

Unpacking the Multifaceted Burden: A Cross-sectional Analysis of Challenges Faced by Dementia Family Caregivers in Rural China

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Abstract

Background

In rural China, family members serve as the primary caregivers for people with dementia (PWD), and their burden is a multidimensional concept that is particularly burdensome in the resource-limited rural context. However, the previous study investigated caregiver burden as a holistic concept, which limits the identification of different types of burdens and their contributing factors. This study aims to explore the specific domain structure and reliability of the Caregiver Burden Inventory (CBI) among dementia family caregivers in rural China, and to determine the levels and key determinants of these domains.

Methods

This study enrolled 145 PWD and their family caregivers from rural areas. Data collected included PWDs' socio-demographic information and the severity of neuropsychiatric symptoms, as well as family caregivers' socio-demographic information, caregiver burden, social support, and mental health. Exploratory graph analysis was used to define the CBI's domains and the structure of each domain, and Cronbach's alpha coefficients were calculated to assess reliability. Multiple linear regression was used to assess factors influencing caregiver burden domains.

Results

Exploratory graph analysis revealed a robust four-domain model, with Cronbach's alphas between 0.690 and 0.846. Rural family caregivers reported high time-dependence and developmental burdens, while emotional and social burdens were lower. Multiple regression analyses identified PWD's self-care ability, the presence of comorbidities, rural family caregivers' depression levels, and weekly caregiving hours as significant predictors of these burdens.

Conclusions

This study validated the multidimensional structure of the CBI in rural Chinese family caregivers, demonstrating its utility in capturing diverse aspects of caregiver burden. These findings emphasize the need for targeted interventions to address the time management and personal development burdens faced by rural family caregivers.

Background

China has the world's largest population of people with dementia (PWD), contributing approximately 25.5% of global cases [1]. A large-scale study estimates the national prevalence of dementia among those aged 60 + at 6.0%, with rural areas exhibiting significantly higher rates than urban ones [2].

Influenced by national conditions and the traditional filial piety, about 80% of PWD receive home-based care from family caregivers [3], imposing substantial demands on these caregivers.

Family caregivers are spouses, children, or other family members who provide unpaid care to patients [4]. They are responsible not only for providing daily care and health monitoring, but also for coping with the PWD's functional deterioration and dementia-related symptoms, such as declines in activities of daily living (ADL) or instrumental activities of daily living (IADL), as well as symptoms like agitation and hallucinations [5–7]. These heavy and complex caregiving tasks place a substantial, multifaceted burden on caregivers, including physiological, psychological, social, and economic challenges, which can often be more severe in rural China [8–10]. People in rural areas are more likely to uphold traditional filial piety, emphasizing family responsibility toward elders, than urban dwellers influenced by Western independence values [11, 12]. Moreover, lower dementia knowledge in rural areas can exacerbate stigma and caregiver isolation [13]. In addition, rural caregivers face unique obstacles, including lower levels of education, financial strain, and limited healthcare resources [14]. More seriously, the mass migration of younger generations further weakens traditional family support systems [15]. These cumulative factors contribute to an increased burden on rural caregivers.

Dementia family care support programs can effectively enhance family caregivers' ability to provide care and alleviate their burden [16, 17]. Understanding caregiver burden is a prerequisite for implementing the support program, yet most assessments rely on a single global score [3, 18]. Given the multidimensional nature of the burden, reliance on global scores may not provide a comprehensive or accurate assessment [19]. This oversimplification hinders a deeper understanding of distinct burdens, potentially leading to generalized interventions that fail to address caregivers' specific needs. Therefore, identifying these distinct burden domains is essential for developing effective, targeted support programs for dementia family caregivers in rural China.

The Caregiver Burden Inventory (CBI) is a widely used instrument for measuring multiple domains of caregiver burden, including time-dependence burden (stress resulting from time constraints), emotional burden (negative feelings toward the care recipient), social burden (feelings arising from role conflicts), physical burden (fatigue and health deterioration resulting from long-term caregiving), and developmental burden (a sense of "stagnation" in personal development compared to peers) [20]. While providing valuable insights into the patterns of burden experienced by caregivers, the CBI was developed in a Western cultural context and primarily validated in urban Chinese populations [21, 22]. Given the sociocultural correlates of caregiver burden, the applicability of the CBI's original factor structure to rural areas is uncertain. Previous studies have shown that, despite its internal validity and reliability, the CBI exhibits inconsistent factor structures in different economic and cultural contexts [20, 22, 23]. Thus, exploratory analysis of the CBI in rural China is warranted.

Traditional factor analysis methods suffer from sample-size sensitivity in factor identification and involve subjectivity in rotation method selection and in the interpretation of factor loadings [24]. Furthermore, they also lack effective assessment of the stability and replicability of factor structure and

item allocation across different samples [25]. To overcome these methodological limitations, this study introduces Exploratory Graph Analysis (EGA), an emerging network psychometric technique [24]. EGA constructs a variable network model, transforming variables and their relationships into nodes and edges to identify variable communities (network clusters of items with strong conditional dependencies). These communities represent underlying psychological structures, which are equivalent to “factors” in traditional factor analysis, that is, domains or dimensions [24, 26]. In terms of technical implementation, EGA uses the Gaussian Graphical Model (GGM) combined with community detection algorithms (such as the “walktrap” algorithm) to construct these models and identify domains and their structures [24]. EGA demonstrates accuracy comparable to or superior to traditional methods while enabling automated factor estimation and visualization of results [27, 28]. Additionally, to address potential biases from sampling variability, EGA is augmented with the bootstrap technique (bootEGA), which provides insights into the stability of item assignments and domain estimates [28, 29]. This study pioneers the application of EGA to explore the domains of the CBI among rural dementia family caregivers, offering a novel methodological approach to burden assessment.

In addition to identifying the domains of burden, it is necessary to investigate their determinants. Previous studies have divided the factors affecting caregiver burden into three categories: PWD-related variables (e.g., dementia duration, neuropsychiatric symptoms), caregiver-related factors (e.g., age, gender, mental health), and social factors (e.g., perceived social support, economic status) [21]. However, prior studies have predominantly focused on urban populations; the factors influencing caregiver burden among rural family caregivers remain under-investigated. For instance, behaviors and psychological symptoms of dementia (BPSD) have a 90% incidence rate [30]. Rural family caregivers typically demonstrate lower health literacy [31], which may increase the burden of managing these potentially disruptive symptoms. Additionally, these caregivers often face mental health issues such as depression and anxiety, which can further exacerbate their burden [32]. Although social support is known to alleviate caregiver burden, the most effective sources in rural China are still underexplored. A comprehensive understanding of these determinants helps in designing the dementia family care support program that precisely targets the most impactful factors.

Given the insufficient validation of the CBI among family caregivers of PWD in rural China, and the lack of in-depth understanding of the domains, levels, and influencing factors of caregiver burden in this unique context, this study aims to: (1) evaluate the domains and associated structures and reliability of the CBI among family caregivers of PWD in rural China, and (2) identify the levels and key determinants of different burden domains.

Methods

Study design

This cross-sectional study was conducted between April 2022 and February 2023, and its reporting adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)

guidelines.

Participants and sampling

The required sample size was calculated using the cross-sectional sample size formul: $n = \left(\frac{Z_{1-\alpha/2} \sigma}{d} \right)^2$ [33]. Here, $Z_{1-\alpha/2}$ denotes the critical value of the standard normal distribution. With a significance level “ α ” of 0.05, $Z_{0.975} = 1.96$. The population standard deviation (σ) was estimated at 19.7, based on prior research [22]. The allowable error “ d ”, which is usually set at 0.25 or 0.5 times the standard deviation, is chosen to be 0.25 times the standard deviation to balance sample size and precision, resulting in $d = 0.25 \times 19.7 = 4.925$. The calculated theoretical sample size was 62. Accounting for a 20% invalid questionnaire rate, the final sample size was set at 75.

Participants were recruited from rural community health centers and tertiary hospitals’ memory clinics in Hunan Province, China. These settings were carefully chosen to capture the diverse experiences of rural family caregivers of PWD, recognizing the significant differences in access to healthcare and support services between rural and urban environments.

Participants were purposefully recruited from hospital and rural community health center patient lists. Inclusion criteria were: (1) permanent rural residents (having rural household registration and residing in a natural village for more than six months of the year); (2) care recipients with a confirmed diagnosis of dementia; (3) caregivers who assumed primary caregiving responsibilities (providing the majority of daily care for at least six months, including but not limited to meal assistance, personal hygiene, medication reminders, accompanying outings, and managing medical affairs); (4) caregivers with sufficient literacy and communication skills to participate in the study (i.e., ability to read, write, understand, and converse in Mandarin); (5) voluntary participation and able to give informed consent. Family-employed caregivers and those currently participating in similar research were excluded.

Measures

General Information Questionnaire

A self-designed questionnaire was used to collect socio-demographic information about the family caregivers (e.g., age, gender, education, marital status, employment status, perceived health status, presence of acute or chronic diseases, monthly household income, relationship to the PWD, co-residence, weekly caregiving hours) and the PWD (e.g., age, gender, education, presence of acute or chronic diseases, prior role as primary income earner, type of medical insurance, level of self-care, duration of dementia).

Caregiver Burden Inventory (CBI)

The CBI was used to assess the level of burden among rural family caregivers. This 24-item inventory, originally developed by Novak and Guest [20], evaluates five domains of burden: time-dependence (5 items), emotional (5 items), social (5 items), physical (4 items), and developmental (5 items). Each item is rated on a scale from 0 (not descriptive) to 4 (highly descriptive), yielding a total score ranging from 0 to 96, with higher scores indicating greater burden. The Chinese version of the CBI, translated and validated by Chou et al. [22], was used in this study.

Neuropsychiatric Inventory Questionnaire (NPI-Q)

The NPI-Q developed by Kaufer et al. [34] was used to assess the severity of BPSD and related caregiver distress. The questionnaire consists of 12 items corresponding to various symptoms such as hallucinations, delusions, agitation, and anxiety. Family caregivers are required to assess whether the patient has experienced these symptoms over the past month, and only evaluate the severity (1–3 points) and caregiver distress (0–5 points) for symptoms that are present (rated as “yes”). This study primarily utilized the NPI-Q severity scores, with a total score ranging from 0 to 36. Higher scores indicate more severe symptoms. The Chinese version validated by Ma et al. [35] showed good reliability, with a Cronbach’s alpha of 0.85 for the NPI-Q.

Multidimensional Scale of Perceived Social Support (MSPSS)

Perceived social support among family caregivers was measured using the MSPSS [36]. The scale comprises three subscales, each containing four items, assessing support from family members, friends, and significant others, for a total of 12 items. Each item is rated on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree), with total scores ranging from 12 to 84. Higher scores reflect greater perceived social support. The total Cronbach’s alpha coefficient for the Chinese version of MSPSS was 0.90, with subscale coefficients of 0.87 (family), 0.82 (friends), and 0.90 (significant others), demonstrating satisfactory reliability [37].

Depression-Anxiety-Stress Scale (DASS-21)

The mental health of rural family caregivers was evaluated with the DASS-21, a simplified version of the original 42-item DASS, which includes three subscales: depression, anxiety, and stress [38]. Each subscale consists of 7 items, scored from 0 (doesn’t apply to me at all) to 3 (applies to me a lot). Scores for each subscale are calculated by summing all item scores and multiplying by 2. Caregivers with scores above 9 for depression, above 7 for anxiety, and above 14 for stress are considered to exhibit mental health issues, with higher scores indicating greater severity of symptoms. The Cronbach’s alpha coefficient for the Chinese version of the DASS-21 total scale was 0.92, and the subscales were 0.80–0.83 [39].

Data collection and ethical considerations

Data were collected through face-to-face structured interviews conducted by two trained researchers. Hospital nurses and community health center staff assisted the researchers by distributing the study information to potential participants. Rural family caregivers interested in the study were instructed to text the researcher via WeChat. The researcher contacted eligible caregivers by telephone to obtain initial consent and schedule face-to-face interviews. The interviews were conducted at outpatient departments of hospitals and community health centers. Before the interviews, participants were informed about the study's purpose, procedures, rights, and potential risks. After obtaining signed informed consent, participants completed the questionnaire.

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Xiangya School of Nursing, Central South University (Approval No.: E2021143).

Statistical Analysis

We utilized the EGAnet package in R 4.4.1 to explore the network structure. Employing the Glasso model and the walktrap community detection algorithm to identify the number of domains and the domain affiliations of the items. We then conducted bootEGA with 1000 iterations to evaluate the stability. The criteria for evaluation included the frequency of detecting the same number of domains, the frequency with which items were categorized into their respective domains (item replication index), and the frequency of structural consistency within each domain, each with an acceptable threshold of 0.75 [29]. Aiming for distinct yet cohesive burden domains, we retained items based on the item replication index to enhance internal consistency within the CBI. As suggested by Golino et al. [40], items with a replication index below 0.75 were excluded, and the analysis was rerun.

After establishing the domain, we analyzed the data with SPSS 26.0. To ensure the maximum internal reliability of the CBI's domains, we calculated Cronbach's alpha coefficients for each subdomain. Data normality was assessed with the Kolmogorov-Smirnov test. For normally distributed data, we reported results as means and standard deviations ($M \pm SD$), whereas for non-normally distributed data, we reported medians and interquartile ranges ($M [IQR]$). Categorical variables were reported as frequencies and percentages. Group comparisons were conducted using t-tests or ANOVA for normally distributed data, and Mann-Whitney U or Kruskal-Wallis H test for non-normally distributed data. Correlations were evaluated using either Pearson (for normally distributed data) or Spearman (for non-normally distributed data), and multiple linear regression was used to identify factors affecting each domain of caregiver burden. Statistical significance was set at $p < 0.05$.

Results

Socio-demographic characteristics

A total of 150 questionnaires were collected, with 145 valid responses, yielding an effective response rate of 96.7%. The majority of rural family caregivers in the study were female (56.6%), married (89.0%), and adult children of PWD (60.0%), with an average age of 52.61 ± 13.84 years (Table 1).

The average age of PWD was 71.74 ± 8.55 years, and most of them were female (54.5%). The median duration since dementia diagnosis was 3.0 (2.0–4.0) years. A significant percentage, 75.2%, suffered from comorbidities. Only 35.9% of PWD are fully capable of self-care and do not require assistance from others (Table 1).

Table 1
Socio-demographic characteristics of the family caregivers and PWD (n = 145).

Socio-demographic characteristics	Family Caregivers	PWD
Gender, n (%)		
Male	63 (43.4)	66 (45.5)
Female	82 (56.6)	79 (54.5)
Age (years old), Mean $\pm$ SD	52.61 $\pm$ 13.84	71.74 $\pm$ 8.55
Age, n (%)		
≤ 60 years old	103 (71.0)	18 (12.4)
> 60 years old	42 (29.0)	127 (87.6)
Marital status,n (%)		
Spousal	129 (89.0)	—
Non-spouse	16 (11.0)	—
Employment, n (%)		
Employed	74 (51.0)	—
Unemployed	71 (49.0)	—
Educational level, n (%)		
Illiteracy	4 (2.8)	22 (15.2)
Primary school	34 (23.4)	62 (42.8)
Middle school	40 (27.6)	46 (31.7)
High school or junior college	40 (27.6)	9 (6.2)
Professional training college	19 (13.1)	1 (0.7)
Bachelor and above	8 (5.5)	5 (3.4)
Perceived health status, n (%)		
Poor	45 (31.0)	—
General	72 (49.7)	—
Good	28 (19.3)	—
Comorbidity, n (%)		
None	73 (50.3)	36 (24.8)

Socio-demographic characteristics	Family Caregivers	PWD
Gender, n (%)		
Have	72 (49.7)	109 (75.2)
Monthly household income, n (%)		
< 1000 yuan	5 (3.4)	—
1000–1999 yuan	65 (44.8)	—
> 1999yuan	75 (51.7)	—
Relationship to PWD, n (%)		
Spouse	37 (25.5)	—
Adult child	87 (60.0)	—
Daughter/son-in-law	16 (11.0)	—

Table 1
Socio-demographic characteristics of the rural family caregivers and PWD (n = 145)
(Continued).

Socio-demographic characteristics	Family Caregivers	PWD
Others	5 (3.4)	—
Co-residence or not		
Yes	107 (73.8)	—
No	38 (26.2)	—
Weekly caregiving hours (h), Median (IQR)	70.0 (46.5–144.0)	—
Weekly caregiving hours, n (%)		
< 40 h	23 (15.9)	—
40–79 h	58 (40.0)	—
80–120 h	26 (17.9)	—
> 120 h	38 (26.2)	—
Duration of dementia (years), Median (IQR)	—	3.0 (2.0–4.0)
Duration of dementia, n (%)		
≤ 5 years	—	119 (82.1)
> 5 years	—	26 (17.9)
Income was ever the primary source, n (%)		
Yes	—	72 (49.7)
No	—	73 (50.3)
Medical insurance, n (%)		
Provincial and municipal health insurance	—	46 (31.7)
Rural cooperative medical insurance	—	69 (47.6)
Self-financed	—	21 (14.5)
Other Insurance	—	9 (6.2)
Level of self-care, n (%)		
Fully self-care	—	52 (35.9)
Partially self-care	—	52 (35.9)
Note: PWD=People with Dementia, IQR=Interquartile Range, SD=Standard Deviation.		

Socio-demographic characteristics	Family Caregivers	PWD
Completely unable to self-care	—	41 (28.3)
Note: PWD=People with Dementia, IQR=Interquartile Range, SD=Standard Deviation.		

Caregiver burden of rural family caregivers measured by the CBI

The EGA identified a five-domain network (Fig. 1), in which the 24 scale items are represented as nodes, and line thickness and color denote the strength and nature of associations between items. Details of the items within each domain are in Supplementary Table S1.

As shown in Table 2, bootEGA detected five domains with a frequency of 0.660 (i.e., in 1000 bootstrap samples, 660 samples identified five domains). Figure 3 shows that the item replication indexes for items C1 (“I’m not getting enough sleep”), C2 (“I’m physically tired”), C3 (“Caregiving has made me physically sick”), C4 (“My health has suffered”), C9 (“I don’t do as good a job at work as I used to”), and C19 (“I don’t have a minute’s break from my caregiving chores”) are all significantly below 0.75, indicating poor stability of these items. The structural consistency frequencies for Domain 1 (developmental burden) and Domain 2 (physical burden) also fell below the 0.75 threshold (Table 3), suggesting that some items were misclassified into these domains. It is necessary to delete these low-stability items.

After exclusion, a four-domain network structure with 18 items was obtained (Fig. 2), categorized into social burden, emotional burden, time-dependence burden, and developmental burden. Upon re-examining the EGA structure through bootstrap, the frequency of the four domains rose to 0.941, while that of the five domains decreased to 0.055 (Table 2). Figure 4 and Table 3 demonstrate that the replication index of items and the consistency of domain structures within the scale have reached satisfactory levels (> 0.75). The Cronbach’s alpha coefficients for each domain ranged from 0.690 to 0.846. The complete list of 18 items and Cronbach’s alpha coefficients are available in Supplementary Table S2.

Scores across all four domains showed skewed distributions (Supplementary Table S2). Specifically, the median score for the time-dependence burden was 13.0 (11.0–15.0). Both the developmental and social burdens had median scores of 12.0 (10.0–14.0) and 7.0 (5.0–9.5), respectively. The emotional burden had the lowest median score, at 5.0 (4.0–8.0).

Table 2
Frequency of the CBI domains across all bootstrap replicate samples.

Number of domains	Frequency	
	EGA (24 items)	EGA (18 items)
3	0.007	0.003
4	0.180	0.941
5	0.660	0.055
6	0.144	0.001
7	0.009	—
Note: EGA=Exploratory Graph Analysis.		

Table 3
Frequency with consistent internal structure across all domains.

Domains	Frequency of structural consistency	
	EGA(24 items)	EGA(18 items)
Time-dependence burden	0.997	1.000
Emotional burden	0.932	0.912
Social burden	0.824	0.847
Development burden	0.313	0.870
Physical burden	0.606	—
Note: EGA = Exploratory Graph Analysis.		

Relationships between caregiver burden and socio-demographic characteristics

A univariate analysis revealed that among the socio-demographic variables of rural family caregivers, significant differences in emotional and developmental burden were observed only for weekly caregiving hours ($p < 0.05$). Time-dependence burden showed significant differences across age, employment status, and monthly household income ($p < 0.05$). Notably, social burden did not show statistically significant differences across any of the examined sociodemographic variables among family caregivers ($p > 0.05$).

Among the PWD's socio-demographic variables, significant differences in the emotional burden of rural family caregivers were observed in PWD's age and types of medical insurance ($p < 0.05$). Significant differences in time-dependence burden were found in PWD's age, presence of acute or chronic diseases,

levels of self-care, and duration of dementia ($p < 0.05$). The other two burdens (social burden and developmental burden) showed no significant differences across PWD's socio-demographic characteristics ($p > 0.05$). Specifics are presented in Table 4.

Correlation between caregiver burden and perceived social support, mental health, and BPSD

Spearman correlation analysis (Table 5) showed that social burden was negatively correlated with overall perceived social support ($r = -0.296, p < 0.001$), support from family ($r = -0.320, p < 0.001$), friends ($r = -0.268, p < 0.01$), and significant others ($r = -0.264, p < 0.01$), and positively correlated with depression ($r = 0.359, p < 0.01$). Emotional ($r = 0.183, p < 0.05$) and developmental burdens ($r = 0.268, p < 0.01$) were each positively associated with depression, while time-dependence burden correlated positively with BPSD severity ($r = 0.326, p < 0.001$).

Multiple regression of factors influencing caregiver burden

The four domains of burden were each examined as the dependent variable in a multiple linear regression analysis (Table 6). The significant variables from the univariate and Spearman correlation analyses served as the independent variables. The multiple linear regression analyses revealed that: (1) Social burden is associated with rural family caregivers' depression (explaining 18.9% of the variance). (2) Emotional burden is associated with the rural family caregivers' weekly caregiving hours (explaining 9.1% of the variance). (3) Higher time-dependence burden was associated with the presence of comorbidities and poorer self-care ability in PWD (explaining 28.3% of the variance). (4) Developmental burden is associated with depression and weekly caregiving time among family caregivers (explaining 9.3% of the variance).

Table 4
Univariate analysis of caregiver burden (n = 145).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
Rural family caregivers				
Gender				
Male	8.0 (5.0–10.0)	5.0 (3.0–7.0)	13.0 (12.0–15.0)	11.10 $\pm$ 3.04
Female	7.0 (5.0–9.3)	5.5 (5.0–8.0)	13.0 (11.0–15.0)	12.02 $\pm$ 2.97
<i>t/F/Z/H</i>	-0.465 ^c	-1.198 ^c	-1.282 ^c	-1.847 ^a
<i>p</i> -value	0.642	0.231	0.200	0.067
Age				
$\leq$ 60 years old	7.0 (5.0–9.0)	5.0 (4.0–8.0)	13.0 (11.0–14.0)	12.0 (10.0–14.0)
> 60 years old	8.0 (4.0–10.0)	5.0 (3.0–7.0)	13.5 (13.0–15.0)	11.0 (10.0–13.0)
<i>t/F/Z/H</i>	-0.353 ^c	-0.015 ^c	-2.613 ^c	-1.351 ^c
<i>p</i> -value	0.724	0.988	0.009**	0.177
Marital status				
Spousal	7.0 (5.0–9.0)	5.0 (4.0–8.0)	13.0 (11.0–15.0)	12.0 (10.0–13.5)
Non-spousal	9.0 (5.5–10.0)	5.0 (0.0–7.8)	14.0 (11.0–15.0)	13.0 (10.3–15.0)
<i>t/F/Z/H</i>	-1.545 ^c	-1.146 ^c	-0.450 ^c	1.149 ^c
<i>p</i> -value	0.122	0.252	0.653	0.251
Employment				
Employed	8.0 (5.0–10.0)	5.0 (4.0–8.0)	12.0 (10.0–14.0)	12.0 (10.0–15.0)

Table 4
Univariate analysis of caregiver burden (n = 145) (Continued).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
Unemployed	7.0 (4.0–9.0)	5.0 (3.0–7.0)	14.0 (12.0–15.0)	12.0 (10.0–13.0)
<i>t/F/Z/H</i>	-0.619 ^c	-0.008 ^c	-3.755 ^c	-1.347 ^c
<i>p</i> -value	0.536	0.994	< 0.001***	0.178
Educational level				
Illiteracy	9.5 (7.5–10.8)	9.5 (5.0–14.8)	13.5 (12.3–15.5)	14.0 (10.8–17.3)
Primary school	7.0 (4.0–9.0)	6.0 (5.0–7.0)	13.0 (12.0–15.3)	12.0 (10.0–13.0)
Middle school	7.5 (4.0–10.0)	5.0 (3.0–8.8)	13.0 (12.3–14.0)	11.0 (10.0–13.0)
High school or junior college	7.0 (5.0–8.8)	5.0 (4.0–6.0)	13.0 (11.0–15.0)	12.0 (10.0–14.8)
Professional training college	7.0 (5.0–10.0)	5.0 (1.0–7.0)	13.0 (11.0–16.0)	11.0 (9.0–13.0)
Bachelor and above	9.0 (5.3–10.5)	7.0 (3.5–8.8)	11.0 (10.0–12.8)	15.0 (10.0–15.8)
<i>t/F/Z/H</i>	8.078 ^d	5.757 ^d	6.467 ^d	7.461 ^d
<i>p</i> -value	0.152	0.331	0.263	0.189
Perceived health status				
Poor	8.0 (6.0–10.0)	7.0 (5.0–9.0)	13.0 (12.0–15.0)	12.0 (11.0–14.5)
General	7.0 (5.0–9.0)	5.0 (3.0–7.0)	13.0 (11.0–14.0)	11.0 (9.3–14.0)
Good	7.0 (4.0–8.0)	5.0 (3.0–6.8)	12.5 (10.0–15.0)	10.5 (8.3–13.8)
<i>t/F/Z/H</i>	3.427 ^d	4.675 ^d	3.276 ^d	3.300 ^d
<i>p</i> -value	0.180	0.097	0.194	0.192

Table 4. Univariate analysis of caregiver burden (n = 145) (Continued).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
Acute or chronic disease				
None	7.0 (5.0–9.0)	5.0 (4.0–7.5)	13.0 (11.0–15.0)	12.0 (9.0–14.0)
Have	7.5 (4.3–10.0)	5.0 (3.3–8.0)	13.0 (12.0–15.0)	12.0 (10.0–13.0)
<i>t/F/Z/H</i>	0.187 ^c	-0.162 ^c	1.520 ^c	0.682 ^c
<i>p</i> -value	0.852	0.871	0.128	0.495
Monthly household income				
< 1000 yuan	9.0 (3.0–12.5)	5.0 (1.0–9.0)	10.0 (5.5–16.0)	12.0 (10.0–15.5)
1000–1999 yuan	7.0 (5.5–10.0)	5.0 (4.5–7.0)	14.0 (12.0–15.0)	11.0 (10.0–13.0)
> 1999 yuan	7.0 (4.0–9.0)	5.0 (4.0–8.0)	13.0 (11.0–14.0)	12.0 (10.0–14.0)
<i>t/F/Z/H</i>	0.617 ^d	0.174 ^d	7.142 ^d	1.095 ^d
<i>p</i> -value	0.734	0.917	0.028*	0.578
Relationship to PWD				
Spouse	8.0 (4.5–10.0)	5.0 (3.0–7.0)	13.0 (13.0–15.5)	11.0 (9.5–13.0)
Adult child	7.0 (5.0–10.0)	5.0 (4.0–8.0)	13.0 (11.0–15.0)	12.0 (9.0–14.0)
Daughter/son-in-law	6.0 (4.0–8.0)	5.5 (4.3–8.5)	12.0 (11.0–14.5)	12.0 (11.0–14.0)
Others	8.0 (7.0–8.5)	5.0 (4.0–7.0)	13.0 (10.5–15.0)	11.0 (10.5–16.5)
<i>t/F/Z/H</i>	3.510 ^d	0.654 ^d	5.059 ^d	3.848 ^d
<i>p</i> -value	0.319	0.884	0.168	0.278

Table 4. Univariate analysis of caregiver burden (n = 145) (Continued).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
Cohabitation or not				
Yes	8.0 (4.0–9.0)	5.0 (3.0–7.0)	13.0 (12.0–15.0)	11.0 (10.0–13.0)
No	7.0 (6.0–10.0)	5.5 (5.0–8.3)	12.0 (10.0–14.3)	12.5 (11.0–15.0)
<i>t/F/Z/H</i>	-0.502 ^c	-1.114 ^c	-1.790 ^c	-1.811 ^c
<i>p</i> -value	0.616	0.265	0.073	0.070
Weekly caregiving hours				
< 40 h	8.0 (6.0–9.0)	6.0 (5.0–8.0)	13.0 (12.0–15.0)	12.0 (11.0–15.0)
40–79 h	7.0 (5.8–10.0)	6.0 (5.0–8.3)	13.0 (11.0–14.0)	12.0 (11.0–14.0)
80–120 h	8.0 (4.0–10.3)	6.0 (3.0–8.3)	14.0 (12.0–16.0)	10.5 (8.8–12.8)
> 120 h	7.0 (4.0–9.0)	5.0 (2.8–5.3)	13.0 (11.0–15.3)	10.0 (8.8–13.0)
<i>t/F/Z/H</i>	1.412 ^d	14.004 ^d	5.077 ^d	10.813 ^d
<i>p</i> -value	0.703	0.003**	0.166	0.013*
PWD				
Gender				
Male	8.0 (5.0–10.0)	5.0 (3.8–7.0)	13.0 (12.0–15.0)	11.76 $\pm$ 3.39
Female	7.0 (4.0–9.0)	5.0 (4.0–8.0)	13.0 (11.0–14.0)	11.51 $\pm$ 2.70
<i>t/F/Z/H</i>	-1.484 ^c	-0.735 ^c	-1.871 ^c	0.496 ^a
<i>p</i> -value	0.138	0.462	0.061	0.620

Table 4. Univariate analysis of caregiver burden (n = 145) (Continued).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
Age				
≤ 60 years old	7.0 (3.0–10.3)	3.0 (1.0–5.5)	11.5 (8.0–13.0)	11.0 (9.0–14.3)
> 60 years old	7.0 (5.0–9.0)	5.0 (5.0–8.0)	13.0 (12.0–15.0)	12.0 (10.0–13.0)
<i>t/F/Z/H</i>	-0.217 ^c	-2.417 ^c	-3.344 ^c	-0.087 ^c
<i>p</i> -value	0.828	0.016*	0.001**	0.930
Educational level				
Illiteracy	7.5 (6.0–9.3)	5.0 (4.8–7.0)	13.0 (11.8–14.3)	11.0 (10.8–15.0)
Primary school	8.0 (5.0–10.0)	6.0 (5.0–8.0)	13.0 (12.0–15.0)	12.0 (10.0–13.0)
Middle school	7.0 (4.0–9.0)	5.0 (3.0–8.3)	13.0 (10.8–15.0)	12.0 (10.0–15.0)
High school and junior college	6.0 (4.0–11.0)	5.0 (0.0–6.5)	11.0 (6.5–16.0)	10.0 (7.0–12.5)
Professional training college	—	—	—	—
Bachelor and above	7.0 (4.5–10.0)	5.0 (3.0–9.0)	13.0 (11.0–15.5)	12.0 (6.5, 13.5)
<i>t/F/Z/H</i>	2.568 ^d	5.962 ^d	2.491 ^d	4.957 ^d
<i>p</i> -value	0.766	0.310	0.778	0.421
Comorbidity				
None	7.0 (5.0–10.8)	5.0 (1.0–6.8)	12.0 (10.0–14.0)	11.5 (9.3–14.0)
Have	8.0 (5.0–9.0)	5.0 (5.0–8.0)	13.0 (12.0–15.0)	12.0 (10.0–14.0)
<i>t/F/Z/H</i>	0.065 ^c	-1.595 ^c	3.084 ^c	0.191 ^c
<i>p</i> -value	0.798	0.111	0.002**	0.848

Table 4. Univariate analysis of caregiver burden (n = 145) (Continued).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
Duration of dementia				
≤ 5 years	7.0 (5.0–9.0)	5.0 (4.0–8.0)	13.0 (11.0–14.0)	11.0 (10.0–13.0)
> 5 years	7.5 (5.0–10.0)	5.0 (4.5–7.3)	15.0 (13.0–16.0)	12.0 (10.0–14.0)
<i>t/F/Z/H</i>	-0.345 ^c	-0.245 ^c	-3.479 ^c	-0.811 ^c
<i>p</i> -value	0.730	0.806	0.001**	0.417
Income was ever the primary source				
Yes	7.0 (5.0–10.0)	5.0 (3.3–7.8)	13.0 (11.0–15.0)	11.63 $\pm$ 3.30
No	8.0 (4.5–9.0)	5.0 (4.0–8.0)	13.0 (11.0–15.0)	11.62 $\pm$ 2.76
<i>t/F/Z/H</i>	-0.350 ^c	-0.656 ^c	-0.264 ^c	0.017 ^a
<i>p</i> -value	0.726	0.512	0.792	0.986
Medical insurance				
Provincial and municipal health insurance	7.0 (5.8–10.0)	6.0 (5.0–8.0)	13.0 (11.8–15.0)	11.0 (10.0–14.0)
Rural cooperative medical insurance	8.0 (6.0–10.0)	5.0 (3.0–7.0)	14.0 (11.0–15.0)	12.0 (10.0–13.0)
Self-financed	8.0 (4.0–9.0)	5.0 (3.5–9.0)	13.0 (10.0–13.5)	12.0 (10.0–14.0)
Others	4.0 (1.5–7.5)	3.0 (0.0–4.5)	12.0 (12.0–15.0)	10.0 (8.0–12.5)
<i>t/F/Z/H</i>	4.845 ^d	8.686 ^d	5.587 ^d	4.295 ^d

Table 4. Univariate analysis of caregiver burden (n = 145) (Continued).

Socio-demographic characteristics	Social burden	Emotional burden	Time-dependence burden	Developmental burden
	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD	Median (IQR) / Mean $\pm$ SD
<i>p</i> -value	0.183	0.034*	0.134	0.231
Level of self-care				
Fully self-care	7.0 (5.0–10.0)	5.0 (5.0–7.8)	12.0 (10.0–13.0)	12.00 $\pm$ 3.35
Partially self-care	7.5 (5.0–9.8)	6.0 (3.5–8.0)	13.0 (12.0–14.0)	11.69 $\pm$ 2.76
Completely unable to self-care	8.0 (5.0–9.0)	5.0 (2.0–7.0)	15.0 (14.0–16.0)	11.05 $\pm$ 2.91
<i>t/F/Z/H</i>	0.177 ^d	4.680 ^d	41.541 ^d	1.156 ^b
<i>p</i> -value	0.915	0.096	< 0.001***	0.318
Note: PWD = People with Dementia, IQR = Interquartile Range, SD = Standard Deviation.				

a = t-test, b = ANOVA, c = Mann-Whitney U test, d = Kruskal-Wallis H test.

p* < 0.05, *p* < 0.01, ****p* < 0.001.

Table 5

Correlation between perceived social support, negative emotions, severity of BPSD, and caregiver burden (n = 145).

Variables	Median (IQR)	Social burden	Emotional burden	Time-dependence burden	Developmental burden
MSPSS total score	53.0 (48.0–57.0)	-0.296***	-0.024	0.075	-0.046
family	18.0 (17.0–19.0)	-0.320***	-0.022	0.083	-0.031
friends	17.0 (16.0–19.0)	-0.268**	-0.006	0.073	-0.023
significant others	17.0 (15.0–19.0)	-0.264**	-0.068	0.046	-0.096
Depression	8.0 (4.0–10.0)	0.359***	0.183*	0.046	0.268**
Anxiety	8.0 (4.0–11.0)	0.012	-0.051	0.080	-0.087
Stress	12.0 (8.0–16.0)	0.118	-0.039	-0.033	0.032
NPI-S	13.0 (10.0–15.0)	0.116	-0.050	0.326***	-0.017
Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.					

Table 6
Multivariate linear regression related to caregiver burden (n = 145).

Variables	B	SE	95%CI	p-value	Adjusted R ²
Dependent variable: Social burden					
Support from significant others	-0.024	0.126	(-0.272, 0.224)	0.849	18.9%
Support from friends	-0.077	0.172	(-0.416, 0.262)	0.654	
Support from family	-0.318	0.182	(-0.677, 0.042)	0.083	
Depression	0.191	0.053	(0.087, 0.296)	< 0.001***	
Dependent variable: Emotional burden					
Weekly caregiving hours (< 40 h = 1)	-0.654	0.258	(-1.164, -0.145)	0.012*	9.1%
PWD's age (≤ 60 years old = 1)	1.433	0.818	(-0.184, 3.050)	0.082	
Medical insurance (Provincial and municipal)	0.283	0.846	(-1.390, 1.956)	0.739	
Medical insurance (Rural cooperative)	-0.144	0.802	(-1.730, 1.443)	0.858	
Medical insurance (others)	-2.261	1.261	(-4.753, 0.232)	0.075	
Depression	0.072	0.055	(-0.037, 0.182)	0.193	
Dependent variable: Time-dependence burden					
Caregiver's age (< 60 years old = 1)	0.024	0.578	(-1.107, 1.155)	0.967	28.3%
Work status (employed = 1)	0.918	0.520	(-0.110, 1.947)	0.080	
Monthly household income (< 1000 yuan = 1)	0.129	0.377	(-0.616, 0.874)	0.733	
PWD's age (≤ 60 years old = 1)	0.995	0.667	(-0.324, 2.314)	0.863	
Comorbidity (none = 1)	1.261	0.504	(0.265, 2.257)	0.013*	

Variables	B	SE	95%CI	p-value	Adjusted R ²
Dependent variable: Social burden					
Duration of dementia (≤ 5 years = 1)	0.598	0.560	(-0.509, 1.705)	0.287	
Level of self-care (fully self-care = 1)	1.234	0.301	(0.634, 1.824)	< 0.001***	
NPI-S total score	0.028	0.057	(-0.084, 0.140)	0.621	

Table 6
Multivariate linear regression related to caregiver burden (n = 145) (Continued).

Variables	B	SE	95%CI	p-value	Adjusted R ²
Dependent variable: Developmental burden					
Weekly caregiving hours (< 40 h = 1)	-0.761	0.229	(-1.215, -0.307)	0.001**	9.3%
Depression	0.120	0.051	(0.020, 0.219)	0.019*	
Note: SE = Standard Error, CI = Confidence Interval.					

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

Discussion

Numerous comparative studies [41–43] have shown that caregivers of PWD experience a greater burden than those caring for individuals with other chronic diseases, such as cancer, multiple sclerosis, or mild cognitive impairment. The burden on caregivers related to dementia care is particularly acute in rural China, where access to resources and support services is limited. Consequently, family caregivers of PWD in rural China represent a vulnerable population who need formal support. A comprehensive assessment of the various burdens they face is essential for developing effective support services for this population. The CBI serves as a valuable tool that not only quantifies the overall burden but also assesses its various aspects [44].

In this study, we employed EGA to explore the domains and associated structures of the CBI among family caregivers of PWD in rural areas. The initial EGA results revealed five domains: developmental, physical, social, emotional, and time-dependence, consistent with the original English version [20] and the existing Chinese version [22]. However, in this study, items C1 (“I’m not getting enough sleep”) and C2 (“I’m physically tired”) were categorized under “developmental burden” rather than “physical burden”,

and items C9 (“I don’t do as good a job at work as I used to”) and C19 (“I don’t have a minute’s break from my caregiving chores”) were shifted to “developmental burden” from “emotional” and “time-dependence” burdens, respectively. These differences may be attributed to cultural factors. In Western countries and urban Chinese populations, sleep deprivation and physical fatigue are typically associated with physical burden. However, in rural China, family caregivers of PWD may view these issues as an inevitable cost of fulfilling family responsibilities, which can affect their productivity (e.g., farming or working) and self-improvement (e.g., learning or skill training), ultimately restricting personal development. Similarly, items C9 and C19 reflect emotional exhaustion due to decreased work performance and restricted time freedom in Western countries and urban Chinese populations. In the rural Chinese sample in this study, these two items more directly reflect the negative impact of caregiving responsibilities on career development and personal growth opportunities, as evidenced by decreased job performance and the occupation of personal time.

Additionally, EGA constructs network models based on the co-occurrence relationships among items and clusters those that frequently co-occur [28]. The strength of the connections between items reflects their correlations. As shown in Fig. 1, items C1, C2, C9, and C19 have denser connections with nodes representing developmental burden, as indicated by thicker edges, suggesting strong correlations with developmental burden and are thus classified as such. However, these items still have connections to the nodes of the original domains, but these connections are sparser and thinner, indicating weaker correlations. Besides, the only two items of physical burden — item C3 (“Caregiving has made me physically sick”) and item C4 (“My health has suffered”) — also connect with developmental, social, and emotional burden nodes, suggesting that these experiences are not solely physical but intertwined with multiple pressures. The cross-domain connections of these six items indicate instability and cross-loadings, supported by their low item replication indexes in bootEGA (below the 0.75 threshold). The frequent cross-domain occurrence of items leads to low structural consistency, which is why the structural consistency of developmental and physical burden is also below the threshold.

After excluding the six unstable items, a subsequent EGA revealed that the remaining 18 items clustered into four burden domains: social, emotional, time-dependence, and developmental, confirming the multidimensionality of caregiver burden. The social burden emerged primarily as a conflict between caregiving duties and social roles, which aligns with previous findings [20]. Emotional burden refers to the negative emotions caregivers experience [20]. The time-dependence burden reflects significant time constraints imposed by dementia care, confirming the considerable commitment required from family caregivers [20]. The developmental burden, closely related to the time-dependence burden, mainly reflects caregivers’ feelings of being out of step with their peers in terms of personal growth [20]. Unlike the initial EGA, the second analysis did not retain the physical burden domain, as its only two items were excluded. The developmental burden domain, however, contained more items, and after excluding unstable items, the item replication indexes and structural consistency within the domain reached acceptable levels, allowing it to be retained. BootEGA indicated that the four dimensions appeared with a frequency of 0.941 in 1000 bootstrap replications, demonstrating high statistical stability and supporting the conclusion that the CBI presents a four-domain structure among rural family caregivers in China.

Some may question why item C24 (“I expected that things would be different at this point in my life”) in the 18-item CBI is categorized under developmental burden, despite its weak connections (thin edges) with other items in that domain: item C20 (“I feel that I am missing out on life”), item C21 (“I wish I could escape from this situation”), item C22 (“My social life has suffered”), item C23 (“I feel emotionally drained due to caring for my care-receiver”).. Firstly, while it has weak connections with nodes in the developmental burden domain (as shown in Fig. 2), it links to four other items within this domain, significantly more than in other domains (emotional and time-dependence burdens), indicating domain specificity. Secondly, the item replication indexes in two bootEGA exceeded the threshold, demonstrating its consistent allocation to the developmental burden domain. Thirdly, the item captures the unique psychological experience of the discrepancy between caregivers’ reality and expectations, distinct from emotional and time-dependence burdens and aligning with the developmental burden’s theoretical significance. Lastly, its consistent classification in both the original English version [20] and the existing Chinese version [22] further supports its placement in this domain. Thus, both network analysis and theoretical considerations justify assigning item C24 to the developmental burden domain.

We also evaluated the CBI’s internal consistency using Cronbach’s alpha. An alpha coefficient of 0.70 or higher for the total scale and 0.60 or higher for each domain suggests satisfactory reliability [45]. The Cronbach’s alpha coefficients obtained in our study further confirm that the CBI is a suitable instrument for assessing the burden of family caregivers of PWD in rural China.

Next, our regression analysis showed that the characteristics of both rural PWD and their family caregivers significantly impact caregiver burden. Within the PWD-related variables, we found that the level of self-care and the presence of acute or chronic illnesses are associated with a time-dependence burden. The anticipated impact of PWDs’ self-care levels on this burden aligns with research in Gushan Town, Fuzhou [46]. A possible explanation is that dementia, as a neurodegenerative disease, progressively impairs PWD’s memory and cognition, leading to a decline in their self-care abilities [47–49]. This decline means that family caregivers must spend more time and energy assisting with ADL and IADL, such as dressing, eating, transportation, and housekeeping [50]. There is also no doubt that caring for PWD with comorbidities increases the time-dependence burden, as family caregivers often need to accompany PWD to medical appointments and manage their illnesses. To alleviate these burdens, we recommend a two-pronged approach: enhancing the self-care abilities of PWD through home-based multimodal exercise programs [51, 52] and providing respite services, such as daycare centers and home care assistance, to give family caregivers much-needed breaks [53].

Further, rural family caregiver-related variables, including weekly caregiving hours and depression, were analyzed. Surprisingly, longer weekly caregiving hours correlated with lower emotional and developmental burdens. The median caregiving time in this study was 70.0 hours (46.5–144.0), with 26.2% of caregivers dedicating over 120 hours per week, surpassing the averages in individualistic countries with advanced dementia care systems [54, 55]. This suggests that rural family caregivers who are more willing to devote time to caring for PWD are deeply influenced by filial piety. As a core ethical norm in Confucian culture, filial piety emphasizes the obligation of younger generations to support, care

for, and respect their parents and elders, leading caregivers to prioritize the elderly's health over their own well-being [56]. The internalization of this ethical norm motivates them to overcome negative emotions and limitations in personal development.

Depression was significantly associated with developmental burden and was the sole factor explaining the social burden. While the causal relationship between depression and caregiver burden remains to be clarified, it is crucial to recognize depression as a prevalent psychological disorder that can adversely affect caregiver well-being. Healthcare providers and policymakers should improve mental health services in rural areas, screen caregivers for depression, and implement supportive measures such as mobile-based psychoeducation [57] or exergaming [58] to improve family caregivers' mental health and reduce their burden.

Surprisingly, contrary to previous studies [59, 60], we found that perceived social support and the severity of BPSD did not influence caregiver burden. Although rural family caregivers received considerable support in this study, the general lack of dementia-related knowledge and caregiving skills in rural areas often results in support that falls short of meeting their actual needs [61, 62]. In addition, cultural emphasis on family and filial piety in rural settings may lead family caregivers to view elderly care as an inherent duty [11], making their burden more dependent on their self-efficacy and self-satisfaction in their caregiver role [21] rather than on the amount of external support. Similarly, due to the limited knowledge of dementia among rural family caregivers, they may be more prone to misinterpret the BPSD as normal aspects of aging, rather than perceiving them as an additional burden. These reasons confirm the importance of the dementia care support program in rural areas. To construct and refine such a program, it is imperative to vigorously cultivate professional multidisciplinary care teams.

Strengths and limitations

To our knowledge, this is the first study to employ EGA to explore the structure of the CBI and to investigate the factors influencing various burden domains among rural Chinese dementia caregivers. It fills a critical gap in the literature and provides both theoretical support and practical guidance for designing a dementia care support program for rural China. While the study provides several valuable insights, it also has some limitations. First, recruiting participants exclusively from Hunan Province may introduce bias and limit the generalizability of the findings to other rural regions. Secondly, we did not collect specific indicators of participants' residential rurality (e.g., village population size, distance to tertiary hospitals), which precluded a deeper understanding of how the rural environment affects caregiver burden. Moreover, the cross-sectional design restricts our ability to capture dynamic trends or causal relationships in caregiver burden. Finally, the overall multiple regression models explained relatively low variances across different types of burden, with a maximum of 28.3%, which may be attributed to the exploratory nature of the study.

To address current limitations and improve future research quality, we propose the following recommendations. First, future studies should expand the sample to include multiple provinces to

improve representativeness. Second, standardized rurality indicators should be incorporated to better characterize how rural contexts influence caregiver burden. Third, longitudinal research methods are needed to track changes in caregiver burden and establish causal relationships between caregiver burden and various factors. Lastly, other potential influencing factors should be considered to gain a deeper understanding of the burden's origins.

Conclusion

In conclusion, this study indicates that caregiver burden among rural Chinese dementia family caregivers is composed of four distinct domains: social, emotional, time-dependence, and developmental burdens. It is worth noting that the time-dependence and development burdens of rural family caregivers are particularly heavy, revealing the impact of caregiving tasks on caregivers' time investment and personal development. Additionally, the study identified key factors affecting each domain of burden, including PWD's self-care abilities and health status, the time family caregivers spend on care, and their mental health.

These findings highlight the urgent need for a family care support program in rural China. Such a program should involve a multidisciplinary team focused on enhancing PWD self-care capabilities, providing respite care, and improving family caregivers' mental health through education. Recognizing the multidimensionality of caregiver burden will foster a more supportive environment, ultimately enhancing family caregiver well-being and the quality of care for PWD.

Abbreviations

PWD

People with dementia

ADL

Activities of daily living

IADL

Instrumental activities of daily living

CBI

Caregiver burden inventory

EGA

Exploratory graph analysis

GGM

Gaussian graphical model

BPSD

Behaviors and psychological symptoms of dementia

STROBE

Strengthening the reporting of observational studies in epidemiology

NPI-Q

Neuropsychiatric inventory questionnaire
MSPSS
Multidimensional scale of perceived social support
DASS-21
Depression-anxiety-stress scale
IQR
interquartile ranges
ANOVA
Analysis of variance

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Xiangya School of Nursing, Central South University (Approval No. : E2021143) and followed the principles of the Declaration of Helsinki. All participants provided informed written consent before their participation.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

JZ conceptualized the study, developed the methodology, performed the formal analysis, and was a major contributor in writing the original draft as well as reviewing and editing the manuscript. LX contributed to the conceptualization and methodology, reviewed and edited the manuscript, and supervised the study. XJG contributed to the conceptualization and methodology, and reviewed and edited the manuscript. HY contributed to the conceptualization, conducted the investigation, and curated the data. YW reviewed and edited the manuscript, supervised the study, curated the data, handled project

administration, provided resources, and managed funding acquisition. All authors read and approved the final manuscript.

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Data Availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

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Figures

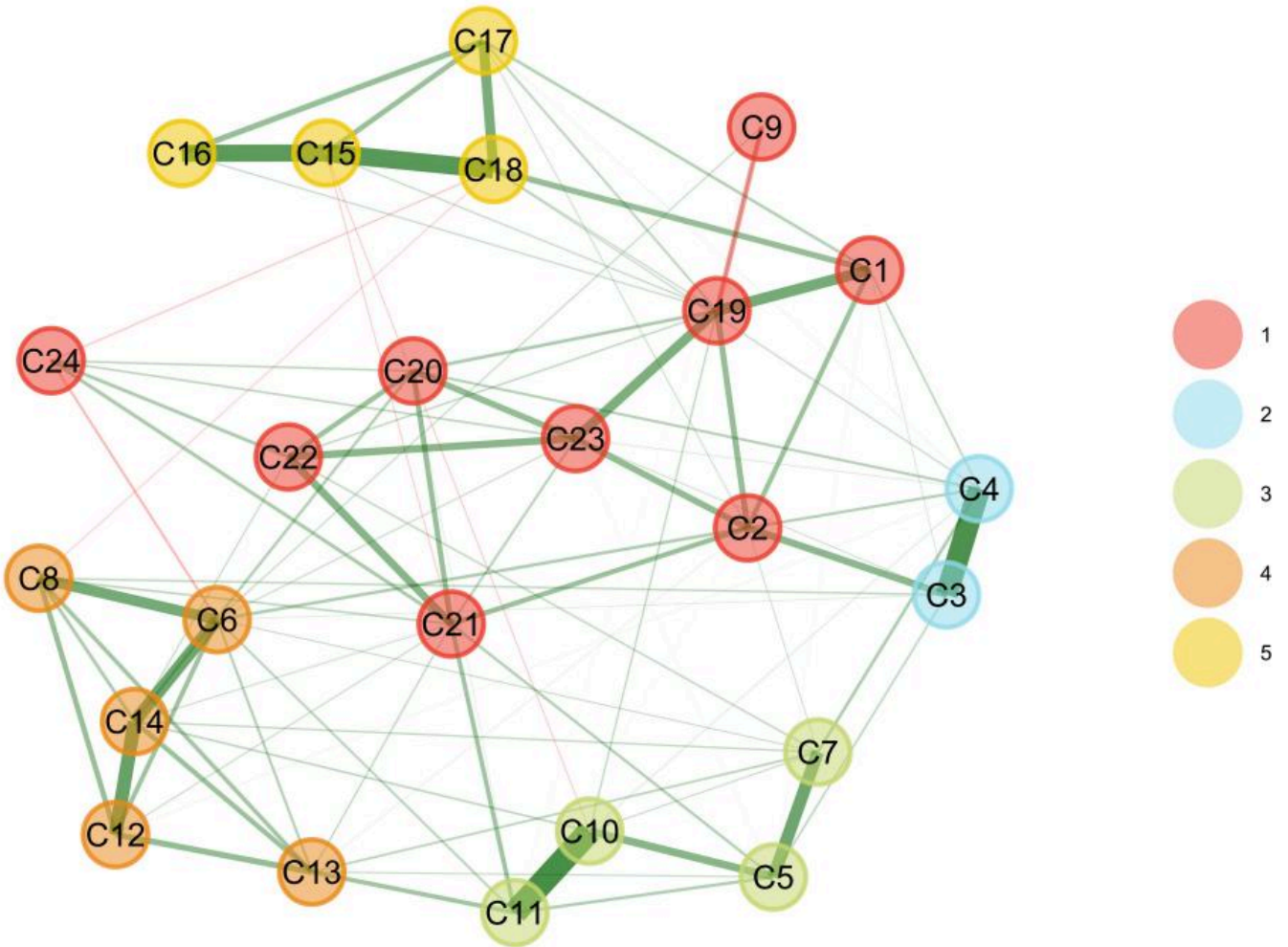


Figure 1

Network structure of Caregiver Burden Inventory (24 items).

Note: 1 = Developmental burden, 2 = Physical burden, 3 = Social burden, 4 = Emotional burden, 5 = Time-dependence burden.

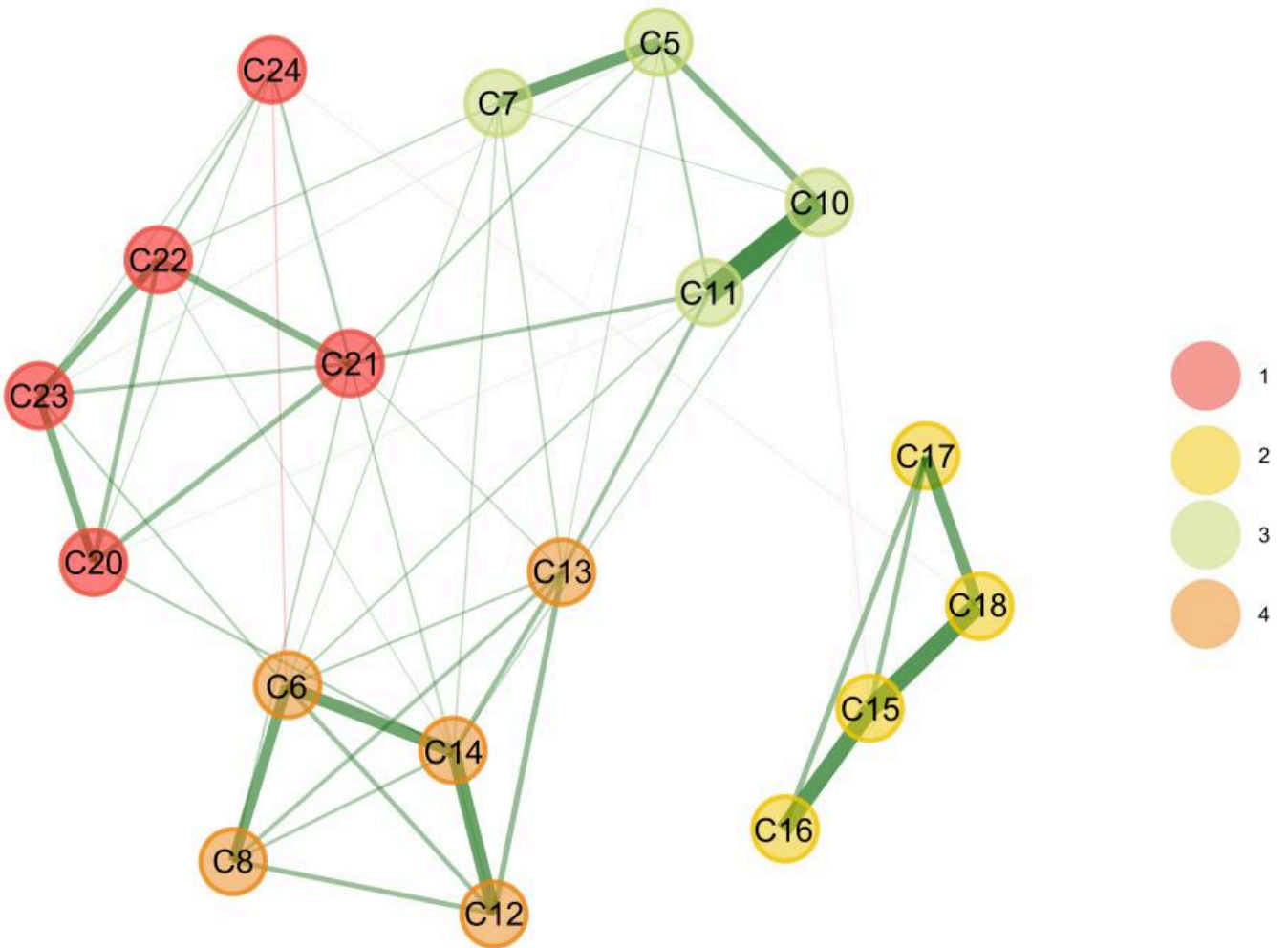


Figure 2

Network structure of Caregiver Burden Inventory (18 items).

Note: 1 = Developmental burden, 2 = Time-dependence burden, 3 = Social burden, 4 = Emotional burden.

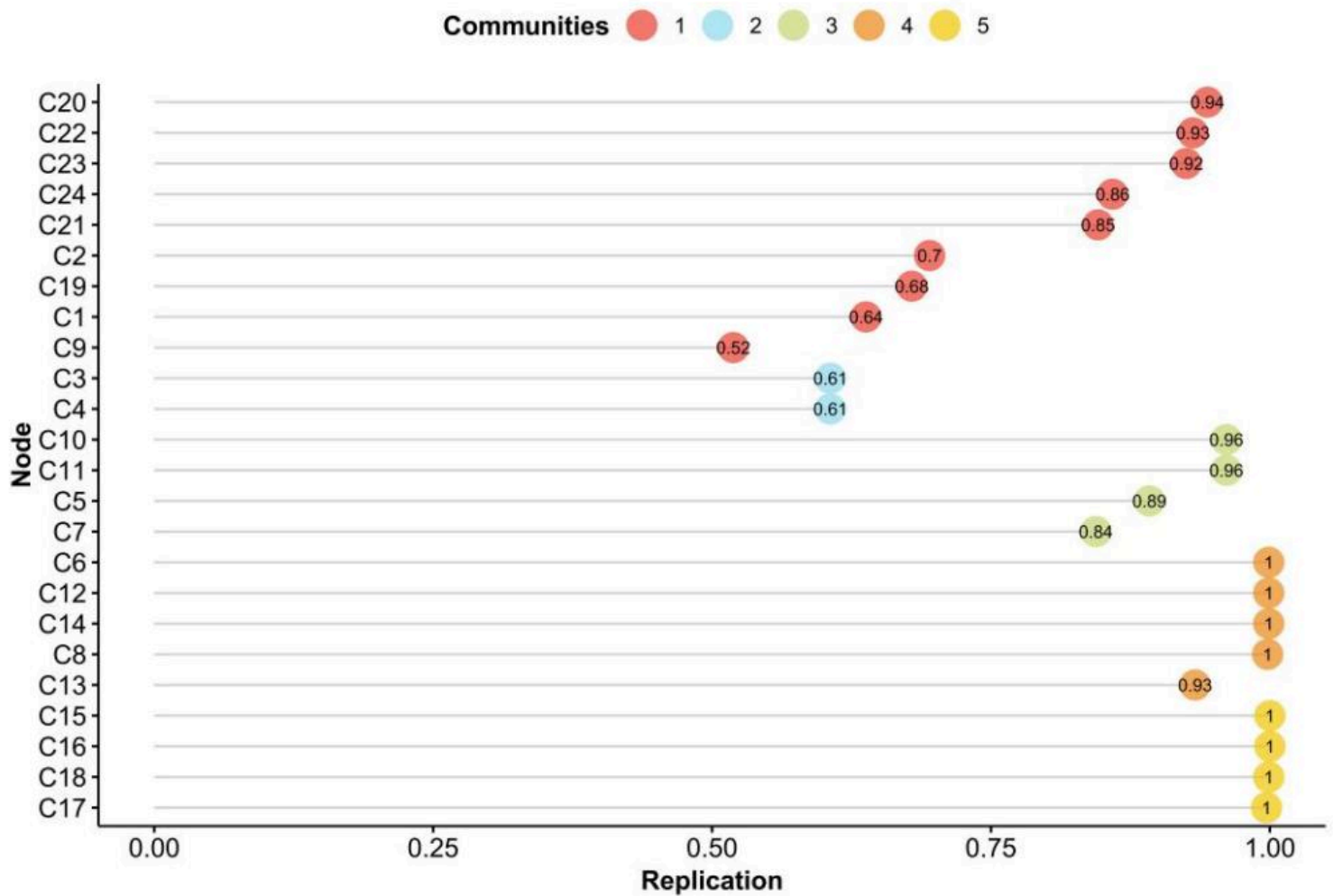


Figure 3

Item stability plot of the CBI based on bootstrapped EGA results (24 items).

Note: 1 = Developmental burden, 2 = Physical burden, 3 = Social burden, 4 = Emotional burden, 5 = Time-dependence burden.

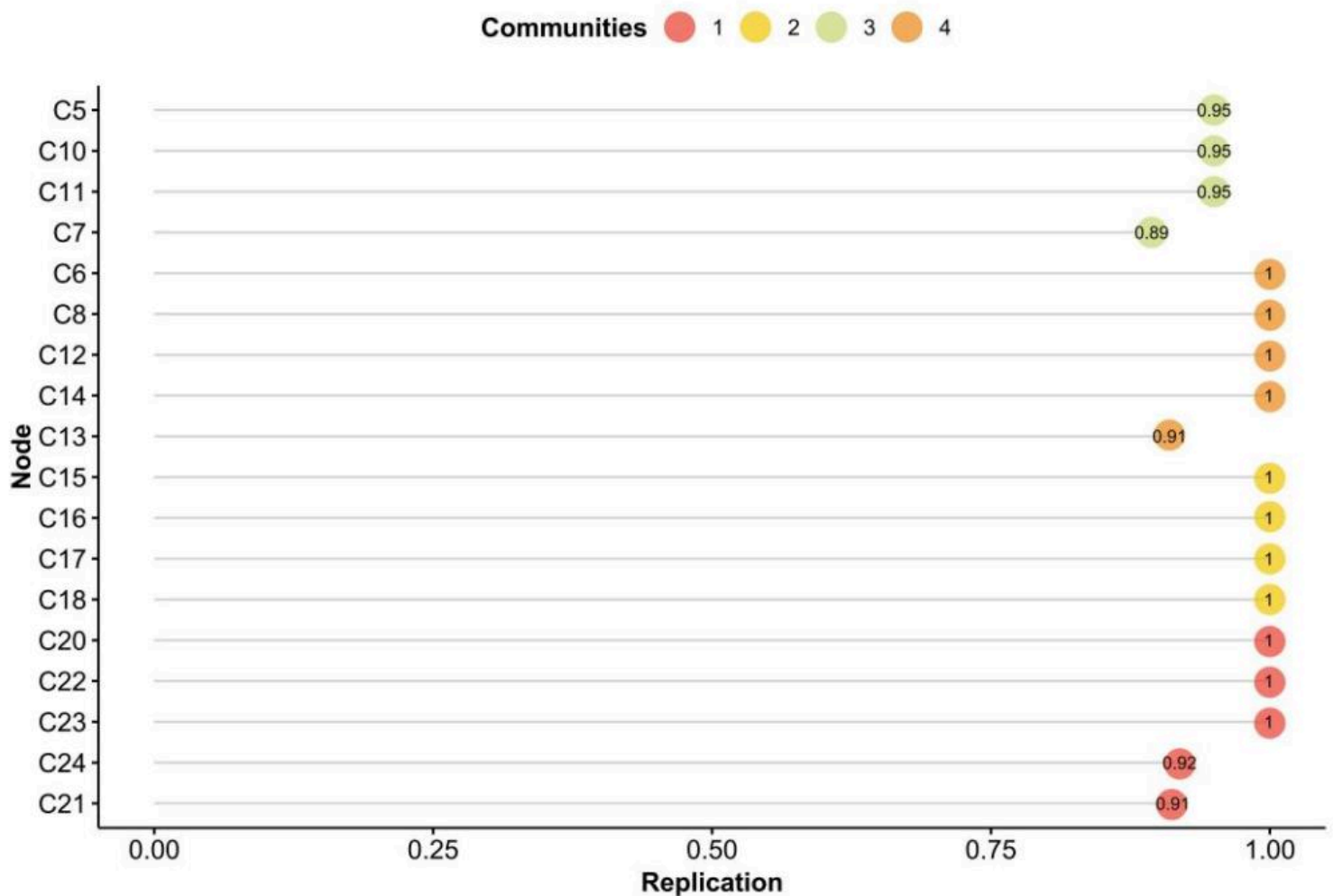


Figure 4

Item stability plot of the CBI based on bootstrapped EGA results (18 items).

Note: 1 = Developmental burden, 2 = Time-dependence burden, 3 = Social burden, 4 = Emotional burden.

Supplementary Files

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- [AppendixA.Supplementarymaterials.docx](#)