

Using the Apriori Algorithm to Explore Caregivers' Depression by the Combination of the Patients with Dementia and Their Caregivers

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Purpose: The purpose of this study was to identify the caring scenarios that result in severe depression in caregivers caring for dementia patients.

Patients and Methods: A cross-sectional study with 1111 dementia patients and their caregivers in Taiwan from October 2015 to January 2020 was conducted. Gender, age, type of dementia, clinical dementia rating, walking ability, mood symptoms, behavioral symptoms, and psychological symptoms were the variables from the dementia patients. Age, relation to the patient, employment, type of primary care, frequency of care, mood symptoms, and the score from the Center for Epidemiologic Studies Depression Scale were the variables from the caregivers. A comprehensive viewpoint of both dementia patients and their caregivers was evaluated by the Apriori algorithm to find the attributes resulting in different caregiving depressions.

Results: Forty-seven rules were found with 18 rules of mild depressive symptomatology, 17 rules of moderate depressive symptomatology, and 12 rules of severe depressive symptomatology. A total of 7 general rules were summarized to be the severe depressive symptomatology. The results showed that an unemployed or retired caregiver with the mood symptoms such as helplessness, anger, emotional lability, or anxiety who took care of AD patients or AD patients with a moderate severity would have severe depression. Increased care frequencies (≥ 6 days per week) and multiple mood problems from caregivers result in severe depression. The composition of adult children, patients' aggression, and caregivers' helplessness as well as the combinations of male patients aged 75–84 years with the caregiver's mood of helplessness or nervousness and hopelessness were highly associated with severe depression.

Conclusion: For those caring for AD patients, severe depression was associated with the combination of different parameters to constitute each of these seven scenarios. Unlike previous studies which often evaluated one or two variables related to caregiver's depression, this study provided a more comprehensive viewpoint that enabled the collaborative team to efficiently identify and manage different scenarios by summarizing the rules of caregivers with severe depression from a systematic viewpoint.

Keywords: patient with dementia, Alzheimer's disease, behavioral and psychological symptoms of dementia, caregiver, caregiver's mood, depressive symptomatology, Center for Epidemiologic Studies Depression Scale, caring scenario, Apriori algorithm

Introduction

Due to global aging, the number of people with dementia is doubling every 20 years. The costs of dementia to society are very large and have been estimated to exceed 1 trillion US dollars globally in 2020.¹ Over 50% of dementia caregivers

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experience health problems as a consequence of their caring responsibilities.¹ In Taiwan, the population of dementia has exceeded 270 thousand in the end of 2017. Due to the increased aging population, the number of people with dementia in Taiwan is on track with international numbers, and is projected to reach 0.32 million and 0.6 million by 2030 and 2050, respectively.² In 1992, the percentage of the population over the age of 65 years was 6.8% but the number became 14.1% in 2018. With an 8.04% prevalence of all-cause dementia in older Taiwanese in 2014 based on a nationwide cross-sectional survey, the number of persons living with dementia (PLWD) in 2018 was estimated to be 250,000.³

Previous studies have reported that nearly 80% of PLWD were cared for by family members in Western countries, and this phenomenon was similar in Taiwan.^{4–6} Family caregivers played an important role in caring for patients with Alzheimer's disease (AD), but the caregiving load often brought the problems in their mental and physical health.⁷ For dementia caregivers, the prevalence of caregivers' depression ranged from 30%–83%.^{8–11}

Several factors have been reported to be highly correlated with the caregiver's depression, including female gender,¹² spousal relationship,^{13,14} living with the patient,^{12,15,16} caregiver's relatively poor health status,^{15,16} higher caregiver's distress,^{15–17} and more behavioral and psychological symptoms of dementia (BPSD).^{18–20} However, no studies have been found to explore the comprehensive viewpoints of dementia patients and caregivers by combining multiple variables attributing to caregivers' depression in PLWD. Clissett et al²¹ pointed out that person-centered care would be an ideal approach to care for PLWD from a long-term perspective. In order to have a holistic healthcare, both the individual and the care team for PLWD should be evaluated. Therefore, the relationships between PLWD and caregivers should be combined together to provide comprehensive person-centered care.

The purpose of this study was to assess severe depression in caregivers caring for PLWD. We encompassed variables such as type of dementia, age of caregiver and PLWD, type of primary care, caregiver's mood, caregiver's employment, dementia severity, frequency of care, and BPSD by applying the Apriori algorithm to identify possible combinations of attributes that could result in severe caregiver's depression through a comprehensive viewpoint of both people with dementia and their caregivers.

Patients and Methods

A total of 1629 registered dementia patients in the database of a medical center in Taiwan from October 2015 to January 2020 was used. By removing incomplete data sets containing missing information from one or more columns, 518 data sets were removed and the effective number of PLWD and their caregivers was 1111. In this study, the most recent diagnosis and interview data were used to record the conditions of dementia patients and their caregivers in a timely basis. The clinical trial approval certificate was approved by the Institutional Review Board of Changhua Christian Hospital in Changhua County, Taiwan with the protocol number of CCH IRB 160615. This study used a retrospective study design such that the informed consent was waived by the Institutional Review Board of Changhua Christian Hospital. The recorded data used in this study had the highest confidentiality and compliance with the Declaration of Helsinki. The variables assessed for PLWD included gender, age, type of dementia, clinical dementia rating (CDR), walking ability, mood symptoms, behavioral symptoms, and psychological symptoms as shown in Table 1, while the variables assessed for caregivers consisted of age, relation to the patient, employment, type of primary care, frequency of care, mood symptoms, and the score from the Center for Epidemiologic Studies Depression Scale (CES-D) as shown in Table 2.

The presence of BPSD was assessed by psychologists or trained nursing case managers of the collaborative team members in this medical center. All of the BPSD in the neuropsychiatric inventory were used, such as delusion, hallucination, anxiety, irritability, agitation, aggression, aberrant motor activity, and disinhibition. Please refer to Table 1 for the detailed information of mood, behavioral and psychological symptoms.²² Other abnormal behaviors including wandering, pathological crying or laughing, cursing others, akathisia, and akinesia were also evaluated by nursing case managers. New case managers received standardized training in the first month in order to collect data correctly and learn how to form an individualized care plan. Caregiver's depression was evaluated by the CES-D.²³ Both the Chinese Health Questionnaire (CHQ-12) and the Brief Symptom Rating Scale (BSRS-5), which are short, self-administered screening tools for general mental health, were applied to assess the caregiver's mood.^{24,25} When caregivers felt worried and nervous, easily felt angry, felt low or sad, or felt that it was difficult

Table I Demographic Variables for PLWD

Variables		Frequency	Percentage	Data Type
Gender	Male	413	37.2	1
	Female	698	62.8	0
Age	<65 years old	55	5.0	1
	65–74 years old	166	14.9	2
	75–84 years old	498	44.8	3
	≥85 years old	392	35.3	4
Type of dementia	Alzheimer's disease	576	51.8	1
	Vascular dementia	242	21.8	2
	Mixed dementia	50	4.5	3
	Lewy body Disease	28	2.5	4
	Parkinson's disease	51	4.6	5
	Alcohol related dementia	2	0.2	6
	Frontotemporal dementia	20	1.8	7
	Others	142	12.8	8
CDR	Very mild dementia	401	36.1	0
	Mild dementia	451	40.6	1
	Moderate dementia	184	16.6	2
	Severe dementia	75	6.8	3
Walking ability	Independent	676	60.8	0
	Walker or cane	304	27.4	1
	Wheelchair	121	10.9	2
	Bedridden	10	0.9	3
Mood symptoms (multiple choice)	Pathological crying or laughing	42	3.8	1: with the symptom; and 0: without the symptom
	Phobia	7	0.6	
	Dysthymia	198	17.8	
	Depression	135	12.2	
	Anxiety	79	7.1	
	Worry	58	5.2	
	Anger	189	17.0	
	Irritability	116	10.4	
	Emotional Liability	116	10.4	
Behavioral symptoms (multiple choice)	Apathy	46	4.1	
	Agitation	39	3.5	
	Screaming	0	0	
	Curse	32	2.9	
	Akathisia	30	2.7	
	Wandering	15	1.4	
	Pacing	0	0	
	Nighttime behavior	80	7.2	
	Akinesia	50	4.5	
	Shadowing	10	0.9	
	Aggression (verbal/body)	49	4.4	
	Aberrant motor behavior (stereotype)	22	2.0	
	Disinhibition	0	0	
Psychological symptoms (multiple choice)	Delusion	223	20.1	
	Hallucination	142	12.8	
	Misidentification	74	6.7	

Abbreviation: CDR, clinical dementia rating.

Table 2 Demographic Variables for Caregivers

Variables		Frequency	Percentage	Data Type
Age	<50 years old	274	24.7	1
	50–59 years old	391	35.2	2
	60–69 years old	218	19.6	3
	≥70 years old	228	20.5	4
Relation to the patient	Spouse	290	26.1	1
	Partner	3	0.3	2
	Child	619	55.7	3
	Brothers/sisters	8	0.7	4
	Other relatives	191	17.2	5
Employment	Unemployed or retired	512	46.1	0
	Employed	599	53.9	1
Type of primary care	Sole caregiver	351	31.6	1
	Shared caregiving by a caregiver and a foreign worker/household	411	37.0	2
	Shared caregiving by different relatives	22	2.0	3
	Caregiving by a foreign worker	153	13.8	4
	Other	174	15.6	5
Frequency of care	1–2 days per week	105	9.5	1
	3–5 days per week	110	9.9	2
	≥6 days per week	896	80.6	3
Caregiver's mood (multiple choice)	Helplessness	964	86.8	1: with the mood; and 0: without the mood
	Loneliness	1074	96.7	
	Anxiety	963	86.7	
	Frustration	1015	91.4	
	Nervousness	895	80.6	
	Anger	901	81.1	
	Sadness	1066	95.9	
	Emotional lability	1032	92.9	
	Troublesome	920	82.8	
	Hopelessness	966	86.9	
Caregiver's depression	No depressive symptomatology	758	68.2	1: applied to a particular depression; and 0: otherwise
	Mild depressive symptomatology	145	13.1	
	Moderate depressive symptomatology	128	11.5	
	Severe depressive symptomatology	80	7.2	

to catch up with others, the terms of nervousness, anger, sadness, or frustration are defined in Table 2, respectively. In addition, when caregivers had the feeling of unable to get along with families and friends, loss of confidence or a feeling of helplessness, tension or anxious, discourage or troublesome about family, and hopeless in life were defined as loneliness, helplessness, anxiety, troublesome, and hopelessness, respectively.²⁴ In contrast, somatic symptoms including feeling paresthesia, palpitation, chest tightness, or insomnia in the CHQ-12²⁴ were not used in this study because those symptoms were difficult to distinguish from other diseases. Moreover, if a caregiver had

rapid, exaggerated changes in the mood assessed by the collaborative team members, emotional lability was chosen.

A two-point scale was applied in PLWD's mood symptoms and BPSD and the caregiver's mood (1 if the symptom/mood was applied; 0 if not). Additionally, caregiver's depression, as assessed by the CES-D, was classified into four categories based on numerical scores from 0 to 60: no depressive symptomatology (0 point), mild depressive symptomatology (1–15 points), moderate depressive symptomatology (16–23 points), and severe depressive symptomatology (24–60 points). The stratification was

based on a previous report to reveal the standard cut-offs of CES-D of ≥ 16 and ≥ 24 for “possible depression” and “probable depression”, respectively.²⁶ A value of 1 was given to a particular category of a caregiver’s depression, while a value of zero was assigned to the other three categories.

Most of PLWD in Table 1 were female (62.8%) with Alzheimer’s disease (51.8%), aged 75 years or older (80.1%), and had mild dementia (CDR=1, 40.6%). The majority of the patients could either walk independently (60.8%) or use a walker or cane (27.4%). The age of the caregivers was distributed across four age groups, and children (55.7%) and spouses (26.1%) were the major forces to care PLWD. Sole caregiver (31.6%) and shared caregiving by a caregiver and a foreign worker/household (37.0%) were the two major types of primary care. Frequency of care ≥ 6 days per week was the most (80.6%). Additionally, caregiver’s depression mainly fell into the category of no depressive symptomatology (68.2%).

The aim of the study was to find the associations among PLWD, caregivers, and the caregiver’s depression levels. In other words, this study intended to find attribute combinations (scenarios) resulting in the severe depressive symptomatology for each caregiver. Association rules using “If antecedent, then consequent” to generate rules enables the decision makers to identify statistical correlations among a group of attributes.^{27,28} The Apriori algorithm, which has been applied in dementia-related studies, was employed in this study to find statistical associations between any of the attributes by satisfying both minimum support and confidence threshold values along with lift > 1 .^{6,7,29–33}

The definitions of support, confidence, and lift are depicted as below.^{6,29,32,33} The support of $A \Rightarrow B$ calculates the percentage of transactions containing both A and B in the database depicted in Equation (1):

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

The confidence of $A \Rightarrow B$ evaluates the accuracy of the rule by computing the percentage of transactions containing A and also containing B simultaneously in the database depicted in Equation (2):

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

Lift defined in Equation (3) is to evaluate the relationship between A and B. A lift value of one indicates A and B are independent such that no rules will be found. When a lift value is larger than one, A and B are dependent and correlated positively.

$$\text{Lift } (A, B) = \frac{P(A \cup B)}{P(A)P(B)} \quad (3)$$

The IBM SPSS modeler 14.1 was the software package to perform the Apriori algorithm. Tables 1 and 2 provide the notations in terms of numerical values for PLWD and caregivers, respectively. The input variables for antecedents included gender, age, type of dementia, CDR, walking ability, mood symptoms (10 types), behavioral symptoms (11 types), and psychological symptoms (3 types) from PLWD as well as age, relation to the patient, employment, type of primary care, frequency of care, and caregiver’s mood (10 types) from caregivers. Caregiver’s depression (4 types) was the input variables for the consequent. Due to the heterogeneous data, the minimum support and minimum confidence were set to 2% and 80%, respectively, along with a lift > 1 .

Results

In the beginning, 390 rules were found by the Apriori algorithm. However, those rules which belonged to no depressive symptomatology (CES-D=0) and did not provide useful information to identify caregivers with severe depression. Therefore, the 758 data sets containing CES-D=0 were removed. That is, there were 353 data sets left containing CES-D=1, CES-D=2, and CES-D=3. The Apriori algorithm was performed again with support of 2%, confidence of 80%, and lift > 1 . In doing so, 47 rules were found, with 18 rules of mild depressive symptomatology, 17 rules of moderate depressive symptomatology, and 12 rules of severe depressive symptomatology. The rules of mild depressive symptomatology and moderate depressive symptomatology are summarized in the Appendix. Table 3 lists the detailed information of the severe depressive symptomatology including antecedents, number of the cases in the database, support, confidence, and lift.

The rules summarized in Table 3 can be interpreted as follows. For instance, in the first rule, a caregiver would

Table 3 Twelve Rules with CES-D=3

Rule no.	Antecedent	No. of the Cases in the Database	Support (%)	Confidence (%)	Lift
1	Relation to the patient: Child Behavioral symptoms of PLWD: Aggression Caregiver's mood: Helplessness	8	2.27	87.50	3.86
2	CDR of PLWD: Moderate dementia Caregiver's mood: Helplessness Caregiver's mood: Anxiety	8	2.27	87.50	3.86
3	Age of PLWD: 75–84 years Gender of PLWD: Male Caregiver's mood: Nervousness Caregiver's mood: Hopelessness	8	2.27	87.50	3.86
4	Age of PLWD: 75–84 years Type of dementia: Alzheimer's disease Age of Caregiver: 50–59 years Caregiver's mood: Helplessness	8	2.27	87.50	3.86
5	Type of dementia: Alzheimer's disease Caregiver's employment: Unemployed or retired Caregiver's mood: Helplessness Caregiver's mood: Anxiety Caregiver's mood: Emotional liability	8	2.27	87.50	3.86
6	Type of dementia: Alzheimer's disease Type of primary care: Sole caregiver Caregiver's mood: Anxiety Caregiver's mood: Anger Caregiver's mood: Emotional liability	8	2.27	87.50	3.86
7	Type of dementia: Alzheimer's disease Walking ability of PLWD: Independent Type of primary care: Sole caregiver Caregiver's mood: Anxiety Caregiver's mood: Anger Caregiver's mood: Emotional liability	8	2.27	87.50	3.86
8	CDR of PLWD: Moderate dementia Caregiver's employment: Unemployed or retired Caregiver's mood: Helplessness	10	2.83	80.00	3.53
9	Age of PLWD: 75–84 years Type of dementia: Alzheimer's disease Caregiver's mood: Helplessness Caregiver's mood: Anxiety	10	2.83	80.00	3.53
10	Type of dementia: Alzheimer's disease Caregiver's employment: Unemployed or retired Caregiver's mood: Anxiety Caregiver's mood: Anger Caregiver's mood: Emotional liability	10	2.83	80.00	3.53

(Continued)

Table 3 (Continued).

Rule no.	Antecedent	No. of the Cases in the Database	Support (%)	Confidence (%)	Lift
11	Frequency of care: ≥ 6 days per week Caregiver's mood: Helplessness Caregiver's mood: Anxiety Caregiver's mood: Hopelessness	10	2.83	80.00	3.53
12	Walking ability of PLWD: Independent Frequency of care: ≥ 6 days per week Caregiver's mood: Helplessness Caregiver's mood: Anxiety Caregiver's mood: Hopelessness	10	2.83	80.00	3.53

Abbreviations: CDR, clinical dementia rating; PLWD, persons living with dementia.

have severe depression when the patient cared by his or her child had a behavioral symptom of aggression and the caregiver felt helpless. The second rule expressed that the caregiver would experience severe depression when the caregiver cared the patient with moderate dementia and felt helpless and anxious. That is, when the terms in antecedent in Table 3 were incurred simultaneously, the depressive symptomatology would be severe. These twelve rules in Table 3 can be further summarized into seven general rules with similarities as shown in Table 4. These general rules were composed of different patient-caregiver parameters, including age, gender, type of dementia, dementia severity, relation with patients, frequency of care, and caregiver's mood.

The first general rule containing the original 6th and 7th rules showed that AD patients cared by a sole caregiver who felt anxiety, anger, and emotional liability was highly correlated with severe depression. In addition to the above scenario, if AD patients could walk independently, the odds of severe depression in the caregiver was also high. The second general rule containing the original 4th and 9th rules indicated that the caregiver who felt helpless in caring AD patients aged 75–84 years had higher odds of severe depression. The third general rule expressed that the odds of caregiver's depression was increased when the caregiver was unemployed or retired with some mood problems such as helplessness, anger, emotional liability, or anxiety developed in caring AD patients. The fourth general rule depicted that unemployed or retired caregivers caring for PLWD with moderate severity as well as experiencing some mood states (helplessness and anxiety) were associated with severe depression. The fifth general rule showed that increased care frequencies (≥ 6 days per week)

in caregivers who experienced multiple mood problems (helplessness, hopelessness, and anxiety) were highly correlated with severe depression. Additionally, independent walking ability added the odds of severe depression. The composition of adult children, patients' aggression, and caregivers' helplessness was associated with severe depression in the sixth general rule. Finally, severe depression in the caregiver was highly associated with the combinations of male PLWD aged 75–84 years and the caregiver's mood (helplessness or nervousness and hopelessness).

Discussion

The study found that caregivers experienced severe depression with the following scenarios. AD patients were cared by a caregiver solely who had mood symptoms of anxiety, anger, and emotional liability. AD patients aged 75–84 years were cared by a caregiver who felt helpless. An unemployed or retired caregiver with the mood symptoms such as helplessness, anger, emotional liability, or anxiety took care of AD patients or PLWD with CDR=2. Increased care frequencies (≥ 6 days per week) and multiple mood problems (helplessness, hopelessness, and anxiety) from caregivers result in severe depression scores. The composition of adult children, patients' aggression, and caregivers' helplessness as well as the combinations of male patients aged 75–84 years and the caregiver's mood (helplessness or nervousness and hopelessness) were highly associated with severe depression.

Previous studies such as Cheng³⁴ and Schulz and Williamson³⁵ reported that more social support for caregivers were related to less depression. Etters et al³⁶ pointed out caregiver's gender, relationship to the patient,

Table 4 Seven General Rules Based on 12 Rules with CES-D=3

General Rule	Original rule	Antecedent	Consequent
1	6	Type of dementia: AD Type of primary care: Sole caregiver Caregiver's mood: Anxiety, Anger, and Emotional liability	CES-D=3
	7	Type of dementia: AD Walking ability of PLWD: Independent Type of primary care: Sole caregiver Caregiver's mood: Anxiety, Anger, and Emotional liability	
2	4	Type of dementia: AD Age of PLWD: 75–84 years Age of caregiver: 50–59 years Caregiver's mood: Helplessness	CES-D=3
	9	Type of dementia: AD Age of PLWD: 75–84 years Caregiver's mood: Helplessness and Anxiety	
3	5	Type of dementia: AD Caregiver's employment: Unemployed or retired Caregiver's mood: Helplessness, Anxiety, and Emotional liability	CES-D=3
	10	Type of dementia: AD Caregiver's employment: Unemployed or retired Caregiver's mood: Anxiety, Anger, and Emotional liability	
4	2	CDR of PLWD: Moderate dementia Caregiver's mood: Helplessness and Anxiety	CES-D=3
	8	CDR of PLWD: Moderate dementia Caregiver's employment: Unemployed or retired Caregiver's mood: Helplessness	
5	11	Frequency of care: ≥ 6 days per week Caregiver's mood: Helplessness, Anxiety, and Hopelessness	CES-D=3
	12	Walking ability of PLWD: Independent Frequency of care: ≥ 6 days per week Caregiver's mood: Helplessness, Anxiety, and Hopelessness	
6	1	Relation to the patient: Child Behavioral symptoms of PLWD: Aggression Caregiver's mood: Helplessness	CES-D=3
7	3	Age of PLWD: 75–84 years Gender of PLWD: Male Caregiver's mood: Nervousness and Hopelessness	CES-D=3

Abbreviations: CDR, clinical dementia rating; AD, Alzheimer's disease; PLWD, persons living with dementia.

and personal characteristics were the factors that might influence the impact of the caregiving experience. In a Korean community study, cohabited family caregiver with dementia patients was significantly associated with depression, and the significance remained high especially in male caregivers in a low-income family and female caregivers in a high-income family.³⁷ However,

caregiver's gender was not an important factor related to depression in our study.

Cheng³⁴ identified that neuropsychiatric symptoms were the most predictive variable of caregivers' depression regardless of types of dementia. Black and Almeida³⁸ and Pinquart and Sorensen³⁹ summarized that associations between the BPSD and negative outcomes for caregivers

of AD patients included the increased caregiver's burden, stress, or depressive symptoms. However, few studies focused on the psychological state or even mood disturbance of caregivers related to depression. The mood impact may precede the development of depression. Bowen et al⁴⁰ found that not only low or high moods but also mood instability were highly correlated with depression. Helplessness, anger, and emotional lability may be a proxy of depression. Therefore, more attention is needed for the mood change in caregivers.

The studies regarding the dementia severity and caregiver's depression are inconsistent. For instance, Omranifard et al⁴¹ reported that the dementia severity was highly related to caregiver's depression but no significant association between patients' dementia severity and their caregivers' depression scores was found statistically.⁴² In our study, the fourth general rule indicated that unemployed or retired caregivers in caring PLWD with moderate severity as well as experiencing some mood states (helplessness and anxiety) were associated with severe depression. This implied that caregivers with emotional problems in caring PLWD with a moderate severity may be prone to having severe depression.

Increased care frequencies (≥ 6 days per week) in caregivers who experienced multiple mood problems (helplessness, hopelessness, and anxiety) were highly correlated with severe depression. Additionally, PLWD's independent walking ability added the odds of severe depression. In contrast to our findings, Covinsky et al¹³ found that more dependency in activities of daily living increased the risk of caregiver depression by 1.55-fold. In our study, it was possible that these patients wandered around without purposes to result in an increased caregiving burden, which in turn led to more depressive symptomatology.¹⁶

Determining specific BPSD that increases caregivers' depression may decrease the caregiving burden and can prevent the development of depression in caregivers. BPSDs include many varieties of patient behaviors, and aggression has been one of the most frequently cited symptoms associated with caregiver's depression.²⁰ Other BPSDs, such as patient's depression, psychosis, and agitation, were also reported in multiple studies.²⁰ For each individual BPSD, agitation/aggression, anxiety, nighttime behavior disturbances, irritability/lability, and hallucinations were the five leading symptoms significantly associated with caregiver's depression.¹⁰ However, no symptom was found as having a negative impact on caregiver's depression consistently. In our study, adult children experiencing helplessness in

tackling the aggression in PLWD had more odds of severe depression. Similar to our study, Choi et al¹⁸ reported that agitation alone was not correlated with caregiver's depression, multiple symptom clusters had a positive correlation with caregiver's depression.

Female caregivers had more depressive symptoms than male caregivers.^{12,38} In a cohort of 335 dyads of wife-husband couples, the caregiving burden scale was higher among female than male caregivers statistically though depression between male and female caregivers was not statistically significant.⁴³ In a systematic review including 22 studies, the physical and mental health of family caregivers on gender differences were inconsistent.⁴⁴ In our study, if a caregiver felt nervous and hopeless in caring male PLWD aged 75–84 years, the possibility of severe depression in caregivers should be highlighted.

Clissett et al²¹ have suggested person-centered care as the ideal approach to care for PLWD because the person-centered approach is to identify the interconnected relationships between PLWD and their caregivers and to respect personhood as a respected and valued social being despite cognitive impairment.⁴⁵ The value of our study was to group together different scenarios leading to caregiver's depression systematically that enables a collaborative care team to provide more efficient care for AD patients as well as PLWD.

The strength of this study was that it provided a comprehensive viewpoint to combine a wide variety of variables into consideration. The Apriori algorithm was employed to combine various variables and to identify the association between particular conditions and severe caregiver depression. In doing so, the collaborative team can understand the care needs more efficiently and lessen the severity of the caregiving depression. Unlike previous studies which often evaluated one or two variables related to caregiver's depression such as Cheng,³⁴ De Fazio et al⁴⁶ and Jang et al,³⁷ our study can provide a more comprehensive scenario to reduce caregiver's depression from a systematic viewpoint.

There are several limitations in our study. First, it was a cross-sectional study; thus, we could not reach conclusions regarding the causality. Second, though our study had a relatively large sample size, it would be recommended to have a much larger sample size in order to have more generalized findings. Third, our study was carried out in a medical center, and these results may not be generalized to other settings such as primary care or residential care.

Conclusion

This study identified associations between PLWD and their caregivers by combining various variables in order to find attributes resulting in severe depression scores of caregivers from a comprehensive viewpoint. This study showed that caregiver's severe depression was associated with seven general rules by the combination of different parameters to constitute each particular scenario. Unlike previous studies which often evaluated one or two variables related to caregiver's depression, our study provided a more comprehensive viewpoint that enabled the collaborative team to efficiently identify and manage different scenarios for reducing the caregiver's depression from a systematic viewpoint.

Disclosure

The authors report no conflicts of interest in this work.

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