RESEARCH

Utilization of home-based care and its buffering effects between dementia caregiving intensity and caregiver burden in China

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Abstract

Background Home-based care (HBC) services have gained global attention for their potential to reduce caregiver burden among informal caregivers of persons with dementia (PwDs), who experience high caregiving intensity. However, research on HBC and its effects on dementia caregiving in China remains limited.

Methods Data were collected from primary caregivers of PwDs in Jiangsu Province, China. Caregiving intensity and HBC utilization were measured using self-developed instruments. Caregiver burden was assessed by The Burden Scale for Family Caregivers-short. Factor analysis was employed to decompose HBC services. Hierarchical multiple regression analysed the moderating effects of HBC on the relationship between caregiving intensity and burden.

Results A community sample of 318 caregiver and PwDs dyads was included. Caregivers averagely aged 62.16 years, with 61% being female, 84% not employed, and 66.2% having low income. PwDs aged 77.45 years averagely, with 52.8% being female and an average behavioural problems score of 42.27. Caregivers averaged 15.19 on response measures. The number and time spent on ADL-based tasks were positively associated with caregiver burden ($\beta = 0.26$, $p < .001$; $\beta = 0.16$, $p < .01$). However, attendance and time of supervision tasks were not significant predictors of burden. HBC services in China comprised four dimensions: Referral service, Household care, Skilled care, and Mental health service. While these did not directly predict caregiver burden, they moderated the associations between ADL-based tasks and caregiver burden ($\beta = -0.25$, $p < .001$; $\beta = -0.24$, $p < .001$; $\beta = -0.23$, $p < .001$; $\beta = -0.20$, $p < .001$), between time of ADL-based tasks and caregiver burden ($\beta = -0.17$, $p < .001$; $\beta = -0.18$, $p < .001$; $\beta = -0.17$, $p < .001$; $\beta = -0.15$, $p < .01$), and between the attendance at supervision tasks and caregiver burden ($\beta = -0.11$, $p < .05$; $\beta = -0.20$, $p < .001$; $\beta = -0.17$, $p < .001$; $\beta = -0.17$, $p < .001$). Only Referral service buffered the relationship between supervision time and caregiver burden ($\beta = -0.13$, $p < .01$).

Conclusion Informal caregivers of PwDs face high caregiving intensity and burden. HBC services may moderate this relationship, with different services playing varying roles. Further research is essential to explore the impact of supervision levels and develop effective strategies to enhance HBC services for dementia caregiving in China.

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Background

Dementia is a debilitating condition characterized by a decline in cognitive function that exceeds normal aging. Globally, there are approximately 44.5 million people with dementia (PwDs), and this number is expected to double every 20 years, reaching 152 million in 2050 [1]. In China, the prevalence of dementia among individuals aged 65 years and older is 6.1%, with an estimated 10.5 million cases, expected to increase to 23 million by 2050 [1]. Informal caregivers played a critical role as part of the healthcare team and accounted for a significant proportion of home care [2]. Approximately 80% of PwDs received care at home from family caregivers, and as many as 96% of care recipients were cared for by their family members or domestic workers in urban areas [3, 4]. Home-based and community-based care services were the foundation of community care for the Chinese elderly, with institutional care as the last resort [5]. However, in reality, the development of such services has been inadequate, especially with regard to specialized dementia care. Furthermore, there was no currently national plan for dementia care, and only a small proportion of PwDs received medical care services from the primary health care system in China [6]. The lack of formal care services, standards, and regulations has created a challenging situation for family-based dementia caregiving [7, 8]. Consequently, informal caregivers of PwDs faced high-intensity caregiving and usually reported a consistent and substantial burden [9, 10]. Therefore, it is crucial to examine the contents and utilization conditions of general Home-based care (HBC) and its role in mitigating the relationship between caregiving intensity and caregiver burden among informal caregivers of PwDs. By addressing these issues, we can ensure that HBC provide maximum benefits to the caregivers in China.

Caregiving intensity and caregiver burden

Extensive discourse in the literature has addressed the considerable levels of intensity associated with caregiving [11–13]. However, there was no universally accepted gold standard for conceptualizing and measuring caregiving intensity in informal caregiving [14]. Caregiving intensity has been defined and measured in various ways, including: (1) the operationalization of caregiving intensity was dichotomized as cared or not [11], (2) the quantification of number of hours or tasks involved in daily/weekly/monthly care [14–16], and (3) the classification levels based on the dichotomization or the number of caregiving tasks and hours devoted to caregiving [17, 18] Most of the research has been conducted on evaluating caregivers' assistance related to ADLs- and IADLs-related care tasks. For instance, Cohen and associates (2019) [14] evaluated caregiving using three measures in National Study of Caregiving (NSOC) survey: the number of ADLs-related assistance, the number of IADLs-related care provided, and monthly hours spent in caregiving, evaluated as 2.1 items, 8.0 items, and 84.5 h, respectively. Yet, supervision has been less studied as a sperate assessment with other caregiving tasks [19]. Alternatively, it was assessed alongside other caregiving tasks, with one study reporting an average daily caregiving time of approximately 16 h, more than 8 of which were spent on supervision [20]. Supervision is defined as a need for surveillance to prevent dangerous episodes (e.g., accidents at home and outside) and to protect other persons if the PwDs was aggressive [21]. Notably, the time spent on supervision was the largest portion of caregiver time, identified as the most significant component of caregiving time and resulted in great differences in caregiving intensity across studies [22]. Therefore, in this study, we measured caregiving identity with both ADL-based tasks, covering basic ADL and IADL tasks, and supervision and time spent on them respectively.

Perception of dementia caregiver burden was a complex construct, which contained multidimensional factors [9]. Although among prior studies, care-recipients' duration of disease illness, neuropsychiatric symptoms, caregiver's gender, age, SES status, relationship with PwDs were suggested as the predictors of subjective burden, the number of caregiving hours was proved contribute the most to perceived burden among dementia caregivers [7, 23–25]. Moreover, subjective caregiver burden was a multidimensional phenomenon, which was influenced by the diversity of personal viewpoints and different culture contexts [26]. Studies have shown that the number of hours spent on care tasks has been directly associated with caregiver burden [19, 27]. However, it was also unclear whether caregiving time influenced subjective caregiver burden [28]. Some studies also posited that physical involvement was less important in predicting carers' subjective burden in developed countries and caregiving hours have even been negatively correlated with burden among African American caregivers [11, 29]. Overall, it is crucial to measure caregiving intensity accurately and explore its association with caregiver burden among informal caregivers of PwDs with cultural and societal contexts.

Utilization and effects of HBC

The increasing proportion of PwDs and the decrease in availability of family caregivers have led to a growing need for formal community-based home care services.

Dementia-specific care services were critical to meet the special needs of PwDs and their informal caregivers. Compared to those caring for someone with non-dementia, dementia caregivers tended to use home care or community health-care services more frequently and were more inclined to use formal services [30, 31]. HBC referred to the various forms of care, treatment, and support provided to ill individuals in their homes, according to the WHO (2002) [32]. The Alzheimer's Association (2023) [33] has identified four common types of in-home services: companion services, personal care services, homemaker services, and skilled care. Another scholar roughly divided HBC into five categories: informal services, medicare skilled home health, hospital-at-home services, formal personal care services, and physician house calls [34]. Focused and advanced home-based non-pharmacological interventions for dementia caregiving have been provided to caregivers of PwDs in home settings, including tailored physical exercise, occupational therapy, psychosocial interventions [35–38].In recent years, there has been a growing literature on community services for aging care in China, mostly focused on the service system setting, utilization status, needs and determinants of services, as well as specific psychosocial interventions [39–43].

Prior research has indicated that utilizing formal services is linked to improved psychological well-being, especially among older adults in China [27, 44, 45]. These formal social support services offer practical assistance to caregivers, enhancing their capacity to cope with the challenges of caregiving and alleviating feelings of stress [46]. The stress of caring for PwDs was proved exacerbated by a lack of supportive response from local health and social services [31]. However, some studies have reported no significant association between the use of HBC services and caregiver burden [47, 48]. It has been suggested that the inclusion of HBC may not necessarily provide a distinct advantage for caregivers [49]. Furthermore, the Stress-buffering hypothesis posits that community care services, as a form of social support, can mitigate the negative impacts of stressors on the physical and mental burdens faced by family caregivers [50–52]. Research focusing on family and spousal caregivers highlights that various forms of support can alleviate the physical and mental burdens that arise from caregiving stress [52, 53]. The stress-buffering hypothesis asserts that social support can diminish or counteract the adverse effects of stress by offering emotional, informational, or practical assistance, which has been applied in studies involving dementia patients and caregivers [51, 52, 54–56]. Therefore, this study will examine the effects of HBC on caregiver burden, discussing the moderating role of HBC in the relationship between caregiving intensity and burden among caregivers of people with dementia (PwDs) in China, based on this theoretical framework.

Methods
Study design
This study endeavours to achieve three main objectives: (1) to provide a comprehensive understanding of the content framework and utilization of general HBC services in China; (2) to investigate the impact of caregiving intensity on caregiver burden; and (3) to examine the moderating effects of general HBC services on the aforementioned associations. Our central hypothesis posits that informal caregivers, who undergo higher levels of caregiving intensity, will experience reduced burden, and that the utilization of HBC services in China will positively moderate the relationship between caregiving intensity and burden. It included caregivers of PwDs who met the following eligibility criteria: (a) PwDs dowelled at home; (b) were spouses, children, or other relatives of PwDs; (c) identified themselves as the primary family member responsible for the patients' care and one family chose one participant; and (d) provided care to PwDs for more than half a month. Data were collected between October 2017 and February 2018 using a multistage cluster random sampling method in 91 communities, 14 streets, and 14 districts in Nanjing and Wuxi, known for their developed social services. During recruitment, staff members from the Community Neighborhood Committee assisted in identifying and contacting potential caregivers, who provided verbal consent to participate in the project. Trained investigators conducted interviews with caregivers to complete the questionnaires.

Measures
Caregiving intensity
Caregiving intensity was assessed using a self-developed instrument adapted from the Resource Utilization in Dementia (RUD) instrument [14, 20]. The item contents were based on Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL). This instrument comprised four subscales: ADL-based task measures, supervision tasks measures, time spent on ADL-based tasks, and supervision time measures. The ADL-based task measures recorded the total number of ADL tasks performed to assist people with dementia (PwDs) in their daily activities, including six basic items, such as bathing, and nine instrumental items, such as managing money. Responses were recorded as a binary variable with "Yes" or "No," and the range of scores for ADL-based tasks was from 0 to 15. The supervision tasks measures recorded the attendance of supervision tasks required to ensure the safety of PwDs, with responses noted as "0=No supervision" or "1=Supervision present." The time spent on ADL-based tasks recorded the total

number of hours spent on these tasks per week, while the supervision time measures recorded the total number of hours spent on supervision tasks per week. The range for both time measures was from 0 to 168 h. The reliability of the caregiving task checklist (ADL-based tasks and supervision tasks) was 0.83, as determined by Cronbach's alpha.

Home-based care services

HBC has not been consistently measured in Western countries due to differences in service design. However, the Medicare Alzheimer's Disease Demonstration has implemented a method for assessing service utilization among caregivers, which involves identifying services used in the previous six months from a fixed list of options and indicating frequency of use [57]. In this study, we utilized a self-constructed scale to assess the application conditions of HBC services of dementia caregivers. As specialized HBC services for dementia patients are yet to be established in China, we evaluated the utilization of HBC services based on the service package for general aging population offered by the Nanjing Civil Affairs Department in Jiangsu Province [58]. The package contained 11 core items: Meal service, Bath service, House-cleaning service, Medical assistance, Emergency assistance, Psychological service, Housekeeping counselling, Health counselling, Law counselling, Recreational activities, and Agency service. Service utilization by either caregivers or PwDs, or both, was captured as a dichotomous variable, with a "Yes" response coded as 1 and a "No" response coded as 0. The scores ranged from 0 to 11. The reliability of the subscales was measured using Cronbach's alpha, resulting in a value of 0.84.

Caregiver burden

The short version of the Burden Scale for Family Caregivers–short (BSFC-s) was used to measure the perceived caregiver burden among informal caregivers of PwDs [59]. The scale consists of five dimensions: "Physical and emotional problems," "Perception of the cared person as a provocateur," "Personal and social restrictions," "Economic costs," and "Value investment in caregiving," comprising a total of 10 items, such as "I often feel physically exhausted." Each item was based on a four-point Likert scale of 0 (strongly agree) to 3 (strongly disagree), with total score ranging from 0 to 30 points [59]. The selected items in the scale were reverse-coded, and higher total scores were indicative of heavier caregiver burden on the caregivers. A Chinese version of the scale was used among Chinese Canadian family caregiver of PwDs and its Cronbach's alpha was found to be 0.91 [60]. In this study, the reliability of the BSFC-s, measured by Cronbach's alpha, was 0.89.

Covariates

The present study utilized a data collection tool based on the existing caregiver literature to gather socio-demographic information about both caregivers and PwDs and caregiving experience. To measure disease disruption and caregivers' reactions, the 24-item Revised Memory and Behavior Problems Checklist (RMBPC) was employed [61]. This scale assessed observable behavioral issues in dementia patients and the distress perceived by their caregivers in three domains, including memory, depression, and disruptive behaviors. The scale yields total scores from two subscales: one for patient symptoms (Frequency scale: F), which includes items that assess the frequency of various memory and behaviour issues, such as forgetfulness, difficulty in concentrating, repetitive questions, and irritability. The second subscale measures caregiver distress (Reaction scale: R), capturing the emotional responses of caregivers to these symptoms, with items that reflect feelings of frustration, sadness, stress, and helplessness in managing the patient's condition. Caregivers rated the frequency of these problems on a Likert scale (Frequency scale: F) ranging from 0 (never) to 4 (daily or more often), and their reactions to each behavior were scored on a Likert scale (Reaction scale: R) ranging from 0 (not at all) to 4 (extremely). The total score ranged from 0 to 96, with higher scores indicating greater severity of memory and problem behaviors in PwDs and more distress reactions from caregivers. Previous studies have reported the scale's internal consistency to range from 0.75 to 0.87 [61]. The Cronbach's alpha values for the RMBPC-C among Chinese dementia caregivers were 0.82 for the frequency score and 0.90 for the reaction score [62]. The Chinese version utilized in this study exhibited an internal consistency of 0.89 and 0.93.

Statistical analysis

This study used descriptive statistics to determine the distribution of demographic characteristics. Variables were presented as absolute values and frequencies or means and standard deviations. Independent samples t-tests and one-way ANOVA were conducted to compare mean differences in caregiver burden between categorical variables. Pearson correlation analysis was conducted for analysis of correlations among continuous variables. The normality of distribution was assessed by preliminary analyses of skewness and kurtosis, with acceptable ranges referred to the normality criterion proposed by Curran and colleagues (1996) [63] (skewness ≤ 2; kurtosis ≤ 7).

Exploratory factor analysis (EFA) was performed to explore the latent content framework of HBC services. The items were analysed using principal components factor analysis and varimax rotation. Factors were extracted based on eigenvalues greater than 1.0. Items were retained with a factor loading of 0.40 or above on

the first factor [64]. The interpretability of the dimension was an essential criterion based on theoretical interpretation. A confirmatory factor analysis (CFA) was conducted to assess the goodness-of-fit and verify the model constructed by EFA. Preliminary analyses indicated that seven of the HBC services, such as meal service, were non-normally distributed. Therefore, a generalized least square (GLS) was used. The model fit indices were evaluated with values of χ^2/df was <5; goodness-of-fit (GFI), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) values of 0.90 or above; and Root Mean Square Error of Approximation (RMSEA) were 0.08 or below [65].

Hierarchical regression analysis was used to indicate the variation in caregiving outcome based on the composite effect of all factors. Moderation effects were examined with interactions between each of the caregiving intensity domains and HBC. The variables of caregiving intensity and moderators were standardized before being entered into the regression analysis to avoid problems with multicollinearity. There were no indications of multicollinearity, with all Durbin Watson values between one and two, VIF values<2, and tolerance ranging between 0.51 and 0.96 [64]. The predictor variables were included in four steps: (1) control variables, (2) caregiving intensity, (3) utilization of HBC services, and (4) interaction terms. A two-sided p-values≤0.05 was considered statistically significant. Simple slopes for effect significant interaction effects were graphed following the recommendations made by Aiken and West (1991) [66]. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 26 and Amos 26.

Results
Characteristics of the samples
In this study, 318 caregiver and PwD pairs participated in a survey. Caregivers had a mean age of 62.16 years (SD=10.55) and were mostly female (61%), married (97.2%), and had urban household registration (73.9%). Many caregivers had completed high middle school (35%) and were not employed (84%), with low levels of annual income (66.2%), defined as earning between no income and the 2018 per capita disposable income of 38,096 yuan (RMB) for Jiangsu residents [67]. The majority of caregivers were children/children-in-law (57.5%). PwDs had an average age of 77.45 years (SD=9.34) and were mostly female (52.8%), married (53.5%), not educated (63.8%), with low levels of income (58.2%), and had urban household registration (73.6%). PwDs had an average score of 42.27 (SD=15.04) on subscale of behavioral problems, while caregivers reported an average score of 15.19 (SD=15.44) on subscale of responses.

The study found that the average number of helpers assisting caregivers was 1.03 (SD=0.63), with a mean caregiving duration of 74.76 months (SD=38.49). Caregivers were responsible for an average of 11.47 (SD=3.78) ADL-based tasks and spent 31.77 h (SD=13.88) per week on such tasks, while spending 95.57 h (SD=58.67) per week on supervision tasks. The majority of caregivers (93.1%) performed supervision tasks and they had an average score of 0.93 (SD=0.25) on it. The mean score for caregiver burden was 16.49 (SD=4.53).

The study also found caregiver burden was positively correlated with education (F=3.328, *p*<.05), income (F=3.784, *p*<.05), and employment (t=2.872; *p*<.01). Moreover, significant differences in caregiver burden scores were observed in relation to duration (*r*=.19, *p*<.001), RMPBC-F (*r*=.37, *p*<.001), and RMBPC-R (*r*=.41, *p*<.001). For further details, please refer to Tables 1 and 2 for a comprehensive presentation of the study's results.

Contents and utilization rates of HBC
The significance of Bartlett's test of sphericity (*p*<.001) and the size of the KMO (0.76) indicated the appropriateness and adequacy of factor analysis [68]. EFA was conducted to gain a better understanding of the latent dimensions of HBC. As shown in Table 3, an overall of four factors were tested to have eigenvalues greater than 1, and they occupied 74.22% of the variance. The standard factor loading ranged from 0.50 to 0.90. Meanwhile, according to a meaningful interpretation of items, Agency service was transformed to Factor 1. CFA model was used to verify the results of EFA, which initially did not show satisfactory model fit, with $\chi^2(45)=462.13$, *p*<.001, CFI=0.71, TLI=0.65, RMSEA=0.17. Post-hoc model modification was performed to improve the model fit. Correlated residual error terms were identified as the cause of the model misfit [69]. Thus, we correlated all the pairs of items with regression weights coefficients above 10, based on the assumptions that the items were conceptually related (e.g., items 2 and 3). After the modification, the model showed an improvement in goodness-of-fit indicators, with $\chi^2(25)=70.07$, *p*<.001, CFI=0.97, TLI=0.93, RMSEA=0.08 (0.075). The standardized factor loadings ranged from 0.64 to 1.05. The corrected item-total correlations for each subscale were all above 0.35.

This study identified four underlying dimensions of the contents of HBC and highlighted their corresponding functions: Referral service (Factor 1), Household care (Factor 2), Skilled care (Factor 3), and Mental health service (Factor 4). Referral service assisted caregivers in connecting with professionals who meet their specific needs and preferences, including housekeeping counselling (utilization frequency: 22.3%), health counselling (19.5%), law counselling (11.3%), and agency service (6.3%), with a mean score of 1.01 (SD=1.33). Household care involved

Table 1 Demographic characteristics and univariate analysis for the factors

	Variable	N	Frequency (%)	t/F[b]	p
Gender (CG) (n=318)	Male	124	39.0	1.536	0.125
	Female	194	61.0		
Household registration (CG) (n=318)	Urban	235	73.9	-0.914	0.316
	Rural	83	26.1		
Education (CG) (n=317)	Not educated	69	21.8	3.328	**0.020**
	Primary school	99	31.2		
	High middle school	111	35.0		
	Senior school	38	12.0		
Marriage (CG) (n=318)	Married	309	97.2	-0.625	0.532
	Not married	9	2.8		
Income (CG) (n=317) [a]	None	39	12.3	3.784	**0.024**
	Low	210	66.2		
	High	68	21.5		
Employment (CG) (n=318)	Not working	267	84.0	2.872	**0.006**
	Working	51	16.0		
Relation to PwDs (CG) (n=318)	Spouse	121	38.1	1.516	0.221
	Children	183	57.5		
	Other relative	14	4.4		
Gender (CR) (n=318)	Male	150	47.2	1.044	0.297
	Female	168	52.8		
Household registration (CR) (n=318)	Urban	234	73.6	-0.756	0.450
	Rural	84	26.4		
Education (CR) (n=317)	Not educated	206	65.0	1.835	0.141
	Primary school	74	23.3		
	High middle school	27	8.5		
	Senior school	10	3.2		
Marriage (CR) (n=318)	Married	170	53.5	-1.494	0.136
	Not married	148	46.5		
Income (CR)(n=311) [a]	None	60	19.3	1.544	0.215
	Low	181	58.2		
	High	70	22.5		
Supervision tasks	No	22	6.9		
	Yes	296	93.1		

Notes[a] According to Jiangsu Provincial Bureau of Statistics (2019) [67], the 2018 per capita disposable income of Jiangsu residents was 38,096 yuan, and income of caregivers and PwDs in this study has been recoded as three levels, namely None: no income, Low: 1–38,096 (RMB); High: 38,096 and above (RMB). [b] independent samples t-tests have been used to test the BSFC-s scale mean differences between binary variables, including both caregivers and care-recipients' gender, household registration, employment, and marriage; One-way ANOVA was used to test the differences between three or more means, containing their education, income, and relation

helping with personal care and homemaker services, such as house-cleaning (4.3%), meal service (3.9%), and bath service (2.6%), with an average score of 0.18 (SD=0.60). Skilled care referred to skilled care for patients, including medical assistance (9.6%) and emergency assistance (7.8%), with a mean score of 0.30 (SD=0.64). Mental health service encompassed services helping with psychological support to maintain mental health, such as psychological consults (6.5%) and recreational activities (5.9%), with an average score of 0.21 (SD=0.52). Overall, the study revealed that caregivers had a lower level of utilization of HBC services despite the presence of these four supportive functions.

Moderating effects of utilization of HBC

A hierarchical regression model was conducted to examine the buffering effect in the relationships between caregiving intensity and caregiver burden, as indicated in Table 4. Caregivers' Education, employment, income, duration, responses, and frequency of PwDs' behavioral problems were identified as covariates. Four types of HBC services were tested as moderators in separate models.

In this study, as shown in Table 4(a), the control variables were analyzed in Block 1, while ADL-based tasks were added to Block 2. Block 3 included analysis incorporating Referral service, Household care, Skilled care, and Mental health service individually, while Block 4 incorporated the interaction terms: ADL-based tasks

Table 2 Means, standard deviations, and pearson correlations for continuous variables ($n = 318$)

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.Age (CG)	62.16	10.55	1														
2.Helpers	1.03	0.63	-0.21***	1													
3.Age (CR)	77.45	9.34	0.07	0.29***	1												
4.Duration (M)	74.76	38.49	0.08	0.10	0.21***	1											
5.RMBPC-F	42.27	15.04	0.11	0.03	0.08	0.11	1										
6.RMBPC-R	15.19	15.44	0.05	0.04	0.14*	0.21***	0.59***	1									
7.ADL-based tasks	11.47	3.78	-0.01	-0.06	0.01	0.02	0.37***	0.26***	1								
8.Supervision tasks	0.93	0.25	0.09	0.01	-0.00	0.06	0.21***	0.12*	0.35***	1							
9.ADL-based time	31.77	13.88	0.10	-0.18***	-0.03	0.10	0.25***	0.17***	0.45***	0.13*	1						
10.Supervision time	95.57	58.67	0.46***	-0.19***	-0.31***	0.01	0.16**	0.03	0.24***	0.32***	0.18***	1					
11.Burden	16.49	4.53	0.04	-0.100	0.05	0.19***	0.37***	0.41***	0.28***	0.08	0.32***	0.16**	1				
12.Referral service	1.01	1.33	-0.00	-0.14*	-0.23***	-0.01	-0.01	-0.22***	0.09	-0.09	0.10	0.13*	0.01	1			
13.Household care	0.18	0.60	-0.04	0.07	-0.06	-0.12*	-0.06	-0.12*	-0.06	-0.12*	0.05	0.00	-0.10	0.30***	1		
14.Skilled care	0.30	0.64	-0.00	-0.04	-0.16**	0.02	0.05	-0.10	0.11	-0.03	0.07	0.07	-0.07	0.52***	0.45***	1	
15.Mental health service	0.21	0.52	-0.05	-0.01	-0.16**	-0.09	-0.08	-0.07	0.05	-0.11	0.03	-0.01	-0.05	0.35***	0.42***	0.37***	1

Note RMBPC-F: the frequency of behavioral problems in patients. RMBPC-R: reactions to problem behaviors in caregivers; ADL-based tasks: number of ADL-based tasks; ADL-based time: hours of ADL-based tasks. * $p < .05$;
** $p < .01$; *** $p < .001$

and Referral service, ADL-based tasks and Household care, ADL-based tasks and Skilled care, ADL-based tasks and Mental health service, alongside the variables from the previous steps. Additionally, the same steps were followed for supervision tasks, the time of ADL-based tasks and the time of supervision tasks as independent variables separately, as displayed in Table 4(b), Table 4(c) and Table 4(d).

Regression results on ADL-based tasks and caregiver burden

As indicated in Table 4(a), in the model where Referral service moderated the relationship between the number of ADL-based tasks and caregiver burden, the β1 column from Block 1 showed that employment was negatively associated with caregiver burden (β= -0.18, $p < .001$), while frequency of PwDs' behavioral problems (β=0.13, $p < .05$) and caregivers' responses (β=0.29, $p < .001$) were positively related to caregiver burden. The R-squared was 0.24, indicating that 24% of the variance in caregiver burden was explained by these variables. From Block 2, the β value indicated that the number of ADL-based tasks was a significant predictor of caregiver burden (β=0.26, $p < .001$). The R-squared reflected an additional 1% of variance explained. In Block 3, Referral service did not predict caregiver burden. However, when the interaction term was included in Block 4, the interaction variables ADL-based tasks and Referral service (ADLtask*RS) demonstrated a significant impact on caregiver burden (β=-0.25, $p < .001$). The introduction of Referral service interactions further increased the R-squared to 0.30, suggesting that the moderator contributed an additional 4% to the explained variance. Overall, the final model accounted for an adjusted 28% of the variance in caregiver burden, highlighting that Referral service moderated the relationship between the number of ADL-based tasks and caregiver burden. To illustrate this relationship, we plotted the relationship between ADL-based tasks and caregiver burden in Fig. 1(a).

The values in the β2 column reflected the results showing that Household care moderated the relationship between the number of ADL-based tasks and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.21, $p < .001$), while caregivers' responses were positively related to caregiver burden (β=0.29, $p < .001$). The R-squared remained at 0.24. From Block 2, the β value indicated that the number of ADL-based tasks was a significant predictor of caregiver burden (β=0.20, $p < .001$), which reflected an additional 1% of variance explained. In Block 3, Household care did not predict caregiver burden significantly. In Block 4, when interaction terms were included, the interaction variables ADL-based tasks and Household care (ADLtask*HC) demonstrated a significant impact on caregiver burden (β = -0.24, $p < .001$). The introduction

Table 3 Factor loading of factors and correction item-total correlations (*n* = 318)

	Fre-quency (%)	EFA				CFA				correction item-total correlations
		Factor 1	Factor 2	Factor 3	Factor 4	Factor 1	Factor 2	Factor 3	Factor 4	
Health counselling	19.5	**0.86**	0.10	0.21	0.11	0.68	-	-	-	0.81
Housekeeping counselling	22.3	**0.81**	0.02	0.32	-0.03	0.66	-	-	-	0.82
Law counselling	11.3	**0.77**	0.01	0.10	0.17	0.78	-	-	-	0.82
Agency service	6.3	**0.50**	0.35	-0.11	**0.57**	1.05	-	-	-	0.82
Bath service	2.6	0.09	**0.90**	0.11	0.02	-	0.85	-	-	0.40
Meal service	3.9	0.01	**0.85**	0.12	0.22	-	0.69	-	-	0.41
House-cleaning service	4.3	0.09	**0.57**	0.51	0.26	-	0.71	-	-	0.55
Emergency assistance	7.8	0.24	0.10	**0.79**	0.12	-	-	0.78	-	0.53
Medical assistance	9.6	0.38	0.27	**0.74**	0.03	-	-	0.75	-	0.64
Recreational activities	5.9	0.17	0.27	0.05	**0.84**	-	-	-	0.68	0.48
Psychological service	6.5	-0.04	-0.05	0.48	**0.70**	-	-	-	0.64	0.37
eigenvalue	-	2.50	2.14	1.85	1.68					
% of variance (%)	-	22.73	19.41	16.80	15.27					
Cumulative % of variance (%)	-	22.73	42.15	58.95	74.22					

Note Factor 1: Referral service, Factor 2: Household care, Factor 3: Skilled care, Factor 4: Mental health service

of Household care interactions further increased the R-squared to 0.30, indicating that the moderator contributed an additional 5% to the explained variance. Ultimately, the model accounted for an adjusted 28% of the variance in caregiver burden, highlighting the significance of the moderating effects. To visualize this relationship, we plotted the relationship between ADL-based tasks and caregiver burden in Fig. 1(a).

The values in the β3 column reflected the results indicating that Skilled care moderated the relationship between the number of ADL-based tasks and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.20, *p* < .001), while the frequency of PwDs' behavioural problems (β = 0.13, *p* < .05) and caregivers' responses (β = 0.29, *p* < .001) were positively related to caregiver burden. The R-squared was consistent at 0.24. From Block 2, the β value indicated that the number of ADL-based tasks was a significant predictor of caregiver burden (β = 0.22, *p* < .001). The R-squared also indicated an additional 1% of variance explained. In Block 3, Skilled care did not predict caregiver burden significantly. In Block 4, when interaction terms were included, the interaction variables ADL-based tasks and Skilled care (ADLtask*SC) demonstrated a significant impact on caregiver burden (β = -0.23, *p* < .001). The introduction of Skilled care interactions further increased the R-squared to 0.30, indicating that the moderator contributed an additional 4% to the explained variance. The final model also accounted for an adjusted 28% of the variance in caregiver burden,

highlighting the significance of the moderating effects. To illustrate this relationship, we plotted the relationship between ADL-based tasks and caregiver burden in Fig. 1(a).

The values in the β4 column reflected the results showing that Mental health service moderated the relationship between the number of ADL-based tasks and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.20, *p* < .001), while caregivers' responses were positively related to caregiver burden (β = 0.32, *p* < .001). The R-squared remained at 0.24. From Block 2, the β value indicated that the number of ADL-based tasks was a significant predictor of caregiver burden (β = 0.20, *p* < .001), reflecting an additional 1% of variance explained. In Block 3, Mental health service did not predict caregiver burden significantly. In Block 4, when interaction terms were included, the interaction variables ADL-based tasks and Mental health service (ADLtask*MH) demonstrated a significant impact on caregiver burden (β = -0.20, *p* < .001). The introduction of Mental health service interactions further increased the R-squared to 0.28, indicating that the moderator contributed an additional 3% to the explained variance. The final model also accounted for an adjusted 26% of the variance in caregiver burden, underscoring the significance of the moderating effects. To visualize this relationship, we plotted the relationship between ADL-based tasks and caregiver burden in Fig. 1(a).
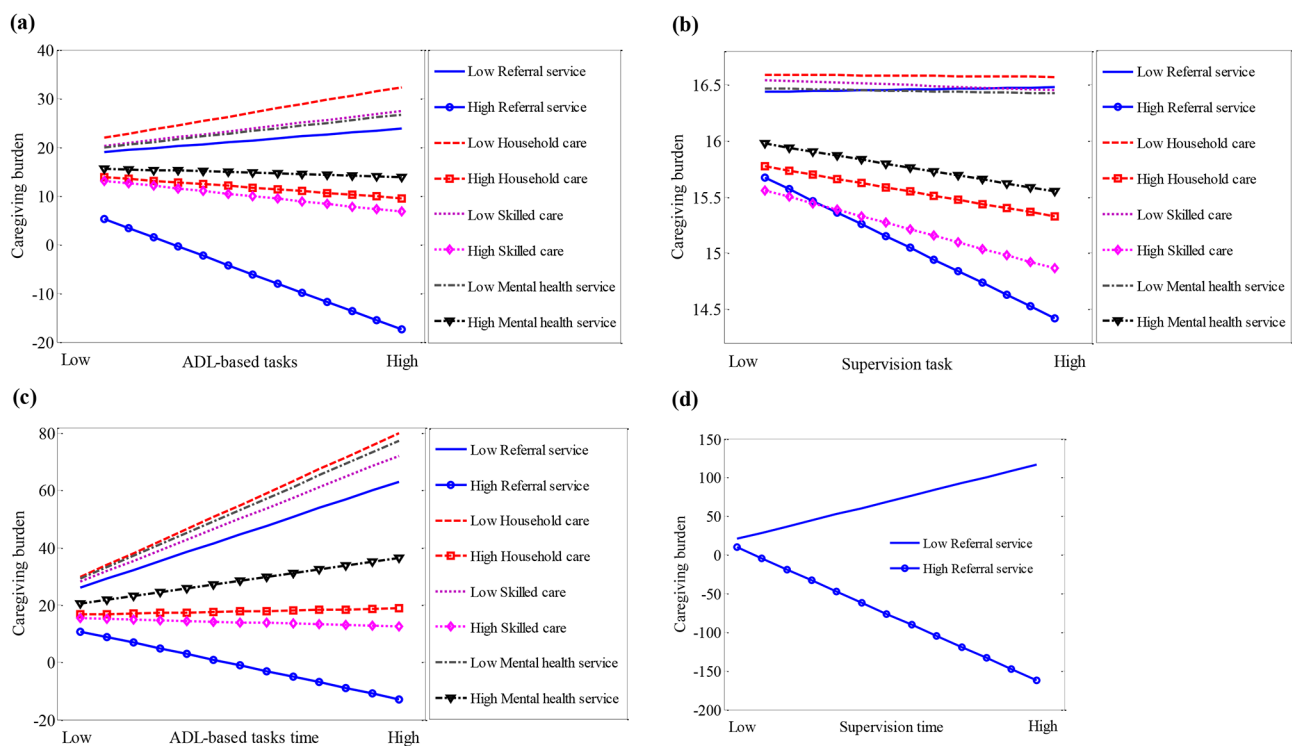
Table 4 Moderating effects of HBC on the associations between caregiving intensity and burden

	(a) IV: ADL-based tasks				(b) IV: Supervision tasks			
	β1	β2	β3	β4	β5	β6	β7	β8
Block 1: Covariates								
Education	-0.02	-0.02	-0.04	-0.02	-0.02	-0.02	-0.02	-0.02
Employment	-0.18***	-0.21***	-0.20***	-0.20***	-0.22***	-0.22***	-0.23***	-0.23***
Income	-0.02	0.02	0.02	0.01	0.03	0.04	0.06	0.05
Duration	0.08	0.07	0.08	0.07	0.09	0.08	0.09	0.08
RMBPC-F	0.13*	0.09	0.13*	0.10	0.14*	0.16*	0.18**	0.14*
RMBPC-R	0.29***	0.32***	0.29***	0.32***	0.34***	0.34***	0.33***	0.36***
R^2	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***
Block 2: Caregiving intensity								
ADL-based tasks (ADLtask)	0.26***	0.20***	0.22***	0.20***				
Supervision tasks (Suptask)					-0.03	-0.05	-0.08	-0.05
ΔR^2	0.01*	0.01*	0.01*	0.01*	0.01	0.01	0.01	0.01
Block 3: Utilization of HBC								
Referral service (RS)	0.03				0.02			
Household care (HC)		-0.08				-0.09		
Skilled care (SC)			-0.05				-0.09	
Mental health service (MH)				-0.01				-0.05
ΔR^2	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00
Block 4: Interaction term								
ADLtask*RS	-0.25***							
ADLtask*HC		-0.24***						
ADLtask*SC			-0.23***					
ADLtask*MH				-0.20***				
Suptask*RS					-0.17***			
Suptask*HC						-0.18***		
Suptask*SC							-0.17***	
Suptask*MH								-0.15**
ΔR^2	0.04***	0.05***	0.04***	0.03***	0.03***	0.03***	0.03***	0.02**
R^2 model	0.30	0.30	0.30	0.28	0.27	0.27	0.27	0.26
Adj. R^2 model	0.28	0.28	0.28	0.26	0.25	0.25	0.25	0.24
	(c) IV: Time of ADL-based tasks				(d) IV: Supervision time			
	β9	β10	β11	β12	β13	β14	β15	β16
Block 1: Covariates								
Education	-0.05	-0.04	-0.04	-0.03	-0.02	-0.00	0.00	0.01
Employment	-0.13*	-0.16**	-0.16**	-0.17**	-0.15**	-0.17**	-0.18***	-0.18***
Income	0.01	0.01	0.02	0.01	0.01	0.02	0.03	0.02
Duration	0.07	0.07	0.07	0.06	0.08	0.08	0.09	0.09
RMBPC-F	0.09	0.13*	0.13*	0.11	0.12	0.15*	0.14*	0.14*
RMBPC-R	0.31***	0.28***	0.29***	0.31***	0.34	0.31***	0.32***	0.34***
R^2	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***
Block 2: Caregiving intensity								
Time of ADL-based tasks (ADLtime)	0.16**	0.18***	0.17***	0.20***				
Supervision time (Suptime)					0.08	0.08	0.08	0.09
ΔR^2	0.04***	0.04***	0.04***	0.04***	0.01	0.01	0.01	0.01
Block 3: Utilization of HBC								
Referral service (RS)	0.05				0.05			
Household care (HC)		-0.09				-0.04		
Skilled care (SC)			-0.05				-0.06	
Mental health service (MH)				-0.01				-0.01
ΔR^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4 (continued)

Block 4: Interaction term								
ADLtime*RS	-0.11*							
ADLtime*HC		-0.20***						
ADLtime*SC			-0.17***					
ADLtime*MH				-0.17***				
Suptime*RS					-0.13**			
Suptime*HC						-0.08		
Suptime*SC							-0.05	
Suptime*MH								-0.06
ΔR^2	0.01*	0.03***	0.03***	0.03***	0.02**	0.00	0.00	0.00
R^2 model	0.28	0.31	0.30	0.30	0.26	0.25	0.25	0.25
Adj. R^2 model	0.26	0.29	0.28	0.28	0.24	0.23	0.23	0.22

Note $^*p<.05$; $^{**}p<.01$; $^{***}p<.001$

Fig. 1 **a** Moderating effects of HBC on the relationship between ADL-based tasks and caregiver burden. **b** Moderating effects of HBC on the relationship between supervision tasks and caregiver burden. **c** Moderating effects of HBC on the relationship between time of ADL-based tasks and caregiver burden. **d** Moderating effects of HBC on the relationship between supervision time and caregiver burden

Regression results on supervision tasks and caregiver burden
As shown in Table 4(b), the values in the β5 column indicate that the model examining how Referral service moderated the relationship between the attendance of supervision tasks and caregiver burden revealed that in Block 1, employment had a negative association with caregiver burden (β = -0.22, *p*<.001). In contrast, the frequency of PwDs' behavioural problems (β=0.14, *p*<.05) and caregivers' responses (β=0.34, *p*<.001) were positively correlated with caregiver burden. The R-squared value was 0.24, indicating that these variables accounted for 24% of the variance in caregiver burden.

In Block 2, supervision tasks did not significantly predict caregiver burden, and Referral service also did not significantly predict caregiver burden in Block 3. However, upon including the interaction term in Block 4, the interaction between supervision tasks and Referral service (Suptask*RS) showed a significant effect (β = -0.17, *p*<.001). This addition increased the R-squared to 0.27, indicating that the moderator contributed an additional 3% to the explained variance. Overall, the final model adjusted for 25% of the variance in caregiver burden, confirming that Referral service moderated the relationship

with supervision tasks. To illustrate this, we plotted the relationship in Fig. 1(b).

The results in the β6 column indicated that Household care served as a moderator in the relationship between supervision tasks and caregiver burden. In Block 1, employment again showed a negative relationship with caregiver burden (β = -0.22, *p*<.001), while the frequency of PwDs' behavioural problems (β=0.16, *p*<.05) and caregivers' responses (β=0.34, *p*<.001) positively influenced the burden. The R-squared remained consistent at 0.24. From Block 2, the β value indicated that the participation of supervision tasks was not a significant predictor of caregiver burden. In Block 3, Household care did not significantly predict caregiver burden. However, in Block 4, when the interaction terms were included, the interaction between supervision tasks and Household care (Suptask*HC) showed a significant effect (β = -0.18, *p*<.001). The introduction of Household care interactions further increased the R-squared to 0.27, indicating that the moderator contributed an additional 3% to the explained variance. The final model adjusted for 25% of the variance in caregiver burden, emphasizing the importance of the moderating effects. This relationship was also illustrated in Fig. 1(b).

In the β7 column, results indicated that Skilled care moderated the relationship between supervision tasks and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.23, *p*<.001), while the frequency of PwDs' behavioral problems (β=0.18, *p*<.01) and caregivers' responses (β=0.33, *p*<.001) were positively related. The R-squared remained at 0.24. From Block 2, the β value indicated that the participation of supervision tasks was not a significant predictor of caregiver burden. In Block 3, Skilled care did not significantly predict caregiver burden. In Block 4, the interaction between supervision tasks and Skilled care (Suptask*SC) showed a significant impact (β = -0.17, *p*<.001). The introduction of Skilled care interactions further increased the R-squared to 0.27, indicating that the moderator contributed an additional 3% to the explained variance. The final model also explained an adjusted 25% of the variance in caregiver burden, highlighting the significance of these moderating effects. This relationship is also depicted in Fig. 1(b).

The β8 column results revealed that Mental health service moderated the relationship between supervision tasks and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.23, *p*<.001), while the frequency of PwDs' behavioural problems (β=0.14, *p*<.05) and caregivers' responses (β=0.36, *p*<.001) were positively related. The R-squared was consistent at 0.24. From Block 2, the β value indicated that the number of supervision tasks was not a significant predictor. In Block 3, Mental health service did not significantly predict caregiver burden. In Block 4, the inclusion of interaction terms demonstrated that the interaction between supervision tasks and Mental health service (Suptask*MH) significantly impacted caregiver burden (β = -0.19, *p*<.001). The introduction of Mental health service interactions further increased the R-squared to 0.26, indicating that the moderator contributed an additional 2% to the explained variance. The final model also explained an adjusted 24% of the variance in caregiver burden, underscoring the significance of the moderating effects. This relationship is illustrated in Fig. 1(b).

Regression results on the time of ADL-based tasks and caregiver burden

As indicated in the β9 column of Table 4(c), the model assessing how Referral service moderated the relationship between the time of ADL-based tasks and caregiver burden demonstrated that in Block 1, employment was negatively associated with caregiver burden (β = -0.13, *p*<.05). In contrast, caregivers' responses had positive correlations with caregiver burden (β=0.31, *p*<.001). The R-squared value was 0.24, suggesting that these variables accounted for 24% of the variance in caregiver burden. In Block 2, the β value confirmed that the time of ADL-based tasks was a significant predictor (β=0.16, *p*<.01), contributing an additional 4% to the explained variance. In Block 3, Referral service did not significantly predict caregiver burden. However, after including the interaction term in Block 4, the interaction between the time of ADL tasks and Referral service (ADLtime*RS) revealed a significant effect (β = -0.11, *p*<.05). This inclusion raised the R-squared to 0.28, indicating that the moderator contributed an additional 1% to the explained variance. Overall, the final model adjusted for 26% of the variance in caregiver burden, confirming that Referral service moderated the relationship with the time of ADL-based tasks. This relationship is illustrated in Fig. 1(c).

The results in the β10 column indicated that Household care functioned as a moderator in the relationship between the time of ADL-based tasks and caregiver burden. In Block 1, employment again exhibited a negative association with caregiver burden (β = -0.16, *p*<.01), while the frequency of behavioral problems exhibited by PwDs (β=0.13, *p*<.05) and caregivers' responses (β=0.28, *p*<.001) had positive correlations with caregiver burden. The R-squared value remained steady at 0.24. From Block 2, the β value showed that the time of ADL-based tasks was a significant predictor (β=0.18, *p*<.001), reflecting an additional 4% of explained variance as well. In Block 3, Household care did not significantly predict caregiver burden. However, in Block 4, when the interaction terms were introduced, the interaction between the time of ADL tasks and Household care (ADLtime*HC)

revealed a significant effect (β = -0.20, p<.001). This inclusion raised the R-squared to 0.31, indicating that the moderator contributed an additional 3% to the explained variance. The final model adjusted for 29% of the variance in caregiver burden, highlighting the significance of the moderating effects. This relationship is also depicted in Fig. 1(c).

In the β11 column, results suggested that Skilled care moderated the relationship between the time of ADL-based tasks and caregiver burden. In Block 1, employment was negatively correlated with caregiver burden (β = -0.16, p<.001), while the frequency of PwDs' behavioral issues (β=0.13, p<.05) and caregivers' responses (β=0.29, p<.001) were positively associated. The R-squared remained at 0.24. From Block 2, the time of ADL-based tasks was identified as a significant predictor (β=0.17, p<.001), contributing an additional 4% of explained variance as well. In Block 3, Skilled care did not significantly predict caregiver burden. In Block 4, when the interaction terms were introduced, the interaction between the time of ADL tasks and Skilled care (ADLtime*SC) showed a significant impact (β = -0.17, p<.001). This inclusion raised the R-squared to 0.30, indicating that the moderator contributed an additional 3% to the explained variance. The final model adjusted for 28% of the variance in caregiver burden, emphasizing the importance of these moderating effects. This relationship is also illustrated in Fig. 1(c).

The β12 column results indicated that Mental health service moderated the relationship between the time of ADL-based tasks and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.17, p<.01), while caregivers' responses were positively correlated (β=0.31, p<.001). The R-squared remained stable at 0.24. In Block 2, the time of ADL-based tasks emerged as a significant predictor (β=0.20, p<.001), reflecting an additional 4% of explained variance as well. In Block 3, Mental health service did not significantly predict caregiver burden. In Block 4, the inclusion of interaction terms showed that the interaction between the time of ADL tasks and Mental health service (ADLtime*MH) had a significant effect on caregiver burden (β = -0.17, p<.001). This inclusion raised the R-squared to 0.30, indicating that the moderator contributed an additional 3% to the explained variance. The final model explained an adjusted 28% of the variance, underscoring the importance of these moderating effects. This relationship is illustrated in Fig. 1(c).

Regression results on supervision time and caregiver burden
As illustrated in Table 4(d), the β13 column data indicate that the model investigating how Referral service moderated the link between supervision time attendance and caregiver burden revealed that, in Block 1, employment

negatively correlated with caregiver burden (β = -0.15, p<.01). The R-squared value of 0.24 suggests that these variables accounted for 24% of the variance in caregiver burden. In Block 2, supervision time did not serve as a significant predictor of caregiver burden, nor did Referral service in Block 3. However, when the interaction term was added in Block 4, the interaction between supervision time and Referral service (Suptime*RS) exhibited a significant effect (β = -0.13, p<.01). This change increased the R-squared to 0.26, indicating that the moderator contributed an additional 2% to the explained variance. Ultimately, the final model accounted for 24% of the variance in caregiver burden, confirming that Referral service moderated the relationship with supervision time, as shown in Fig. 1(d).

The findings in the β14 column revealed that Household care functioned as a moderator in the relationship between supervision time and caregiver burden. In Block 1, employment again showed a negative correlation with caregiver burden (β = -0.17, p<.01), while the occurrence of behavioral problems among PwDs (β=0.15, p<.05) and caregivers' responses (β=0.31, p<.001) positively influenced the burden. The R-squared value remained constant at 0.24. In Block 2, the β value indicated that engagement in supervision time was not a significant predictor of caregiver burden. Similarly, in Block 3, Household care did not significantly predict caregiver burden. In Block 4, the interaction between supervision time and Household care (Suptime*HC) did not demonstrate a significant effect.

In the β15 column, the results suggested that Skilled care moderated the association between supervision time and caregiver burden. In Block 1, employment was negatively related to caregiver burden (β = -0.18, p<.001), while the frequency of behavioral issues in PwDs (β=0.14, p<.05) and caregivers' responses (β=0.32, p<.001) were positively correlated. The R-squared value remained steady at 0.24. From Block 2, the β value indicated that participation in supervision time did not significantly predict caregiver burden. Likewise, in Block 3, Skilled care did not predict caregiver burden significantly. In Block 4, the interaction between supervision time and Skilled care (Suptime*SC) did not show a significant effect.

The β16 column results illustrated that Mental health service moderated the relationship between supervision time and caregiver burden. In Block 1, employment was negatively associated with caregiver burden (β = -0.18, p<.001), while the frequency of behavioral problems in PwDs (β=0.14, p<.05) and caregivers' responses (β=0.34, p<.001) were positively correlated. The R-squared value remained consistent at 0.24. In Block 2, the β value indicated that supervision time was not a significant predictor, though it contributed an additional

1% to the explained variance. In Block 3, Mental health service did not significantly predict caregiver burden. Finally, in Block 4, the interaction between supervision time and Mental health service (Suptime*MH) did not yield a significant effect.

Discussion

This study is the first investigation into caregiving intensity, caregiver burden, and the utilization of general HBC services among Chinese informal caregivers of persons with dementia (PwDs) in a community sample. The study reported a high level of caregiving intensity among these caregivers, which is consistent with previous research suggesting that dementia caregivers face a significant number of ADL-based tasks and caregiving hours [14, 70]. Moreover, the significant relationship found between ADL tasks and caregiver burden highlighted the critical role of daily living activities in shaping the experiences of informal caregivers for individuals with dementia. This finding aligns with prior research indicating that a higher frequency and complexity of ADL tasks are associated with increased caregiver strain and decreased psychological well-being [9, 31, 71]. For instance, caregivers who assist with multiple tasks, such as bathing, dressing, and feeding, may experience not only physical fatigue but also emotional stress.

It is noteworthy that caregivers devoted an average of 95.57 h per week to supervising PwDs. As previously demonstrated, supervision constituted the largest portion of caregiving hours for PwDs at home [19]. It was imperative to recognize that supervision was a critical aspect of dementia caregiving, as neglecting this element could significantly impact caregiving research findings [22]. Interestingly, in this study, neither the supervision tasks nor the time spent on supervision were significant factors in caregiver burden. This finding contradicted the literature, which suggested supervision time was an important contributor to caregiver burden [19]. This may be attributed to the fact that engagement in supervision was a natural response to perceived hazardous behaviour, and caregivers who provided constant supervision were more likely to believe that the patient was safe, which in turn reduced subjective caregiver burden [72]. This reaffirmed the assertion that caregiver supervision time was an essential independent outcome, and a comprehensive description of care needs was necessary to account for allocated formal care hours and provide adequate care services.

Consistent with previous reports [33, 34], HBC in China has been found to be able to meet fundamental caregiving needs through four functional categories: Referral service, Household care, Skilled care, and Mental health service. However, the range of services offered was limited, with only eleven core items available. Despite the availability of HBC, the utilization rates of these services in China were found to be low, as indicated by the frequency of utilization and mean score of the services. This could be attributed to the prevalence of informal social support from immediate and extended family members [7]. As the disease progressed, caregivers tended to spend more time providing care and gradually withdrew from support systems and other services in China [73]. Furthermore, the study revealed that Referral services were the most utilized, while Household care services were the least utilized. This could be attributed to cultural norms in China that viewed household work as a private matter to be managed by family members, primarily spouses and children, influenced by the concept of filial piety and family obligation in family-based care [27, 74]. In cases where families were unable to handle the work, they would be likely to hire domestic helpers [4]. Further research is necessary to identify possible factors that prevented caregivers from utilizing HBC services in China.

In line with previous studies reporting a lack of association between formal service use and caregiver burden, this study found no significant relationship between HBC services usage and caregiver burden [47, 48]. However, the study's findings reveal a nuanced understanding of the relationship between HBC services and caregiver burden. While the direct usage of HBC services does not correlate significantly with reduced caregiver burden, it is important to note that these services act as moderators in the context of caregiving intensity. This may indicate that simply accessing HBC services is insufficient; rather, caregivers need to engage with these services in ways that directly address the challenges posed by their specific caregiving roles. This suggests that HBC services may be most effective when combined with higher levels of caregiving intensity, potentially helping caregivers manage the burden of their role. This is consistent with previous studies showing that the use of formal services was associated with better psychological well-being, particularly among the aging population in China [27, 44, 45]. Formal social support provided functional assistance, which strengthened caregivers' ability to manage caregiver strains and relieved them of stressful overload [46]. They even had unique functions as reported that healthcare service was the only area of care where formal providers exclusively substitute for informal caregivers [50]. The study identified that the use of Referral services alleviated the negative effects of caregiving intensity on caregiver burden. Meanwhile, the use of Household care, Skilled care, and Mental health service reduced the negative effects of the amounts of ADL-based tasks and supervision tasks on caregiver burden. However, these services did not have significant buffering effects on the relationship between supervision time and caregiver burden, according to the Stressor-support specificity model,

which proposed that moderating effects only occur when there was a good match between the stressors' demands and the types of support available [75]. For example, short-term care for PwDs and day-off or day-to-day support with supervision could be provided to help caregivers cope with the stress of long-term of supervision [76]. Thus, we need to identify the caregiving demands and determine the effects of different types of support.

Besides, the impact of caregiving intensity and general HBC services on caregiver burden was limited. Even with the introduction of interaction terms, the predictors accounted for only about 30% of the variance. Therefore, it was necessary to identify specific requirements imposed by stressors and types of support that best meet these requirements, as proposed by the Stressor-support specificity model. Studies revealed that the main challenges faced by Chinese dementia caregivers included a lack of reliable and accessible information about dementia care, communication difficulties with the care recipients, disturbances in daily routines, and difficulty in balancing the caregiver's own health needs [43]. This highlighted the importance of specialized HBC services to address the needs of PwDs and their informal caregivers in China.

Limitations and implications
The present study has several limitations that need to be taken into consideration when interpreting the results. Firstly, the cross-sectional design of the study precluded the establishment of causal relationships between variables and caregiver burden. Thus, future longitudinal and experimental studies may provide more insight into changes in the relationships over time. Secondly, the study faced common method bias due to the reliance on self-reported instruments, leading to socially desirable responses and caregiver's reluctance to disclose their true feelings about caregiver burden [7, 77, 78]. Furthermore, caregivers may overemphasize positive experiences to avoid stigma [79], and complementing quantitative methods with qualitative research may provide a more comprehensive understanding of the content and dynamics of the subjective experience of caregivers [77]. Lastly, participants have been recruited from Jiangsu Province in China, which has a high socioeconomic status, improved health care resources, and advanced community services, and the findings may not be generalizable to informal caregivers living in more disadvantaged areas, where caregiver burden would be expected to be higher.

The findings of this study carry significant implications for policymakers and healthcare providers in China, underscoring the crucial role of informal caregivers in providing dementia care. As such, supporting family caregivers must be regarded as a national public health priority. Additionally, it is essential to provide long-term support to prevent negative consequences like abuse and institutionalization of persons with dementia [80]. The study highlights the importance of a well-designed social service structure in dementia care that addresses the needs of caregivers, thereby reducing their burden. To this end, we recommend the implementation of dementia-specific HBC services that cater to both persons with dementia and caregivers. However, the study also reveals shortcomings in the utilization and effectiveness of existing HBC services in China. Further research is therefore necessary to identify the multidimensional factors and barriers to the use of such services, with the aim of enhancing their quality. Lastly, more tailored or intensive support mechanisms, such as support groups, training, and psychosocial interventions [36], should be considered to reduce caregiver burden among informal caregivers of PwDs in China.

Conclusions
The results of this study revealed that the ADL-based tasks levels significantly impacted caregiver burden, whereas supervision tasks levels did not. Despite the fact that HBC services for the whole aging population in China are considered fundamental in meeting caregiving needs with identified four functional contents, the level of utilization was not high and did not predict caregiver burden. However, these services were found to significantly moderate the relationships between caregiving intensity and burden, although with limited explanatory power. These findings suggest that improving HBC services may be an effective strategy to alleviate the negative effects of high caregiving intensity on caregiver burden. Furthermore, enhancing the development of dementia-specificized HBC services in China can help protect caregivers from burden during caregiving. Overall, this study highlights the need for further research on supervision tasks in dementia caregiving and provides insights that may inform the development of HBC policies and interventions to support informal caregivers of PwDs in China.

Abbreviations
HBC   Home-based care
PwDs   Persons with dementia
ADL   Activities of Daily Living
IADL   Instrumental Activity of Daily Living

Author contributions
Y.Z. worked on conceptualization, data curation, formal analysis, funding acquisition; investigation, methodology, software, validation, visualization, interpretation of data, the draft and substantive revision. W.C.C worked on conceptualization, investigation, methodology, project administration,

resources, supervision, validation, interpretation of data, the draft and substantive revision. All authors reviewed the manuscript.

Data availability
The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study obtained ethical approval from The Survey and Behavioral Research Ethics Committee of The Chinese University of Hong Kong (The approval letter can be found in the Supplementary material). Informed consent was obtained from all the participants or their LAR.

Consent for publication
None.

Competing interests
The authors declare no competing interests.

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