Risk Profiles for Care Dependency: Cross-Sectional Findings of a Population-Based Cohort Study in Germany

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Abstract

Background: Rising life expectancy in Western societies is accompanied by a rising incidence of care dependency (CD) among older people. **Objective:** The aim of the study was to examine which health-related and social determinants were associated with CD. **Method:** We used cross-sectional data from the first follow-up ($N = 1,699$) of a prospective, population-based cohort study of older participants (≥ 70 years). CD was assessed if participants required substantial assistance in at least two activities of daily living for $90+$ minutes daily. Multivariate logistic regressions were applied. **Results:** Participants' mean age was 82 years; 18.9% were care-dependent. CD was significantly associated with older age, urinary incontinence, stroke, falls, cancer, diabetes, education level, having no partner, limited mobility, and limited physical activity. **Discussion:** Our research highlights the importance of promoting mobility, even in care-dependent people. Further research should investigate the role of partnership in terms of the prevention and delay of CD.

Background

As life expectancy continues to rise, the impact of demographic change on health and disease is already evident: increases in age-related illnesses, psychosocial limitations, need for assistance and nursing care present individual, and economic and health policy challenges. Little is known about how patterns of morbidity, frailty, and social determinants are associated with care dependency (CD) in old age. For the purposes of our study, CD means that a person requires substantial assistance in activities of daily living and is therefore receiving benefits covered by long-term care insurance within the German social insurance system. Currently, around 2.9 million people in Germany meet the CD criteria set forth in the German Social Code (SGB XI). The number of care-dependent persons has increased by around 500,000 since 2010 and is projected to reach around 3.4 million by 2030 (Statistisches Bundesamt, 2017). The CD ratio, that is, the percentage of persons requiring care in relation to their peer group, increases significantly with age. Within the 80 to 84 age group, the ratio is approximately 24% for women and 18% for men. In the 85 to 89 age group, this rises to approximately 44% for women and 31% for men. Among the over-90s, 70% of women and more than 50% of men are care-dependent as defined in the German Social Code (Statistisches Bundesamt, 2015).

In the international context, assessment of functional impairments using the Barthel Index (Mahoney & Barthel, 1965; Shah, Vanclay, & Cooper, 1989) or scales for measuring activities of daily living (Katz, Downs, Cash, & Grotz, 1970; Lawton & Brody, 1969; Wallace & Herzog, 1995) may be regarded as broadly approximating the German definition of CD. Corresponding assessment categories are feeding, transfers (bed to chair and back), grooming (personal care), toilet use, independent bathing, mobility (wheelchair/walking), use of stairs, dressing/undressing, and fecal and urinary incontinence.

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Very few studies have investigated determinants of CD so far. In a German study by Van den Bussche et al. (2014), which was based on claims data, the authors identified old age, dementia, urinary incontinence, stroke, and cardiac insufficiency as being significantly associated with CD. A German population-based prospective cohort study by Hajek et al. (2017) revealed that the probability that a patient would become care-dependent significantly increased with the onset of old age and dementia. The authors also analyzed the effect of mobility impairment on CD. An international study on longitudinal predictors of functional impairments in older adults in Europe showed that limitations increased significantly with age, depression, cognitive impairment, the number of chronic conditions, less than daily alcohol consumption, smoking, and living without a spouse/partner in the household (Hajek & König, 2016). Borchert and Rothgang (2008) emphasized the protective effect of partnership on CD risk for older men. Information about the sociodemographic determinants of CD (education, income) is particularly patchy and inconsistent (Ramsay, Whincup, Morris, Lennon, & Wannamethee, 2008; Sulander et al., 2012).

Against the background of the limited number of studies on determinants of CD, our exploratory study investigated risk profiles for CD. The Roper–Logan–Tierney (RLT) Model of Nursing (Roper, Logan, & Tierney, 2009) was our theoretical starting point. The RLT Model offers a broader perspective on the emergence and definition of CD since it is based on (health-relevant) activities of daily living and the physical, psychological, and social factors affecting them. Crucially, it is the combination of these various factors that determines the need for care and assistance on a continuum that ranges from complete dependency to complete independence.

Our study therefore investigated how different sets of physical and social determinants were associated with CD. It focused on the following research questions:

Research Question 1: How is CD associated with social determinants, geriatric conditions, morbidity, and health behavior?
Research Question 2: Which risk profiles can be detected if all determinants are analyzed together?
Research Question 3: Which associations between potential explanatory factors do exist?

Our research was based on the Berlin Initiative Study (BIS), a prospective, longitudinal, population-based cohort study (Ebert et al., 2017; Schaeffner et al., 2010). Because geriatric assessment tools were not integrated until the first follow-up, we will present cross-sectional analyses.

Method

Study Design

The BIS methodology has been described in detail elsewhere (Ebert et al., 2017; Schaeffner et al., 2010). Briefly, BIS is a prospective, longitudinal, population-based cohort study of 2,069 randomly selected elderly participants (≥70 years of age) covered by Germany's largest health insurance provider. The study was set up to investigate the epidemiology of chronic kidney disease in elderly people and provides information on demographics, lifestyle variables, comorbidities, and cardiovascular events. Study visits took place in 2009, 2011, and 2013. The first follow-up between December 2011 and 2013 with 1,699 respondents from the first wave (response rate: 90.9%, without taking deaths into account) incorporated additional geriatric assessment tools. This article focuses on the first follow-up and provides a cross-sectional analysis of the cohort. The study participants agreed to the collection and transfer of their data in compliance with data protection regulations. The study was approved by the Ethics Commission of Charité – Universitätsmedizin Berlin (Ref. EA2/009/08).

Outcome Measures of CD

In the German health care system, CD is measured by the amount of time (at least 90 min per day over a period of at least 6 months) needed daily for substantial assistance in at least two activities of daily living in the personal hygiene, nutrition, and mobility categories, and, additionally, assistance with domestic tasks. Insurance benefits must be applied for by the person in need of care. The level of care to be provided is determined by an expert assessment conducted in the applicant's home and may be reviewed at a later date (Buchmann, 2014; Koller et al., 2014). Care services are provided regardless of where the person lives, whether at home or in a retirement or nursing care facility (Schnitzer et al., 2017). In this study, the information about the need for care was obtained from claims data supplied by the participant's health insurance provider (data were linked to patient survey data).

Morbidities and Health Behavior

Various studies have revealed the association between CD/functional impairments and chronic conditions (Hajek & König, 2016; Koller et al., 2014). We therefore included all chronic conditions and morbidities covered by the BIS dataset: history of stroke, myocardial infarction, cancer, kidney disease (eGFR < 60 ml/min/1.73 m²), diabetes mellitus (intake of antidiabetic medication and/or HbA1c level >6.5%, yes/no), and body mass index (<25, 25-30, >30). Data were collected at baseline through self-reporting, with validation of all defined endpoints (myocardial infarction, stroke) provided by physicians' letters, generally 2 years after the visit. Certain chronic diseases, for example, diabetes, were additionally validated through laboratory test results (HbA1c) and documented medication. More details are provided in Schaeffner et al. (2010) and Ebert et al. (2017). As regards health behavior, there is some evidence that

Table 1. Assessments.

Assessment	Description	Items	Quality criteria/cutoff values
Timed Up & Go (TUG) (Podsiadlo & Richardson, 1991)	Mobility impairments assessment	Time in seconds: Stand up from the chair, walk 3 m, turn, walk back to the chair, and sit down again	Cutoff: 20 s (Shumway-Cook, Brauer, & Woollacott, 2000)
Fall risk (developed at Charité Berlin)	Fall and fall situation in the last 4 weeks	2 items: (a) How often? (b) Fall situation (housekeeping, walk, sport, transportation, other)	
Brief Pain Inventory (BPI) (Cleeland & Ryan, 1994) German version: (Radbruch et al., 1999)	Pain, pain intensity assessment and pain impairment	4 items: (a) Pain in the past 24 hr, (b) Pain today, (c) Localization, (d) Pain intensity from 0 to 10, (e) Impairment in everyday life	Cronbach's α: .86
Incontinence (developed at Charité Berlin)	Urinary incontinence assessment	2 items: (a) During the past 4 weeks, have you leaked urine (even a small amount), (b) How often?	
Sleep (Herrmann & Flick, 2011)	Sleep satisfaction assessment	4 items: (a) To sleep all night, (b) To sleep well through the night, (c) To fall asleep again, (d) General sleep satisfaction	
Mental Health Inventory (MHI-5) (Rumpf, Meyer, Hapke, & John, 2001)	Psychological well-being assessment. Short version of Mental Health Inventory (MHI-38; Veit & Ware, 1983)	5 items: (a) Agitation (b) Depression (c) Behavioral control (d) Positive affect (e) General distress	Sensitivity: 0.83 (Depression) 0.73 (Agitation) Specificity: 0.78 (Depression) 0.60 (Agitation) Cutoff: 60 P.
Micro-Mental Test (MMT) (Rapp, Rieckmann, Gutzmann, & Folstein, 2002)	Cognition test. Short version of MMST (Folstein, Folstein, & McHugh, 1975)	5 items: (a) Registration, (b) Language, (c) Orientation to time, (d) Complex commands, (e) Recall Sum score from 0 to 20	Sensitivity: 0.89 Specificity: 0.88 Cutoff values: 14, 15, 16 P.

functional impairments increase with tobacco consumption (Hajek et al., 2017). Physical activity is a protective health factor in older adults (Paterson & Warburton, 2010) and we assumed that the same holds true for CD. We therefore integrated smoking (never smoked or stopped smoking >10 years, current smoker or stopped ≤ 10 years) and physical activity (self-reported frequency of walking at least 30 min: <1 time a week; 1-2 times a week; 3-5 times a week; >5 times a week) in our analyses.

Geriatric Assessment

To assess participants' mobility, we used the Timed Up and Go (TUG) Test and defined limited mobility if participants were unable to perform the TUG Test within 20 s (cutoff value). Pain was assessed using the Brief Pain Inventory. Psychological well-being was assessed with the Mental Health Inventory (MHI-5) and cognitive impairment with the Micro-Mental Test (MMT). Questions about falls, urinary incontinence, and sleep were developed as part of research on geriatric health at Charité Berlin. Table 1 provides an overview of the assessments used, their sources, a brief description, the items included, and their quality criteria (Cleeland & Ryan, 1994; Folstein, Folstein, & McHugh, 1975; Herrmann & Flick, 2011; Podsiadlo & Richardson, 1991; Radbruch et al., 1999; Rapp, Rieckmann, Gutzmann, & Folstein, 2002; Rumpf, Meyer, Hapke, & John, 2001; Shumway-Cook, Brauer, & Woollacott, 2000; Veit & Ware, 1983).

Social Determinants

A large body of scientific evidence has shown that social determinants influence health. This applies particularly to socioeconomic factors such as income and education, but also to gender, age, and social circumstances such as partnership status or networks (Marmot, 2005, 2018). Information about the social determinants of CD is particularly patchy at present. We analyzed gender and age as nonmodifiable determinants and partnership status ("Do you have a partner?"), income (monthly individual net income: low <€1000; moderate €1000-2000; high >€2000), and education (Comparative Analysis of Social Mobility in Industrial Nations [CASMIN]) as modifiable social determinants (Hradil, 2001). The CASMIN index is based on two classification systems, taking into account the qualitative differences between school-based and vocational education (Kunst, 2006). CASMIN's nine levels of classification were collapsed into three categories: (a) no school-leaving qualifications or low educational level (primary education), (b) intermediate educational level (lower and upper secondary education), and (c) high educational level (bachelor's, master's, PhD).

Statistical Analyses

We used the chi-square test or the Mann–Whitney *U* test to explore group differences between care-dependent and non–care-dependent participants. Statistical significance was set at

Table 2. Description of the BIS Cohort and Comparison of Participants With and Without Care Dependency at the First Follow-Up.

	Overall[a]	No care dependency (%)	Care dependency (%)	Significance (*p*)
n	1,699	1,378	321	
Age	*M*: 82 years	*M*: 81 years	*M*: 86 years	<.001
70-79 years	782	52.0	20.6	
80-89 years	700	40.0	46.4	
>90 years	217	8.1	33.0	
Sex				.07
Male	793	47.8	42.1	
Female	906	52.2	57.9	
Income (monthly)				.17
Above €2,000	95	6.1	6.4	
€1,000-2,000	994	63.6	68.9	
Up to €1,000	450	30.3	24.6	
Education (CASMIN)				.04
High	336	21.0	15.0	
Intermediate	342	19.8	21.8	
Low	1,014	59.2	63.2	
Partner				<.001
Yes	912	58.0	36.0	
No	781	42.0	64.0	

[a]Difference between totals and 1,699 = no data; care level = not care-dependent.

p < .05. A series of nested binary logistic regression models were used to examine which health-related and social determinants were associated with CD. The stepwise forward procedure was chosen to detect unadjusted and adjusted results and to determine associations between potential explanatory factors. Four models were considered in a manual part by defining the blocks of variable sets. In a first step, we included social determinants (Model 1) and, additionally, parameters of geriatric assessment (Model 2) in a second step. In Model 3, we added morbidities, and in Model 4, we included health behavior (physical activity, smoking) in addition to all previously included variables. The forward Wald procedure was used to guide model entry; only those variables that showed significant effects were selected in the final models. The standard procedure was applied to adjust for gender in all models. We used Nagelkerke R^2 to assess the level of explained variance and the Hosmer–Lemeshow test to ascertain the quality of fit. Omnibus tests were conducted to determine whether changes (additions of variables in the different steps) were significant. Test results are listed as footnotes at the bottom of Table 4. The regression results are shown as odds ratios (ORs) and 95% confidence intervals (CIs). All statistical analyses were performed using SPSS 22.

Results

Comparison Between Non–Care-Dependent and Care-Dependent Participants

Of the 1,699 participants studied and surveyed at first follow-up, 18.9% were care-dependent (*N* = 321; Table 2).

The average age of the cohort was 82 years. Care-dependent participants were significantly older (*M*: 86 years) than participants who were not accessing care services (*M*: 81 years). Participants with low or intermediate education were care-dependent more often than those with a higher level of formal education. Participants who were not care-dependent reported being in a stable partnership significantly more often (58.0% vs. 36.0%). Regarding mobility, nearly half (47.1%) of all care-dependent participants were unable to do the TUG Test within 20 s, whereas only 8.3% of non–care-dependent people were unable to do so (Table 3). Although more than half (60.9%) of all care-dependent participants were physically inactive (<once a week), 17% reported that they were physically active 1 or 2 times a week and 22.1% reported being active 3 to 4 times a week or more.

Regression Analysis

When all health-related and social determinants were integrated into the final model (Model 4), the following risk profiles were produced: CD was significantly associated with older age, limited mobility (TUG), falls, urinary incontinence, stroke, cancer, diabetes, limited physical activity, partnership status, and education level (Table 4). ORs for participants with limited mobility were more than 6 times higher than for mobile participants (OR: 6.10; CI: [4.08, 9.11]). Physical activity was not generally associated with CD. Only participants who were physically active less than once a week had a higher risk of being care-dependent (OR: 2.50; CI: [1.47, 4.26]).

Table 3. Health (Behavior) of Non–Care-Dependent and Care-Dependent Participants.

	Overall (*n*)	No care dependency (%)	Care dependency (%)	*p*
n	1,699	1,378	321	
Geriatric assessment				
Mobility (TUG)	266	8.3	47.1	<.001
Fall	189	8.9	21.0	<.001
Incontinence	609	31.9	56.7	<.001
Pain	818	46.9	58.3	<.001
Sleep dissatisfaction	669	38.8	45.2	<.05
MMT	189	8.6	24.3	<.001
MHI-5	250	13.5	21.6	<.001
Morbidity				
Renal insufficiency (eGFR<60)	696	37.6	59.6	<.001
Diabetes	381	21.3	27.4	<.05
Stroke	171	8.2	18.7	<.001
Cancer	427	23.5	32.6	<.005
Myocardial infarction	232	12.7	18.4	<.01
Obesity	395	23.0	26.1	.24
Smoking				.55
Never	873	52.3	49.7	
Previous	727	42.9	44.3	
Current	85	4.8	6.0	
Physical activity				<.001
<1 time/week	534	25.2	60.9	
1-2 times/week	426	27.3	17.0	
3-5 times/week	407	26.7	13.8	
>5 times/week	309	20.7	8.3	

Note. TUG = Timed Up and Go Test; MMT = Micro-Mental Test: Cutoff <14; MHI-5 = Mental Health Inventory: Cutoff 60; eGFR = estimated glomerular filtration rate (<60 ml/min/1.73 m^2).

Results of Stepwise Regression

In Model 2, when geriatric assessment parameters were included, there was the highest increase in explained variance, from 15.8% in Model 1 to 31.5% in Model 2 (Table 4). Compared to this, the model fit increased less with the inclusion of the morbidities (from 31.5% in Model 2 to 34.4% in Model 3). This indicates that the reported morbidities were reflected in the geriatric assessment tools. With the inclusion of physical activity in the final model (Model 5), more than one third of the total variance could be explained (36.5%). The stepwise forward procedure revealed that the significant association between intermediate education and CD remained stable in all four models, that is, after adjustment for morbidity and geriatric assessment. Although the association between CD and partnership status remained significant in all models as well, here ORs decreased noticeably with the inclusion of geriatric assessment parameters in Model 2 (from OR 1.87 in Model 1 to OR 1.53 in Model 2) and physical activity in Model 4 (from OR 1.54 in Model 3 to OR 1.48 in Model 4). This indicates that the association between partnership status and CD may be partly explained by factors such as limited mobility, falls, and physical activity.

Discussion

Main Results

Our study revealed the following risk profile for CD: older age, urinary incontinence, stroke, falls, cancer, diabetes, education level, and having no partner were significantly associated with CD. Furthermore, care-dependent participants had higher odds of having limited mobility and being less physically active. However, more than half of all care-dependent participants were able to manage the TUG Test and more than one third of all care-dependent participants were physically active on a low level one or more times a week. Our research thus highlights the importance of promoting mobility, even in care-dependent people.

Morbidity

Few studies have explored associations between CD/functional impairments and morbidities. In most of these studies, a multimorbidity index was used (Hajek & König, 2016; Koller et al., 2014). In conformity with our findings, some studies found stroke, cancer, diabetes, and urinary incontinence as determinants (Appelros, Nydevik, & Viitanen, 2003; Kemper,

Table 4. Multivariate Associations Between CD, Health-Related and Social Determinants (*N* = 1,425).

Sociodemographics	Model 1 Nagelkerke R^2 = 15.8 OR (95% CI)	*p*	Model 2 Nagelkerke R^2 = 31.5 OR (95% CI)	*p*	Model 3 Nagelkerke R^2 = 34.4 OR (95% CI)	*p*	Model 4 Nagelkerke R^2 = 36.5 OR (95% CI)	*p*
Sex								
Female	*[0.71, 1.41]*	.992	*0.87 [0.59, 1.26]*	.455	*0.93 [0.64, 1.37]*	0.725	*0.94 [0.64, 1.39]*	.753
Age								
70-79 years	1		1		1		1	
80-89 years	2.81 [1.97, 3.99]	<.001	2.50 [1.71, 3.64]	<.001	2.33 [1.58, 3.44]	<0.001	2.08 [1.40, 3.09]	<.001
>90 years	8.37 [5.35, 13.11]	<.001	5.09 [3.08, 8.42]	<.001	4.85 [2.88, 8.16]	<0.001	4.08 [2.41, 6.90]	<.001
Education (CASMIN)								
High	1		1		1		1	
Intermediate	1.73 [1.14, 2.63]	.010	1.82 [1.15, 2.88]	.011	1.73 [1.08, 2.77]	0.022	1.63 [1.01, 2.62]	.045
Low	*1.58 [0.97, 2.57]*	.069	*1.67 [0.97, 2.86]*	.062	*1.71 [0.99, 2.95]*	0.055	*1.62 [0.93, 2.82]*	.089
Partner								
No	1.87 [1.34, 2.61]	<.001	1.53 [1.06, 2.19]	.023	1.54 [1.06, 2.23]	0.023	1.48 [1.02, 2.16]	.040
Geriatric assessment								
Impaired mobility (TUG)			7.77 [5.28, 11.43]	<.001	7.02 [4.73, 10.41]	<0.001	6.10 [4.08, 9.11]	<.001
Fall			1.94 [1.23, 3.04]	.004	1.92 [1.21, 3.04]	0.005	1.78 [1.11, 2.85]	.017
Incontinence			2.12 [1.53, 2.95]	<.001	2.15 [1.53, 3.00]	<0.001	2.06 [1.46, 2.89]	<.001
Morbidity								
Diabetes					1.62 [1.12, 2.34]	0.011	1.53 [1.05, 2.23]	.026
Stroke					2.36 [1.49, 3.75]	<0.001	2.17 [1.35, 3.48]	.001
Cancer					1.53 [1.07, 2.19]	0.021	1.65 [1.14, 2.37]	.007
Renal insufficiency (eGFR<60)					1.42 [1.01, 1.99]	0.043	1.35 [0.95, 1.90]	.091
Physical activity								
>5 times/week							1	
3-5 times/week							1.12 [0.62, 2.03]	.705
1-2 times/week							1.10 [0.61, 1.99]	.748
<1 times/week							2.50 [1.47, 4.26]	.001

Note. Hosmer–Lemeshow test: Model 1: χ^2 = 4.06, *df* = 7, *p* = .07; Model 2: χ^2 = 4.56, *df* = 8, *p* = .80; Model 3: χ^2 = 7.44, *df* = 8, *p* = .50; Model 4: χ^2 = 4.98, *df* = 8, *p* = .76. Omnibus-Tests: Model 1 to Model 2: χ^2 = 155.89, *df* = 3, *p* < .001; Model 2 to Model 3: χ^2 = 31.35, *df* = 4, *p* < .001; Model 3 to Model 4: χ^2 = 22.99, *df* = 3, *p* < .001. Excluded nonsignificant variables: Model 1: Income, Model 2: Cognitive impairments, sleep dissatisfaction, pain; Model 3: Myocardial infarction, obesity; Model 4: Smoking. Nonsignificant values are shown in italics. OR = odds ratio; CI = confidence interval; TUG = Timed Up and Go Test (<20s could not be performed); eGFR = estimated glomerular filtration rate (<60 ml/min/1.73m²).

Koller, Glaeske, & van den Bussche, 2011; Koller et al., 2014; McCallum, Simons, Simons, & Friedlander, 2005). Our results thus add to existing knowledge in this context. Urinary incontinence in particular is a well-known risk factor for CD and various authors emphasize that therapeutic measures such as supporting mobility may prevent or delay its onset (Schnitzer et al., 2017). Cognitive impairment was not a predictor in our multivariate analysis. However, this result is difficult to compare with previous studies. Either the tools differ from those applied in our assessment (Hajek & König, 2016) or dementia was used to assess cognitive impairment. Because our assessment is a screening tool used prior to dementia onset (Rapp et al., 2002), comparison of the results was impossible.

Mobility and Physical Activity

Regarding mobility, our findings correspond to the study by Hajek et al. (2017). Here, mobility impairment was a predictor for CD, despite some lack of clarity in connection with the question of how mobility was assessed. It is not surprising that care-dependent participants showed limited mobility more often than non–care-dependent participants due to their worse health status. However, because our data showed that more than half of all care-dependent participants were able to manage the TUG Test, our findings highlight the importance of promoting mobility. This conclusion is reinforced by the results for physical activity. Our analyses showed that nearly 40% of all care-dependent participants were physically active (on a low level) at least once a week. The results of other studies support the finding that physical activity (categorized by a variety of methods) is a protective factor in older adults (Paterson & Warburton, 2010; World Health Organization, 2010). Supporting physical activity, even in care-dependent people, may thus be beneficial to health. In a review of the effects of physical activity and exercise on cognitive and brain functions in older adults, the authors found that frailty is not a

contraindication for physical activity; on the contrary, it is a compelling reason to prescribe physical exercise (Bherer, Erickson, & Liu-Ambrose, 2013). Our results confirm this recommendation.

Social Determinants

The association between age and CD/functional impairments is well established (Hajek & König, 2016; Schnitzer et al., 2015). By contrast, research findings on gender-specific differences are less consistent, varying according to whether they are adjusted for age and morbidities (Hajek et al., 2016; Schnitzer et al., 2017). Regarding the effect of education on CD, results are scarce and inconsistent. Some studies identified an increased risk of disability (Sulander et al., 2012) and functional impairments (Huisman et al., 2005) for less educated older adults. Because results were not adjusted for morbidities in these studies, this may be explained by subjects' poorer health. However, in our study a significant association between CD and rather low (intermediate) education remained even after adjustment for morbidities and geriatric assessment parameters. Our findings thus indicate that the higher odds of participants with rather low (intermediate) education being care-dependent can only partially be explained by their poorer health.

Due to the various measures used for partnership and living situation (marital status, partnership irrespective of marital status, living together), our findings are difficult to compare. However, most of the studies revealed a higher risk of CD or functional impairments onset for older adults without a partner/living alone (Hajek & König, 2016; Kharicha et al., 2007; Nilsson, Avlund, & Lund, 2010). Hajek assumed that "living alone" as a risk factor for FI might be explained by the fact that it reflects other factors that increase the risk of FI, such as falls or decreased physical activity (Hajek & König, 2016). This hypothesis may be supported by our data as the effects of partnership decreased after adjustment for limited mobility, falls, urinary incontinence, and physical activity. Further research is required to investigate the possible role of partnership status in preventing and delaying CD.

Strengths and Weaknesses

In our data, morbidities, laboratory and study parameters such as body mass index, and a broad range of survey data were collected. These data were merged with health insurance data to obtain information about participant's need for care. This combination of survey, study, and health insurance data, along with participants' high average age, is our study's particular strength. Few previous studies have combined these various data sources; however, this approach is increasingly recommended (Unger, Giersiepen, & Windzio, 2015). Another strength of our study is that it assesses a fairly comprehensive list of social determinants and the CD measurement, something that has not been done systematically before in the way the authors did.

Some limitations should be mentioned. Only 8.1% of the participants contacted for the baseline survey could be included. However, this response rate is not unusual, especially with elderly people, as the willingness to participate in studies is known to decrease with age (Murphy, Schwerin, Eyerman, & Kennet, 2008). The low response rate had no impact on the morbidity structure of the participants, as was shown by a rigorous comparison of the distribution of chronic diseases in the study cohort and among the provider's insurees of the same age and gender from which the study population was drawn (Ebert et al., 2017). Another limitation may be that the number of care-dependent participants in the BIS cohort was underestimated, as participants who are receiving informal care without accessing care services or who have not (yet) applied for care-related benefits were not included. The number of physically active participants may have been underestimated as well, because we only assessed regular walking, not activities such as household chores, or cycling (World Health Organization, 2010). For our statistical analysis, we conducted stepwise regression analyses to explore unadjusted and adjusted results and to assess the percentage variability explained by the models. This may be a limitation because the degree of explained variance will always increase when variables are added to the model. To mitigate this limitation, we compared the different models' Nagelkerke values and conducted the Hosmer–Lemeshow test to obtain more information about the quality of fit. As in other observational studies, we cannot exclude potential residual confounding, although—based on the literature—we considered a wide range of relevant determinants.

As the results described above are based on cross-sectional analyses, it is not possible to draw firm conclusions about causality between health-relevant factors (morbidities, health behavior, geriatric testing, and social variables) and the onset of CD. It does, however, seem plausible that morbidities (stroke, cancer, myocardial infarction, kidney disease and diabetes) often occur ahead of the need for care—in that these diagnoses give rise to a requirement for care—whereas limited physical activity and mobility may often be the consequence of existing CD.

Conclusion

Our research highlights the importance of promoting mobility, even in care-dependent people. Physical activity and mobility are significant in two respects: First, these factors make appropriate interventions highly accessible and influenceable. Second, the present study shows that almost 40% of participants who are already care-dependent report being physically active to some degree despite limitations. This shows that even after the onset of CD, activity and mobility remain important starting points for tertiary prevention.

Declaration of Conflicting Interests

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References

Appelros, P., Nydevik, I., & Viitanen, M. (2003). Poor outcome after first-ever stroke: Predictors for death, dependency, and recurrent stroke within the first year. *Stroke*, *34*, 122-126.

Bherer, L., Erickson, K. I., & Liu-Ambrose, T. (2013). A review of the effects of physical activity and exercise on cognitive and brain functions in older adults. *Journal of Aging Research*, *2013*, Article 657508. doi:10.1155/2013/657508

Borchert, L., & Rothgang, H. (2008). Soziale Einflüsse auf das Risiko der Pflegebedürftigkeit älterer Männer [The influence of social determinants on the care dependency risk of older men]. In U. Bauer & A. Büscher (Eds.), *Soziale Ungleichheit und Pflege* (pp. 215-237). Wiesbaden: VS Verlag für Sozialwissenschaften. doi:10.1007/978-3-531-91014-7_8.

Buchmann, K.-P. (2014). Die Begutachtungs-Richtlinien und die Aufgaben der Medizinischen Dienste [Guidelines and tasks of the Medical Review Board of the Statutory Health Insurance Funds]. In K.-P. Buchmann & F. Hirschkorn (Eds.), *Pflegestufen – beurteilen und widersprechen* (pp. 35-49). Berlin, Germany: Springer. doi:10.1007/978-3-642-41816-7_3

Cleeland, C. S., & Ryan, K. M. (1994). Pain assessment: Global use of the Brief Pain Inventory. *Annals of the Academy of Medicine, Singapore*, *23*, 129-138.

Ebert, N., Jakob, O., Gaedeke, J., van der Giet, M., Kuhlmann, M. K., Martus, P., . . . Schaeffner, E. S. (2017). Prevalence of reduced kidney function and albuminuria in older adults: The Berlin Initiative Study. *Nephrology, Dialysis, Transplantation: Official Publication of the European Dialysis and Transplant Association—European Renal Association*, *32*, 997-1005. doi:10.1093/ndt/gfw079

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Minimental state." A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189-198.

Hajek, A., Brettschneider, C., Ernst, A., Posselt, T., Mamone, S., Wiese, B., . . . König, H.-H. (2017). Einflussfaktoren auf die Pflegebedürftigkeit im Längsschnitt [Longitudinal predictors of the need for care]. *Gesundheitswesen (Bundesverband der Ärzte des Öffentlichen Gesundheitsdienstes (Germany))*, *79*(2), 73-79. doi:10.1055/s-0041-111841

Hajek, A., Brettschneider, C., Lange, C., Posselt, T., Wiese, B., Steinmann, S., . . . König, H.-H. (2016). Gender differences in the effect of social support on health-related quality of life: Results of a population-based prospective cohort study in old age

in Germany. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *25*, 1159-1168. doi:10.1007/s11136-015-1166-5

Hajek, A., & König, H.-H. (2016). Longitudinal predictors of functional impairment in older adults in Europe—Evidence from the survey of health, ageing and retirement in Europe. *PLoS ONE*, *11*(1), e0146967. doi:10.1371/journal.pone.0146967

Herrmann, W. J., & Flick, U. (2011). Nursing home residents' self-perceived resources for good sleep. *Scandinavian Journal of Primary Health Care*, *29*, 247-251. doi:10.3109/02813432.2011.628243

Hradil, S. (2001). *Soziale Ungleichheit in Deutschland* [*Social Inequality in Germany*] (8th ed.). Wiesbaden, Germany: VS Verlag für Sozialwissenschaften.

Huisman, M., Kunst, A. E., Bopp, M., Borgan, J.-K., Borrell, C., Costa, G., & Mackenbach, J. P. (2005). Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. *The Lancet*, *365*, 493-500. doi:10.1016/S0140-6736(05)17867-2

Katz, S., Downs, T. D., Cash, H. R., & Grotz, R. C. (1970). Progress in development of the index of ADL. *The Gerontologist*, *10*, 20-30.

Kemper, C., Koller, D., Glaeske, G., & van den Bussche, H. (2011). Mortality and nursing care dependency one year after first ischemic stroke: An analysis of German statutory health insurance data. *Topics in Stroke Rehabilitation*, *18*, 172-178. doi:10.1310/tsr1802-172

Kharicha, K., Iliffe, S., Harari, D., Swift, C., Gillmann, G., & Stuck, A. E. (2007). Health risk appraisal in older people 1: Are older people living alone an "at-risk" group? *The British Journal of General Practice: The Journal of the Royal College of General Practitioners*, *57*, 271-276.

Koller, D., Schön, G., Schäfer, I., Glaeske, G., van den Bussche, H., & Hansen, H. (2014). Multimorbidity and long-term care dependency—A five-year follow-up. *BMC Geriatrics*, *14*, Article 70. doi:10.1186/1471-2318-14-70

Kunst, A. E. (2006). Herausforderungen bei der Beschreibung gesundheitlicher Ungleichheit in Europa: Ein Überblick aktueller Studien [The challenge to describe health inequality in Europe - an overview on recent studies]. In M. Richter & K. Hurrelmann (Eds.), *Gesundheitliche Ungleichheit* (pp. 353-370). Wiesbaden, Germany: VS Verlag für Sozialwissenschaften. doi:10.1007/978-3-531-90357-6_21

Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, *9*, 179-186.

Mahoney, F. I., & Barthel, D. W. (1965). Functional evaluation: The Barthel index. *Maryland State Medical Journal*, *14*, 61-65.

Marmot, M. (2005). Social determinants of health inequalities. *The Lancet*, *365*, 1099-1104.

McCallum, J., Simons, L. A., Simons, J., & Friedlander, Y. (2005). Patterns and predictors of nursing home placement over 14 years: Dubbo study of elderly Australians. *Australasian Journal on Ageing*, *24*, 169-173. doi:10.1111/j.1741-6612.2005.00116.x

Murphy, J., Schwerin, M., Eyerman, J., & Kennet, J. (2008). Barriers to survey participation among Older Adults in the National Survey on Drug Use and Health: The importance of establishing trust. *Survey Practice*, *1*(2), 1-6.

Nilsson, C. J., Avlund, K., & Lund, R. (2010). Social inequality in onset of mobility disability among older Danes: The mediation effect of social relations. *Journal of Aging and Health*, *22*, 522-541. doi:10.1177/0898264309359684

Paterson, D. H., & Warburton, D. E. (2010). Physical activity and functional limitations in older adults: A systematic review related to Canada's Physical Activity Guidelines. *The International Journal of Behavioral Nutrition and Physical Activity*, *7*, Article 38. doi:10.1186/1479-5868-7-38

Podsiadlo, D., & Richardson, S. (1991). The timed "Up & Go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*, *39*, 142-148.

Radbruch, L., Loick, G., Kiencke, P., Lindena, G., Sabatowski, R., Grond, S., . . .Cleeland, C. S. (1999). Validation of the German version of the Brief Pain Inventory. *Journal of Pain and Symptom Management*, *18*, 180-187. doi:10.1016/S0885-3924(99)00064-0

Ramsay, S. E., Whincup, P. H., Morris, R. W., Lennon, L. T., & Wannamethee, S. G. (2008). Extent of social inequalities in disability in the elderly: Results from a population-based study of British men. *Annals of Epidemiology*, *18*, 896-903. doi:10.1016/j.annepidem.2008.09.006

Rapp, M. A., Rieckmann, N., Gutzmann, H., & Folstein, M. F. (2002). Mikro-Mental-Test - Ein Kurzverfahren zum Demenzscreening [Micro-Mental Test—A short method of dementia screening]. *Der Nervenarzt*, *73*, 839-844. doi:10.1007/s00115-002-1324-1

Roper, N., Logan, W. W., & Tierney, A. J. W. (2009). *Das Roper-Logan-Tierney-Modell.Basierend auf Lebensaktivitäten* [The Roper-Logan-Tierney-model. Based on activities of living]. Bern, Switzerland: Huber.

Rumpf, H. J., Meyer, C., Hapke, U., & John, U. (2001). Screening for mental health: Validity of the MHI-5 using *DSM-IV* Axis I psychiatric disorders as gold standard. *Psychiatry Research*, *105*, 243-253.

Schaeffner, E. S., van der Giet, M., Gaedeke, J., Tölle, M., Ebert, N., Kuhlmann, M. K., & Martus, P. (2010). The Berlin initiative study: The methodology of exploring kidney function in the elderly by combining a longitudinal and cross-sectional approach. *European Journal of Epidemiology*, *25*, 203-210. doi:10.1007/s10654-010-9424-x

Schnitzer, S., dem Knesebeck, O., von Kohler, M., Peschke, D., Kuhlmey, A., & Schenk, L. (2015). How does age affect the care dependency risk one year after stroke? A study based on claims data from a German health insurance fund. *BMC Geriatrics*, *15*, Article 135. doi:10.1186/s12877-015-0130-0

Schnitzer, S., Deutschbein, J., Nolte, C. H., Kohler, M., Kuhlmey, A., & Schenk, L. (2017). How does sex affect the care dependency risk one year after stroke? A study based on claims data from a German health insurance fund. *Topics in Stroke Rehabilitation*, *24*, 415-421. doi:10.1080/10749357. 2017.1305645

Shah, S., Vanclay, F., & Cooper, B. (1989). Improving the sensitivity of the Barthel Index for stroke rehabilitation. *Journal of Clinical Epidemiology*, *42*, 703-709.

Shumway-Cook, A., Brauer, S., & Woollacott, M. (2000). Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Physical Therapy*, *80*, 896-903.

Statistisches Bundesamt. (2015). *Pflegestatistik 2013*. Wiesbaden, Germany: Author.

Statistisches Bundesamt. (2017). *Pflegestatistik 2015*. Wiesbaden, Germany: Author.

Sulander, T., Heinonen, H., Pajunen, T., Karisto, A., Pohjolainen, P., & Fogelholm, M. (2012). Longitudinal changes in functional capacity: Effects of socio-economic position among ageing adults. *International Journal for Equity in Health*, *11*, Article 78. doi:10.1186/1475-9276-11-78

Unger, R., Giersiepen, K., & Windzio, M. (2015). Pflegebedürftigkeit im Lebensverlauf [Care dependency in the life course]. In K. Hank & M. Kreyenfeld (Eds.), *Kölner Zeitschrift für Soziologie und Sozialpsychologie. Social Demography Forschung an der Schnittstelle von Soziologie und Demografie* (pp. 193-215). Wiesbaden, Germany: Springer Fachmedien Wiesbaden. doi:10.1007/978-3-658-11490-9_9

Van den Bussche, H., Heinen, I., Koller, D., Wiese, B., Hansen, H., Schäfer, I.,. . . Schön, G. (2014). Die Epidemiologie von chronischen Krankheiten und Pflegebedürftigkeit: Eine Untersuchung auf der Basis von Abrechnungsdaten der gesetzlichen Krankenversicherung [The epidemiology of chronic diseases and long-term care: Results of a claims data-based study]. *Zeitschrift fur Gerontologie und Geriatrie*, *47*, 403-409. doi:10.1007/s00391-013-0519-3

Veit, C. T., & Ware, J. E. (1983). The structure of psychological distress and well-being in general populations. *Journal of Consulting and Clinical Psychology*, *51*, 730-742.

Wallace, R. B., & Herzog, A. R. (1995). Overview of the health measures in the health and retirement study. *The Journal of Human Resources*, *30*, 84-107. doi:10.2307/146279

World Health Organization. (2018). *Social determinants of health*. Retrieved from http://www.who.int/social_determinants/en

World Health Organization. (2010). *Global recommendations on physical activity for health*. Geneva, Switzerland: Author.