

Using The Apriori Algorithm To Classify The Care Needs Of Patients With Different Types Of Dementia

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Purpose: To elucidate specific combinations of care needs for people living with dementia (PLWD) and their caregivers according to specific subtypes of dementia.

Patients and methods: A cross-sectional study at memory clinics in Changhua Christian Hospital, Taiwan, was conducted. Five hundred and eight people living with dementia and their caregivers joined the dementia collaborative care model. The care team established 15 care needs containing most of quality measures for PLWD and their caregivers. Individualized care plans including different combinations of care needs were addressed through face-to-face assessments. Apriori algorithm was used to find specific combinations of care needs for particular groups of PLWD and their caregivers.

Results: This study identified the basic care needs of PLWD and caregivers including appropriate scheduling of activities, regular outpatient follow-up treatment, introduction and referral of social resources, referral to family support groups and care skills training, and health education for dementia and behavioral and psychological symptoms of dementia. Patients with Alzheimer's dementia required more care to prevent traffic accidents and getting lost, while patients with vascular dementia required more care to prevent falls. The older (≥ 75 years old) PLWD were associated with more needs of fall prevention and care for the mood of the caregiver, especially in the female patients with mild Alzheimer's dementia (CDR = 1).

Conclusion: Bundling the needed care needs might be a more effective means to care for a wide variety of patients with dementia.

Keywords: people living with dementia, behavioral and psychological symptoms of dementia, dementia collaborative care model, care need, Apriori algorithm

Introduction

Dementia is one of the greatest global challenges for health and social care in the 21st century.¹ While prevalence trajectories are unclear in high-income countries, the number of people living with dementia (PLWD) continues to grow globally, especially in low- and middle-income countries.² Some evidence supports that the prevalence of dementia is increasing in East Asia.^{3,4}

The number of older people in Taiwan has grown rapidly in the past decades, with the percentage of the population over the age of 65 years increasing from 6.8% in 1992 to 14.1% in 2018.⁵ The prevalence of all-cause dementia in older Taiwanese in 2014 was 8.04% according to a nationwide cross-sectional survey, with an estimated 250,000 PLWD in 2018.⁶ PLWD need help with challenging changes in behavior, cognition, and mood, and their caregivers often suffer from the caregiving, depression and health problems.^{1,7}

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To address patients' and caregivers' complex healthcare needs, several collaborative care models have been published in the last decade.⁸⁻¹¹ These models are characterized by interprofessional teams, multicomponent interventions, and shared decision-making between healthcare professionals and patients as well as their caregivers.¹² Previous studies have performed comprehensive patient-centered assessments of PLWD and their care partners, including the patient's function, behavior and health status, and their challenges or unmet needs.^{9,10} The goal of a systematic assessment is to identify opportunities to support personhood, reduce safety risks, optimize quality of life, and form team-approached care planning.¹⁰ Although still controversial, several studies suggest that a collaborative approach improves the quality of care for patients with dementia, increases adherence to dementia guidelines, and decreases behavioral problems.¹³⁻¹⁵

We established a dementia collaborative care model at Changhua Christian Hospital, a medical center in Changhua, Taiwan, in October 2014. The care team includes physicians (including neurologists, psychiatrists, gerontologists, and primary care physicians), psychologists, social workers, dietitians, occupational therapists, pharmacists, and nursing case managers. This team performs patient and care partner interventions when a diagnosis of dementia (including mild cognitive impairment (MCI) and very mild dementia) has been made. More than 95% of PLWD are community residents at the first intervention. The cognition, function, living status, home environment, behavior and psychological symptoms of the patient, as well as the stress, mood and preference of the caregiver are assessed through both telephone and face-to-face interviews. After team-approached assessments, an individualized care plan is formed. The care team addresses 15 different care needs (Table 1) containing most of quality measures and needs for dementia patients and their caregivers.^{9,10,12,16,17} Care needs provide main care targets and guide team members for subsequent follow-up. Each need is addressed when assessments are abnormal (e.g. if the environment is unsafe or there are economic difficulties).

In clinical practice, the collaborative team observed that certain care needs often occur in combination and that some occurred more frequently in people with specific subtypes of dementia. Most previous studies have focused on the prevalence of various care needs of dementia.¹⁸⁻²⁰ However, no previous study has attempted to group or classify care needs. Grouping care needs for particular conditions such as the severity or subtype of dementia would allow for more efficient and holistic care. Therefore, the aim of the present study was to elucidate

whether specific combinations of care needs can be applied to particular groups of PLWD and their caregivers using the Apriori algorithm, as this algorithm can reveal interesting statistical correlations from a multidimensional viewpoint when each attribute is viewed as a dimension by establishing threshold values of support and confidence.²¹

Materials And Methods

Patients diagnosed as mild cognitive impairment or dementia at memory clinic from October 2015 to April 2017 in Changhua Christian Hospital were enrolled. The clinical trial was approved by the Institutional Review Board of Changhua Christian Hospital (CCH IRB 160165). Because the design of the present study was a retrospective chart review, informed consent was waived by the Institutional Review Board of Changhua Christian Hospital. All data were recorded in the electronic medical chart with the highest confidentiality and compliance with the Declaration of Helsinki. Six hundred and eight patients who received team-approached assessment were screened, and after excluding those with incomplete data and those with a dementia subtype including fewer than 10 registered patients, the remaining 508 were included for analysis. The demographic information including gender, age, type of dementia, and clinical dementia rating (CDR) is summarized in Table 2. A majority of the patients were women (66%) with Alzheimer's disease (72%) aged 75 years and older (82%) who had mild dementia (51%). National Institute on Aging-Alzheimer's Association (NIA-AA),^{22,23} International Society for Vascular Behavioral and Cognitive disorders (VASCOG)²⁴ and Movement Disorder Society-Task force criteria were used for diagnosis of AD, vascular dementia and Parkinson's disease dementia, respectively.²⁵ Patients fit both possible AD by NIA-AA criteria and possible major vascular cognitive disorder by VASCOG criteria were classified as mixed dementia. The 15 care needs listed in Table 1 were then assessed.

The purpose of this study was to identify whether specific combinations of several care needs could be applied to particular groups of PLWD and their caregivers and thereby to provide more efficient and holistic care. That is, we intended to group the care needs for patients with dementia by gender, age, type of dementia, and dementia severity. The Apriori algorithm has been proven to be a very useful approach to discover previously

Table 1 Fifteen Care Needs Addressed By Changhua Christian Hospital

Number	Description	Contents
1	Adequate nutrition and diet	This need was selected if the nutritional assessment was abnormal through evaluating a patient's oral intake ability and recent body weight change. A nursing case manager or dietician gave individualized nutritional suggestions
2	Maintenance of personal hygiene	This need was chosen if a patient's activity of daily living was impaired. Care skills education and in-house reablement program were introduced
3	Appropriate schedule of activities	This need was targeted if a patient's daily physical activity was low. A nursing case manager would provide a daily schedule suggestion
4	Adequate sleep and rest	This need was selected if poor sleep quality was recorded. The study team then provided sleep hygiene education and discussed the usage of sleep medication
5	Fall prevention	This need was added if a risk of fall score located within a high-risk group. Physical training program and assistive devices evaluation were introduced
6	Preventing traffic accidents and getting lost	This need was chosen if a patient's ambulatory function was preserved with the history of traffic accident or getting lost due to a cognitive decline. A nursing case manager then provided the driving ability evaluation and assistive device for prevention of getting lost
7	Preventing misuse of medications	This need was selected if misuse of medication was detected through asking residual drugs or from the care partner. Strategies including using drug boxes and decreasing use frequency were suggested
8	Adjusting home environment safety	This need was selected if any event of indoor safety concern has been recorded (eg, overcooked or burning). An experienced nurse or therapist then provided home environmental evaluation and adjustment
9	Regular outpatient follow-up treatment	This need was added if a physician suggested a medication treatment. A case manager would follow the patient every month to maintain adherence
10	Behavioral and psychological symptoms of dementia (BPSD) treatment	This need was selected if presence of any BPSD, which was detected through neuropsychiatric inventory annually. Non-pharmacological treatments were given first and pharmacological interventions were only reserved for severe patients
11	Referral to other specialists	This need was added if any medical problem which needs other subspecialists was detected during the assessment
12	Introduction and referral of social resources	This need was selected if PLWD and their caregivers asked social resources such as disability card, day care facilities, or guardianship
13	Referral to family support groups and care skills training	This need was chosen if a high Zarit's caregiver burden score was recorded during the assessment. Support groups of dementia caregivers were introduced
14	Care for the mood of the caregiver	This need was selected if a caregiver presented with depressive mood (screen by CES-D). The caregiver with the severe condition received emotional support and transferred to psychiatrist
15	Education for dementia and BPSD	This need was chosen if PLWD and caregivers asked education information about dementia or BPSD, such as prevention, disease course, and medications. Different education programs were arranged according to the learning ability

Abbreviation: CES-D, Center for Epidemiologic Studies-Depression Scale.

unknown interesting relationships in data sets by finding rules and associations between any of the attributes by establishing support, confidence, and lift, which are

defined as follows.^{21,26,27} The support for an association rule $A \Rightarrow B$ is assessed by calculating the percentage of transactions in the database containing both A and B:

Table 2 Information Of The Patients With Dementia

Variables		Frequency	Percentage	Data Type
Gender	Male	175	34	M
	Female	333	66	F
Age	Less than 65 years old	17	3	0
	65–69 years old	20	4	1
	70–74 years old	56	11	2
	75–79 years old	147	29	3
	80–84 years old	145	29	4
	85 years old and above	123	24	5
Type of dementia	Alzheimer's disease	363	72	AD
	Parkinson's disease	26	5	PDD
	Vascular dementia	93	18	VaD
	Mixed dementia	26	5	MD
CDR	Very mild dementia	104	21	0
	Mild dementia	260	51	1
	Moderate dementia	89	18	2
	Severe dementia	55	11	3

Abbreviation: CDR, clinical dementia rating.

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

The confidence of the association rule $A \Rightarrow B$ is assessed by evaluating the accuracy of the rule based on the calculation of the percentage of transactions in the database containing A and also containing B simultaneously:

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

Lift is a simple correlation measuring whether A and B are independent or dependent and correlated events as shown in Equation (3). If a rule has a lift of one, A and B are independent and no rule will be generated containing either event. If a rule has a lift greater than one, A and B are dependent and correlated positively. In practice, analysts tend to prefer rules with either high support or high confidence and usually both.²⁸ In fact, strong rules will be found when certain minimum support and confidence conditions have been met.

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

The Apriori algorithm in IBM SPSS Modeler 18 was used in this study. The notations of data type defined by

numerical values or abbreviations are depicted in Table 2. The input variables for antecedents were gender, age, type of dementia, and CDR. The 15 care needs developed by our hospital were classified as both antecedents and consequents. The notations for each care need were 1 or 0. If a particular care need was applied to a patient, a value of 1 was assigned. If not, a value of 0 was used. This allowed for the identification of combinations of care needs. Minimum support, minimum confidence, and lift were set to 10%, 90%, and greater than one, respectively. The rules with higher support values indicated that the care need bundles could fulfill the majority of the patients' needs. In contrast, the rules with relatively lower support values indicated that the care need bundles may only be applicable to a small portion of the patients, ie, special needs. The settings of antecedents and consequents in the Apriori algorithm allow the decision-maker to identify what combinations of care needs would be needed according to the specific demographic information of the patients.

Results

A total of 1759 rules were generated by the Apriori algorithm (Table 3 lists a sample of some of the rules). For instance, Rule 1 indicated that a patient aged 70–74 years required education for dementia and BPSD (Care (15)). Rule 2 showed that preventing the misuse of medications (Care (7)) and Care (15) should be bundled together to meet the needs of the patient. Rule 3 depicted that a patient with Alzheimer's disease needed Care (7) and the introduction and referral of social resources (Care (12)). In Rule 4, a patient with moderate dementia needed both fall prevention (Care (5)) and also education for dementia and BPSD (Care (15)). Rule 5 suggested that Care (7), Care (12), and Care (9) (regular outpatient follow-up treatment) should be combined with Care (15). Of note, confidence in Rule 5 was 100%, showing that these four rules could definitely be bundled for patients with dementia. Moreover, in Rule 6, the combination of Care (13), Care (12), Care (3), Care (15), and Care (9) could meet the needs of 53.54% of the PLWD.

In order to categorize the rules effectively, the 1759 rules were divided into four categories in terms of different support values, ie, 40% and above, 30% but less than 40%, 20% but less than 30%, and 10% but less than 20%. Rules that had both high support and confidence values could be viewed as the basic requirements for PLWD. That is, the identified care needs could be bundled as a portfolio for PLWD at the first intervention. In contrast, rules with

Table 3 Information Of The Patients With Dementia

Rule No.	Antecedent	Consequent	No. Of Cases In The Database	Support (%)	Confidence (%)	Lift
1	Age = 2	Care (15) = 1	56	11.02	98.21	1.04
2	Care (7) = 1	Care (15) = 1	66	12.99	98.49	1.04
3	Care (7) = 1 Type = AD	Care (12) = 1	51	10.04	90.20	1.12
4	CDR = 2 Care (5) = 1	Care (15) = 1	51	10.04	96.08	1.01
5	Care (7) = 1 Care (12) = 1 Care (9) = 1	Care (15) = 1	51	10.04	100.00	1.05
6	Care (13) = 1 Care (12) = 1 Care (3) = 1 Care (15) = 1	Care (9) = 1	272	53.54	91.54	1.04

lower support but high confidence values could be considered as special needs for a very small group of PLWD.

With support of 40% and above, five basic care needs were identified for the majority of the patients, including appropriate scheduling of activities (Care (3)), regular outpatient follow-up treatment (Care (9)), introduction and referral of social resources (Care (12)), referral to family support groups and care skills training (Care (13)), and education for dementia and BPSD (Care (15)). With support of 30% but less than 40%, in addition to the five basic care needs for the majority of the patients, four additional care needs were identified, including adequate sleep and rest (Care (4)), preventing traffic accidents and getting lost (Care (6)), adjusting home environment safety (Care (8)), and care for the mood of the caregiver (Care (14)).

When the support was 20% but less than 30%, three generalized rules were identified as shown in Table 4. The first generalized rule indicated that a patient with Alzheimer's disease who required the five basic care needs should further receive interventions to prevent traffic accidents and getting lost (Care (6)). The second generalized rule indicated that a patient with Alzheimer's disease is required to focus on fall prevention (Care (5)) in addition to the five basic care needs. Moreover, the third generalized rule depicted that a patient with mild dementia needs to further focus on fall prevention (Care (5)). That is, the caregiver was required to pay extra attention to prevent traffic accidents and getting lost as well as fall prevention for a patient with Alzheimer's disease.

With support of 10% but less than 20%, nine generalized rules were identified as shown in Table 5. The first generalized rule indicated that a patient with vascular dementia needed additional interventions to prevent falls (Care (5)) in addition to the five basic care needs. In the second generalized rule, a patient with moderate Alzheimer's disease was required to the five basic care needs. In the third generalized rule, with the confidence value of 100%, a female patient aged 75–79 years with Alzheimer's disease was required to receive the five basic care needs. The fourth generalized rule said that a patient with moderate dementia needed additional interventions to prevent falls (Care (5)) in addition to the five basic care needs. In contrast, a female patient with moderate dementia was required to concentrate on Care (9) and Care (15) of the five basic care needs as shown in the fifth generalized rule. In the sixth generalized rule, a female patient aged 75–79 years is required to have five basic care needs with a confidence value of 100%. In contrast to the sixth generalized rule, the seventh rule showed that patients aged 75–79 years required the five basic care needs with a confidence value of 100%, and the caregiver's stress and mood should also be monitored (Care (14)). That is, the caregivers may suffer from the caregiving, depression, and health problems when caring for patients aged 75–79 years. The eighth generalized rule indicated that the patients with mild dementia aged 80–84 years required additional interventions for fall prevention (Care (5)) in addition to the five basic care needs with a

Table 4 Three Generalized Rules With Support Of 20% But Less Than 30%

Rule	Antecedent	Consequent	No. Of Cases In The Database	Support (%)	Confidence (%)	Lift
1	Care (6) = 1 Type = AD Care (9) = 1	Care (15) = 1	108	21.26	98.15	1.03
	Care (6) = 1 Type = AD	Care (15) = 1	121	23.82	96.69	1.02
	Care (6) = 1 Type = AD Care (12) = 1	Care (15) = 1	113	22.24	96.46	1.02
	Care (6) = 1 Type = AD	Care (12) = 1	121	23.82	93.39	1.16
	Care (6) = 1 Type = AD Care (15) = 1	Care (12) = 1	117	23.03	93.16	1.15
	Care (6) = 1 Type = AD Care (9) = 1	Care (12) = 1	108	21.26	92.59	1.15
	Care (6) = 1 Type = AD Care (9) = 1 Care (15) = 1	Care (12) = 1	106	20.87	92.45	1.15
	Care (6) = 1 Type = AD Care (15) = 1	Care (9) = 1	117	23.03	90.60	1.03
2	Care (5) = 1 Type = AD Care (3) = 1	Care (15) = 1	114	22.44	96.49	1.02
	Care (5) = 1 Type = AD Care (9) = 1	Care (15) = 1	113	22.24	96.46	1.02
	Care (5) = 1 Type = AD	Care (15) = 1	130	25.59	96.15	1.01
	Care (5) = 1 Type = AD Care (12) = 1	Care (9) = 1	104	20.47	90.39	1.03
3	Care (5) = 1 CDR = 1	Care (15) = 1	111	21.85	96.40	1.02
	Care (5) = 1 CDR = 1 Care (9) = 1	Care (15) = 1	102	20.08	96.08	1.01
	Care (5) = 1 CDR = 1	Care (9) = 1	111	21.85	91.89	1.04
	Care (5) = 1 CDR = 1 Care (15) = 1	Care (9) = 1	107	21.06	91.59	1.04

Table 5 Nine Generalized Rules With The Support Of 10% But Less Than 20%

Rule	Antecedent	Consequent	No. Of Cases In The Database	Support (%)	Confidence (%)	Lift
1	Type = VaD Care (12) = 1	Care (15) = 1	70	13.780	95.71	1.01
	Type = VaD Care (12) = 1 Care (3) = 1	Care (15) = 1	52	10.24	98.08	1.03
	Type = VaD Care (12) = 1 Care (9) = 1	Care (15) = 1	62	12.21	96.77	1.02
	Type = VaD Care (13) = 1 Care (12) = 1	Care (15) = 1	60	11.81	95.00	1.01
	Type = VaD Care (13) = 1 Care (12) = 1	Care (9) = 1	60	11.81	91.67	1.04
	Type = VaD Care (13) = 1 Care (12) = 1 Care (15) = 1	Care (9) = 1	57	11.22	92.98	1.05
	Type = VaD Care (13) = 1 Care (12) = 1 Care (9) = 1	Care (15) = 1	55	10.83	96.36	1.02
	Type = VaD Care (13) = 1 Care (15) = 1	Care (9) = 1	64	12.60	90.63	1.03
	Type = VaD Care (13) = 1 Care (9) = 1 Care (15) = 1	Care (12) = 1	58	11.42	91.38	1.13
	Type = VaD Care (3) = 1	Care (15) = 1	65	12.80	96.92	1.02
	Type = VaD Care (3) = 1 Care (9) = 1	Care (15) = 1	58	11.42	96.55	1.02
	Type = VaD Care (5) = 1	Care (9) = 1	51	10.04	92.16	1.05
2	CDR = 2 Type = AD Care (9) = 1	Care (15) = 1	57	11.22	96.49	1.02
	CDR = 2 Type = AD Care (3) = 1	Care (15) = 1	57	11.22	98.25	1.04
	CDR = 2 Type = AD Care (12) = 1	Care (15) = 1	55	10.83	96.36	1.02
	CDR = 2 Type = AD	Care (15) = 1	66	12.99	96.97	1.02

(Continued)

Table 5 (Continued).

Rule	Antecedent	Consequent	No. Of Cases In The Database	Support (%)	Confidence (%)	Lift
3	Age = 3 Gender = F Type = AD Care (12) = I Care (3) = I	Care (15) = I	60	11.81	100	1.05
	Age = 3 Gender = F Type = AD Care (12) = I Care (9) = I	Care (15) = I	70	13.78	100	1.05
	Age = 3 Gender = F Type = AD Care (13) = I Care (12) = I	Care (15) = I	64	12.60	100	1.05
	Age = 3 Gender = F Type = AD Care (13) = I Care (3) = I	Care (15) = I	55	10.83	100	1.05
	Age = 3 Gender = F Type = AD Care (13) = I Care (9) = I	Care (15) = I	64	12.60	100	1.05
4	CDR = 2 Care (5) = I	Care (15) = I	51	10.04	96.08	1.01
	CDR = 2 Care (5) = I	Care (9) = I	51	10.04	90.20	1.02
5	CDR = 2 Gender = F Care (15) = I	Care (9) = I	53	10.43	90.57	1.03
	CDR = 2 Gender = F	Care (15) = I	54	10.63	98.15	1.03
	CDR = 2 Gender = F	Care (9) = I	54	10.63	90.74	1.03
6	Age = 3 Gender = F Care (12) = I Care (3) = I Care (9) = I	Care (15) = I	64	12.60	100	1.05
	Age = 3 Gender = F Care (13) = I Care (3) = I Care (9) = I	Care (15) = I	61	12.01	100	1.05

(Continued)

Table 5 (Continued).

Rule	Antecedent	Consequent	No. Of Cases In The Database	Support (%)	Confidence (%)	Lift
7	Age = 3 Care (13) = 1 Care (12) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	78	15.35	100	1.05
	Age = 3 Care (13) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	85	16.73	100	1.05
	Age = 3 Care (14) = 1 Care (13) = 1 Care (3) = 1	Care (15) = 1	51	10.04	100	1.05
	Age = 3 Care (14) = 1 Care (3) = 1	Care (15) = 1	62	12.21	100	1.05
	Age = 3 Care (14) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	54	10.63	100	1.05
	Age = 3 Care (14) = 1 Type = AD Care (9) = 1	Care (15) = 1	53	10.43	100	1.05
8	Age = 4 CDR = 1 Care (13) = 1	Care (15) = 1	63	12.40	100	1.05
	Age = 4 CDR = 1 Care (13) = 1 Care (12) = 1	Care (15) = 1	55	10.83	100	1.05
	Age = 4 CDR = 1 Care (13) = 1 Care (12) = 1 Care (3) = 1	Care (15) = 1	51	10.04	100	1.05
	Age = 4 CDR = 1 Care (13) = 1 Care (3) = 1	Care (15) = 1	57	11.22	100	1.05
	Age = 4 CDR = 1 Care (13) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	53	10.43	100	1.05
	Age = 4 CDR = 1 Care (13) = 1 Care (9) = 1	Care (15) = 1	58	11.42	100	1.05

(Continued)

Table 5 (Continued).

Rule	Antecedent	Consequent	No. Of Cases In The Database	Support (%)	Confidence (%)	Lift
	Age = 4 Care (5) = 1 Care (3) = 1	Care (15) = 1	57	11.22	100	1.05
9	Care (8) = 1 Care (12) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	97	19.09	100	1.05
	Care (8) = 1 Care (13) = 1 Care (12) = 1 Care (3) = 1	Care (15) = 1	90	17.72	100	1.05
	Care (8) = 1 Care (13) = 1 Care (12) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	80	15.75	100	1.05
	Care (8) = 1 Care (14) = 1 Care (12) = 1 Care (3) = 1	Care (15) = 1	56	11.02	100	1.05
	Care (8) = 1 Care (14) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	59	11.61	100	1.05
	Care (6) = 1 Care (8) = 1 Care (12) = 1 Care (3) = 1	Care (15) = 1	52	10.24	100	1.05
	Care (6) = 1 Care (8) = 1 Care (12) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	51	10.04	100	1.05
	Care (6) = 1 Care (8) = 1 Care (12) = 1 Care (9) = 1	Care (15) = 1	59	11.61	100	1.05
	Care (6) = 1 Care (8) = 1 Care (13) = 1 Care (12) = 1	Care (15) = 1	51	10.04	100	1.05
	Care (6) = 1 Care (8) = 1 Care (3) = 1 Care (9) = 1	Care (15) = 1	57	11.22	100	1.05

confidence value of 100%. Given that the third, sixth, seventh, and eighth generalized rules had 100% confidence, the five basic care needs were required for the

PLWD aged 75 years and older. Moreover, fall prevention and caring for the mood of the caregiver were also essential care needs.

The ninth generalized rule further considered preventing traffic accidents and getting lost (Care (6)) and adjusting home environment safety (Care (8)) or adjusting home environment safety and care for the mood of the caregiver (Care (14)) in addition to the five basic care needs. In practice, Care (6), Care (8), and Care (14) could be bundled together. Although the generalized rule had a relatively lower support value, the consequent care need was indicated when the antecedent care needs had a confidence value of 100%. Bundling the care needs may be a more effective means to care for patients with dementia.

Discussion

To the best of our knowledge, this is the first study to extensively evaluate the care needs of PLWD and their caregivers and to differentiate them according to the severity and subtype of dementia. The most common combinations of care needs were appropriate scheduling of activities, regular outpatient follow-up treatment, introduction and referral of social resources, referral to family support groups and care skills training, and education for dementia and BPSD. These needs occurred frequently and simultaneously with one another. Black et al¹⁸ reported that the most common unmet needs of community-residing PLWD were safety, followed by meaningful activities, and medical care. For the caregivers, more than 85% had unmet needs of resource referral and education. Eichler et al¹⁹ reported that the most frequent unmet needs of patients with primary care dementia were nursing treatment and care, social counseling and legal support, and pharmaceutical treatment and care. The results of the present study are consistent with those of the previous studies and further strengthened the fundamental role of these needs. The five basic needs can be viewed as basic care needs for PLWD and their care partners, and a collaborative team should consider these needs as first priority care.

Other less frequent combinations were preventing traffic accidents and getting lost, adjusting home environment safety, and caring for the mood of the caregiver. When one of the care needs was selected, the others were usually also present. Our previous study showed that caregivers have the highest burden when taking care of patients who do not need help with daily activities (that is, they can walk around and do housework).²⁷ PLWD have a high risk of getting lost and having household emergencies if they still have the ability to perform daily activities, which then increases the caregiver's burden. This suggests that if

one of the needs is unmet, case managers should pay more attention to the other two care needs.

The present study also found that the care needs were different for specific subtypes and severity of dementia. Except for the five basic care needs, patients with Alzheimer's dementia had needs for preventing traffic accidents and getting lost and fall prevention, while patients with vascular dementia needed more attention for fall prevention. The older (≥ 75 years old) PLWD were associated with more needs of fall prevention and care for the mood of the caregiver, especially in the female patients with mild Alzheimer's dementia (CDR = 1). Whereas, patients with moderate dementia (CDR = 2) were associated with greater needs of fall prevention, particularly in female patients with Alzheimer's dementia. Previous studies have discussed the different care needs of patients with mild cognitive impairment or dementia and for those with young onset dementia.^{20,29} However, only a few studies have focused on care needs for specific types of dementia, and studies on the care needs specific for patients with vascular cognitive impairment are lacking.^{30,31} Currently, no studies have compared the care needs for patients with different etiologies of dementia. The present study highlights the shortage of related research and provides a future direction for research.

The strengths of this study include that it provides a more comprehensive viewpoint by combining various care needs using a scientific method. Most previous studies have only shown the percentage of each unmet need for PLWD and their caregivers.^{18–20} Through the identification of the most common care needs, collaborative team members can understand the care focus more efficiently, especially for elementary dementia case managers. Another strength is the Apriori algorithm combining various variables to identify the care needs for particular conditions. Unlike previous studies such as Black et al¹⁸ and Eichler et al¹⁹ which only evaluated one or more variables causing a higher degree of unmet needs, our results provide a more clear scenario. For example, the appropriate care needs for elderly female PLWD with mild-stage Alzheimer's disease were appropriate scheduling of activities, regular outpatient follow-up treatment, education for dementia and BPSD, and fall prevention. Care needs for their caregivers were introduction and referral of social resources, referral to family support groups and care skills training, and care for their mood.

This study did not include some care needs of dementia that have been reported in past reviews, including early dementia evaluation and diagnosis and advanced care

planning.^{9,17} Because of the convenience and accessibility to medical care in Taiwan, PLWD and their care partners have easy access to subspecialists, especially in urban areas. People with suspected dementia usually receive a final etiological diagnosis within 1 month after complete evaluations. Therefore, early dementia evaluation and diagnosis were not considered as care needs for the PLWD and caregivers in this study. Advanced care planning is an important care need in patients with incurable chronic illnesses. The Patient Autonomy Act was passed in December 2015 in Taiwan and has been enforced since January 2019, which safeguards the medical autonomy and end-of-life rights of Taiwanese residents. In our site, the advanced care planning has been implemented for every PLWD who can name a surrogate decision-maker since 2016. Because our collaborative care model was implemented in October 2014, the advanced care planning was not selected as one of the care needs for dementia.

The quality measures and needs for patients with MCI were still unclear. However, American Academy of Neurology practice guideline³² for MCI highlighted the importance of the assessment and treatment of BPSD, financial and driving safety evaluation, and treatment and prognosis education in MCI patients. Therefore, the present study included MCI patients with a suspected etiology according to the best opinion at diagnosis and provided collaborative care. Only 5% of the subjects had Lewy body disease, and none had frontotemporal dementia in the present study. Further studies are needed to investigate the care needs of people with those subtypes of dementia. The present study did not include caregiver's characteristics, which may also have influenced the care needs.³³

Limitation

The Apriori algorithm, which is one of the most commonly seen association rules, has been widely used to discover previously unknown interesting relationships in data sets by finding rules and associations between any of the attributes by establishing support, confidence, and lift. However, there are some limitations when the Apriori algorithm is used. First, there is no universal approach to set up support and confidence values in order to generate association rules. In general, a higher confidence value, say 90% or above, is recommended when a conditional probability is applied to study the associations of attributes. 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, ie, lower support values. On the

other hand, setting a lower support value could result in a large number of rules that might hinder the management to summarize rules because rules should be examined manually to determine whether or not they are meaningful. Therefore, there is a trade-off between higher or lower support values. Second, the Apriori algorithm could be viewed as a screening approach to identify associations among a wide variety of attributes by setting up support and confidence values. Other approaches such as decision trees can be applied to reduce ambiguity in a decision-making process by assigning specific values to the problem, decisions, and outcomes of each decision.

Conclusion

Most previous studies have focused on the percentage of each unmet need for patients with dementia and their caregivers, however no studies have classified care needs.^{18–20} Grouping care needs according to the severity or subtype of dementia may allow for more efficient and holistic care. This study used the Apriori algorithm to elucidate whether care needs can be bundled to meet the needs of particular groups of PLWD and their caregivers and identified the basic care needs including appropriate scheduling of activities, regular outpatient follow-up treatment, introduction and referral of social resources, referral to family support groups and care skills training, and education for dementia and BPSD. In addition, patients with Alzheimer's dementia required more care to prevent traffic accidents and getting lost as well as fall prevention, while patients with vascular dementia required more care to prevent falls. Bundling care needs may be a more effective means to care for a wide variety of patients with dementia.

Author Contributions

All authors contributed to data analysis, drafting or revising the article, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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