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Predictors of care dependency in nursing home residents with moderate to severe dementia: A cross-sectional study

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ABSTRACT

Background: Nursing home residents with dementia show a rapid decline in their ability to perform activities of daily living. This decline is linked to a greater care dependency, which is associated with a reduced quality of life. Care dependency is influenced by multiple predictors, yet current research often focuses on the contribution of a single or a small number of predictors of care dependency.
Objectives: To examine the contribution of multiple predictors in predicting care dependency.
Design: The present study analyzed baseline data from a 6-month double-parallel randomized controlled trial which examined the effect of three physical activity interventions on multiple outcomes.
Setting: This study was conducted in eleven nursing homes in Bergen op Zoom, the Netherlands.
Participants: In total, 85 nursing home residents with moderate to severe dementia were included in the study, of which 75 were included for analysis.
Methods: Predictors considered were cognitive, physical, neuropsychiatric, demographic, and disease related factors. The outcome measure care dependency was assessed with the Care Dependency Scale and the Erlangen Test of Activities of Daily Living. Linear multilevel regression analyses were used to identify the most important predictors of care dependency.
Results: Apathy, physical endurance, number of comorbidities, and global cognition were significant predictors of care dependency. The model explained 66% of the variance in care dependency. Global cognition was a significant predictor of ability to perform activities of daily living and explained 60% percent of its variance.
Conclusion: The present study shows that multiple predictors (i.e., apathy, cognitive and physical abilities, and disease-related factors) contribute to predicting care dependency. Future research could focus on the effectiveness of multifactorial interventions to maintain the highest possible level of independence in nursing home residents with dementia.

What is already known about the topic?

- Care dependency is very common in nursing home residents with dementia and has been related to the severity of dementia, demographic factors, cognitive and physical abilities, neuropsychiatric factors, and medical comorbidities in persons with mild to moderate dementia.
- Previous studies examined the contributions of one or a small number of predictors on care dependency. The relative contribution of multiple predictors on care dependency is unknown.
- Evidence pertaining to home-dwelling persons with mild to moderate dementia does not apply to nursing home residents with moderate to severe dementia, as independent functioning deteriorates differently during the progression of dementia.

What this paper adds

- This is the first study to investigate the relative contribution of a broad range of predictors to identify the most important

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predictors of care dependency in a cohort with moderately severe dementia.
- The findings of this study both support and extend previous literature. The results show that care dependency is affected by multiple predictors, including apathy, physical endurance, number of comorbidities, and cognitive functions. Apathy and physical endurance were most predictive of caregiver-rated care dependency, while global cognition was most predictive of disability in activities of daily living.
- The associations found between care dependency and multiple predictors underscores the importance of considering multifactorial interventions for maintaining the highest possible level of independence in nursing home residents with dementia.

1. Introduction

Older persons with dementia often display a progressive deterioration in activities of daily living (ADL) (Martyr and Clare, 2012). ADLs are functional tasks which are important for independence in self-care and functioning. Especially nursing home (NH) residents with dementia show a faster than expected decline in ADL ability (Carpenter et al., 2006; Lee et al., 2015), and this decline in functional abilities is inevitably linked to a greater care dependency (Meinerding et al., 2018). Care dependency occurs when a patients' self-care abilities (e.g., eating and drinking, hygiene, dressing, social contacts) have decreased to such an extent that they are, to some degree, dependent on nursing care (Dijkstra et al., 1998). In some studies, dependency has been defined as a composite measure of functional disability, while others conclude that dependency is strongly associated with, but not defined by, functional disability (Picco et al., 2016). An increase in care dependency is closely related to the development of dementia (Schüssler and Lohrmann, 2017) and health related nursing care problems (i.e., malnutrition, pressure ulcers, incontinence, falls, restraints) (Schüssler et al., 2014). For instance, dependency in eating and drinking may lead to nursing care problems like malnutrition. Moreover, care dependency is associated with a reduced quality of life (Ballard et al., 2001; Garre-Olmo et al., 2017) and high caregiver burden (Gallagher et al., 2011). Since dementia is one of the most common disorders in the NH (Schüssler et al., 2014), and NH residents with dementia show a significantly higher degree of, and a faster decline in care dependency than NH residents without dementia (Giebel et al., 2016; Schüssler et al., 2016) it is relevant to identify predictors of care dependency in NH residents with dementia. This knowledge can help target multifactorial interventions to support the patients' highest level of independence in order to stabilize care dependency in dementia.

Care dependency or functional disability has been related to the severity of dementia (Benke et al., 2013; Hill et al., 1995; Meinerding et al., 2018), and multiple demographic predictors, such as age and gender (Benke et al., 2015; Caljouw et al., 2014; Van Rossum and Koek, 2016), cognitive and physical abilities (Benke et al., 2013; Caro et al., 2002; Garre-Olmo et al., 2017; Holtzer et al., 2003; Kim, 2003; Marshall et al., 2011; Martyr and Clare, 2012; Meinerding et al., 2018; Nygard et al., 1998; Spackman et al., 2013; Van Rossum and Koek, 2016), neuropsychiatric factors (Benke et al., 2013; Boyle et al., 2003; Gallagher et al., 2011; Garre-Olmo et al., 2017), and medical comorbidities in persons with mild to moderate dementia (Garre-Olmo et al., 2017).

Despite the available evidence that care dependency is related to multiple predictors, previous research mostly examined the contributions of only a single predictor or a small number of predictors (Benke et al., 2015; Garre-Olmo et al., 2017; Kim, 2003; Meinerding et al., 2018; Van Rossum and Koek, 2016). Consequently, the contribution of multiple predictors on care dependency, and which predictors are most influential, remains relatively unknown. The predictors that have been most consistently reported in the literature are cognitive abilities (Boyle et al., 2003; Caro et al., 2002; Marshall et al., 2011; Martyr and Clare, 2012; Meinerding et al., 2018; Nygard et al., 1998) and disease severity measured by the Mini-Mental State Examination (MMSE) (Hill et al., 1995; Kim, 2003; Zanetti et al., 1993), which indicates that cognitive abilities may be important predictors of care dependency (Kim, 2003). However, it was shown that cognitive abilities accounted for only a limited amount of variance in care dependency (ranging from 11 to 37%), suggesting that other predictors may also contribute to dependency (Benke et al., 2015; Kim, 2003).

Besides studies focusing on a limited number of predictors, the majority of the studies into predictors of care dependency focused on persons with mild to moderate dementia, while few studies focused on moderate to severe dementia (Benke et al., 2015). One study that did investigate, but was not limited to, persons with moderate to severe dementia found that cognitive function, functional capabilities, and behavioral symptoms were significant predictors of care dependency for the group as a whole (Garre-Olmo et al., 2017). It is clinically relevant to investigate different stages of dementia, since independent functioning deteriorates differently during the progression of dementia, and therefore findings in mild to moderate dementia may not apply to the overall patient group (Giebel et al., 2015; Marra et al., 2007). Specifically, ADL functions seem largely preserved in mild cognitive impairment (Van Rossum and Koek, 2016), whereas early stages of dementia are particularly characterized by a decline in complex ADLs (e.g., using the telephone) and later stages of dementia by basic ADLs (e.g., bathing) (Marra et al., 2007). In addition, different predictors may affect care dependency differently depending on the stage of dementia. For example, the ability to perform complex ADLs appears to rely more on cognitive functions (e.g., planning), whereas basic ADLs rely more on physical abilities (e.g., balance) (Marra et al., 2007). Considering this stage-dependent variability in ability to function independently, and the potential changing relation with predictors throughout the course of the disease, it is relevant to examine NH residents with moderate to severe dementia separately.

In sum, the contribution of multiple predictors on care dependency in persons with dementia is still unknown, and particularly in persons with moderate to severe dementia. Therefore, the present study focuses on NH residents with moderate to severe dementia, and aimed to examine the contribution of multiple predictors in predicting care dependency.

2. Methods

2.1. Study design and population

The present study analyzed the collected baseline data from a 6-month double-parallel randomized controlled trial (RCT) which examined the effect of three physical activity interventions (i.e., ADL training, exercise training, and a combined ADL and exercise training) on multiple outcomes (Henskens et al., 2018). In total, 87 participants were included in the RCT based on inclusion and exclusion criteria. Details on enrollment, intervention procedures, and the results of the interventions have been described previously (Henskens et al., 2018). Study inclusion criteria were: (1) living on a psychogeriatric ward of NH 'tanteLouise' in the Netherlands, (2) diagnosis of dementia, (3) functional mobility level A or B (according to the Arjo mobility gallery) (Huntleigh, 2005), (4) age $\geq$ 65 years, (5) a score on the Mini-Mental State Examination (MMSE) (Folstein et al., 1975) between 1 and 24, and (6) able to complete the six minutes walking test (6MWT) (Rikli and Jones,

1998) (with or without walking aid). Exclusion criteria were (1) wheelchair bound, (2) very poor vision, (3) severe cardiovascular problems, (4) unstable diabetes mellitus, or (5) aggressive or runaway behavior. The medical and physical capabilities of the residents were carefully examined by their geriatrician to ensure safe participation in physical interventions. Even though the interventions are beyond the scope of this paper, a short description is given since it has influenced our selection of participants. In the ADL training, nursing staff stimulated movement by encouraging participants to perform as much of their self-care as independently as possible throughout the day. In the multicomponent exercise intervention, participants performed strength and aerobic exercises guided by qualified movement teachers, with a frequency of three times per week, for 30–45 min per session. Ethical approval was granted by the scientific and Ethical Review Board (VCWE) of the Faculty of Behavior & Movement Sciences of VU University Amsterdam (VCWE-2015-183R1). Participants' legal representatives (i.e., partner, family member, or curator) gave written informed consent prior to inclusion.

2.2. Measurement methods

For this study, the outcome measures collected at baseline of the RCT were assessed. The CDS, depression, apathy, and agitation questionnaires were completed by the participants' first responsible caregivers. The E-ADL, cognitive, and physical tasks were administered by trained neuropsychology and human movement science students.

2.3. Care dependency

Care dependency was measured in two ways: (1) a caregiver-rated questionnaire and (2) a performance-based test which measured the patients' ability to independently carry out ADLs.

The Care Dependency Scale (CDS, scored 15–75) (Dijkstra et al., 1996) is a 15-item caregiver-rated questionnaire concerning a person's level of care dependency with regard to eating and drinking, continence, body posture, mobility, day and night patterns, getting dressed and undressed, body temperature, hygiene, danger avoidance, communication, contact with others, sense of rules and values, daily activities, recreational activities, and learning abilities. Higher scores indicated a higher level of independence (Dijkstra et al., 1999a). The CDS is reliable (Cronbach's alpha 0.97; inter-rater reliability 0.51-0.71) and has a strong hierarchical scale (H-coefficient 0.75) (Dijkstra et al., 1999b,2006).

The Erlangen ADL (E-ADL, scored 0–30) (Graessel et al., 2009) was used to measure functional disability. The E-ADL is a performance-based test in which residents are asked to perform five basic ADL tasks; pouring a drink, spreading butter on bread, opening a cabinet, washing the hands, and tying a bow. Higher scores indicated better ability to carry out ADLs (Graessel et al., 2009). The E-ADL has a high validity and a good reliability (Cronbach's alpha 0.77; test retest reliability 0.73) (Graessel et al., 2009).

2.4. Predictors of care dependency

Candidate predictors were selected *a priori* based on variables found to be associated with dependence in previous literature.

2.4.1. Demographics

The following characteristics were considered: age, gender, educational level, and total number of comorbidities. Educational level was categorized as low (score 1–3), medium (score 4–5), or high (score 6–7) using the classification of Verhage (Verhage, 1964). Comorbidities were derived from the patients' medical charts, and were categorized according to the Dutch translation of the Long-Term Care Facility Resident Assessment Instrument (RAI), section I disease diagnosis (Centers for Medicare & Medicaid Services, 2008). The section consists of 44 subcategories that belong to eight categories: (1) endocrine/metabolic diseases, (2) cardiovascular diseases, (3) diseases of the musculoskeletal system, (4) neurological diseases, (5) sensory impairments, (6) psychiatric/mood disorders, (7) pulmonary diseases, and (8) other diseases, including allergies, anemia, cancer, and renal failure. The neurological subcategories 'Alzheimer's disease' and 'Dementia, other than Alzheimer's disease' were not included, as these subcategories are part of the inclusion criteria. For each participant, the total number of comorbidities was calculated.

2.4.2. Cognitive factors

Cognitive functioning was measured with the MMSE (Folstein et al., 1975) and the Severe Impairment Battery - Short Form (SIB-S) (Saxton et al., 2005). The MMSE consists of 20 items, with scores ranging from 0 to 30. The internal consistency of the MMSE as indicated by the Cronbach's alpha varies between 0.54–0.96 (Tombaugh and McIntyre, 1992). The SIB-S consists of 26 items, with scores ranging from 0 to 50. The internal consistency of the SIB-S is very high (Cronbach's alpha 0.97) (De Jonghe et al., 2009). Executive functioning (EF) was measured with the category fluency subtest of the Groninger Intelligentie Test (Snijders and Verhage, 1983) and the Wechsler Digit Span Task backward (DSB) (Wechsler, 1987). The category fluency task and DSB were administered only to participants with an MMSE score of 5 or higher. For all cognitive measures, higher scores indicated better cognitive functioning.

2.4.3. Physical factors

Physical endurance was measured with the six-minute walk test (6MWT) (Rikli and Jones, 1998). The outcome measure was the total walking distance in meters. Higher scores indicated better performance. Functional mobility was measured with the timed up and go test (TUG) (Podsiadlo and Richardson, 1991). The outcome measure was the time (in seconds) it took to stand up from a chair, walk three meters, turn, return to the chair, and sit down. Lower scores indicated better performance. Hand-grip strength was measured with the Jamar hand dynamometer (Schaubert and Bohannon, 2005), where higher scores indicated better grip strength. Dynamic balance was measured with the Figure-of-8 walk test (F8W) (Hess et al., 2010). The outcome measure was number of steps and time taken to walk in a figure of eight around two cones placed 1.5 m apart. Static balance was measured with the Frailty and Injuries: Cooperative Studies of Intervention Techniques- 4 scale (FICSIT-4), which measured balance in parallel, semi-tandem, and one-legged stances (Rossiter-Fornoff et al., 1995). Higher scores represented better balance.

2.4.4. Mood and behavior

Depressive symptoms were measured with the Cornell Scale for Depression in Dementia (CSDD). The questionnaire consists of 19 items rated on a two-point scale (range 0–38). Higher scores indicated more depressive symptoms (Droës, 1993). The CSDD has a high internal consistency (Cronbach's alpha 0.84) and is sufficiently valid in persons with dementia (Alexopoulos et al., 1988; Leontjevas et al., 2012a). Apathy was measured with the Apathy Evaluation Scale-10 (AES-10). The questionnaire consists of 10 items rated on a four-point scale (range 10–40). Higher scores indicated more apathetic behavior (Lueken et al., 2007). The internal consistency of the AES-10 is high (Cronbach's alpha 0.95) (Leontjevas et al., 2012b). The frequency of agitated behaviors was

measured with the Cohen-Mansfield Agitation Inventory (CMAI). The questionnaire consists of 29 items rated on a 7-point scale. Symptoms were clustered into four scales, i.e. aggressive behavior (scored 9–63), physically nonaggressive behavior (scores 6–42), verbally agitated behavior (scored 5–35), and other behavior (scored to 9–63). For each participant, a total CMAI score was calculated. Higher scores indicated more agitated behaviors (Cohen-Mansfield et al., 1989; Jonghe and Kat, 1996). The internal consistency of the CMAI is high (Cronbach's alpha 0.83) (Shah et al., 1998).

2.5. Statistical analysis

Statistical analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) 24.0. Assumptions of a linear regression model were not violated. Cooks distance revealed no outliers (values >1 were considered outliers). Participants with missing data on one or more variables were excluded from the analyses. A 'balance' domain was created which is the average of the sum of the z-scores of the F8W and the FICSIT-4. A dummy variable was created for educational level. The Cronbach's alpha was calculated for all multi-item scales and showed that all scales had an acceptable to good internal consistency (Cronbach's alpha range: 0.729-0.909), except for the E-ADL which had a poor internal consistency (Cronbach's alpha 0.485). A two-level regression model was used where participants (level 1) were nested within NHs (level 2). The maximum likelihood method was used to examine the possible superiority of random intercept and slope models. The model of the best fit was used for the final analyses. Simple and multiple linear regression models were performed separately for two measures of dependence (i.e. CDS and E-ADL). First, simple linear regression analyses were conducted for all variables to screen for candidate predictors of care dependency. Candidate predictors with p-values lower than .10 were included in the multiple regression analysis. Second, a multiple linear regression analysis was performed using a backward stepwise regression method to identify the most important predictors of care dependency. Significance levels of the multiple linear regression analyses were set at $p < .05$. There was a relatively large percentage of missing data (32.3%) on four candidate predictors (i.e., category fluency, DSB, balance, and level of education). Category fluency and DSB was often missing since EF tasks were only administered to persons with an MMSE score of 5 or higher. Missing data of educational level was the result of the legal representatives' who were not aware of the educational level of the participants. Reasons for missing data on balance tasks were unknown. These four candidate predictors were excluded from the analyses in order to preserve the sample size. An additional subgroup analysis was conducted including these four candidate predictors in order to determine their contribution in the prediction of CDS and E-ADL scores.

3. Results

Demographic and clinical characteristics of the participants are shown in Table 1. The mean global deterioration score (GDS) indicates a moderate to severe stage of cognitive decline. The mean CDS score was 50.2, which indicates that participants are partially dependent on nursing care (Dijkstra et al., 2012).

Table 2 shows the results of the simple linear regression analyses between candidate predictors and the CDS and E-ADL scores.

3.1. Care Dependency Scale (CDS)

In the simple regression analyses, significant associations were found for nine predictor variables and the CDS score. The apathy score (β = -0.67) and the 6MWT (β = 0.66) showed the strongest association with the CDS score. Results of the multiple regression model of predictors of CDS are shown in Table 3. Backward stepwise procedures showed that the apathy score (β = -0.43), 6MWT (β = 0.40), total number of comorbidities (β = -0.19), and the MMSE (β = 0.18) were significant, independent predictors of care dependency. These predictors explained 66% of the variance in CDS score. Apathy and the 6MWT were the most important predictors.

Table 1
Descriptive statistics for demographic and clinical variables (N = 75).

Variables	Participants
Age, mean *(SD)*	85.72 (5.71)
Gender (female), *n* (%)	59 (78.7%)
Education, *n (%)*	
Low (1-3)	24 (32%)
Medium (4-5)	39 (52%)
High (6-7)	6 (8%)
Diagnosis, *n* (%)	
Alzheimer's disease (AD)	29 (38.7%)
Vascular dementia (VD)	11 (14.7%)
Mixed VaD and AD	6 (8.0%)
Other	28 (37.3%)
Unknown dementia type	1 (1.3%)
Total number of comorbidities, mean *(SD)*[b]	4.56 (1.94)
GDS, mean *(SD)*	5.24 (0.81)
GDS classification	
1: No cognitive decline	0
2: Very mild cognitive decline	0
3: Mild cognitive decline	3 (4%)
4: Moderate cognitive decline	8 (10.7%)
5: Moderately severe cognitive decline	30 (40%)
6: Severe cognitive decline	31 (41.3%)
7: Very severe cognitive decline	0
Missing	3 (4%)
CDS, mean *(SD)*	50.15 (11.20)
E-ADL, mean *(SD)*	22.52 (7.17)
Cognitive factors, mean *(SD)*	
MMSE	12.69 (5.48)
GIT[a] (N = 59)	5.09 (2.98)
SIB-S	40.80 (7.53)
DSB (N = 59)	4.56 (2.08)
Physical factors, mean *(SD)*	
6MWT	209.54 (74.01)
HHD	16.54 (8.36)
TUG	24.75 (11.92)
Z-score balance[a] (N = 59)	0.02 (0.88)
Mood and behavioral factors, mean *(SD)*	
CSDD	7.92 (4.48)
CMAI	48.45 (14.32)
AES	25.29 (7.24)

Note [a] Z-score balance included figure of eight test, Frailty and Injuries, cooperative Studies of Intervention Techniques- 4 scale. [b]Endocrine/metabolic diseases (i.e. diabetes mellitus, hypothyroidism, hyperthyroidism), cardiovascular diseases (i.e. arteriosclerotic disease, arrhythmias, heart failure, deep vein thrombosis, hypertension, hypotension, peripheral vascular disease, other), diseases of the musculoskeletal system (i.e. rheumatic diseases, hip fracture, amputation, osteoporosis, pathologic bone fracture), neurological diseases (i.e. aphasia, cerebral palsy, stroke, hemiplegia/hemiparesis, paraplegia, multiple sclerosis, Parkinson disease, seizures, transient cerebral ischemia, traumatic brain injury, quadriplegia), sensory impairments (i.e. cataract, diabetic retinopathy, glaucoma, macular degeneration), psychiatric/mood disorders (i.e. anxiety disorder, depression, manic depression, schizophrenia), other diseases (i.e. asthma, emphysema/COPD, allergies, anemia, cancer, renal failure).
Abbreviations. GDS, global deterioration scale; CDS, care dependency scale; E-ADL, Erlangen activities of daily living; MMSE, mini-mental state examination; GIT, Groninger intelligentie test; SIB-s, severe impairment battery short version; DSB, digit span backward; DSF, digit span forward; 6MWT, 6 min walk test; HHD, handheld dynamometer; TUG, timed up and go test; CSDD, Cornell Scale for Depression in Dementia; CMAI, Cohen-Mansfield Agitation Inventory; AES, apathy evaluation scale-10.

3.2. E-ADL

In the simple regression, analyses significant associations were found for eight predictor variables and the E-ADL score. The

Table 2
Univariable linear mixed regression analyses of associations between predictors and CDS and E-ADL (N = 75).

	CDS				E-ADL			
Predictor	B (95%CI)	β	R^2	*p*	B (95%CI)	β	R^2	*p*
Age	−0.44 (−0.88, 0.00)	−0.22	0.12	0.05	−0.26 (−0.55, −0.03)	−0.21	0.04	0.08
Gender	−2.95 (−9.12, 3.23)	−0.11	0.08	0.34	1.06 (−2.99, 5.11)	0.07	0.01	0.60
Comorbidities	−1.36 (−2.67, 0.05)	−0.24	0.14	0.04	−0.38 (−1.23, 0.48)	−0.10	0.00	0.38
HHD	0.62 (0.33, 0.91)	0.46	0.24	<0.001	0.28 (0.08, 0.48)	0.33	0.11	0.009
6MWT	0.10 (0.07, 0.13)	0.66	0.46	<0.001	0.03 (0.01, 0.05)	0.31	0.07	0.02
TUG	−0.37 (−0.56, −0.17)	−0.39	0.25	<0.001	−0.16 (−0.30, −0.03)	−0.27	0.06	0.02
MMSE	0.95 (0.53, 1.37)	0.46	0.24	<0.001	0.90 (0.68, 1.13)	0.69	0.47	<0.001
SIB-S	0.46 (0.13, 0.79)	0.31	0.14	0.007	0.72 (0.58, 0.87)	0.76	0.57	<0.001
CSDD	−0.63 (−1.19, −0.07)	−0.25	0.13	0.03	−0.16 (−0.53, 0.21)	−0.10	0.00	0.40
CMAI	−0.14 (−0.32, 0.04)	−0.18	0.08	0.12	−0.13 (−0.24, −0.01)	−0.26	0.05	0.03
AES	−1.03 (−1.30, −0.77)	−0.67	0.46	<0.001	−0.33 (−0.55, −0.11)	−0.33	0.10	0.004

Abbreviations. B, unstandardized regression coefficient; β, standardized regression coefficient; CDS, care dependency scale; E-ADL, Erlangen activities of daily living; MMSE, mini-mental state examination; SIB-s, severe impairment battery short version; DSB, digit span backward; DSF, digit span forward; 6MWT, 6 min walk test; HHD, handheld dynamometer; TUG, timed up and go test; Balance: z score of figure of eight test and the Frailty and Injuries: Cooperative Studies of Intervention Techniques- 4 scale; CSDD, Cornell Scale for Depression in Dementia; CMAI, Cohen-Mansfield Agitation Inventory; AES, apathy evaluation scale-10.

association was strongest for the SIB-S (β = 0.76) and the MMSE (β = 0.69). Results of the multiple regression model of predictors of E-ADL are shown in Table 3. Backward stepwise procedures showed that the SIB-S (β = 0.55) and the MMSE (β = 0.28) were significant, independent predictors of ADL disability. Sixty percent of the variance in E-ADL score was accounted for by the full model.

3.3. Subgroup analysis

3.3.1. Care Dependency Scale (CDS)

An additional subgroup analysis was performed with 59 participants which also included EF tasks, balance, and educational level. In the simple regression analyses, significant associations were found for ten predictor variables and the CDS score

Apathy (β = -0.72) and 6MWT (β = 0.68) showed the strongest associations (see supplementary table). In the multiple regression analyses, apathy (β = -0.47), 6MWT (β = 0.34), handgrip strength (β = 0.23), and category fluency (β = 0.16) were significant, independent predictors of CDS (Table 4). The model predicted 75% of variation in CDS score. Apathy and the 6MWT remained the most important predictors of the CDS score.

3.3.2. E-ADL

In the simple regression analyses, significant associations were found for nine predictor variables and the E-ADL score. MMSE (β = 0.62) and the SIB-S (β = 0.72) showed the strongest associations (see supplementary table). In the multiple regression analyses, SIB-S (β = 0.52), MMSE (β = 0.27), and age (β = 0.19) were significant, independent predictors of E-ADL (see Table 4). Fifty-eight percent of the variance in E-ADL was accounted for by the full model. The SIB-S was the most important predictor of E-ADL.

Table 3
Multiple linear mixed regression analysis predicting CDS and E-ADL (N = 75).

	B (95%CI)	β	*p*	*Adjusted* R^2
CDS				0.66
AES	−0.67 (−0.92, −0.42)	−0.43	<0.001	
6MWT	0.06 (0.03, 0.08)	0.40	<0.001	
Comorbidities	−1.12 (−1.95, −0.29)	−0.19	0.009	
MMSE	0.36 (0.04, 0.68)	0.18	0.026	
EADL				0.60
SIB-S	0.52 (0.30, 0.74)	0.55	<0.001	
MMSE	0.37 (0.08, 0.67)	0.28	0.014	

Abbreviations. B, unstandardized regression coefficient; β, standardized regression coefficient; CDS, care dependency scale; EADL, Erlangen activities of daily living; AES, apathy evaluation scale-10; 6MWT, 6 min walk test; MMSE, mini-mental state examination; HHD, handheld dynamometer.

4. Discussion

The current study showed that apathy, lower physical endurance, higher number of comorbidities, and global cognition are important predictors of care dependency. These predictors explained 66% of the observed variance in care dependency in NH residents with moderate to severe dementia. These results both support and extend previous literature reporting associations between care dependency and physical (Spackman et al., 2013), cognitive (Caro et al., 2002; Stern et al., 1994), and neuropsychiatric predictors (Gallagher et al., 2011; Murman et al., 2007; Zahodne et al., 2015). In our study, apathy and physical endurance were most predictive of care dependency. A previous study examining a cohort with mild to moderate dementia found that neuropsychiatric symptoms were correlated with dependence, but had only limited power to explain its variance (Benke et al., 2015). This discrepancy with the current study may be explained by the fact that we examined NH residents at a more severe stage of dementia who were more dependent and had more neuropsychiatric problems than participants in other studies (Benke et al., 2015). The large role which apathy plays in predicting care dependency is reasonable inasmuch as apathy manifests as a lack of motivation, taking initiative, and goal-directed behavior. Impairment in these functions may prevent patients from performing self-care activities (Burton et al., 2017). These results suggest that interventions

Table 4
Multiple linear mixed regression analysis predicting CDS and E-ADL in a subgroup (n = 59).

	B (95%CI)	β	*p*	*Adjusted* R^2
CDS[a] (n = 59)				0.75
AES	−0.74 (−0.99, −0.49)	−0.47	<0.001	
6MWT	0.05 (0.03, 0.08)	0.34	<0.001	
HHD	0.30 (0.09, 0.51)	0.23	0.006	
Category Fluency	0.58 (0.04, 1.11)	0.16	0.034	
E-ADL[b] (n = 59)				0.58
SIB-S	0.59 (0.33, 0.85)	0.52	<0.001	
MMSE	0.36 (0.06, 0.67)	0.27	0.021	
Age	−0.21 (−0.41, −0.02)	0.19	0.031	

Note: [a] significant univariable associations: age, HHD, 6MWT, TUG, MMSE, SIB-S, AES, GIT, DSB, balance; bsignificant univariable associations: age, HHD, 6MWT, TUG, MMSE, SIB-S, GIT, DSB, balance.
Abbreviations. B, unstandardized regression coefficient; β, standardized regression coefficient; CDS, care dependency scale; E-ADL, Erlangen activities of daily living; AES, apathy evaluation scale-10; 6MWT, 6 min walk test; HHD, handheld dynamometer; SIB-s, severe impairment battery short version; MMSE, mini-mental state examination.

targeted at reducing apathy may in turn benefit care dependency. Previous research has provided evidence of the effectiveness of individually tailored therapeutic activities for reducing apathy in dementia (Brodaty and Burns, 2012).

In addition to apathy, physical endurance emerged as one of the most important predictors of care dependency. This was to be expected considering the involvement of motor skills in many self-care tasks (e.g., dressing, eating, continence) (Marra et al., 2007). Other physical functions, such as handgrip strength and functional mobility, were individually associated with care dependency, but not when other factors were taken into account. These results suggest that physical endurance is a stronger predictor of care dependency than other physical factors, emphasizing the importance of stimulating physical activity to keep the physical endurance optimal, even in advanced stages of dementia. However, despite emerging evidence for the benefits of physical activity interventions in persons with dementia, uncertainty remains regarding the optimal type, intensity, duration, and frequency of exercise (Brett et al., 2016; Forbes et al., 2015). Further, it was found that the total number of comorbidities significantly predicted care dependency. This finding suggests that particular attention should be given to individuals with dementia who have multiple other medical conditions, as they may be at risk for increased care dependency.

With regard to ADL ability, this study showed that global cognition was the most important predictor. This may be explained by the nature of the E-ADL task, which measures a sequence of actions relevant to self-care. Understanding the test instructions and executing the sequences depends on the level of cognitive abilities. The large proportion of variance in ADL ability which was explained by global cognition (60%) is more than reported in previous studies (20–26%) (Mcalister et al., 2016; Royall et al., 2007). There are two possible explanations for this difference. First, previous studies typically included only caregiver-rated assessments of ADL disability (Benke et al., 2013; Burton et al., 2017; Hesseberg et al., 2013; Vallotti et al., 2001; Van Rossum and Koek, 2016), which may produce different estimates of ADL disability than performance-based assessments (Gold, 2012). Second, unlike previous studies that used only the MMSE, we also used the SIB-S to measure global cognition. The SIB-S may be a better predictor of ADL disability than the MMSE as it is a broader scale (Panisset et al., 1994), and more sensitive to the measurement of cognitive functioning in persons with a MMSE score below 12 (Panisset et al., 1994).

Results from the subgroup analyses suggest that besides apathy and physical predictors, executive functions (i.e., category fluency) may play an important role in predicting care dependency. This is in line with previous studies which demonstrated a consistent moderate relationship between EF and functional dependence (Burton et al., 2017; Martyr and Clare, 2012). The category fluency task is a measure of executive control ability. Important components of executive control ability are set-shifting (i.e., the ability to flexibly switch between tasks), goal-directed behavior, and self-initiation. Deficits in these abilities may negatively influence the ability to function independently (Shao et al., 2014). With regard to ADL ability, the subgroup analyses showed that global cognition remained the most important predictor of E-ADL, even when executive functions were also considered. Global cognition together with age explained 58% of the variance in E-ADL. Although the subgroup analyses must be interpreted cautiously due to the limited sample size, the results suggest that EF contributes to the prediction of care dependency, highlighting the relevance to further examine the relative contribution of EF in a larger sample.

Strengths of this study were the inclusion of a broad range of predictors, the inclusion of participants with moderate to severe dementia, and the use of outcome measures specifically designed and validated for use in NH residents with dementia. A limitation of our study was the amount of missing data. Considering the nature of the missing data, multiple imputations would not have been fully reliable. For this reason, the subgroup analyses which included EF tasks were restricted to participants with higher cognitive abilities, which in turn may limit the generalization of our results. A second limitation is that the study was cross-sectional in design, which restricts the ability to draw causal inferences. Third, information regarding the presence of comorbid nursing care problems (e.g., incontinence, malnutrition, restraints, falls, and pressure ulcers) was not collected. These nursing care problems are common in NH residents with dementia and are related to care dependency (Schüssler et al., 2016, 2015; Schüssler et al., 2014). Therefore, the presence and influence of nursing care problems should be considered in future research. In addition, the NH setting may influence care dependency, as there may be differences in care management between NH locations. However, we controlled for this by examining the nested structure of the data. Related, for some participants, the same caregiver rated the CDS, as well as the questionnaires (i.e., depression, apathy, and agitation). This may have artificially inflated the beta coefficients. In conclusion, our results showed that care dependency is affected by multiple predictors, including apathy, physical endurance, number of comorbidities, and cognitive functions. Previous studies showed that apathetic persons with dementia suffer more rapid cognitive and functional decline than persons without apathy (Starkstein et al., 2006). It is possible that apathetic, cognitive, and physical problems reinforce each other thereby causing more dependency, as the ability to understand and execute self-care tasks depends on cognitive functions, physical capabilities, and the ability to take initiative. The results of the present study suggest that NH residents with dementia are more care dependent if they are apathetic, have worse cognitive function, and worse physical function.

The results of this study are clinically relevant, as NH residents with dementia have a high level of care dependency (Dijkstra et al., 1999a, b; Schüssler et al., 2016, 2015). An improved understanding of the predictors of care dependency is particularly relevant for the development of interventions designed to maintain the residents' highest levels of independence. The results advocate a multidisciplinary approach for interventions to stabilize care dependency, as interventions focusing on a single predictor may be less effective considering that multiple factors contribute to care dependency. Future research could focus on the effectiveness of multifactorial interventions such as individually tailored therapeutic interventions which focus on reducing apathy, as well as stimulating physical and cognitive performance. In addition, proper treatment and efforts to stabilize medical comorbidities in the NH population may benefit care dependency.

Conflict of interest

This study was funded by Stichting tanteLouise, who contributed to the conception and design of the study and helped with data acquisition. The study funders had no role in the analysis and interpretation of the data. The authors declare that they have no competing interests.

Ethics approval and informed consent

The Medical Ethics Review Committee of Amsterdam University Medical Center, location VU University Medical Center (2015.446) concluded that this study was not subject to the Medical Research Involving Human Subjects Act (WMO). Ethical approval was granted by the scientific and Ethical Review Board (VCWE) of the Faculty of Behavior & Movement Sciences of VU University Amsterdam (VCWE-2015-183R1). Written informed consent was obtained from the legal representatives of the participants.

Authors' contributions

MH conducted the study, supervised data collection, and performed the data analysis and interpretation and writing of the manuscript. IN designed and conducted the study, supervised data collection, contributed to the data analysis and writing of the manuscript. KTD advised in designing and conducting the study, and critically revised the manuscript. MM contributed to interpretation of data, and critically revised the manuscript. ES advised in designing the study, contributed to interpretation of data, and critically revised the manuscript. All authors read and approved the final manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijnurstu.2018.12.005.

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