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Is there an association between social determinants and care dependency risk? A multi-state model analysis of a longitudinal study

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Abstract

Despite a growing body of knowledge about the morbidities and functional impairment that frequently lead to care dependency, the role of social determinants is not yet well understood. The purpose of this study was to examine the effect of social determinants on care dependency onset and progression. We used data from the Berlin Initiative Study, a prospective, population-based cohort study including 2,069 older participants living in Berlin. Care dependency was defined as requiring substantial assistance in at least two activities of daily living for 90 min daily (level 1) or 3+ hours daily (level 2). Multi-state time to event regression modeling was used to estimate the effects of social determinants (partnership status, education, income, and sex), morbidities, and health behaviors, characteristics, and conditions. During the study period, 556 participants (27.5%) changed their status of care dependency. Participants without a partner at baseline were at a higher risk to become care-dependent than participants with a partner (hazard ratio [HR], 95% confidence interval [CI]: 1.24 (1.02–1.51)). After adjustment for other social determinants, morbidities and health behaviors, characteristics, and conditions the risk decreased to a HR of 1.19 (95% CI: 0.79–1.79). Results indicate that older people without a partner may tend to be at higher risk of care dependency onset but not at higher risk of care dependency progression. Clinicians should inquire about and consider patients' partnership status as they evaluate care needs.

KEYWORDS

activities of daily living, care dependency, cohort studies, marital status, proportional hazards models, social determinants of health

Alice Schneider and Stefan Blüher contributed equally to this study.

1 | INTRODUCTION

One of the consequences of rising life expectancy and aging is that more people are facing the prospect of becoming dependent on assistance and care at some point in their lives. In Germany, three out of four women and approximately one man in every two will become care-dependent as defined in the German Long-Term Care Insurance Act (*Pflegeversicherungsgesetz*) during their lifetime (Rothgang, 2010). Care dependency has thus become a major individual and social risk in long-lived populations.

In this context, care dependency means that a person is receiving benefits covered by long-term care insurance within the German social insurance system. This is contingent on submission of an application by the insured person and an assessment by medical or care professionals that the person concerned has a substantial need for assistance in basic routines and activities of daily living (ADL). In the international context, the Barthel Index (Mahoney, 1965; Shah, Vanclay, & Cooper, 1989)—a weighted scale to measure performance or limitations in ADL—may be regarded as approximating this understanding of care dependency. Under the classification system of relevance to the present study (i.e., to December 31, 2016), the German long-term care insurance system provides benefits based on three levels of care that accounts assistance time required: Care level 1 requires assistance for 90 min daily; care level 2 requires assistance for 3 hr daily; and care level 3 requires 5 hr daily (Maidhof et al., 2002).

1.1 | Care dependency onset

Despite a growing body of knowledge about the morbidities and functional impairment that frequently lead to care dependency, it is to a large extent unclear which other health-related factors, and in which combinations, are associated with the risk of care dependency onset and progression. The relevance of age as a key determinant of need for care has been described repeatedly (Hajek & König, 2016; Schnitzer et al., 2015). The research findings on sex-specific differences are less consistent, varying according to whether they are adjusted for age and morbidities (Hajek, Brettschneider, Lange et al., 2016; Schnitzer et al., 2017). The role of socioeconomic factors (education, income, and occupation) has not been fully explained (Ramsay, Whincup, Morris, Lennon, & Wannamethee, 2008; Sulander et al., 2012). Least researched at present is the impact of basic social determinants for care dependency, such as marital status, social networks, and aspects such as living arrangements.

The research results currently available provide information about social determinants as important characteristics: In a recent publication based on cross-sectional cohort data we could show that—next to older age, urinary incontinence, stroke, falls, cancer, diabetes, education, limited mobility, and limited physical activity—care dependency was associated with "having no partner" (Schnitzer et al., 2019). Hajek, Brettschneider, Ernst et al. (2016) identified a higher risk of functional impairment for persons who lost a partner compared to those with a partner. A Danish study by Nilsson, Avlund, and Lund (2010) analyzed participation and networks and found evidence that social resources protect against risk for mobility limitations. And as early as 2008, Borchert and Rothgang (2008) emphasized the protective effect of partnerships on care dependency risk for older men.

As regards prevention strategies for care dependency, knowledge of the factors causing care dependency onset is key. Another question of interest in this context is whether the determinants of care dependency onset differ (in scope and direction of the association) from those causing a worsening of care dependency. In their longitudinal study, Borchert and Rothgang (2008) differentiate between individual levels of care but analyze them as dependent variables in different models, meaning that possible transitions to a different level of care were not examined within one model (Beyersmann, Allignol, & Schumacher, 2011). Analyzing time to competing events and transitions from one state to another in one single statistical model (multi-state model) allows us to determine whether the scope and direction of the associations between covariates and various transitions differ. The use of multi-state models for similar research questions with time-to-event data is still novel.

1.2 | Aim of the study

Researchers have not fully answered the question about the association between social determinants and the risk of onset or worsening of care dependency. The present study addresses this study gap, analyzing several events in one model and focusing on social determinants such as partnership status, education, income, and sex. The aims of this study are (a) to examine the effect of social determinants on care dependency onset and progression, and (b) to analyze the effect of social determinants on various levels of care dependency.

2 | MATERIALS AND METHODS

2.1 | Data and design

We used data from the ongoing Berlin Initiative Study (BIS). The BIS is a prospective, longitudinal, population-based cohort study designed to evaluate the epidemiology of chronic kidney disease in older adults (≥70 years of age). Data included information on sociodemographics, lifestyle variables, morbidities, medication, and measurements of blood and urine samples, which were collected every 2 years in a face to face interview since 2009. Inclusion criteria were having a specific German statutory health insurance (AOK-Nordost Die Gesundheitskasse), living in Berlin, and not being on dialysis or kidney transplanted. Participant's survey data were also linked with their health insurance data. The study was approved by the local ethics committee (Ethics Committee of Charité—Universitätsmedizin Berlin, Ref. EA2/009/08) and the participants gave written informed consent. For further details of study design and methodology see Schaeffner et al. (2010).

2.2 | Outcome measures of care dependency

Care dependency is determined by the amount of time needed daily for substantial assistance in at least two ADLs in the personal hygiene, nutrition, and mobility categories, and, additionally, assistance with domestic tasks (at least 90 min per day over a period of at least 6 months; Schnitzer et al., 2017). We considered two levels of care dependency as outcomes: Level 1 (90 min of assistance per day), and levels 2 and 3, which were combined because of the small sample size ($n = 47$) for level 3 (at least 3 hr assistance per day). The information regarding the need for care was obtained from claims data provided by the participant's health insurance provider. Data on time points of change in registered care dependency were linked to patient survey data (last updated information from health insurer AOK-Nordost January 12, 2016). The dataset thus includes all information about the care dependency level and dates of change in care dependency for all participants (including those with loss to follow up) from the start of the study in 2009 until January 2016. Insured persons who needed at least 5 hr assistance per day (level 3 care dependency) at baseline were not included in this study, as they were at the highest level of dependency and no further worsening was possible.

2.3 | Measures of social determinants

Our term "social determinants" subsumes partnership ("do you have a partner"), monthly individual income, and education. In addition, age and sex were considered as social determinants in the analysis, because they are associated to a high degree with the allocation of social roles (Hradil, 2006). Educational attainment was assessed using the Comparative Analysis of Social Mobility in Industrial Nations (CASMIN) index (Kunst, 2009), with participants classified 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, and PhD).

2.4 | Additional variables of interest

With focus on our research question, we included the following variables: Smoking (never smoked or stopped smoking >10 years ago, current smoker or stopped ≤10 years ago), alcohol consumption (no regular consumption; moderate consumption: women ≤12 g alcohol/day, men ≤24 g alcohol/day; risky drinking: women >12 g alcohol/day, men >24 g alcohol/day), body mass index (BMI; <25, 25–30, >30), arterial hypertension (intake of antihypertensive medication); history of stroke, myocardial infarction, or cancer (all self-reported yes/no and validated by physician letters); kidney disease (estimated glomerular filtration rate < 60 ml/min/1.73 m^2); and diabetes mellitus (intake of antidiabetic medication and/or HbA1c level > 6.5%, yes/no); see Schaeffner et al. (2010) and Ebert et al. (2016) for further details.

2.5 | Statistical analyses

We evaluated the effect of social determinants and morbidities on the transition time to different events. As we were considering more than one event and different transitions, we used a multi-state model with three possible states: no care dependency, care dependency level 1 and care dependency level 2 (composite level 2 and level 3). We analyzed the three transitions from no care dependency to level 1 (transition 1: $0 \rightarrow 1$), from no care dependency to level 2 (transition 2: $0 \rightarrow 2$), and from level 1 to level 2 (transition 3: $1 \rightarrow 2$). For this analysis, participants who died during the study period were censored, since mortality was not the focus of this analysis and is one of the primary outcomes of the BIS that will be analyzed and reported in future publications. With a multi-state model, it is possible to include all given information in one statistical model. The model allows different effects of a single covariate corresponding to the different transitions by estimating transition-specific covariate effects.

2.5.1 | Specifications and assumptions

With one exception, we used participant age as the time scale in our time-to-event models. Due to this specification these models are by definition age-adjusted; therefore, age was not additionally included in the models as a covariate. For the definition of time t the "clock forward" approach was used (Beyersmann et al., 2011; Putter, Fiocco, & Geskus, 2007). We assumed different baseline hazards for the three types of transition. We therefore calculated a stratified Cox proportional hazards model by transition (Andersen & Keiding, 2002). By doing so, we also accounted for the dependency of the data that results from repeatedly using information from the same participants. To examine the bivariate association between age and time to care dependency levels, we fitted a separate multi-state model with time-on-study as the time scale variable and with age as covariate (Table 1).

2.5.2 | Transition-specific hazards

Based on our research question, we assumed different effects of participant characteristics on each transition; for example, the association between sex and care dependency is different for the transition from no care dependency to level 1 than for the transitions from levels 1 to 2 and from no care dependency to level 2. We therefore estimated transition-specific coefficients in the complex model. To decide whether regression coefficients should be fixed or transition-specific, we used the Bayesian Information

TABLE 1 Age-adjusted hazard ratio (HR) estimates (95% CI) for separate single-variable multi-state models

	Overall	n (%), HR (95% CI)			Transition-specific coefficients improve model fit[a]
		0 → 1	1 → 2	0 → 2	
	n = 2,021	n = 431	n = 146	n = 77	
Social determinants					
Age[b]					–
≤75	572	48 (8.4)	6 (1.0)	7 (1.2)	
75–85	892	173 (19.4)	50 (5.6)	31 (3.5)	
		2.62 (1.90–3.61)	2.60 (1.11–6.06)	3.24 (1.43–7.35)	
>85	557	210 (37.7)	90 (16.2)	39 (7.0)	
		8.83 (6.44–12.11)	3.20 (1.40–7.32)	11.48 (5.12–25.78)	
Sex					Yes
Male	958	197 (20.6)	79 (8.2)	50 (5.2)	
Female	1,063	234 (22.0)	67 (6.3)	27 (2.5)	
		1.31 (1.08–1.59)	0.48 (0.35–0.67)	0.60 (0.37–0.96)	
Income, EUR					No
<1,000	562	107 (19.0)	21 (3.7)	12 (2.1)	
≥1,000	1,167	264 (22.6)	95 (8.1)	52 (4.5)	
(292 Missing)		0.85 (0.67–1.07)	1.97 (1.21–3.19)	1.55 (0.82–2.95)	
Education					No
Low	1,212	248 (20.5)	87 (7.2)	51 (4.2)	
Middle	398	104 (26.1)	27 (6.8)	9 (2.3)	
(CASMIN-short) (10 missing)					
		1.15 (0.91–1.45)	0.92 (0.60–1.42)	0.47 (0.23–0.96)	
High	401	79 (19.7)	32 (8.0)	17 (4.2)	
		0.79 (0.61–1.02)	1.39 (0.92–2.11)	0.78 (0.45–1.35)	
Partner (2 missing)					Yes
Yes	1,193	208 (17.4)	69 (5.8)	49 (4.1)	
No	827	223 (27.0)	77 (9.3)	28 (3.4)	
		1.24 (1.02–1.51)	0.66 (0.47–0.93)	0.63 (0.39–1.02)	
Health conditions					
Smoking (5 missing)					No
Never, stop > 10 years	1,824	384 (21.1)	136 (7.5)	66 (3.6)	
Current, stop ≤ 10 years	192	47 (24.5)	10 (5.2)	10 (5.2)	
		1.79 (1.31–2.43)	0.85 (0.44–1.64)	2.37 (1.21–4.65)	
Alcohol (25 missing)[c]					No
Not regularly	494	108 (21.9)	38 (7.7)	21 (4.3)	
Moderate	1,283	272 (21.2)	96 (7.5)	50 (3.9)	
		0.88 (0.70–1.11)	1.26 (0.86–1.84)	0.82 (0.49–1.37)	
Risky	220	50 (22.7)	11 (5.0)	5 (2.3)	
		0.99 (0.70–1.38)	0.85 (0.43–1.67)	0.53 (0.20–1.42)	
Diabetes mellitus					No
Yes	527	123 (23.3)	51 (9.7)	20 (3.8)	
		1.27 (1.03–1.57)	1.14 (0.80–1.62)	1.11 (0.66–1.84)	
No	1,494	308 (20.6)	95 (6.4)	57 (3.8)	
Stroke (25 missing)					No
Yes	163	38 (23.3)	18 (11.0)	9 (5.5)	
		1.24 (0.89–1.74)	0.99 (0.60–1.63)	1.69 (0.84–3.40)	
No	1,833	388 (21.2)	128 (7.0)	68 (3.7)	
Myocardial infarction (24 missing)					
Yes	274	76 (27.7)	34 (12.4)	12 (4.4)	
		1.27 (0.99–1.63)	1.59 (1.07–2.35)	1.05 (0.56–1.94)	
No	1,723	348 (20.2)	110 (6.4)	65 (3.8)	

(Continues)

TABLE 1 (Continued)

	Overall	*n* (%), HR (95% CI)			Transition-specific coefficients improve model fit[a]
		0 → 1	1 → 2	0 → 2	
	n = 2,021	*n* = 431	*n* = 146	*n* = 77	
Cancer (9 missing)					No
Yes	452	109 (24.1)	48 (10.6)	23 (5.1)	
		1.24 (1.00–1.54)	1.35 (0.95–1.91)	1.51 (0.92–2.46)	
No	1,560	322 (20.6)	98 (6.3)	54 (3.5)	
Kidney disease[d]					No
Yes	752	209 (27.8)	84 (11.2)	38 (5.1)	
		1.14 (0.93–1.40)	1.16 (0.83–1.62)	1.06 (0.66–1.71)	
No	1,268	222 (17.5)	62 (4.9)	39 (3.1)	
BMI (1 missing)					No
≤25	552	126 (22.8)	48 (8.7)	28 (5.1)	
25–30	935	178 (19.0)	64 (6.8)	30 (3.2)	
		0.97 (0.77–1.22)	1.01 (0.69–1.49)	0.71 (0.42–1.20)	
>30	533	127 (23.8)	34 (6.4)	19 (3.6)	
		1.39 (1.08–1.79)	0.87 (0.54–1.40)	0.94 (0.52–1.71)	
Hypertension					No
Yes	1,586	369 (23.3)	129 (8.1)	61 (3.8)	
		1.69 (1.29–2.22)	1.20 (0.72–2.00)	1.02 (0.59–1.77)	
No	435	62 (14.3)	17 (3.9)	16 (3.7)	

Note: The provided row percentages do not take the censoring into account, but refer only to baseline number of participants.
Abbreviations: 95% CI, 95% confidence interval; BMI, body mass index; CASMIN, Comparative Analysis of Social Mobility in Industrial Nation; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; eGFR, estimated glomerular filtration rate.
[a]Comparison of the Bayesian Information Criterion (BIC) for a model with versus without transition-specific coefficients.
[b]Estimated hazard ratios from multi-state model with time-on-study as the time scale.
[c]Alcohol consumption; moderate: women ≤12 g alcohol/day, men ≤24 g alcohol/day; risky: women >12 g alcohol/day, men >24 g alcohol/day.
[d]Kidney disease: eGFR <60 ml/min/1.73 m^2 (GFR estimated by the CKD-EPI(crea) equation).

Criterion (BIC). For each explanatory variable, we calculated the BIC for a simple single-variable model (only one of the independent variables included) with the regression coefficient fixed and the BIC for the more complex single-variable model with transition-specific coefficients. We estimated transition-specific coefficients for a given explanatory variable in the final model if the BIC was smaller (indicating better fit) in its more complex model (Table 1). For visualization we estimated the Nelson–Aalen cumulative hazard function for each transition.

The covariate "partnership" was included as a time-dependent variable (Kleinbaum & Klein, 2010), since we noticed that for 218 participants (11%), partnership status changed over study time. We were especially interested in how partnership was related to changes in care dependency levels. The exact date of change of partner status was unknown, hence date of change was estimated as the midpoint between two visits or 1 year after the last visit, if one visit was missed by the participant.

We accounted for missing data by using multivariate imputation by chained equation. We included all covariates from Table 1, age, the time-dependent variable partner status, and the information of transition times to generate 10 imputed datasets. For continuous variables, we used predictive mean matching. The estimated hazard ratios (HRs) in Table 2 are based on multiple imputed datasets.

For data handling and multiple imputation IBM SPSS 25 statistics software was used. Multi-state models were calculated in R version 3.4.2 using the package "mstate" (Putter et al., 2007; de Wreede, Fiocco, & Putter, 2010, 2011), and the package "mvna" for the Nelson–Aalen estimator (Allignol, Beyersmann, & Schumacher, 2008). No adjustment for multiple testing was applied.

3 | RESULTS

Figure 1 shows the BIS data flowchart. Four participants who showed an improvement (downgrading) in their level of care during the study period and participants in level 2 care at baseline (V1) (*n* = 44) were excluded from the analysis because the present study investigated the progression of care levels. In total we included *n* = 2,021 participants in Visit 1 (V1). Of these, 1,669 (83%) took part in Visit 2 (V2), and 1,423 (70%) in Visit 3 (V3). The median observation period was 5 years and 2 months (interquartile range: 4 years 8 months–5 years 6 months).

During the study period, the care dependency status of 556 participants changed, including 98 participants with more than one transition (total number of transitions = 431 + 77 + 146 = 654). In total 431 participants changed from "no care dependency" to care level 1, 77 participants from no care dependency directly to levels

TABLE 2 Hazard ratio (HR) estimates for multiple multi-state model adjusted for smoking, arterial hypertension, alcohol consumption, and BMI (estimates are based on 10 multiple imputed datasets; transition-specific estimates for sex and partner status)

n = 2,021	0 → 1 HR (95% CI)	*p* Value	1 → 2 HR (95% CI)	*p* Value	0 → 2 HR (95% CI)	*p* Value
Sex						
Male						
Female	1.07 (0.75–1.53)	.723	0.71 (0.41–1.22)	.220	0.62 (0.29–1.31)	.216
Education (CASMIN-short)						
Low						
Middle	1.04 (0.80–1.35)	.781	1.04 (0.80–1.35)	.781	1.04 (0.80–1.35)	.781
High	0.88 (0.65–1.19)	.415	0.88 (0.65–1.19)	.415	0.88 (0.65–1.19)	.415
Partner						
Yes						
No	1.19 (0.79–1.79)	.412	0.73 (0.38–1.39)	.347	0.72 (0.28–1.83)	.503
Income, EUR						
Unknown						
<1,000						
≥1,000	1.05 (0.64–1.72)	.857	1.05 (0.64–1.72)	.857	1.05 (0.64–1.72)	.857
Diabetes mellitus						
Yes	1.15 (0.93–1.42)	.197	1.15 (0.93–1.42)	.197	1.15 (0.93–1.42)	.197
No						
Stroke						
Yes	1.14 (0.76–1.69)	.531	1.14 (0.76–1.69)	.531	1.14 (0.76–1.69)	.531
No						
Myocardial infarction						
Yes	1.16 (0.86–1.56)	.334	1.16 (0.86–1.56)	.334	1.16 (0.86–1.56)	.334
No						
Cancer						
Yes	1.26 (0.99–1.60)	.059	1.26 (0.99–1.60)	.059	1.26 (0.99–1.60)	.059
No						
Kidney disease[a]						.438
Yes	1.09 (0.88–1.35)	.438	1.09 (0.88–1.35)	.438	1.09 (0.88–1.35)	

Abbreviations: 95% CI, 95% confidence interval; BMI, body mass index; CASMIN, Comparative Analysis of Social Mobility in Industrial Nation; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; eGFR, estimated glomerular filtration rate.
[a]Kidney disease: eGFR <60 ml/min/1.73 m^2 (GFR estimated by the CKD-EPI(crea) equation).

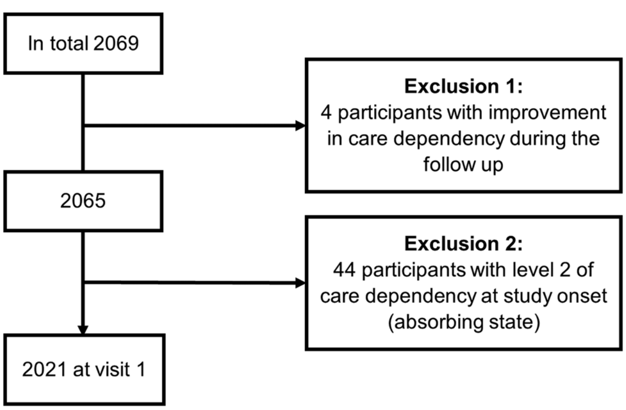

FIGURE 1 Flowchart

2 (*n* = 68) or 3 (*n* = 9), and 146 from care levels 1–2 (*n* = 131) or 3 (*n* = 15; Figure 2).

Descriptive and exploratory analysis of demographics, social determinants, health behaviors, characteristics conditions, and morbidities for persons with changes in care dependency (0 → 1, 1 → 2, 0 → 2) are provided in Table 1. Descriptive statistics are based on the raw (not imputed) data. Table 1 also includes age-adjusted HRs, 95% confidence intervals (95% CIs) and whether the model for each explanatory variable improved by including transition-specific regression coefficients (based on comparison of BIC).

The older the participant, the more likely they were to be affected by onset or worsening of care level (all HRs were >2.60 [Table 1]). Women had a higher risk to enter care level 1 than men (HR [95% CI]: 1.31 [1.08–1.59]) but lower risk for a direct entry into care level 2 (HR [95% CI]: 0.60 [0.37–0.96]). The risk to switch from

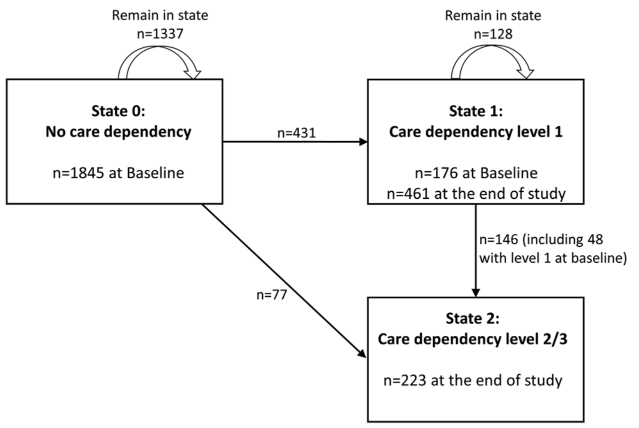

FIGURE 2 Multi-state model to study care dependency related to social determinants. Of 2,021 participants, 1,845 had not been assigned to any level of care at the beginning of the study (the remaining 176 participants had already level 1 care). A total of 1,337 of these participants remained in this state during follow up and had not been assigned to any care level. For 431 of the 1,845 participants the care dependency status changed from no care dependency to level 1, 77 participants changed to level 2. At the conclusion of the three study phases (median observation period was 5 years and 2 months), 461 participants received care at level 1 and 223 participants received care at level 2

care level 1 to care level 2 was lower for women (HR [95% CI]: 0.48 [0.35–0.67]). Approximately a third of women and men were care-dependent at the end of the study (33.1% men/34.5% women). Compared to participants in the low or high education category, those in the intermediate education category had a higher risk to enter care level 1 but lower risk for a direct entry into care level 2 or a worsening of their existing care level. Looking at the income groups, those in the highest income group were affected by transitions more often than those of the lowest income group (transition 1 → 2: HR [95% CI]: 1.97 [1.21–3.19]; transition 0 → 2: HR [95% CI]: 1.55 [0.82–2.95]). Overall, persons who reported having no partner at baseline experienced higher risk of onset in care level 1 (HR [95% CI]: 1.24 [1.02–1.51]) but lower risk of worsening of their care level (HR [95% CI]: 0.66 [0.47–0.93]) than participants with a partner (Figure 3). With regard to direct entry into care level 2, risk of participants with a partner was somewhat lower than for participants without a partner. However, the HR estimate was too imprecise to draw firm conclusions (HR [95% CI]: 0.72 [0.28–1.83]).

Smokers entered care level 1 more often than nonsmokers or ex-smokers. Participants with stroke, myocardial infarction or hypertension at baseline entered a care level or experienced a worsening of care dependency more often than participants without these morbidities (at baseline).

For the multiple model, we included the variables sex and partnership as transition specific, as the BIC was smaller in the more complex models for these covariates. All regression coefficients of the other covariates were estimated as fixed for the different transitions.

Table 2 shows the results of the multiple multi-state model. There was some evidence that having no partner compared to having a partner is associated with a somewhat higher risk of transition from no care dependency to level 1 (HR: 1.19, 95% CI: 0.79–1.79). With regard to transition from level 1 to level 2 and from no care dependency to level 2, there was some evidence of an inverse association between having no partner and the onset and worsening of care dependency (1 → 2 HR: 0.73, 95% CI: 0.38–1.39/0 → 2: HR: 0.72, 95% CI: 0.28–1.83).

Overall, there was little evidence of differences between women and men for the transition from no care dependency to level 1 (Table 2, HR: 1.07, 95% CI: 0.75–1.53). For the transition from no care dependency to level 2 and for the transition from levels 1–2 there was some evidence of lower risk for women compared to men (0 → 2: HR: 0.62, 95% CI: 0.29–1.31; 1 → 2: HR: 0.71, 95% CI: 0.41–1.22). The results on educational status and income showed no substantial differences. Regarding morbidities (stroke, myocardial infarction, cancer, kidney disease, and diabetes mellitus), participants with a morbidity had a higher risk for changes in care dependency levels than participants without morbidities. Here, the estimated effects were similar between the various transitions (Table 1) for each of the morbidity variables without model improvement compared to a more simple model (fixed estimates over transitions), evaluated with the BIC. Therefore the coefficients were set as fixed for the multiple model (Table 2).

As we were also interested in the question of different effects of partnership on care dependency for men and women, we additionally performed analyses stratified by sex for a more thorough understanding of differences, even small ones, between men and women. In separate models, men without a partner had somewhat higher risk for onset of care dependency compared to women without a partner (HR from no care dependency to level 1, men: HR: 1.29, 95% CI: 0.74–2.26, women: HR: 1.06, 95% CI: 0.55–2.06).

4 | DISCUSSION

4.1 | Main results

This study investigated the association between social determinants and care dependency onset and progression in a cohort of older adults. The results suggest, first of all, that care dependency risk may be associated with sex, partnership, and morbidities. The direction of the association with sex was the same for the transition from no care dependency to level 2 and from levels 1–2 (men had a higher care dependency risk), but the strength of the associations varied with level of care. Partnership status appears to be associated with care dependency: Persons with no partner entered level 1 care more often. However, the direction of the association is reversed on onset in care level 2 and on worsening of care dependency; here, persons with no partner tend to be affected less often. The effects were similar in the adjusted model. There was no substantial association between care dependency and income or between care dependency and education after adjustment for morbidity.

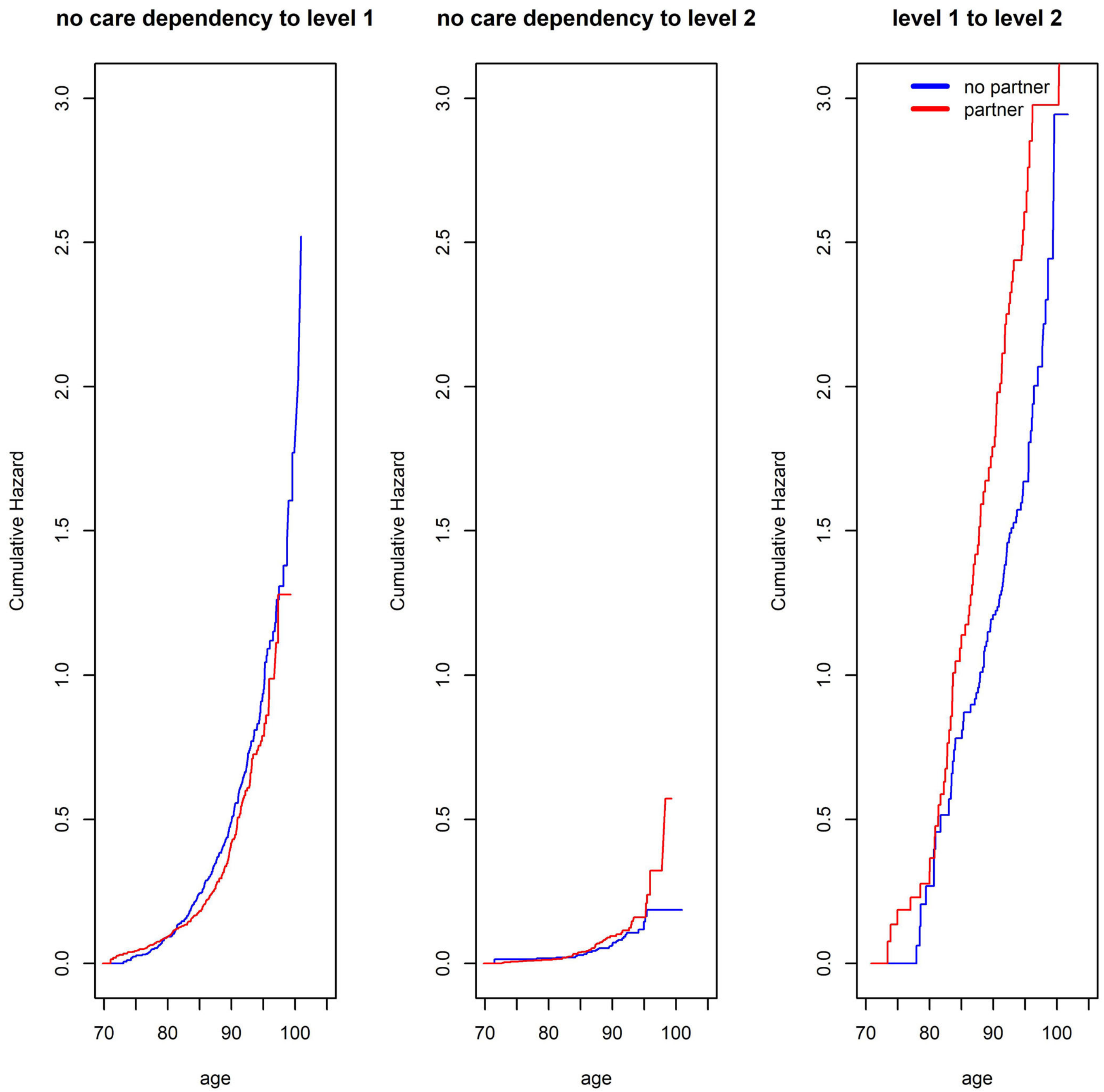

FIGURE 3 Nelson–Aalen cumulative hazard function for each transition

4.2 | Partnership, sex, and care dependency risk

The few studies that investigated the effect of partnership on care dependency risk or physical functional impairment differ in terms of the relationship indicators used: Some used marital status (married, divorced, widowed, and single), while others used cohabitation or partnership status (existing partnership irrespective of marital status). Schneider, Rapp, Klein, and Eckhard (2014) examined if the use of these different indicators leads to different health outcomes and concluded that future health research could benefit from the use of indicators other than marital status. A direct comparison between our study, which used partnership without regard to marital status, and studies that used other relationship indicators is only possible to a limited extent.

In AgeCoDe, a population-based prospective cohort study, participants aged 75 and above were surveyed in a total of four phases (baseline, n = 3,217), and marital status data were collected. Based on this dataset, Hajek et al. (2017) investigated determinants of functional impairment (Barthel Index and instrumental ADL) among elderly Germans in one study, and determinants of care levels in the German health system in another (Hajek, Brettschneider, Lange et al., 2016). In both studies, they found that living without a spouse/partner was related to higher levels of functional impairment/care dependency. Sex-specific analyses of the determinants of functional impairment point to a higher risk only for women who have lost their spouse compared to women with spouse (Hajek & König, 2016). This contrasts with other studies where results show that having a partner is more beneficial for men than for women: Men have a lower risk of onset in care level 1 if they are married (Borchert & Rothgang, 2008; Unger, Giersiepen, & Windzio, 2015). One possible explanation discussed is that support arrangements are mainly made by women, who are more likely than men to mitigate and compensate for limitations in ADL. This hypothesis—that a sex difference exists in the effect of partnership—was not confirmed by our sex-specific analyses as the direction of the association was the same for women and men. An explanation for different findings in other studies could be that sex-specific morbidity structures underlie the finding that men experience onset in care level 1 less often. This is also confirmed by a study of Schnitzer et al. (2017) which indicates that women have a higher risk of becoming care-dependent after stroke than men because they are older on average and suffer more often from geriatric conditions, especially from urinary incontinence.

4.3 | Education, income, and care dependency risk

Studies on the effect of education and income on care dependency risk are scarce, and their findings are inconsistent. In the study by Nilsson et al. (2010) and in their subsequent work on the risk factors for mobility limitations (Nilsson et al., 2014), the authors identified an increased risk for low income groups. Unger et al. (2015) examined lifetime prevalence for care dependency and found a higher incidence of care in lower income groups. In these three studies it was not possible to adjust for morbidities and diagnosis which contribute to care dependency and may be assumed to be the background to the higher disease burden in persons with low socioeconomic status (Avendano, Aro, & Mackenbach, 2005; Ramsay et al., 2008). This assumption is reasonable, as in our study, after adjusting for morbidities, there was no evidence of a substantial association between income and level of care dependency.

Few studies provide information about educational level and care dependency risk. Huisman et al. (2005) investigated educational inequalities in relation to disability in Italy and the Netherlands. They found higher prevalence and incidence of disabilities in persons with a low level of formal education. However, as in the age group that formed the cohort for the present study, inequality was much less marked in the older age group (70–85 years) than in the younger group (55–69 years). Furthermore, the results were not adjusted for morbidities. The same applies to the study by Sulander et al. (2012), which analyzed longitudinal changes in functional capacity in three cohorts of participants born in or after 1926. In the German study by Hajek and König (2016) about factors influencing care dependency, the CASMIN classification is used to operationalize educational level (analogous to BIS). Consistent with our own study, no substantial relation between education and care dependency was observed.

In summary, our findings are consistent with the hypothesis that inequalities in care dependency between education and income groups can be explained in terms of morbidities. This is confirmed by Ramsay et al., who studied a sample of men in the 63–82 age range in the United Kingdom and found that most socioeconomic inequalities in care dependencies are explained by health behavior and morbidities (Ramsay et al., 2008).

4.4 | Strengths and weaknesses

In the BIS cohort, morbidities, laboratory, and study parameters such as BMI and a broad range of survey data including sociodemographic variables were collected. These data were merged with health insurance data to determine entry into and progression through different levels of care. This combination of survey, study, and health insurance data and the longitudinal nature of the research, along with the high average age of participants, are our study's particular strengths. Few previous studies have combined these various data sources; however, this approach is increasingly recommended (Unger et al., 2015).

Some limitations should be mentioned. First, there was a low response rate of 8.1% of the contacted individuals eligible for inclusion in the baseline survey. However, it should be noted that this low response rate can be expected in similar studies with older adults (Murphy, Schwerin, Eyerman, & Kennet, 2008). The BIS population has been shown to be representative of the German general population of older adults with regard to the morbidity structure of the participants of the same age and sex (Busch, Schienkiewitz, Nowossadeck, & Gosswald, 2013; Ebert et al., 2016; Gosswald, Schienkiewitz, Nowossadeck, & Busch, 2013; Jacob, Breuer, & Kostev, 2016; Tamayo, Brinks, Hoyer, Kuß, & Rathmann, 2016). A second limitation is that we were not able to use mortality data, so estimated effects may be partially distorted by the censoring of participants who died. Third, the partnership variable used does not distinguish between couples who live together and those who live apart, and no information about living arrangements was available. This fact restricts our findings especially since it is assumed that a partner will provide assistance with ADL. On the other hand, we also assume that partnership is a protective factor irrespective of cohabitation status, as an existing partnership presumably correlates positively with health-promoting behavior (more physical activity, more social participation; Nilsson et al., 2010).

5 | CONCLUSION

Our findings add to the limited research on social determinants of health and care dependency. Results indicate that older people without a partner may be at higher risk of care dependency onset but not on a higher risk of care dependency progression. After adjustment for morbidities, however, the association was not statistically significant at the traditional 0.05 level. The hypothesis that a sex difference exists in the effect of partnership could not be confirmed by our sex-specific analyses as the direction of the association was the same for women and men. Regarding the effect of socioeconomic position on care dependency risk, we found that where differences existed, they could be partly explained in terms of morbidities. Clinicians should inquire about and consider patients' partnership status as they evaluate care needs.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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