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Prevalence and determinants of driving habits in the oldest old: Results of the multicenter prospective AgeCoDe-AgeQualiDe study

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ABSTRACT

Aim: To present data on the prevalence of driving habits and to identify the determinants of driving habits among the oldest old in Germany.
Methods: Cross-sectional data were used from the "Study on Needs, health service use, costs and health-related quality of life in a large sample of oldest-old primary care patients (85+)" (AgeQualiDe), including primary care patients aged 85 years and above (n = 549 at FU 9, mean age was 90.3 years; 86–101 years). Driving habits were measured (driving a car; frequency of driving a car and driving duration). Correlates were quantified using widely established scales (e.g., Geriatric Depression Scale, Instrumental Activities of Daily Living Scale). Multiple regression models were used to identify the determinants of driving habits.
Results: Sixteen percent (87 out of 549) drove a car. Among the car-drivers, about 80% drove at least several times a week and about two-thirds drove longer distances (> 15 min). Multiple logistic regressions showed that among the oldest old being a male was more likely to be a current driver compared to being a female. Other significant factors were subjective memory impairment, severe visual impairment, functional and cognitive impairment. Correlates of frequency of driving a car and driving duration were further identified.
Conclusion: About one in six very old Germans is still a regular car driver. Several determinants of driving habits among the oldest old were identified. Future longitudinal studies are required to clarify the factors leading to changes in driving habits.

1. Introduction

The number and percentage of older car drivers increases (OECD, 2001); driving a car is important for elderly persons in maintaining autonomy and social participation (Hjorthol, 2013; Marottoli et al., 2000). Higher age is not associated with more road accidents (Hakamies-Blomqvist, Raitanen, & O'Neill, 2002). However, in the age group > 75, the risk of being the accident perpetrator increases (DESTATIS, 2017). Among the reasons are little practice (decreasing driving activity) (Langford, Methorst, & Hakamies-Blomqvist, 2006) and

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decreased function in sensory, cognitive and motor domains (Anstey, Wood, Lord, & Walker, 2005). To assist older drivers in maintaining driving safety, in reducing driving activity or in ceasing to drive, knowing their special needs is of high importance (Betz, Lowenstein, & Schwartz, 2013). The characterization of the subgroup of older drivers is a step towards better understanding. This should be stressed as the number of oldest old (≥80 years) individuals is projected to increase considerably in the upcoming decades. Typically, individuals in highest age are characterized by functional impairment, a higher degree of frailty or decreased quality of life (Hajek, Brettschneider, Lange et al., 2016, Hajek, Brettschneider, Posselt et al., 2016; Hajek et al., 2017).

Several studies have focused on the determinants of driving habits in old age (Coxon et al., 2015; Lenardt et al., 2017; Sandlin, McGwin, & Owsley, 2014). For example, Coxon et al. (Coxon et al., 2015) found associations between age, function as well as personal circumstances and driving exposure (total distance driven, furthest distance traveled from home and average trip length) among drivers aged 75 and older using a convenience sample of 380 individuals residing in northwest Sydney. Based on a population-based sample of older adults aged 70 and over from Alabama (with a current driver's license and had driven within the preceding 3 months, n = 2000), Sandlin et al. (Sandlin et al., 2014) found that impaired contrast sensitivity (the ability to see an object against a background) was associated with reduced annual mileage. Moreover, they found that slowed visual processing speed was associated with reduced number of days driven per week, whereas visual acuity was not associated with driving exposure.

However, studies are almost missing presenting data on the prevalence of driving habits and investigating the determinants of driving habits in the *oldest old* based on *population-based samples*. Using the Cambridge City over 75 Cohort (representative sample of individuals aged 84 and over, n = 404), one study has shown that compared with former drivers, current drivers were more likely to be male, married, had better cognitive function, and had higher functionality scores whereas driving was not associated with age, education, depressive symptoms, vision and hearing impairment in unadjusted analysis (Brayne et al., 2000). Consequently, the aim of this study was (1) to present data on the prevalence of driving habits and (2) to identify the determinants of driving habits (driving status, frequency and duration) in the oldest old using a multicenter prospective cohort study. This gives insights into the prevalence and correlates of driving habits in oldest age in Germany.

2. Methods

2.1. Sample

Data were derived from a large multicenter prospective cohort study ("Study on Needs, health service use, costs and health-related quality of life in a large sample of oldest-old primary care patients (85+)", AgeQualiDe) conducted in six large cities in Germany (Bonn, Düsseldorf, Hamburg, Leipzig, Mannheim and Munich). At follow-up (FU) wave 7, patients ≥85 years were interviewed by the trained staff. The AgeQualiDe study continues and extends the German Study on Ageing, Cognition and Dementia in Primary Care Patients (AgeCoDe) which started in 2003/2004 (n = 3327). The participants of the AgeCoDe-study were initially recruited via GP offices. Inclusion criteria of the AgeCoDe-study were ≥75 years, free of dementia, ≥1 contact with the GP in the past 12 months. Exclusion criteria were: Being an irregular patient of the participating practice, consultations only via home visits, residents of a nursing home, severe illness the GP would deem fatal within 3 months, insufficient German language skills, blind or deaf, lacked ability to consent. Further details were provided elsewhere (Eisele et al., 2015). Among the 3327 individuals, n = 549 individuals participated in FU wave 9 and provided data on driving habits. Driving habits had not been measured in former waves. Thus, data from FU wave 9 was used in this study. The most important reasons for drop out were that patients died or refused participation. For further details please see (Hajek, Brettschneider, Lühmann et al., 2016).

The AgeCoDe as well as the AgeQualiDe study have been approved by the ethics committees of all participating study centres and comply with the ethical standards of the Declaration of Helsinki. Prior to participation, all participants gave written informed consent.

2.2. Outcome measures: driving habits

When Mini Mental State Exam (Folstein, Folstein, & McHugh, 1975) was 19 or higher, the driving habits were quantified using three variables:

1 Driving a car (no; yes)

Those individuals still driving a car were also asked about:

2 Frequency of driving a car (every day; several times a week; once a week; less than once a week)
3 Driving duration (short distances (e.g., to the grocery); longer distances (> 15 min))

2.3. Independent variables

In the regression model, based on previous findings (Coxon et al., 2015; Lenardt et al., 2017; Sandlin et al., 2014) and theoretical considerations sex (women; men), marital status (Ref.: married; other (widowed; divorced; single), and the level of education (according to the Comparative Analysis of Social Mobility in Industrial Nations (CASMIN), distinguishing between low, middle and high education (Brauns & Steinmann, 1999)) were included. In addition, the six item version of the Lubben Social Network Scale (LSNS) was used to quantify social network/social support, with higher values (from 0 to 30) reflecting higher social network/social support. This scale has good psychometric properties (Lubben et al., 2006). Moreover, subjective memory impairment (no; yes) was reported. Participants also graded their visual impairment, hearing impairment and mobility impairment on a Likert scale as no impairment, mild, or severe/profound. Cognitive decline was measured using the Global Deterioration Scale (from 1 = no cognitive decline to 7 = severe cognitive decline) (Reisberg, Ferris, de Leon, & Crook, 1982), depressive symptoms were quantified using the Geriatric Depression Scale (from 0 to 15, higher values indicating more depressive symptoms) (Yesavage & Sheikh, 1986) and functional decline was assessed using the Lawton and Brody scale (from 0 = worst score to 8 = best score) (Lawton & Brody, 1969).

2.4. Statistical analysis

First, stratified by driving status (still driving a car or not) descriptive findings were depicted. Bivariate associations were calculated using *t*-test and chi-square procedures, as appropriate.

Second, multiple regressions were computed with outcome measures as follows: driving a car, frequency of driving a car, and driving duration. Logistic (with driving a car and driving duration as outcome measure, respectively) and ordered logit regressions (frequency of driving a car as outcome measure) were used. The level of significance was set at $\alpha = .05$. Statistical analysis was performed using Stata Release 15.0 (Stata Corp., College Station, Texas).

3. Results

3.1. Sample characteristics

Table 1 depicts descriptive findings at FU wave 9 (stratified by driving a car or not; n = 549). In total, 68.5% were female and average age was 90.3 years (± 2.7, 86–101).

Table 1
Descriptive statistics (FU wave 9, n = 549), stratified by driver status (yes; no).

Variables	Not being a current driver (n = 462, 84.2%)	Being a current driver (n = 87, 15.8%)	p-value
Age: Mean (SD); Range	90.5 (2.8) 87–101	89.5 (2.3); 87–98	< .01
Male: N (%)	108 (23.4%)	65 (74.7%)	< .001
Level of education: N (%)			< .01
Low	274 (59.3%)	37 (42.5%)	
Middle	131 (28.4%	29 (33.3%)	
High	57 (12.3%)	21 (24.2%)	
Marital status: Married: N (%)	82 (17.8%)	43 (49.4%)	< .001
Presence of subjective memory impairment: N (%)	282 (61.0%)	53 (60.9%)	.98
Visual impairment: N (%)			< .001
None	282 (61.0%)	75 (86.2%)	
Mild	106 (23.0%)	11 (12.6%)	
Severe or profound	74 (16.0%)	1 (1.2%)	
Hearing impairment: N (%)			.61
None	156 (33.8%)	33 (37.9%)	
Mild	268 (58.0%)	49 (56.3%)	
Severe or profound	38 (8.2%)	5 (5.8%)	
Mobility impairment: N (%)			< .001
None	121 (26.2%)	45 (51.7%)	
Mild	233 (50.4%)	40 (46.0%)	
Severe or profound	108 (23.4%)	2 (2.3%)	
Lubben Social Network Scale: Mean (SD); Range	13.1 (5.1); 0–30	15.2 (5.2); 4–26	< .001
Geriatric Depression Scale: Mean (SD); Range	3.3 (2.8); 0–14	1.9 (2.0); 0–9	< .001
Instrumental Activities of Daily Living Scale: Mean (SD); Range	5.2 (2.4); 0–8	6.6 (1.4); 3–8	< .001
Global Deterioration Scale: Mean (SD); Range	2.2 (1.1); 1–7	1.7 (0.7); 1–4	< .001
Number of chronic diseases (Sum score): Mean (SD); Range	7.2 (3.5); 0–26	5.2 (2.7); 1–14	< .001

To quantify the level of education, the CASMIN classification was used. Lubben Social Network Scale ranges from 0 to 30, with higher values reflecting more social networks and more social support; Geriatric Depression Scale ranges from 0 (no depressive symptoms) to 15 (severe depressive symptoms). Instrumental Activities of Daily Living Scale score ranges from 0 (worst score) to 8 (best score); Global Deterioration Scale ranges from 1 (best score) to 7 (worst score); P-values are based on t-tests or chi^2 tests, as appropriate.

In FU wave 9, 84.2% did not drive a car. Among the 87 individuals driving a car, 6 individuals drove less than once a week, 10 individuals drove once a week, 57 individuals drove several times a week and 14 individuals drove daily. Furthermore, out of the 87 car drivers, 55 individuals drove longer distances (> 15 min).

Bivariately, the likelihood of being a current driver increased with younger age, being male, higher education, being married, less severe visual and mobility impairment, social support, fewer depressive symptoms, lower functional and cognitive impairment, and fewer chronic diseases.

3.2. Regression analysis

Results of multiple regressions (outcome measures: (i) probability of being a current driver (first column); (ii) frequency of driving a car (second column); (iii) driving duration (third column)) are displayed in Table 2. Pseudo R^2 was 0.36 with the probability of being a current driver as outcome measure, 0.13 with frequency of driving a car as outcome measure and 0.34 with driving duration as outcome measure.

Multiple logistic regressions showed that among the oldest old being a male was more likely to be a current driver compared to being a female [OR: 15.84 (95%-CI: 7.53–33.34)]. Other significant factors were: subjective memory impairment [OR: 1.93 (1.01–3.68)], severe visual impairment [severe/profound visual impairment: OR: 0.06 (0.01–0.59)], functional [OR: 1.63 (1.29–2.06)] and cognitive impairment [OR: 0.65 (0.43–0.98)].

Multiple ordinal regressions showed that among the oldest old, being a male was more likely to be a more frequent car driver (reference category: less than once a week) compared to being a female [OR: 5.11 (1.20–21.71)]. The only other significant factor was depressive symptoms [OR: 0.65 (0.49-0.84)]. Multiple logistic regressions showed that among the oldest old, individuals not having subjective memory impairment were more likely to be a longer driver (reference category: short distances) compared to individuals having subjective memory impairment [OR: 0.16 (0.04–0.70)]. Other significant factors were: mobility impairment [OR: 0.16 (0.04–0.59], as well as functional impairment [OR: 0.53 (0.30–0.95)].

It is worth noting that there is *no* significant difference in driving status among individuals without subjective memory impairment and individuals with subjective memory impairment when these individuals are concerned about his or her perceived impairment [OR: 1.82 (.64–5.19)]. In contrast, there is a significant difference in driving status among individuals without subjective memory impairment and individuals with subjective memory impairment when these individuals are not concerned about his or her perceived impairment [OR: 1.94 (1.00–3.78)].

4. Discussion

Based on data from a multicenter prospective cohort study, the objective of the current study was to present data on the prevalence of driving habits and to identify the determinants of driving habits among the oldest old in Germany. In total, sixteen percent drove a car. Thereof, about 80% drove at least several times a week and about two-thirds drove longer distances (> 15 min).

Unsurprisingly, drivers were more likely to be male among the oldest old in this study. These might be, among others, explained by the fact that men tend to perceive the use of a private car as a necessity, whereas women tend to avoid traffic-related stress and certain traffic situations (Hakamies-Blomqvist & Wahlström, 1998). Another explanation for these gender differences might be that in our study the proportion of never drivers (i.e., those who have never driven) was expected to be higher among women – which would be in accordance with previous knowledge (Freeman, Gange, Muñoz, & West, 2006). In addition, further underlying social factors exist explaining inequity in driving (Hakamies-Blomqvist & Siren, 2003).

Previous research has demonstrated that increasing age was associated with driving status (Ragland, Satariano, & MacLeod, 2005). In our study, this was also confirmed in correlation analysis, but not in multiple logistic regressions. However, it is conceivable that age was not independently associated with driving status in multiple regression analysis because various health-related factors (which are linked to age) were considered in our regression model. However, previous studies also showed an independent association between age and driving status (based on the Health and Retirement Study), adjusting for socioeconomic factors as well as physical limitations, cognition, visual impairment, and chronic conditions (e.g., stroke, cancer or diabetes) (Dugan & Lee, 2013). Thus, future research is required to clarify this relationship.

As regards functional impairment, it appears plausible that the probability of being a current driver was negatively associated with it in this study. In addition, drivers were more likely to have less severe cognitive impairment in our study which is in accordance with previous studies (Anstey, Windsor, Luszcz, & Andrews, 2006). This is very conceivable because driving a car is a complex process involving, among others, a series of cognitive functions (e.g., deficits in executive functions and reaction (Kurzthaler et al., 2017)). Thus, individuals with poorer cognitive function tend to modify their driving habits including ceasing their driving which is often interpreted as self-regulation (Ball et al., 1998). Furthermore, there was an association between being a

Table 2
Determinants of driving habits. Results of multiple logistic (driver status or driving duration as outcome measure) and ordered logit regressions (frequency of driving a car) (FU wave 9).

Independent variables	Being a current driver	For current drivers: Frequency of driving a car	For current drivers: Driving duration
Age	0.93	0.96	1.14
	(0.82–1.05)	(0.77–1.19)	(0.84–1.53)
Male (Ref.: Female)	15.84***	5.11*	1.01
	(7.53–33.34)	(1.20–21.71)	(0.18–5.53)
Marital status: Single, widowed, divorced (Ref.: married)	0.59	1.43	0.54
	(0.30–1.19)	(0.39–5.23)	(0.11–2.65)
Level of education: - medium (Ref.: low)	1.57	1.98	2.15
	(0.80–3.08)	(0.62–6.40)	(0.50–9.20)
- high	1.30	1.81	4.18
	(0.60–2.81)	(0.49–6.66)	(0.73–23.85)
Presence of subjective memory impairment (Ref.: Absence of subjective memory impairment)	1.93*	0.98	0.16*
	(1.01–3.68)	(0.35–2.73)	(0.04–0.70)
Visual impairment: - Mild (Ref.: None)	0.56	1.53	0.26
	(0.24–1.35)	(0.32–7.22)	(0.04–1.57)
- Severe or profound	0.06*	0.71	
	(0.01–0.59)	(0.01–57.20)	
Hearing impairment: - Mild (Ref.: None)	0.83	1.05	2.26
	(0.44–1.57)	(0.36–3.04)	(0.59–8.74)
- Severe or profound	3.32	1.39	0.17
	(0.76–14.57)	(0.13–14.65)	(0.01–3.66)
Mobility impairment: - Mild (Ref.: None)	1.08	0.66	0.16**
	(0.58–2.01)	(0.25–1.74)	(0.04–0.59)
- Severe or profound	0.41	0.36	0.07
	(0.08–2.22)	(0.01–10.91)	(0.00–4.75)
Lubben Social Network Scale score	1.05	0.98	0.96
	(0.99–1.11)	(0.88–1.10)	(0.84–1.09)
Geriatric Depression Scale score	0.88	0.65**	0.80
	(0.75–1.04)	(0.49–0.84)	(0.57–1.11)
Instrumental Activities of Daily Living Scale score	1.63***	1.40	0.53*
	(1.29–2.06)	(0.90–2.18)	(0.30–0.95)
Global Deterioration Scale score	0.65*	1.23	0.78
	(0.43–0.98)	(0.61–2.47)	(0.31–1.98)
Constant	2.08		0.04
	(0.00–153,369.26)		(0.00–1.38e+10)
Observations	535	87	86
Pseudo R^2	0.36	0.13	0.34

Odds Ratios were reported; 95%-CI in parentheses; *** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.10; To quantify the level of education, the CASMIN classification was used. Lubben Social Network Scale ranges from 0 to 30, with higher values reflecting more social networks and more social support; Geriatric Depression Scale ranges from 0 (no depressive symptoms) to 15 (severe depressive symptoms). Instrumental Activities of Daily Living Scale score ranges from 0 (worst score) to 8 (best score); Global Deterioration Scale ranges from 1 (best score) to 7 (worst score). Driving a car (0 = not driving a car (reference category); 1 = driving a car) was used to quantify the driving status; Individuals driving a car were asked about (i) the frequency of driving a car (every day; several times a week; once a week; less than once a week (reference category)) and (ii) the driving duration (short distances (reference category); longer distances (> 15 min)). Being a current driver: no (reference category); yes; Frequency of driving a car: every day; several times a week; once a week; less than once a week (reference category); Driving duration: short distances (reference category); longer distances.

current driver and less severe visual impairment. This association also appears highly plausible since visual skills are very important when driving a car and has been demonstrated by previous studies based on younger samples (Lyman, McGwin, & Sims, 2001; O'Connor, Edwards, & Bannon, 2013; Sandlin et al., 2014). It has been shown that there is a significant difference in driving status among individuals without subjective memory impairment and individuals with subjective memory impairment when these individuals are not concerned about his or her perceived impairment. However, future research is required to examine this association in further detail.

As regards depressive symptoms, there is equivocal evidence. While some studies showed an association between depressive symptoms and limiting and ceasing driving (Fonda, Wallace, & Herzog, 2001), there is also evidence showing that these factors are unrelated (Sengupta et al., 2014). In our study, depressive symptoms were not associated with driving status, but were negatively associated with the frequency of driving a car. The latter association might be explained by listlessness among individuals with increased depressive symptoms. However, future studies are required to clarify this relationship.

Among the car drivers, it is worth highlighting that driving duration was positively associated with the *absence* of mobility impairment (compared to mild mobility impairment), and, likewise, the *presence* of functional impairment. This might sound contradictory, but at second glance it appears conceivable that the presence of functional impairment is positively associated with driving duration because individuals with functional impairment might have to drive longer distances in order to receive appropriate care. However, these findings should be regarded as preliminary and interpreted with caution because of the small number of individuals driving shorter distances in this study.

To our knowledge, this is one of the first studies to investigate the determinants of driving habits among the oldest old using a multicenter prospective cohort study. Various explanatory variables were included in the regression models (e.g., depressive symptoms, functional decline, cognitive decline). These explanatory variables were quantified using widely established instruments. Key components of driving habits (driving a car, frequency and duration) were measured. The sample size in the current driving group was rather low (87 out of 549 individuals). However, this is one of very few studies, which identified the determinants of driving habits among the oldest old using a multicenter prospective cohort study. Our study relies on self-reported measures of driving habits, which might cause some inaccuracies (Molnar et al., 2013). Moreover, some other scales (e.g., visual, hearing or mobility

impairments) rely on self-reports, which also may result in over- or underestimation. On the other side, it has been demonstrated that self-report and objective measures of driving exposure are correlated (Marshall et al., 2007). Moreover, our study mainly focused on the status being a current driver or not and thus did not focus on the exact mileage. Furthermore, future research is required distinguishing between former and never drivers (e.g., in women). Being a cross-sectional study, temporality cannot be established in this study. Because there is some attrition bias in this study (Hajek, Brettschneider, Ernst et al., 2016), it is likely that our findings are difficult to generalize to individuals with, for example, very severe cognitive impairment. Further research is required to clarify the role of self-regulation in the association between the independent variables and driving habits (Bergen et al., 2017). Moreover, personality factors might be of importance (Sawula et al., 2017). In addition, future research is needed in rural areas where the infrastructure is generally poorly developed when compared to urban areas.

5. Conclusion

About one in six very old Germans is still a regular car driver. Several determinants of driving habits among the oldest old were identified. Future longitudinal studies are required to clarify the factors leading to changes in driving habits.

Conflict of interest

None.

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