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ORIGINAL RESEARCH

Caregivers' Burden on Patients with Dementia Having Multiple Chronic Diseases

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Purpose: This study aimed to find the caregiving burden level for patients with dementia who had multiple chronic diseases by simultaneously considering both patient and caregiver factors.
Participants and Methods: A cross-sectional study with 284 patients with dementia having multiple chronic diseases managed by the dementia collaborative care team at Changhua Christian Hospital in Taiwan was conducted. The input variables were from patients, such as age, gender, mood symptoms, and behavioral and psychological symptoms, and caregivers, including age, relation to the patient, caregiver's mood, and caregiving burden. The Apriori algorithm was employed to determine the association between patient and caregiver factors and different caregiving burden levels by setting up the minimum support of 1% and confidence of 90% along with lift >1.
Results: When caring for patients with dementia, twenty scenarios were found for caregivers with a severe burden. In addition, 1936 scenarios were related to caregivers with a moderate-to-severe burden. Specifically, there were eight scenarios for patients with three chronic diseases which could be further categorized into five general rules. Two hundred and fifty scenarios belonging to patients with two chronic diseases could be classified into 16 different combinations from eight chronic diseases of the database.
Conclusion: Caregiver's mood, patients with mild dementia, and patients aged 75–84 years were associated with a severe caregiving burden. College and above education of the caregiver, the patient aged 85 years or more, and at least one of caregiver's moods were the variables to result in a moderate-to-severe burden for caregivers caring for patients with three multiple chronic diseases. Moreover, college and above education of the caregiver, mood symptom, age of the caregiver, and age of the patient were important variables for caregivers who had a moderate-to-severe burden taking care of patients with two chronic diseases.

Keywords: patients with dementia, multiple chronic diseases, behavior and psychological symptoms of dementia, mood symptom, caregiving burden, dementia collaborative care team, apriori algorithm

Introduction

Dementia was a neurodegenerative illness strongly associated with aging. Taiwan was an aged society since 2022 and was predicted to become a super-aged society by 2025. The prevalence of all-cause dementia in Taiwanese above 65 years old was 8.04% according to a nationwide cross-sectional survey in 2014,[1] with an estimated number of 320,000 people living with dementia (PLWD) in 2030.[2]

Because of functional decline and neuropsychiatric symptoms, taking care of patients with dementia would often be associated with a high burden of care, especially over a prolonged period of time.[3] Caregiving burden influenced the clinical outcomes of both PLWD and their caregivers. A higher caregiving burden was associated with worse patient quality of life and prediction of institutionalization.[4,5] A high caregiving burden also reduced the caregivers' work productivity, reduced the caregivers' quality of life, and caused depressive symptoms.[6,7]

Many chronic diseases were found to be the risk factors of dementia, and patients with multiple chronic diseases were reported to have increased hazards for developing dementia.[8,9] Specifically, 83% of PLWD had 2 or more chronic comorbid

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conditions, and 18.4% of PLWD even had five or more.[10] The mechanisms leading to chronic diseases, such as hypertension, diabetes, or hyperlipidemia, had a link between atherosclerosis and Aβ metabolism, therefore increasing the risk of dementia.[11] A patient with Alzheimer's disease was also much more frail when bearing other pathologies.[12] PLWD with multiple chronic conditions (MCCs) had a more rapid progression and worse outcomes, including more hospitalization or emergency department visit, mortality, institutionalization, and functional decline than those with fewer conditions.[13–15] Most chronic diseases required some degree of self-management, and dementia could undermine this capacity.[16] Cognitive impairment could affect a person's ability to take their medications as prescribed, to accurately identify or report symptoms, and to manage personal care. The management of MCCs gradually became the caregiver's responsibility.[17] MCCs increased the caregiving load and complicated caregivers' transition experiences.[18] Caregivers usually experienced worse health conditions, deceased social life, and had higher responsibility while taking care of PLWD with MCCs.[18]

Determining factors predicting the caregiving burden was important for addressing care needs for both PLWD and their care partners.[19,20] Strategies to alleviate the caregiving burden might help maintain patients' living in the community and improve caregivers' quality of life.[21] Factors associated with caregiving burden were complex and varied with time.[3] Patient factors included neuropsychiatric symptoms, daily functional limitations, and duration of illness, while caregiver factors such as poor physical and mental health status, low education level, cohabitation with the patient, and female gender were associated with a higher burden of caregiving.[3,22] Better family functioning and higher income had been reported to reduce the burden of the caregiver.[22]

The effect of dementia on caregiving and the caregiving burden in the context of MCCs had been poorly characterized.[23] Dauphinot et al[24] reported the caregiving burden was higher when patients' comorbidities increased, and dementia might be the comorbidity that contributed the most to the caregiving burden. Ding et al[25] found that ethnicity or caregiving load but not dementia was associated with a higher caregiving burden in frail older patients with MCCs. Liu et al[26] concluded that the adult-child primary caregiver experienced a higher burden when taking care of dementia patients with more comorbidities, and the condition was even worse when the spouse of the patient served as the secondary caregiver. Because relatively few studies were reported, we tried to elucidate patient and caregiver factors associated with a high caregiving burden in patients with dementia and MCCs. The aim of the present study was as follows: (1) to determine caring scenarios of a severe caregiving burden and (2) to categorize factors associated with a moderate-to-severe caregiving burden according to the number of MCCs.

Participants and Methods

Patients diagnosed with dementia at the memory clinic of the Changhua Christian Hospital from November 2015 to August 2022 were enrolled in this study. A clinical psychologist diagnosed each patient's dementia in accordance with the Clinical Dementia Rating (CDR) Scale.[27] The clinical trial was approved by the Institutional Review Board of Changhua Christian Hospital (CCH IRB 220928). There was no need for informed consent approved by the Institutional Review Board of Changhua Christian Hospital due to a retrospective study design. All data were recorded in an electronic medical chart with the highest confidentiality and compliance with the Declaration of Helsinki. There were 284 patients who had complete data for analysis. To better reflect the conditions of patients with dementia who had multiple chronic diseases and their caregivers on a timely basis, the most recent diagnosis and interview data were used. It was worth to note that a patient with multiple chronic diseases was defined to have two or more chronic diseases from a list of the database at Changhua Christian Hospital, ie, cardiovascular disease, cerebrovascular disease, hypertension, diabetes, hyperlipidemia, chronic kidney disease, anemia, and hearing impairment.

The variables from patients with dementia who had multiple chronic diseases were summarized in Table 1, including their age, gender, marital status, type of dementia, chronic disease, and CDR. The follow-up information consisting of patients' feeding, hypnotics, mood symptoms, and behavioral and psychological symptoms was depicted in Table 2. More than 77% of the patients were aged 75 years and above, and female patients were more than 60%. The majority of patients were married (60.6%), and Alzheimer's disease was the major type of dementia (55.6%). Hypertension, diabetes, and hyperlipidemia were the top 3 chronic diseases among the patients. Moreover, nearly 60% of the patients had a very mild dementia. The majority of the patients could feed independently (94.7%) and did not need to use hypnotics (75.0%). The top 3 mood symptoms in frequency were dysthymia (20.1%), anger (15.8%), and emotional liability (14.4%). Finally, the top 3 behavioral and psychological symptoms in frequency were delusion (16.2%), hallucination (8.5%), and

Table 1 Variables from Patients with Dementia

Variables		**Frequency**	**Percentage**	**Data Type**
Age	< 65 years old	10	3.5	1
	65–74 years old	54	19.0	2
	75–84 years old	127	44.7	3
	≥ 85 years old	93	32.7	4
Gender	Female	176	62.0	0
	Male	108	38.0	1
Marital status	Married	172	60.6	1
	Divorce	3	1.0	2
	Widow/Widower	105	37.0	3
	Separate	3	1.0	4
	Single	1	0.4	5
Type of dementia	Alzheimer's disease	158	55.6	1
	Vascular dementia	55	19.4	2
	Mixed dementia	7	2.5	3
	Dementia with Lewy bodies	8	2.8	4
	Parkinson's disease	14	4.9	5
	Frontotemporal degeneration	6	2.1	6
	Others	36	12.7	7
Chronic disease (multiple choice)	Cardiovascular disease	27	9.5	1: with the disease; and 0: without the disease
	Cerebrovascular disease	43	16.2	
	Hypertension	222	78.2	
	Diabetes	193	68.0	
	Hyperlipidemia	186	65.5	
	Chronic kidney disease	47	16.5	
	Anemia	102	35.9	
	Hearing impairment	81	28.5	
Clinical dementia rating	Very mild dementia	164	57.7	0
	Mild dementia	92	32.4	1
	Moderate dementia	23	8.1	2
	Severe dementia	5	1.8	3

nighttime behavior (6.7%). The presence of behavioral and psychological symptoms of dementia (BPSD) was evaluated by psychologists or trained nursing case managers, and most of the BPSD listed in the neuropsychiatric inventory were recorded. Other abnormal behaviors frequently observed in dementia patients such as wandering, pathological crying or laughing, curse, akathisia, and akinesia were noted by trained nursing case managers.

There were nine variables from caregivers including age, relation to the patient, marital status, education, employment, type of primary care, frequency of care, caregiver's mood, and caregiving burden as shown in Table 3. The caregiving burden evaluated by the Zarit burden interview was classified into four categories, including little or no burden (0–20 points), mild-to-moderate burden (21–40 points), moderate-to-severe burden (41–60 points), and severe burden (61–88 points).[28] If a caregiving burden belonged to a particular category, a value of 1 was assigned, and a value of zero was given to the other three categories. The majority of caregivers were married (82.0%), patients' children (63.7%), and less than 60 years old (61.9%). Nearly half of caregivers were college and above educated (45.1%), and most of them were employed (61.3%). The major type of primary care was shared caregiving by a caregiver and a foreign worker/household (41.5%), and the frequency of care with ≥6 days per week was incurred most often (80.6%). The top 3 caregiver's moods were troublesome (33.1%), nervousness (30.6%), and anger (19.7%). Finally, the major caregiving burden fell in either mild-to-moderate burden (50.4%) or little or no burden (33.8%).

Table 2 Follow-Up Variables of Patients with Dementia Who Had Multiple Chronic Diseases

Variables		Frequency	Percentage	Data Type
Feeding	Independent	269	94.7	0
	Feed by others	12	4.2	1
	On nasogastric tube	3	1.1	2
Hypnotics	No use	213	75.0	0
	Fair response	45	15.8	1
	Poor response	26	9.2	2
Mood symptoms (multiple choice)	Pathological crying or laughing	4	1.4	1: with the symptom; and 0: without the symptom
	Phobia	1	0.4	
	Dysthymia	57	20.1	
	Depression	40	14.1	
	Anxiety	30	10.6	
	Worry	18	6.3	
	Anger	45	15.8	
	Irritability	33	11.6	
	Emotional liability	41	14.4	
	Apathy	10	3.5	
Behavioral and psychological symptoms (multiple choice)	Agitation	12	4.2	1: with the symptom; and 0: without the symptom
	Akathisia	6	2.1	
	Wandering	2	0.7	
	Screaming	0	0	
	Curse	8	2.8	
	Pacing	0	0	
	Shadowing	0	0	
	Aggression (verbal/body)	8	2.8	
	Disinhibition	1	0.4	
	Akinesia	4	1.4	
	Nighttime behavior	19	6.7	
	Aberrant motor behavior (stereotype)	5	1.8	
	Delusion	46	16.2	
	Hallucination	24	8.5	
	Misidentification	7	2.5	

This study aimed to determine caring scenarios of a severe caregiving burden as well as to elucidate factors associated with a moderate-to-severe caregiving burden in accordance with the number of MCCs listed in the database at Changhua Christian Hospital. Studies such as Chen et al[29] and Jhang et al[30] showed that the Apriori algorithm was an effective approach to find caring scenarios of caregiving burden associated with PLWD and their caregivers by revealing statistical associations through setting up support, confidence, and lift. The terminologies of support, confidence, and lift were described below.[31–34] The support (A ⇒ B) was defined to calculate the percentage of transactions containing both A and B in the database, depicted in Equation (1):

$$\text{Support } (\text{A} \Rightarrow \text{B}) = P(A \cap B) = \frac{\text{number of transactions containing both Aand B}}{\text{total number of transactions}} \tag{1}$$

The confidence (A ⇒ B), as shown in Equation (2), was to compute the percentage of transactions containing A and also containing B simultaneously in the database:

$$\text{Confidence } (\text{A} \Rightarrow \text{B}) = P(B|A) = \frac{P(A \cap B)}{P(A)} = \frac{\text{number of transactions containing both Aand B}}{\text{number of transactions containing A}} \tag{2}$$

Table 3 Variables from Caregivers

Variables		**Frequency**	**Percentage**	**Data Type**
Age	< 50 years old 50–59 years old 60–69 years old ≥ 70 years old	70 106 54 54	24.6 37.3 19.0 19.0	1 2 3 4
Relation to the patient	Spouse Child Other relatives	69 181 34	24.3 63.7 12.0	1 2 3
Marital status	Married Divorce Widow/widower Separate Single	233 2 6 1 42	82.0 0.7 2.1 0.4 14.8	1 2 3 4 5
Education	Illiterate Elementary school Junior high school Senior high school College and above	5 33 22 96 128	1.8 11.6 7.7 33.8 45.1	1 2 3 4 5
Employment	Unemployed or retired Employed	110 174	38.7 61.3	0 1
Type of primary care	Sole caregiver Shared caregiving by a caregiver and a foreign worker/household Shared caregiving by different relatives Caregiving by a foreign worker Others	80 118 4 26 56	28.2 41.5 1.4 9.2 19.7	1 2 3 4 5
Frequency of care	1–2 days per week 3–5 days per week ≥ 6 days per week	28 27 229	9.9 9.5 80.6	1 2 3
Caregiver's mood (multiple choice)	Helplessness Loneliness Anxiety Frustration Nervousness Anger Sadness Emotional liability Troublesome Hopelessness	40 11 29 46 87 56 10 16 94 30	14.1 3.9 10.2 16.2 30.6 19.7 3.5 5.6 33.1 10.6	1: with the mood; and 0: without the mood
Caregiving burden	Little or no burden Mild-to-moderate burden Moderate-to-severe burden Severe burden	96 143 39 6	33.8 50.4 13.7 2.1	1: applied to a particular burden; and 0: otherwise

The lift measured the correlation between A and B to be either independent or dependent, depicted in Equation (3). If the lift value was equal to one, A and B were to be independent, and no rule would be generated containing either event. In contrast, if the lift value was greater than one, A and B were reported to be positively dependent.

$$\mathrm{Lift}\ (\mathrm{A}, \mathrm{B})\ = \frac{P(A \cap B)}{P(A)P(B)} \tag{3}$$

The Apriori algorithm in the IBM SPSS Modeler 18.0 was used. The data type for each variable was defined by numerical values and summarized in Tables 1–3. The input variables for antecedents included variables from Tables 1–3, with the exception of caregiving burden. In contrast, four types of caregiving burden were the input variables for consequents. Owing to the heterogeneous data, the minimum support and confidence were set to 1% and 90%, respectively, along with a lift of >1. If variable A and variable B were found in the antecedent and consequent in a rule, respectively, then variables A and B were highly associated. In our study, four types of caregiving burden were the consequent, the rules could reveal the possible combination of variables from patients and caregivers that might result in different types of caregiving burden for caregivers.

Results

There were 20, 1936, 35,661, and 2254 rules found for caregivers with severe burden, moderate-to-severe burden, mild-to-moderate burden, and little or no burden, respectively. Studies had found that caregivers who cared for patients with dementia reported higher levels of depression and anxiety, engagement in fewer protective health behaviors, and were at an increased risk of medical illness and mortality.[30,35–38] Compared with mild-to-moderate burden and little or no burden, caregivers who had severe burden and moderate-to-severe burden should be placed in a high priority. This study only focused on caregivers who had severe burden and moderate-to-severe burden. Twenty rules related to caregivers who had a severe burden could be further grouped into four general rules based on their similarities as shown in Table 4. The first general rule, containing six rules, characterized the caregiver as having a severe burden when the caregiver had the moods of helplessness, frustration, and anger who took care of a dementia patient whose age was 75–84 years. The second general rule was based on six rules that showed that the caregiver had a severe burden when the caregiver had the moods of helplessness and frustration who took care of a mild dementia patient whose age was 75–84 years.

The third general rule summarized seven rules that showed that the caregiver had a severe burden when the caregiver had the moods of helplessness and anger who took care of a mild dementia patient whose age was 75–84 years. In general, the other scenario, such as the caregiver was employed or married and the patient had hypertension, could eat

Table 4 Four General Rules for Caregivers with a Severe Burden

Rule no.	Antecedent	Support (%)	Confidence (%)	Lift
1	Age of the patient: 75–84 Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33
	Age of the patient: 75–84 Employment: Employed Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33
	Age of the patient: 75–84 Hypnotics: No use Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33
	Age of the patient: 75–84 Chronic disease: Hypertension Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33
	Age of the patient: 75–84 Caregivers' marital status: Married Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33
	Age of the patient: 75–84 Feeding: Independent Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33

(*Continued*)

Table 4 (Continued).

Rule no.	Antecedent	Support (%)	Confidence (%)	Lift
2	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Caregiver's mood: Helplessness and Frustration	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Employment: Employed Caregiver's mood: Helplessness and Frustration	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Hypnotics: No use Caregiver's mood: Helplessness and Frustration	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Chronic disease: Hypertension Caregiver's mood: Helplessness and Frustration	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Caregivers' marital status: Married Caregiver's mood: Helplessness and Frustration	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Feeding: Independent Caregiver's mood: Helplessness and Frustration	1.05	100	47.33
3	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Caregiver's mood: Helplessness and Anger	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Employment: Employed Caregiver's mood: Helplessness and Anger	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Hypnotics: No use Caregiver's mood: Helplessness and Anger	1.05	100	47.33
	Age of the patient: 75–84 Chronic disease: Hypertension Clinical dementia rating: Mild dementia Caregiver's mood: Helplessness and Anger	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Caregivers' marital status: Married Caregiver's mood: Helplessness and Anger	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Feeding: Independent Caregiver's mood: Helplessness and Anger	1.05	100	47.33
	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Caregiver's mood: Helplessness, Frustration, and Anger	1.05	100	47.33

(*Continued*)

Table 4 (Continued).

Rule no.	Antecedent	Support (%)	Confidence (%)	Lift
4	Age of the patient: 75–84 Clinical dementia rating: Mild dementia Hypnotics: No use Caregiver's mood: Frustration and Anger	1.05	100	47.33

independently, or did not use hypnotics, was not the necessary variable to result in a severe burden based on first three general rules. The fourth general rule included one rule. The rule reported that the caregiver had a severe burden when he or she had the moods of frustration and anger who took care of a mild dementia patient without using hypnotics whose age was 75–84 years. Based upon these four general rules, caregivers' moods (such as helplessness, frustration, and anger), patients' CDR (such as mild dementia), and patients aged 75–84 years were critical variables which were highly associated with a severe caregiving burden.

There were 1936 rules related to a moderate-to-severe caregiving burden. Due to the complexity of rules, these rules were further classified into rules with three chronic diseases (8 rules), rules with two chronic diseases (251 rules), rules with one chronic disease (904 rules), and rules without any chronic disease (773 rules). The purpose of this study focused on dementia patients with multiple chronic diseases such that rules showing two or more chronic diseases would be discussed in this study. Eight rules with three chronic diseases that resulted in a moderate-to-severe burden could be categorized further into five general rules as shown in Table 5.

Table 5 Five General Rules Consisting of Patients with Three Chronic Diseases for Caregivers with a Moderate-to-Severe Burden

Rule no.	Antecedent	Support (%)	Confidence (%)	Lift
1	Chronic disease: Hypertension, Anemia, and Hearing impairment Caregiver's education: College and above Caregiver's mood: Hopelessness	1.05	100	7.28
	Age of the patient: ≥ 85 Chronic disease: Hypertension, Anemia, and Hearing impairment Caregiver's mood: Frustration	1.05	100	7.28
	Chronic disease: Hypertension, Anemia, and Hearing impairment Caregiver's education: College and above Caregiver's mood: Frustration	1.05	100	7.28
2	Chronic disease: Diabetes, Hyperlipidemia, and Anemia Caregiver's education: College and above Caregiver's mood: Helplessness	1.05	100	7.28
	Chronic disease: Diabetes, Hyperlipidemia, and Anemia Age of the caregiver: < 50 Caregiver's mood: Troublesome	1.05	100	7.28
3	Chronic disease: Hypertension, Diabetes, and Anemia Caregiver's mood: Helplessness and Sadness	1.05	100	7.28
4	Chronic disease: Hypertension, Hyperlipidemia, and Anemia Caregiver's education: College and above Caregiver's mood: Helplessness	1.05	100	7.28
5	Chronic disease: Hypertension, Diabetes, and Hyperlipidemia Caregivers' marital status: Single Caregiver's mood: Anger	1.05	100	7.28

The first general rule consisting of three rules reported that a moderate-to-severe burden was observed when the caregiver who felt either hopeless or frustrated took care of the patient with hypertension, anemia, and hearing impairment along with either the caregiver was college and above educated or the patient was aged ≥85 years. Two rules were combined into the second general rule. If the caregiver was college and above educated and felt helpless or the caregiver was less than 50 years of age and felt trouble who took care of the patient with diabetes, hyperlipidemia, and anemia, the caregiving burden fell in a moderate-to-severe level. The third general rule consisting of one rule showed that when the caregiver who felt helpless and sad took care of the patient with hypertension, diabetes, and anemia, the caregiver had a moderate-to-severe burden. The fourth general rule containing one rule reported that when the caregiver who was college and above educated and felt helpless took care of the patient with hypertension, hyperlipidemia, and anemia, the caregiving burden was moderate-to-severe. Finally, the fifth general rule had one rule showing that the caregiver had a moderate-to-severe burden when the caregiver was single and felt angry who cared for the patient with hypertension, diabetes, and hyperlipidemia. In general, the patient with three chronic diseases was not the variable to directly result in a moderate-to-severe burden. In contrast, some other variables were required to be associated, such as college and above education of the caregiver, the patient aged 85 years or more, and at least one of caregiver's moods such as hopelessness, frustration, helplessness, or troublesome.

Two hundred and fifty rules were found to be related to the patient with two chronic diseases. Sixteen combinations were found and provided in the supplement (Supplementary Table). A combination of hypertension and anemia had 87 rules, followed by a combination of cardiovascular disease and hypertension with 34 rules and a combination of anemia and hearing impairment with 22 rules. Five variables including caregiver's mood, caregiver's education (college and above), mood symptom, age of the caregiver, and age of the patient were highly associated with a moderate-to-severe burden among 250 rules by counting the frequencies of variables.

Discussion

The present study found that caregiver's mood and employment and patient's age and dementia stage were associated with a severe caregiving burden. An employed caregiver who felt helpless and frustrated taking care of a 75–84-year-old mild dementia patient expressed a severe burden.

Previous systematic reviews reported that caregivers of PLWD with poor psychological health, such as depression, anxiety, and aggressiveness, experienced a high caregiving burden.[3,22] Our previous study also found caregivers expressed any one of the moods (emotional liability, depression, or anxiety) and patients who can still walk independently were associated with a moderate-to-severe caregiving burden.[39] Another study including male patients with vascular cognitive impairment revealed that caregivers who expressed abnormal mood (nervousness, anger, and helplessness) had a moderate-to-severe caregiving burden.[30] Evaluating the caregiver's mood through simple questionnaires (eg the Chinese Health Questionnaire (CHQ-12)[40] or the Brief Symptom Rating Scale (BSRS-5)[41]) might be helpful to find informal caregivers with a severe caregiving burden.

When employed caregivers of PLWD had a high caregiving burden, their work productivity would be decreased.[6,42] Compared to non-caregiving workers, caregivers of PLWD had a higher percentage of absenteeism, presenteeism, and overall work impairment.[43,44] Most of longitudinal studies concluded that cognitive decline was not associated with an increase of caregiving burden over time, but functional decline or severe neuropsychiatric symptoms were predictors.[3,22] Mild dementia patients usually preserved ambulatory function and were more opinionated about their own care, which made the management of MCCs more complex and led to a high caregiving burden in the present study.

When dementia patients had three or more MCCs, caregiver's age, mood, education level, marital status, and care recipient's age predicted a moderate-to-severe caregiving burden. Caregivers experienced hopelessness, frustration, helplessness, troublesome, sadness, or anger when caring PLWD with three or more morbidities. Caregivers who were single, aged less than 50 years, had college or higher education level, or took care oldest old PLWD (≥85 years old) were associated with a moderate-to-severe caregiving burden.

Psychological support was a frequent unmet need for caregivers of PLWD.[45] Our previous studies concluded that "care for the mood of the caregiver" is an important care need for a caregiver of PLWD, especially who took care of female patients with mild Alzheimer's disease or male patients with vascular cognitive impairment.[19,32] When PLWD had MCCs, "care for the mood of the caregiver" should be considered especially in dementia patients with preserved ambulatory function or with symptoms of hallucination.[20] For patients with dementia, there were few reports showing that caregivers with a low education level had a higher caregiving burden.[22,30] For patients with frailty and MCCs, a non-significant trend of a higher burden was found in caregivers with higher education than those with informal education.[46] Caregivers with a high education level gained deeper understanding of the interaction between multimorbidity and cognitive dysfunction and may felt more frustrated and hopeless.

Age, MCCs, and dementia had complex interrelationship. Multimorbidity, particularly when onset was in midlife rather than late life, had a robust association with subsequent dementia.[47] Early and late onset dementia also had different clinical course and brain metabolism.[48] Oldest old populations with dementia usually have more rapid functional decline than those without dementia,[49] which may lead to a higher caregiving burden. There were no uniform reports about the association between caregiver's age, marital status, and their caregiving burden, either for PLWD or for frail older people with MCCs.[3,25,42] Only one rule containing either caregiver's age or marital status in the present study was associated with a moderate-to-severe caregiving burden for PLWD with three or more MCCs; therefore, the relationship maybe not very consolidated.

There are several effective strategies to optimize transitional care coordination for older PLWD and concomitant multimorbidity and their caregivers. A previous systematic review found six elements of care that may improve outcomes, including unmet needs, depression, education and support, physical decline, poor quality of life, and access and knowledge of community services.[50] Effective non-pharmacological interventions to decrease caregiving burden are case management, psychoeducation, and multicomponent intervention.[51] The case management program helps PLWD and caregivers discover their unmet needs and may also improve the severity of neuropsychiatric symptoms.[19,20,32,52] The implementation of the caregiver training program may reduce caregivers' burden and improve their quality of life.[21] Multicomponent or home-based non-exercise interventions such as cognitive stimulation therapy may be effective in reducing caregivers' burden, especially if the intervention improved the PLWD's functional status.[51,53] Transferring to community services delayed global function decline in PLWD,[54] resulting in reducing caregiving burden. For employed caregivers, family care leaves and flexible working hours may also be effective to reduce their burden.[55] A culturally tailored approach to fit the need of informal caregivers in different racial and ethnic was also an important issue. A previous study shows that culturally tailored interventions had the potential to improve the caregiving ability of informal caregivers.[56] Healthcare workers should consider ethnicity or culture preference when implementing person-centred care and support for those planning or evaluating dementia services in outpatient, home, or community settings.[57]

Quiñones et al[16] has published similar research to study the US population with Alzheimer's disease and related dementias (ADRD) with multimorbidity but their focus was on the successful strategies to care for people with ADRD and their caregivers. In contrast, the strength of the present study focused on the caregiver burden of PLWD with MCCs specifically by including several patient's and caregiver's characteristics. This study, however, still had some limitations. First, only eight chronic diseases were included in analysis. Some of the comorbidities frequently co-occurring in PLWD such as arthritis, heart failure, pulmonary diseases, cancers, and mood disorders were not collected in our database.[14] Second, the present study utilized a cross-sectional design, which made it impossible to determine causal relationships between correlates and caregiving burden. Third, because of the heterogeneity between patient's and caregiver's factors and the level of caregiving burden, the minimum confidence and support values were 90% and 1%, respectively, in order to generate association rules. There was no universal approach to set up support and confidence values in order to generate association rules. In general, a higher confidence value, such as 90% or above, was recommended. In contrast to confidence, setting a higher support value would reduce the number of rules that might result in missing some essential rules with low frequencies. The present study used a relatively low support value to generate all possible rules and then categorized them as the number of MCCs.

In summary, caregiver's mood and employment as well as patient's age were associated with a severe burden of care for PLWD with MCCs. An employed caregiver who felt helpless and frustrated taking care of a 75–84-year-old mild patient with dementia expressed a severe burden. Abnormal mood from a caregiver usually accompanied with a high caregiving burden and "care for the mood of the caregiver" should be considered as an important care need. Healthcare providers should provide PLWD's caregivers the strategies of how to cope with their own feelings, arranging a satisfied leisure, and methods to relieve stress. In addition, individualized caregivers' training including disease knowledge, care tips toward BPSD and functional maintenance, and referring appropriate resources such as caregiver supportive group or care facilities were necessary.

Conclusion

This study first determined caring scenarios of a severe caregiving burden and then categorized factors associated with a moderate-to-severe caregiving burden in accordance with the number of MCCs. Caregiver's mood, patient's CDR, and patient's age were found to be highly associated with a severe caregiving burden. In addition, college and above education of the caregiver, the patient aged 85 years or more, and at least one of caregiver's moods such as hopelessness, frustration, helplessness, or troublesome were found to be the critical variables associated with patients with three multiple chronic diseases. Moreover, sixteen combinations of two multiple chronic diseases with 250 rules were summarized to depict the relationships among MCCs and patient's and caregiver's characteristics. Healthcare providers should provide caregivers with training about disease knowledge, care strategies toward BPSD, prevention of cognitive or functional decline, and methods on how to relieve caregivers' stress.

Data Sharing Statement

According to our hospital's regulations, individual de-identified data should pass both the Research and Development Committee and Institutional Review Board (IRB). Researchers should write a research proposal and apply it in a clinical trial to the IRB of our hospital. All data listed in the present manuscript can be obtained through e-mail if both committees agree to the application.

Disclosure

The authors report no conflicts of interest in this work.

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