including background, living status, work history, and health status were collected in face-to-face interviews. Details of the survey's research design and sampling strategy were reported elsewhere.[24] Respondents aged ≥ 65 years and who had completed the follow-up survey (household interview) in the cohort III in 2003 were enrolled in the present study. Those with ≥ 3 missing values regarding GCs were excluded from further analysis.

2.2. Measurements

2.2.1. Geriatric conditions

The GCs were assessed according to data availability and on the basis of common definitions of GCs; in this study, the following 6 GCs were considered: history of repeated falls, urinary incontinence, functional impairment, cognitive impairment, depressive condition, and underweight status. A history of repeated falls was defined as ≥ 2 fall episodes over the preceding year. Urinary incontinence was defined as an inability to maintain continence of urine over the preceding year. Functional status was defined in accordance with each participant's ability to perform the activities of daily living (ADLs), namely eating, dressing oneself, taking a bath or shower, using the toilet, transferring positions, and walking.[25] Functional impairment was defined as dependence in any ADL. Cognitive performance was measured using the modified Short Portable Mental Status Questionnaire.[26] Answering more than 2 questions incorrectly was considered representative of potentially impaired cognitive function. An additional error was allowed for the participants with education of less than 6 years or incomplete elementary school education, and 1 fewer error was allowed for the participants with high school education or higher.[26,27] Depressive condition was assessed using the 10 items of the shortened Center for Epidemiologic Studies Depression Scale,[28] of which the range was 0 to 30, and a cutoff point of 10 or higher was deemed indicative of a depressive condition.[29] The participants were divided into 4 groups on the basis of their body mass indexes (BMI) and the definitions of the Asia-Pacific Region of the World Health Organization (i.e., underweight: < 18.5 kg/m^2; normal: ≥ 18.5 to < 23 kg/m^2; overweight: ≥ 23 to < 25 kg/m^2; obese: ≥ 25 kg/m^2).

2.2.2. Sociodemographic characteristics and comorbidities

The participants' basic sociodemographic characteristics, including age, sex, years of education, living status (i.e., alone or otherwise), and area of residence, as well as history of institutional care and comorbidities, were recorded at baseline. Years of education were grouped into 3 levels according to international standard classification of education. The participants were categorized as illiterate if they had not received formal education and could not read and write, and they were classified as literate if they could read or write even without having received formal education. Area of residence was recorded as rural, suburban, or urban. Institutional care was defined as currently living in an institution or nursing home or having received institutional care over the preceding year. Comorbid conditions were recorded by asking respondents whether a physician had diagnosed them as having diabetes mellitus, hypertension, stroke, malignant neoplasm, gout, spondylosis, osteoporosis, rheumatism, hip fracture, cataract, or chronic heart, lung, gastric, liver, or kidney diseases.

2.2.3. Health-influencing behaviors and perceived health status

Health-influencing behaviors, namely regular exercise, smoking, and alcohol consumption, were also inquired into. Regular exercise was defined as exercising more than 3 times a week. Smoking behavior consisted of the categories of never, previous, or current. Alcohol consumption included categories of never, socially (from < 1 time/week to every other day), and regular (more than every other day). Perceived health status was self-reported and was composed of the following categories: excellent, good, fair, poor, and very poor.[30]

2.3. Statistical analyses

Data were analyzed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). Categorical variables are expressed as numbers and percentages, and continuous variables are expressed as means ± standard deviations. A one-way univariate analysis of variance between the participants with and without higher numbers of GCs was conducted to compare the percentages of GCs among distinct age groups. If the main effects were significant, Fisher's least significant difference method was applied for multiple comparisons. The associations of each component of GC and accumulated GCs as a distinct outcome variable were assessed. Multiple logistic regression analysis was used to clarify the co-existence of individual GCs and to determine the association between GCs and various number of GCs. The variables with p values of < .05 in the univariate analysis were included. Backward elimination was then conducted to develop the final model. All the analyses were adjusted for statistically significant variables, including age, sex, area of residence, institutional care status, living status, perceived health, alcohol consumption, regular exercise, stroke, lung diseases, liver diseases, renal diseases, rheumatism, and history of hip fracture.

In order to identify groups of individuals with similar profile in the variables of interest and to explore the associations between nominal categorical variables, we used multiple correspondence analysis (MCA),[31] which can summarize and visualize information and enabled us to examine the similarities between the individuals from a multidimensional perspective MCA was conducted by breaking down the total variance or inertia within the data into a series of axes (sometimes described as dimensions or factors), accounting for descending proportions (denoted by eigenvalues). The patterns of association and opposition between variable categories were translated into distances within a space. The graph representing the associations between features can demonstrate the similarities or differences in the profiles simultaneously and identify those dimensions that contain most of the data variability.[32] Our study reduced the variables of interest to two dimensions (retain for interpretation the first 2 axes), which together explain the largest proportion of the variance (total inertia) observed in our dataset. The category points were represented and established according to the percentage coordinates (x- and y-axis) of the graph. The categories of age groups and 6 GCs were denoted by the binary categorical outcome variables, which we utilized to construct an MCA model and examine the relationship. If categories plotted on the graph by MCA were close to each other, it means clusters between the variables were significantly associated.[33] Categories with high coordinates that were close in space indicate they tended to be directly associated. On the contrary, those distant from each other indicate inversely associated. The chi-square distance as a measure of the association between multiple variables was represented by the distance from the center (average) of a cluster of points (categories) in a multidimensional space, and indicated the contribution of the modality to the factorial axes. Inertia was the measure of variance of the individual categories' profiles from the average profile of the cluster. A first direction was interpreted, with the factorial axis explaining most of the inertia with maximum variance from the average profile. The second direction, uncorrelated to the first one, explaining the maximum of residual variance was measured. The relative importance of each independent dimension was quantified by an eigenvalue as the percentage of variance it explains.

2.4. Ethical considerations

The raw data were provided by the Taiwan Health Promotion Administration, formerly known as the Taiwan Bureau of Health Promotion. The Ethical Committee for Human Research at the study hospital (National Cheng Kung University Hospital) approved this study (B-ER-104-077) and waived informed consent.

3. Results

A total of 2,744 respondents aged ≥ 65 years completed the follow-up survey, but 2 persons were excluded for ≥ 3 missing GC information items. A total of 2,742 persons were included in the final analysis, 48.0% of which were women. Among the participants, 53.3% had no GC, and 27.1%, 11.12%, and 8.4% had 1, 2, and ≥ 3 GCs, respectively. The most common GCs were depressive condition (21.4%), urinary incontinence (17.7%), functional impairment (13.8%), and cognitive impairment (11.7%). Univariate comparison of the participants with various numbers of GCs shows that older age, female sex, illiteracy, institutional residency, living alone, poor and very poor perceived health status, no smoking, no drinking, no regular exercise, past histories of chronic disease, and the presence of any GCs, were significantly associated with higher numbers of GCs (see Table 1).

Table 2 presents the results of the generalized logistic regression on higher numbers of GCs. The dependent variable of the generalized logistic regression analysis is the numbers of GCs, which is an interval variable in Table 2. To interpret the odds ratio, we take age as an example: after we adjusted for other variables, compared to the age group of 65–< 75 years, the risk of having a higher number of GCs for the age group of 75–< 85 years is 1.26 times, (p = 0.006); while that for those aged ≥ 85 years is 1.90 times (p < 0.001). This indicates that older age is significantly associated with a higher number of GCs. The overall results showed that older age, female sex, institutional residency, living alone, poor and very poor perceived health status, and past histories of chronic diseases (stroke, lung diseases, renal diseases, rheumatism, hip fracture) were significantly associated with higher numbers of GCs. Liver diseases, living in a suburban area, social and regular drinking of alcohol, and regular exercise were negatively associated with higher numbers of GCs.

Table 3 summarizes coexistence associations between GCs. Except for the nonsignificant association between underweight and 4 other GCs (urinary incontinence, repeated falls, functional impairment, and cognitive impairment) as well as that between cognitive impairment and a history of repeated falls, most of the other GCs were significantly associated. Some of these associations were higher in certain participants; for instance, cognitive impairment was more prevalent in participants with functional impairment, depressive condition, and urinary incontinence, and the association was bidirectional.

Table 4 details the results of the regression analysis on the association of any conditions among the participants with various numbers of GCs. There are three dependent variables (1, 2 and ≥ 3 GCs). To interpret the odds ratio, we take "2 GCs" as an example: after we adjusted other variables, among the participants with 2 GCs, urinary incontinence was more likely to occur (OR = 2.54, p < 0.001) compared to those who have no urinary incontinence; repeated falls was more likely to be present (OR = 2.57, p < 0.001) compared to those who have no repeated falls, and so on. Table 4 shows that among the participants with more GCs, the other GCs were more likely to be present. The association with any GC significantly increased with the number of GCs. Among the participants with more (i.e., ≥ 3) GCs, cognitive impairment, depressive condition, functional impairment, and urinary incontinence were more likely to be present (odds ratio > 3.5).

MCA was used to determine the association among age groups and GCs. The loadings of the age groups and 6 GCs in MCA are indicated in Table 5. Considering the relative distance of the points from the origin across each dimension, we also examined on which dimension each variable was best represented and which variables were loaded on the same dimension. The first 2 principal components of the factorial axes explained 37.26% of the total variance, with the first and second components explaining 24.15% and 13.11% of the total variance, respectively, indicating that the association among the variables was essentially 2 dimensional. The total chi-square statistic of distance, a measure of the association in the full 2 dimensions of the table, was 6040.4 (p < .001). A factor map of the MCA on the data regarding age and the 6 GCs is presented in Figure 1. Except for underweight, all other GCs were located close to each other on the map. The ≥ 85-year age group was close to the cluster of all of the GCs except for underweight, and had relatively high loadings (0.08–0.48) on dimension 1 (first axis; Table 5). Additionally, underweight and the 75-to-< 85-year age group had relatively high loadings (0.57 and 0.42, respectively) on dimension 2. Thus, we interpret the dimension 1 as "physio-mental decline GCs and oldest-old age", with a history of repeated falls, urinary incontinence, functional impairment, cognitive impairment, depressive condition, and the ≥ 85-year age group as the main contributor to this dimension. The dimension 2 can be interpreted as "underweight and mid-old age" with underweight and 75-to-< 85-year age group, as the main determinants of the second dimension. On the basis of the values of the loadings, the absences of GCs remained clustered close to zero for both dimensions.

Table 1
Sociodemographic characteristics based on the numbers of geriatric conditions.

Variables	Total N = 2742	No geriatric conditions N = 1462 (53.32%)	1 geriatric condition N = 744 (27.13%)	2 geriatric conditions N = 305 (11.12%)	≥ 3 geriatric conditions N = 231 (8.42%)	p-value
Age (yrs)						< .001
65–< 75	1156 (42.16)	638 (45.51)	329 (42.07)	118 (39.20)	71 (27.63)	
75–< 85	1364 (49.74)	683 (48.72)	391 (50.00)	152 (50.50)	138 (53.70)	
≥ 85	222 (8.10)	81 (5.78)	62 (7.93)	31 (10.30)	48 (18.68)	
Sex						< .001
Male	1426 (52.01)	838 (59.77)	393 (50.26)	101 (33.55)	94 (36.58)	
Female	1316 (47.99)	564 (40.23)	389 (49.74)	200 (66.45)	163 (63.42)	
Education						< .001
≥ 12 yrs	148 (5.40)	99 (7.06)	37 (4.73)	9 (2.99)	3 (1.17)	
7–12 yrs	460 (16.78)	265 (18.90)	131 (16.75)	31 (10.30)	33 (12.84)	
1–6 yrs	1028 (37.50)	560 (39.94)	289 (36.96)	105 (34.88)	74 (28.79)	
Literate, no formal education	192 (7.00)	90 (6.42)	53 (6.78)	21 (6.98)	28 (10.89)	
Illiterate	914 (33.33)	388 (27.67)	272 (34.78)	135 (44.85)	119 (46.30)	
Area of residence						.032
Urban	1121 (40.97)	563 (42.46)	304 (38.87)	128 (42.67)	96 (37.50)	
Suburban	612 (22.37)	327 (23.39)	173 (22.12)	49 (16.33)	63 (24.61)	
Rural	1003 (36.66)	478 (34.19)	305 (39.00)	123 (41.00)	97 (37.89)	
Type of residence						< .001
Community	2651 (96.93)	1379 (98.50)	752 (96.32)	290 (97.32)	230 (89.84)	
Institution	84 (3.07)	21 (1.50)	29 (3.71)	8 (2.68)	26 (10.16)	
Living						< .001
Living with others	1844 (67.50)	1010 (72.40)	523 (67.14)	173 (57.48)	138 (53.70)	
Living alone	888 (32.50)	385 (27.60)	256 (32.86)	128 (42.52)	119 (46.30)	
Perceived health status						< .001
Excellent	245 (8.94)	165 (11.77)	62 (7.93)	10 (3.21)	8 (3.11)	
Good	612 (22.32)	415 (29.60)	139 (17.77)	42 (13.95)	16 (6.23)	
Fair	846 (30.85)	487 (34.74)	242 (30.95)	85 (28.24)	32 (12.45)	
Poor	249 (9.08)	46 (3.28)	78 (9.97)	34 (11.30)	91 (35.41)	
Very poor	790 (28.81)	289 (20.61)	261 (33.38)	130 (43.19)	110 (42.80)	
Health behavior						
Smoking						< .001
Never	1626 (5930)	765 (54.56)	474 (60.61)	215 (71.43)	172 (66.93)	
Previous	623 (22.72)	339 (24.18)	173 (22.12)	51 (16.94)	60 (23.34)	
Current	493 (17.98)	298 (21.26)	135 (17.26)	35 (11.63)	25 (9.73)	
Alcohol drinking						< .001
Never	2129 (77.64)	1023 (72.97)	611 (78.13)	256 (85.05)	239 (93.00)	
Social	424 (15.46)	252 (17.97)	122 (15.60)	34 (11.30)	16 (6.23)	
Regular	189 (6.89)	127 (9.06)	49 (6.27)	11 (3.65)	2 (0.78)	
Exercise						< .001
Regular exercise	1595 (58.17)	942 (67.19)	457 (58.44)	149 (49.50)	47 (18.29)	
No regular exercise	1147 (41.83)	460 (32.81)	325 (41.56)	152 (50.50)	210 (81.71)	
Chronic diseases						
Diabetes mellitus	477 (17.40)	192 (13.69)	151 (19.31)	57 (18.94)	77 (29.96)	< .001
Hypertension	1172 (42.74)	533 (38.02)	353 (45.14)	143 (47.51)	143 (55.64)	< .001
Heart diseases	672 (24.51)	278 (19.83)	219 (28.01)	86 (28.57)	89 (34.63)	< .001
Stroke	241 (8.80)	74 (5.29)	78 (9.97)	26 (8.64)	63 (24.51)	< .001
Malignant neoplasm	92 (3.36)	39 (2.78)	28 (3.58)	7 (2.33)	18 (7.00)	.005
Lung diseases	405 (14.78)	162 (11.55)	127 (16.24)	49 (16.33)	67 (26.07)	< .001
Gastric diseases	599 (21.85)	276 (19.69)	168 (21.48)	75 (24.92)	80 (31.13)	< .001
Liver diseases	246 (8.98)	122 (8.70)	73 (9.34)	25 (8.33)	26 (10.16)	.840
Renal diseases	283 (10.32)	106 (7.56)	88 (11.25)	46 (15.28)	43 (16.73)	< .001
Gout	276 (10.07)	124 (8.84)	96 (12.28)	32 (10.63)	24 (9.34)	.079
Spondylosis	347 (12.66)	157 (11.20)	100 (12.80)	46 (15.28)	44 (17.12)	.027
Osteoporosis	655 (23.89)	267 (19.04)	194 (24.81)	106 (35.22)	88 (34.24)	< .001
Rheumatism	747 (27.27)	301 (21.48)	244 (31.28)	111 (36.88)	91 (35.41)	< .001
History of hip fracture	128 (4.69)	38 (2.72)	31 (3.98)	25 (8.36)	34 (13.23)	< .001
Cataract	1069 (39.00)	500 (35.66)	331 (42.33)	129 (42.86)	109 (42.58)	.004
BMI (kg/m^2), WHO criteria for Asian						< .001
Underweight, < 18.5	162 (6.41)	59 (4.38)	57 (8.03)	24 (8.66)	22 (11.28)	
Normal, ≥ 18.5 to < 23	1010 (39.94)	525 (38.98)	289 (40.70)	118 (42.60)	78 (40.00)	
Overweight, ≥ 23 to < 25	568 (22.46)	333 (24.72)	148 (20.85)	47 (16.97)	40 (20.51)	
Obesity, ≥ 25	789 (31.20)	430 (31.92)	216 (30.42)	88 (31.77)	55 (28.21)	
Geriatric conditions						
Urinary incontinence	484 (17.65)	0	160 (20.46)	126 (41.86)	198 (77.04)	< .001
Repeated falls	272 (9.92)	0	90 (11.51)	77 (25.58)	105 (40.86)	< .001
Functional impairment	377 (13.75)	0	108 (13.81)	73 (24.25)	196 (76.26)	< .001
Cognitive impairment	322 (11.74)	0	91 (11.64)	77 (25.58)	154 (59.92)	< .001
Depressive condition	588 (21.44)	0	214 (27.37)	171 (56.81)	203 (78.99)	< .001
Underweight	162 (5.91)	0	67 (2.44)	52 (1.90)	43 (1.57)	.001

BMI: body mass index.

Table 2
Generalized logistic regression analysis of increase in number of geriatric conditions.

Variables	Odds ratio	95% confidence interval	p-value
Age			
75–< 85 yrs/65–< 75 yrs	1.26	1.071–1.488	.006
≥ 85 yrs/65–< 75 yrs	1.90	1.422–2.537	< .001
Sex (male/female)	0.70	0.570–0.855	< .001
Education level			
> 12 yrs/illiterate	0.77	0.507–1.164	.214
7–12 yrs/illiterate	0.92	0.705–1.187	.503
1–6 yrs/illiterate	0.84	0.696–1.024	.086
Literate /illiterate	1.17	0.854–1.602	.330
Area of residence			
Urban/rural	0.88	0.735–1.061	.185
Suburban/rural	0.72	0.582–0.888	.002
Type of residence (long-term care facility/community)	1.81	1.179–2.769	.007
Living status (living alone/living with others)	1.32	1.120–1.559	.001
Perceived health status			
Excellent/fair	0.91	0.665–1.252	.571
Good/fair	0.76	0.602–0.949	.016
Poor/fair	4.31	3.207–5.794	< .001
Very poor/fair	2.00	1.635–2.436	< .001
Healthy behavior			
Smoking			
Previous/Never	1.07	0.852–1.332	.577
Current/Never	0.95	0.745–1.206	.663
Alcohol drinking			
Social/Never	0.73	0.577–0.924	.009
Regular/Never	0.68	0.482–0.969	.033
Regular exercise (yes/no)	0.43	0.365–0.500	< .001
Chronic diseases (yes/no)			
Hypertension	1.05	0.889–1.234	.579
Diabetes mellitus	1.19	0.970–1.453	.096
Heart diseases	1.04	0.868–1.256	.648
Stroke	1.47	1.123–1.933	.005
Malignant neoplasm	1.21	0.803–1.835	.358
Lung diseases	1.33	1.074–1.650	.009
Gastric diseases	1.14	0.947–1.381	.163
Liver diseases	0.64	0.488–0.844	.002
Renal diseases	1.34	1.045–1.711	.021
Gout	0.98	0.760–1.268	.887
Spondylosis	1.09	0.862–1.375	.477
Osteoporosis	1.18	0.980–1.424	.080
Rheumatism	1.42	1.188–1.698	< .001
History of hip fracture	1.59	1.123–2.255	.009
Cataract	0.97	0.828–1.144	.741

Table 3
Coexistence associations of individual geriatric conditions.

Variables	Urinary incontinence (yes/no) OR (95% CI)	Repeated falls (yes/no) OR (95% CI)	ADL (yes/no) OR (95% CI)	Cognitive (yes/no) OR (95% CI)	Depression (yes/no) OR (95% CI)	Underweight (yes/no) OR (95% CI)
Urinary incontinence		1.75 (1.284–2.396)***	2.30 (1.689–3.126)***	2.06 (1.531–2.770)***	1.76 (1.361–2.268)***	0.85 (0.546–1.332)
Repeated falls	1.73 (1.270–2.359)***		1.64 (1.125–2.384)*	1.39 (0.969–1.998)	1.70 (1.246–2.320)***	0.60 (0.320–1.048)
Functional impairment	2.14 (1.579–2.900)***	1.58 (1.089–2.304)*		2.34 (1.673–3.277)***	1.84 (1.351–2.499)***	1.05 (0.635–1.731)
Cognitive impairment	2.03 (1.499–2.736)***	1.31 (0.903–1.907)	2.26 (1.589–3.219)***		2.76 (2.061–3.701)***	1.01 (0.617–1.667)
Depressive condition	1.70 (1.316–2.199)***	1.71 (1.254–2.333)***	1.81 (1.326–2.480)***	2.70 (2.015–3.610)***		2.21 (1.507–3.249)***
Underweight	0.88 (0.567–1.371)	0.61 (0.339–1.110)	1.16 (0.706–1.913)	1.08 (0.664–1.749)	2.22 (1.517–3.255)***	

Note. All the analyses were adjusted for age (75–< 85/65–< 75 years, ≥ 85/65–< 75 years), sex (male/female), area of residence (suburban/rural), institutional care status (institution/community, living status (alone/with others), perceived health (good/fair, poor/fair, very poor/fair), alcohol consumption (social/never), regular exercise (yes/no), stroke (yes/no), lung diseases (yes/no), liver diseases (yes/no), renal diseases (yes/no), rheumatism (yes/no), and history of hip fracture (yes/no).
OR: odds ratio; CI: confidence interval; ADL: activities of daily living. *: $p < .05$; **: $p < .01$; ***: $p < .001$.

4. Discussion

Previous studies have not extensively investigated the cumulative effect and coexistence of GCs. Our study used a Taiwanese nationwide representative sample to demonstrate that most GCs, namely repeated falls, cognitive impairment, depressive condition, functional impairment, and urinary incontinence, were clustered as a group of conditions and were more likely to be present in individuals

Table 4
Association of presence of any geriatric condition with increasing number of geriatric conditions.

Dependent variables	1 geriatric condition[a]	2 geriatric conditions[b]	= 3 geriatric conditions[b]
Variables	Odds ratio per 1 geriatric condition increase		
Urinary incontinence	1.87***	2.54***	3.58***
Repeated falls	1.98***	2.57***	3.41***
Functional impairment	1.87***	2.44***	4.02***
Cognitive impairment	1.99***	2.41***	3.73***
Depressive condition	2.00***	2.74***	3.82***
Underweight	1.95***	2.45***	2.70***

Note. All the analyses were adjusted for age (75–< 85/65–< 75 years, ≥ 85/65–< 75 years), sex (male/female), area of residence (suburban/rural), institutional care status (institution/community), living status (alone/with others), perceived health (good/fair, poor/fair, very poor/fair), alcohol consumption (social/never), regular exercise (yes/no), stroke (yes/no), lung diseases (yes/no), liver diseases (yes/no), renal diseases (yes/no), rheumatism (yes/no), and history of hip fracture (yes/no).
The results were analyzed by [a] multiple logistic regression and [b] stepwise regression analysis.
*: $p < .05$; **: $p < .01$; ***: $p < .001$.

with more GCs (≥ 3) and those aged ≥ 85 years, indicating the need for early screening and management, especially for much older adults.

Our study demonstrated that more than half of the participants had no GC, and more than a quarter had only 1 GC. Previous studies have reported that 50% to 80% of older adults had at least 1 GC.[1,19,20] The disparity between our results and those of previous studies may be attributed to the study participants (e.g., some previous studies did not employ randomly recruitment) and variables of interest (i.e., different definitions for GC domains were included).[1,19,20] As the population ages, the high prevalence and the subtle or nonspecific characteristics of GCs may result in them being unrecognized in the conventional disease-based care model unless they are emphasized in older adult health care.

In the sample population, older age, female sex, institutional residency, living alone, poor self-perceived health status, and history of chronic diseases were significantly associated with more GCs. A study that reviewed 79 articles related to GCs reported 6 possible shared risk and protective factors: age, biological sex, education, daily living function, self-rated health, and chronic diseases.[12] Detailed discussions and impacts of risks of GCs are addressed in the following paragraphs. To enhance prevention and early intervention, screening of older adults who are at risk of high numbers of GCs is necessary.

The current study demonstrated that histories of multiple chronic diseases (diabetes, stroke, renal diseases, osteoporosis, rheumatism, a history of hip fracture) were significantly associated with higher number of GCs. A survey of 11,093 older adults from the Health and Retirement Study revealed that diabetes, musculoskeletal disorder, and stroke were associated with risks of higher numbers of GCs.[1] Another study of 6,903 older adults receiving home care services in 11 European countries demonstrated that Parkinsonism, cerebrovascular, and peripheral artery diseases were associated with higher numbers of GCs.[2] Other studies have revealed that cognitive and mood disorders were common in older patients with hip fracture and were associated with greater risk of poor outcomes.[34] By contrast, our study indicated that cancer was not significantly associated with an increased number of GCs. This result is consistent with those of Cigolle and Vetrano, probably because patients with cancer may either recover or deteriorate too rapidly to get GC diagnoses within the follow-up years.[1,2] Nevertheless, the coexistence of

Table 5
Inertia and chi-square decomposition of dimensions and loadings of age groups and 6 geriatric conditions in multiple correspondence analysis.

	1st dimension	2nd dimension	Total
Singular value	0.53	0.39	0.92
Inertia	0.28	0.15	0.43
Inertia proportion	65.1%	34.9%	
Chi-square	6040.4	3278.0	9,318.4 ($p < 0.001$)
Variance proportion	27.6%	15.0%	

Category	1st dimension[a]	2nd dimension[a]
Urinary incontinence	0.145	0.021
No_urinary incontinence	0.031	0.004
Repeated falls	0.078	0.048
No_repeated falls	0.009	0.005
Functional impairment	0.209	0.002
No_functional impairment	0.033	0.000
Cognitive impairment	0.192	0.000
No_cognitive impairment	0.026	0.000
Depressive condition	0.163	0.007
No_depressive condition	0.044	0.002
Underweight	0.014	0.510
No_underweight	0.001	0.032
65–< 75 years	0.016	0.147
75–< 85 years	0.001	0.185
≥ 85 years	0.039	0.036

[a]: The relative contribution (loading) of age group and 6 geriatric conditions across the 2 dimensions.

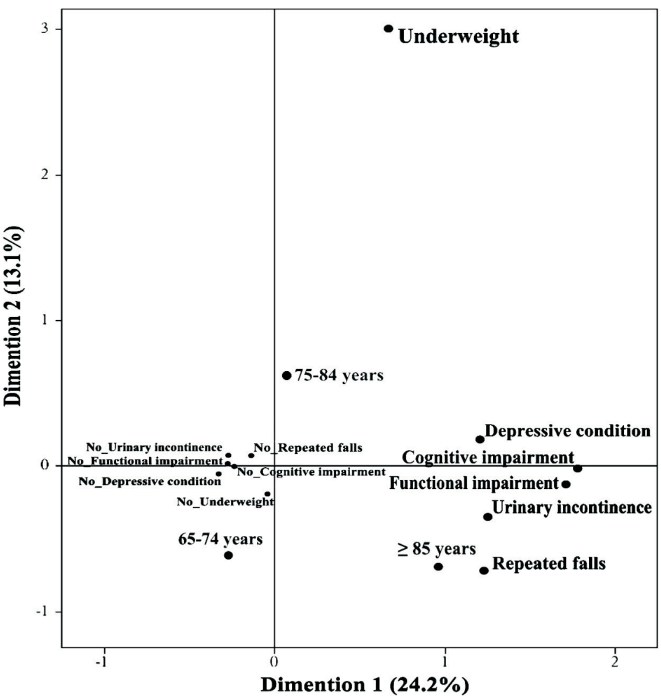

Figure 1. Factor map of multiple correspondence analysis of data pertaining to age group and 6 geriatric conditions.

GCs should be assessed among older adults with the aforementioned chronic diseases.

Our findings indicate that most of the investigated GCs coexisted. Similar to the findings of previous studies, functional impairment was strongly associated with occurrence of other GCs.[1,20] Tinetti[35] noted that GCs may predispose individuals to functional dependence when impairments in multiple domains compromise compensatory ability. Lee et al.[36] reported that falls occurred twice as often in cases with incontinence, but they did not analyze the co-occurrence of any other GCs. Relevant studies have reported a strong association between depression and subsequent fall accidents in older adults.[8,37] In addition, the coexistence of GCs may represent bidirectional associations, including that of depression and falls[9] or memory and physical function.[11] Such findings suggest that one GC may increase the likelihood of another GC; however, this is usually not a one-way straight-line result, and more interactions between GCs are possible, resulting in acumulative effect.[9,21] In addition to biological factors, the cumulative effect of concurrent GCs in the elderly population is commonly influenced by psychological, social, economic or environmental factors that exacerbate the negative health effects of any or all of the GCs involved. Such an effect was regarded as syndemic effect.[23] Due to the higher impact of the syndemic and aggregated effects of concurrent GCs, a brief screening and comprehensive management[22,38,39] are mandatory are essential for those old adults at high risk.

Our study's MCA reveals that most of the GCs were significantly prone to coexistence, especially among the ≥ 85-year age group. However, underweight was not significantly associated with the other GCs. This may have been partly because underweight status alone does not represent malnutrition. A 1-year follow-up study on chronically ill older adults with cognitive and functional disabilities who were residing in sheltered housing suggested that the rate of underweight did not increase significantly (from 35% to 38%); however, 39% of them registered decreases in weight.[40] A Subjective Global Assessment-based study reported that disease-related malnutrition was associated with disturbed tissue properties (measured using bioelectrical impedance vector analysis), but these disturbances were not observed in patients with underweight (according to BMI). BMI alone is also not a suitable tool for identifying risk of malnutrition; instead, results of Subjective Global Assessment or a history of recent loss of body weight may be superior predictors of malnutrition.

In summary, the presence of any 1 GC was significantly associated with increasing number of GCs over time. This implies that any GC is associated with occurrence of another GC, thus triggering a vicious cycle or geriatric cascade. To restore compensatory ability and prevent or delay the onset of multiple GCs, a more unified approach addressing a shared set of predisposing factors for GCs should be developed.[35]

This study has some limitations. First, only 6 GCs were considered in the analysis, and information on certain conditions, such as frailty, nutritional status, sleeping disturbances, and visual or hearing impairment, were not collected in the questionnaires. Second, the information was obtained through self-reported survey responses, and no biochemistry tests were conducted; therefore, the severity of the chronic diseases was unknown. Third, because of the cross-sectional design, the temporal sequence of GC occurrence could not be confirmed. In addition, survival biases may have influenced the estimates. Thus, further longitudinal studies are required to clarify such temporal associations.

5. Conclusions

Our study highlights the coexistence of GCs and the increasing occurrence of additional GCs in older adults. Older age, female sex, institutional residency, living alone, poor self-perceived health status, and history of specific chronic diseases were significantly associated with higher numbers of GCs. Clinicians should be aware of the occurrence of GCs in oldest old adults, and those at high risk. Screening, in-depth evaluation, and early intervention of GCs are essential in clinical practice.[39,40]

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Competing interests

The authors declare no conflicts of interest.

References

1. Cigolle CT, Langa KM, Kabeto MU, Tian Z, Blaum CS. Geriatric conditions and disability: the Health and Retirement Study. *Ann Intern Med*. 2007; 147(3):156–164. doi:10.7326/0003-4819-147-3-200708070-00004
2. Vetrano DL, Foebel AD, Marengoni A, et al. Chronic diseases and geriatric syndromes: the different weight of comorbidity. *Eur J Intern Med*. 2016; 27:62–67. doi:10.1016/j.ejim.2015.10.025
3. Cheung JTK, Yu R, Wu Z, Wong SYS, Woo J. Geriatric syndromes, multimorbidity, and disability overlap and increase healthcare use among older Chinese. *BMC Geriatr*. 2018;18(1):147. doi:10.1186/s12877-018-0840-1
4. Chiu CJ, Cheng YY. Utility of geriatric syndrome indicators for predicting subsequent health care utilization in older adults in Taiwan. *Int J Environ Res Public Health*. 2019;16(3):456. doi:10.3390/ijerph16030456
5. Wang HH, Sheu JT, Shyu YI, Chang HY, Li CL. Geriatric conditions as predictors of increased number of hospital admissions and hospital bed days over one year: findings of a nationwide cohort of older adults from Taiwan. *Arch Gerontol Geriatr*. 2014;59(1):169–174. doi:10.1016/j.archger.2014.02.002
6. Yang DC, Lee JD, Huang CC, Shih HI, Chang CM. Association between multiple geriatric syndromes and life satisfaction in community-dwelling older adults: a nationwide study in Taiwan. *Arch Gerontol Geriatr*. 2015; 60(3):437–442. doi:10.1016/j.archger.2015.02.001
7. Huang CC, Lee JD, Yang DC, Shih HI, Sun CY, Chang CM. Associations between geriatric syndromes and mortality in community-dwelling elderly: results of a national longitudinal study in Taiwan [published correction appears in J Am Med Dir Assoc. 2017 Apr 1;18(4):365. doi: 10.1016/j.jamda.2017.02.017]. *J Am Med Dir Assoc*. 2017;18(3):246–251. doi:10.1016/j.jamda.2016.09.017
8. Kvelde T, McVeigh C, Toson B, et al. Depressive symptomatology as a risk factor for falls in older people: systematic review and meta-analysis. *J Am Geriatr Soc*. 2013;61(5):694–706. doi:10.1111/jgs.12209
9. Kvelde T, Lord SR, Close JCT, et al. Depressive symptoms increase fall risk in older people, independent of antidepressant use, and reduced executive and physical functioning. *Arch Gerontol Geriatr*. 2015;60(1):190–195. doi:10.1016/j.archger.2014.09.003
10. Morley JE. Bidirectional communication between brain and muscle. *J Nutr Health Aging*. 2018;22(10):1144–1145. doi:10.1007/s12603-018-1141-2
11. Chen S, Honda T, Narazaki K, et al. Physical frailty is associated with longitudinal decline in global cognitive function in non-demented older adults: a prospective study. *J Nutr Health Aging*. 2018;22(1):82–88. doi:10.1007/s12603-017-0924-1
12. Wu CH, Chang CI, Chen CY. Overview of studies related to geriatric syndrome in Taiwan. *J Clin Gerontol Geriatr.* 2012;3(1):14–20. doi:10.1016/j.jcgg.2011.05.002
13. Alexopoulos GS. Clinical and biological interactions in affective and cognitive geriatric syndromes. *Am J Psychiatry*. 2003;160(5):811–814. doi:10.1176/appi.ajp.160.5.811
14. Kupisz-Urbanska M, Marcinowska-Suchowierska E. Malnutrition in older adults-effect on falls and fractures: a narrative review. *Nutrients*. 2022; 14(15):3123. doi:10.3390/nu14153123
15. Alhalaseh L, Makahleh H, Al-Saleem B, Al-Omran F, Schoenmakers B.

Functional status in relation to common geriatric syndromes and sociodemographic variables–A step forward towards healthy aging. *Clin Interv Aging*. 2024;19:901–910. doi:10.2147/CIA.S462347

16. Calderón-Larrañaga A, Vetrano DL, Ferrucci L, et al. Multimorbidity and functional impairment–bidirectional interplay, synergistic effects and common pathways. *J Intern Med*. 2019;285(3):255–271. doi:10.1111/joim.12843
17. Arokiasamy P, Uttamacharya U, Jain K, et al. The impact of multimorbidity on adult physical and mental health in low- and middle-income countries: what does the study on global ageing and adult health (SAGE) reveal? *BMC Med.* 2015;13:178. doi:10.1186/s12916-015-0402-8
18. Liu T, Man XY, Miao XX. Geriatric syndromes and the cumulative impacts on quality of life in older people with type 2 diabetes mellitus. *Int J Diabetes Dev Ctries*. 2021;41:148–155. doi:10.1007/s13410-020-00848-x
19. Ates Bulut E, Soysal P, Isik AT. Frequency and coincidence of geriatric syndromes according to age groups: single-center experience in Turkey between 2013 and 2017. *Clin Interv Aging*. 2018;13:1899–1905. doi:10.2147/CIA.S180281
20. Tabue-Teguo M, Grasset L, Avila-Funes JA, et al. Prevalence and co-occurrence of geriatric syndromes in people aged 75 years and older in France: results from the Bordeaux three-city study. *J Gerontol A Biol Sci Med Sci*. 2017;73(1):109–116. doi:10.1093/gerona/glx068
21. Szabat K, Halubiec P, Wasko M, Kenig J. Effectiveness of geriatric assessment in predicting postoperative morbidity after laparoscopic surgery in older patients: A systematic review. *Int J Gerontol*. 2021;15(3):188–194. doi:10.6890/IJGE.202107_15(3).0001
22. Singer M, Bulled N, Ostrach B, Mendenhall E. Syndemics and the biosocial conception of health. *Lancet*. 2017;389(10072):941–950. doi:10.1016/S0140-6736(17)30003-X
23. Mendenhall E, Kohrt BA, Logie CH, Tsai AC. Syndemics and clinical science. *Nat Med*. 2022;28(7):1359–1362. doi:10.1038/s41591-022-01888-y
24. Hermalin A, Liang J, Chang MC. *Survey of the health and living status of the elderly in Taiwan: questionnaire and survey design*. Michigan Population Studies Center; 1989.
25. Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of illness in the aged: the index of ADL: a standardized measure of biological and psychosocial function. *JAMA*. 1963;185:914–919. doi:10.1001/jama.1963.03060120024016
26. Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. *J Am Geriatr Soc*. 1975;23(10):433–441. doi:10.1111/j.1532-5415.1975.tb00927.x
27. Erkinjuntti T, Sulkava R, Wikström J, Autio L. Short Portable Mental Status Questionnaire as a screening test for dementia and delirium among the elderly. *J Am Geriatr Soc*. 1987;35(5):412–416. doi:10.1111/j.1532-5415.1987.tb04662.x
28. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas*. 1977;1(3):385–401. doi:10.1177/014662167700100306
29. Andresen EM, Malmgren JA, Carter WB, Patrick DL. Screening for depression in well older adults: evaluation of a short form of the CES-D (Center for Epidemiologic Studies Depression Scale). *Am J Prev Med*. 1994;10(2):77–84.
30. McDowell I. Measures of self-perceived well-being. *J Psychosom Res*. 2010;69(1):69–79. doi:10.1016/j.jpsychores.2009.07.002
31. Blasius J, Greenacre M. *Visualization and verbalization of data*. 1st ed. Chapman and Hall/CRC Press; 2014.
32. Ezzedine K, Bergqvist C, Baissac C, et al. Use of multiple correspondence analysis to explore associations between caregivers and sun protective habits during summer vacations. *Clin Exp Dermatol*. 2024;49(1):26–34. doi:10.1093/ced/llad260
33. Sourial N, Wolfson C, Zhu B, et al. Correspondence analysis is a useful tool to uncover the relationships among categorical variables. *J Clin Epidemiol*. 2010;63(6):638–646. doi:10.1016/j.jclinepi.2009.08.008
34. Piscitelli P, Metozzi A, Benvenuti E, et al. Connections between the outcomes of osteoporotic hip fractures and depression, delirium or dementia in elderly patients: rationale and preliminary data from the CODE study. *Clin Cases Miner Bone Metab*. 2012;9(1):40–44.
35. Tinetti ME, Inouye SK, Gill TM, Doucette JT. Shared risk factors for falls, incontinence, and functional dependence: unifying the approach to geriatric syndromes. *JAMA*. 1995;273(17):1348–1353.
36. Lee PG, Cigolle C, Blaum C. The co-occurrence of chronic diseases and geriatric syndromes: the health and retirement study. *J Am Geriatr Soc*. 2009;57(3):511–516. doi:10.1111/j.1532-5415.2008.02150.x
37. Wu H, Ouyang P. Fall prevalence, time trend and its related risk factors among elderly people in China. *Arch Gerontol Geriatr*. 2017;73:294–299. doi:10.1016/j.archger.2017.08.009
38. Chang CM, Lin CY, Hu FW, et al. Clinimetric properties of the “FIND-NEEDS” to screen geriatric conditions. *Gerontology.* 2024;70(9):893–902. doi:10.1159/000539261
39. Hung YY, Wang WF, Chang MC, Jhang KM. The effectiveness of an outpatient personalized multidisciplinary intervention model, guided by comprehensive geriatric assessment, for pre-frail and frail elderly. *Int J Gerontol*. 2022;16(2):89–94. doi:10.6890/IJGE.202204_16(2).0003
40. Mamhidir AG, Ljunggren G, Kihlgren M, Kihlgren A, Wimo A. Underweight, weight loss and related risk factors among older adults in sheltered housing-a Swedish follow-up study. *J Nutr Health Aging*. 2006;10(4):255–262.