Vulnerability as a Driver: How Medical Risk Factors Explain Sociodemographic and Environmental Disparities in Dementia Risk among Older Germans (2016-2018)

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Theoretical focus

Germany is expecting an increase in the number of individuals living with dementia as the population is ageing (1). This is because life expectancy increased over the past decades (2). The question remains whether gains in lifetime are spent in health or illness (3–5). A growing share of older adults in Germany may experience chronic diseases, culminating in diverse health pathways, potentially resulting in an increased risk of dementia. Understanding how this risk is differing across Germany's older population is crucial. Disadvantaged population groups are particularly exposed, yet the mechanisms behind sociodemographic and environmental disparities in dementia risk remain unclear. Disadvantaged individuals within these groups may be particularly vulnerable to accumulating risk factors over the life course (6). Not only pharmacological and lifestyle-modifying interventions may reduce dementia risk (7), but also targeting socioeconomic factors may largely contribute to the risk reduction (8). Therefore, to effectively reduce disparities in dementia risk, it is essential to address societal structures (9) while also accounting for individual risk factors that contribute to these disparities through differences in exposure (prevalence) and vulnerability (strength of association).

This study addresses four sociodemographic and environmental indicators to explain disparities in the risk of all-cause dementia among elderly Germans: sex, area-level premature mortality, socioeconomic neighborhood status, and area-level per capita gross domestic product (GDP). Understanding how these indicators interact with medical risk factors may offer insights for equitable dementia prevention and intervention. Sex is a widely explored but complex determinant of dementia (10). Women tend to be at greater risk for dementia than men (11), mainly due to advantages in survival (12–14). Yet, when age and other factors are considered, evidence is less consistent (12,15,16). Some evidence suggests a higher risk among the oldest-old women (12), whereas other studies reported a higher risk among older men in Germany (17). Men are particularly prone to vascular dementia linked to cardiovascular disease (18). Nevertheless, cardiovascular diseases, diabetes, and hypertension may impact both sexes (8,18–20). The role of depression in the sex disparity remains unclear (21). Premature mortality reflects general health risks and healthcare performance (22,23) and is a Sustainable Development Goal target (24). Areas with higher premature mortality indicate worse living conditions and health, potentially increasing dementia risk. The neighborhood is a social environment in which one has certain access to and the availability of social and economic (25) and healthcare resources. Residing in disadvantaged neighborhoods increases the vulnerability to social, psychological, and biological influences (26) and may increase the risk of dementia independent of individual characteristics (8,27–29). Area-level per capita GDP reflects the regional economic standard of living and is positively linked to life expectancy, a measure of overall population health (30–32), also in Germany (33). Yet, its link to specific health outcomes is less consistent (34,35). In a global study, evidence suggested that populations in lower-GDP settings face higher dementia risk due to higher shares of environmental, social, and behavioral risk factors and a smaller share of resources for healthcare and prevention (36). Applying this to small-scale areas, a similar link may exist within Germany, where lower area-level per capita GDP indicates a higher risk of dementia.

This study investigates whether disparities in dementia risk across sociodemographic and environmental indicators can be explained by medical risk factors or whether the indicators themselves produce disparities independently. We distinguished between exposure and vulnerability effects to assess whether the prevalence of risk factors or the strength of the associated risk factors contributes most to the observed disparities.

Data

German longitudinal health claims data from 2014-2019 from an elderly cohort (n=250,000) was obtained of a large statutory health insurance, the Allgemeine Ortskrankenkasse (AOK). Quarterly information on sex, birth date, time of death (if applicable), five-digit zip code of residence, medical conditions (ICD-10), medication (ATC), and surgeries (OPS) was available. Individuals were excluded when they had incomplete zip code information. District (NUTS-3) and five-digit zip code information was obtained from the official List of Municipalities from 2015 and 2016. Based on the districts, information was linked to the German Index of Socioeconomic Deprivation (GISD) for the year 2016 (37). Information on 2016 district-level premature mortality and per capita GDP was linked from the INKAR database. Finally, health claims data was merged with environmental data based on zip code information from 2016.

Dementia was captured using ICD-10 codes. To account for false-positive incident dementia cases, we excluded prevalent dementia cases in 2004 and 2005 and implemented an internal validation strategy. Validation of incident cases in 2019 was not possible. Hence, the observation period started in the first quarter of 2016 and ended in the last quarter of 2018. Process time was measured in age, increasing quarterly. The analyses focused on disparities in dementia risk by sex, district-level premature mortality, socioeconomic neighborhood status, and per capita GDP. Premature mortality, neighborhood status (measured by GISD score), and GDP were divided into terciles, with the highest tercile resembling high premature mortality or neighborhood disadvantage and the lowest tercile indicating low GDP. Besides age at baseline and time, the 18 most important predictors obtained from a study using a machine learning approach to predict the risk of dementia based on similar health claims data were considered (38). Medical conditions, pharmaceutical prescriptions, and one medical procedure were included.

Methods

Analyses proceeded in three steps and were stratified by baseline age groups (70–74, 75–79, and 80–84 years). First, unidimensional Cox proportional hazard models were used to assess whether sociodemographic and environmental disparities were observed in dementia risk. Second, medical risk factors lacking statistical significance in the multivariable Cox models or sufficient case numbers were excluded, namely cough suppressants, lipid modifiers, antibiotics (macrolides, lincosamides, and streptogramins), urologicals, corticosteroids, and endoprosthetic joint or bone replacements. Anti-dementia drugs were excluded due to their inherent linkage to dementia diagnosis. Highly correlated variables were combined: heart diseases including high-ceiling diuretics, diabetes type 2 including insulin and analogues, and depression including antidepressants. The final set of risk factors included heart diseases including medication, diabetes type 2 including medication, depression including medication, cerebrovascular disease, head injuries, antipsychotics, and Parkinson's disease (PD). Third, we calculated age-group-specific period prevalence (2016-2018) of these risk factors by sociodemographic and environmental indicators, obtained relative risks from the multivariable Cox proportional hazard models, and decomposed their contributions to the dementia disparities into exposure (prevalence) and vulnerability (association strength) effects (39).

Preliminary findings

Results

Out of 24,952 older Germans aged 70-74 at baseline, 952 incident dementia cases occurred between 2016 and 2018, while 2,036 dementia cases were observed in 75-79-year-olds (n=31,890) and 2,183 in 80-84-year-olds (n=22,461). With age, prevalence increased for each medical risk factor (Table 1). Men and individuals living in areas with higher premature mortality, disadvantaged neighborhoods and areas with lower per capita GDP showed higher prevalence of heart diseases and diabetes, including medication. Women had a higher prevalence of depression and antipsychotics use, while men showed higher prevalence of PD. Those in areas with higher premature mortality, neighborhood disadvantage and lower GDP showed lower prevalence of depression with medication and cerebrovascular disease. Injuries to the head were less prevalent in high-mortality and disadvantaged areas. Differences in other medical risk factors by indicators remained marginal.

In the univariable Cox proportional hazard models (observed disparities), dementia risk was lower for men aged 75-79 (HR=0.87, 95% CI [0.80-0.95]) and higher for men aged 80-84 (HR=1.10 [1.01-1.20]) compared to women (Table 2). No sex disparity appeared in ages 70-74. Living in areas with higher premature mortality was associated with a significantly higher dementia risk across all age groups (70-74 years, HR=1.20 [1.05-1.37]; 75-79 years, HR=1.19 [1.09-1.30]; 80-84 years, HR=1.12 [1.03-1.22]). Similarly, living in socioeconomically disadvantaged neighborhoods was associated with higher dementia risk (70-74 years, HR=1.15 [1.01-1.31]; 75-79 years, HR=1.13 [1.04-1.24]; 80-84 years, HR=1.12 [1.03-1.22]). Except for the oldest age group, a higher dementia risk existed for those living in areas with lower GDP (70-74 years, HR=1.23 [1.08-1.40]; 75-79 years, HR=1.12 [1.02-1.23]). Overall, environmental disparities in dementia risk decreased with age.

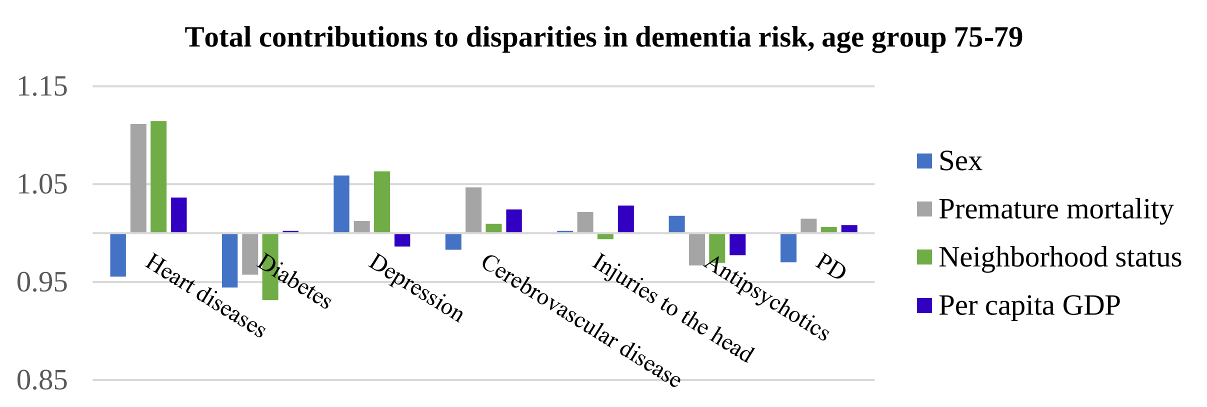

Figure 1: Total contribution to disparities in dementia risk. Total = Exposure * Vulnerability. Sources: Sources: AOK 2014-2019, Destatis 2015/16, RKI 2022, INKAR 2025.

In the multivariable Cox proportional hazard models, medical risk factors explained most sociodemographic and environmental disparities, but not across every age group (Table 2). Only among those aged 75-79 medical risk factors accounted for over half of the observed disparities by sex, premature mortality, socioeconomic neighborhood status, and GDP (Figure 1). For individuals aged 70-74, dementia disparities by the environmental indicators were explained by the medical risk factors to a lesser extent (Table 2). Diabetes, including medication, showed no significant contribution in explaining the environmental disparities. Among the oldest group (80-84), disparities by sex and area-level premature mortality became more pronounced, indicating only partial or independent effects of the medical risk factors.

Focusing on those aged 75-79, diabetes including medication most strongly explained the lower dementia risk for men, while depression including medication had the opposite effect (Figure 1, Table 2). Across environmental indicators, heart diseases including medication showed the strongest contribution to dementia risk increases for the disadvantaged. Contributions to disparities of the medical risk factors were mostly driven by vulnerability (strength of association) and partly by exposure (prevalence of risk factors). Vulnerability effects were most pronounced for heart disease across all indicators. An effect of exposure for depression including medication and cerebrovascular disease was observed, but it was marginal. Exceptionally for the sex disparity, the exposure effect of depression was higher than the vulnerability effect.

Conclusion

As population groups are differently exposed to the risk of dementia, understanding how sociodemographic and environmental disparities intersect with medical risk factors is crucial. We found significant disparities by sex, area-level premature mortality, socioeconomic neighborhood status, and per capita GDP. These were partly explained by medical risk factors. Diabetes and depression drove the sex disparity, while heart diseases contributed most to environmental disparities. Vulnerability to heart diseases was a key driver to dementia disparities. Future intervention should target vulnerable population groups with heart diseases, diabetes, and depression to decrease disparities in dementia risk.

Tables

Prevalence		Sociodemographic and environmental indicators							
		Sex		Area-level premature mortality		Socioeconomic neighborhood status		Area-level per capita GDP	
Medical risk factor	**Age at baseline**	**Men**	**Women**	**Low**	**High**	**Advantaged**	**Disadvantaged**	**High**	**Low**
Heart diseases incl. high-ceiling diuretics	**70-74**	41.4	37.7	38.2	41.7	38.5	41.0	38.1	42.0
	75-79	51.3	49.3	48.6	53.1	49.3	51.8	48.4	53.5
	80-84	62.4	63.5	62.1	64.9	62.5	64.1	61.6	65.8
Diabetes type 2 incl. insulins and analogues	**70-74**	43.0	36.2	38.1	41.8	38.1	41.6	38.6	40.7
	75-79	44.3	40.6	40.3	45.7	40.5	45.3	40.7	45.0
	80-84	46.9	44.2	43.7	47.9	43.5	48.1	44.0	47.5
Depression incl. antidepressants	**70-74**	27.7	44.5	39.0	32.7	38.2	34.3	38.4	33.6
	75-79	28.3	45.6	39.8	35.5	39.7	35.9	39.5	36.1
	80-84	31.1	48.7	44.2	38.9	43.5	40.2	43.4	40.3
Cerebrovascular disease	**70-74**	32.5	26.7	29.8	28.4	30.0	28.1	29.6	28.8
	75-79	38.3	32.2	34.9	34.5	35.3	33.7	35.1	34.0
	80-84	43.0	38.0	40.0	39.5	40.6	38.7	40.0	39.5
Injuries to the head	**70-74**	10.7	11.0	11.1	10.3	10.9	10.7	11.0	10.6
	75-79	13.3	13.3	13.7	12.6	13.8	12.4	13.3	13.4
	80-84	17.8	19.0	18.8	18.2	18.9	17.9	18.8	18.1
Antipsychotics	**70-74**	7.9	9.2	8.8	8.3	8.6	8.6	8.8	8.1
	75-79	10.3	11.2	11.0	10.5	10.9	10.6	11.1	10.3
	80-84	15.7	17.8	17.4	16.5	17.8	15.9	17.0	17.2
Parkinson's disease	**70-74**	3.4	2.6	2.8	3.2	2.8	3.2	2.8	3.4
	75-79	5.3	4.1	4.3	5.0	4.4	4.9	4.3	5.1
	80-84	7.4	5.3	6.3	5.7	6.1	6.0	6.1	6.0

Table 1: Prevalence of medical risk factors by sociodemographic and environmental indicators. Sources: AOK 2014-2019, Destatis 2015/16, RKI 2022, INKAR 2025.

Total = Exposure * Vulnerability	**Baseline age group**		
	70-74	**75-79**	**80-84**
Observed sex disparity (ref. female)	-	0.87	1.10
Unexplained sex disparity (ref. female)	-	0.93	1.23
Heart diseases incl. high-ceiling diuretics	-	0.96=1.00*0.96	-
Diabetes type 2 incl. insulins and analogues	-	0.94=0.99*0.95	-
Depression incl. antidepressants	-	1.06=1.05*1.01	-
Cerebrovascular disease	-	0.98=0.98*1.00	0.95=0.99*0.96
Injuries to the head	-	1.00=1.00*1.00	0.99=1.00*0.99
Antipsychotics	-	1.02=1.00*1.01	-
Parkinson's disease	-	0.97=0.99*0.98	-
Observed premature mortality disparity (ref. low)	1.20	1.19	1.12
Unexplained premature mortality disparity (ref. low)	1.15	1.06	1.18
Heart diseases incl. high-ceiling diuretics	1.00=1.01*0.99	1.11=1.01*1.10	-
Diabetes type 2 incl. insulins and analogues	-	0.96=1.01*0.95	-
Depression incl. antidepressants	0.99=0.97*1.02	1.01=0.99*1.02	-
Cerebrovascular disease	0.98=0.99*0.98	1.05=1.00*1.05	1.00=0.99*1.01
Injuries to the head	0.98=1.00*0.98	1.02=1.00*1.03	0.92=1.00*0.92
Antipsychotics	1.05=1.00*1.05	0.97=1.00*0.97	1.03=1.00*1.03
Parkinson's disease	0.96=1.00*0.96	1.01=1.00*1.01	0.95=1.00*0.95
Observed neighborhood status disparity (ref. advantaged)	1.15	1.13	1.12
Unexplained neighborhood status disparity (ref. advantaged)	1.13	1.05	1.08
Heart diseases incl. high-ceiling diuretics	1.03=1.01*1.02	1.11=1.01*1.11	1.10=1.00*1.10
Diabetes type 2 incl. insulins and analogues	-	0.93=1.01*0.93	0.97=1.00*0.97
Depression incl. Antidepressants	0.99=0.98*1.00	1.06=0.99*1.07	1.05=0.99*1.06
Cerebrovascular disease	0.92=0.99*0.93	1.01=0.99*1.01	0.94=1.00*0.94
Injuries to the head	1.00=1.00*1.00	0.99=0.99*1.00	1.03=1.00*1.03
Antipsychotics	1.04=1.00*1.04	0.97=1.00*0.97	-
Parkinson's disease	0.95=1.00*0.95	1.01=1.00*1.00	-
Observed GDP disparity (ref. high)	1.23	1.12	-
Unexplained GDP disparity (ref. high)	1.16	1.06	-
Heart diseases incl. high-ceiling diuretics	1.05=1.01*1.04	1.04=1.01*1.03	-
Diabetes type 2 incl. insulins and analogues	-	1.00=1.01*1.00	-
Depression incl. Antidepressants	0.95=0.98*0.96	0.99=0.99*0.99	-
Cerebrovascular disease	0.96=1.00*0.97	1.02=1.00*1.03	-
Injuries to the head	0.99=1.00*0.99	1.03=1.00*1.03	-
Antipsychotics	0.97=0.99*0.98	0.98=1.00*0.98	-
Parkinson's disease	1.01=1.01*1.00	1.01=1.00*1.00	-

Table 2: Observed disparity: Risk of dementia in univariable proportional hazard model; Explained disparity: Risk of dementia in multivariable proportional hazard model. “-” resembles no significant disparity/effect. Sources: AOK 2014-2019, Destatis 2015/16, RKI 2022, INKAR 2025.

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