

## Original Article

# Regional Deprivation, Stroke Incidence, and Stroke Care

An Analysis of Billing and Quality Assurance Data from the German State of Rhineland–Palatinate

Armin J. Grau, Sieghard Dienlin, Dirk Bartig, Werner Maier, Florian Buggle, Heiko Becher

## Summary

**Background:** Regional deprivation can increase the risk of illness and adversely affect care outcomes. In this study, we investigated for the German state of Rhineland–Palatinate whether spatial-structural disadvantages are associated with an increased frequency of ischemic stroke and with less favorable care outcomes.

**Methods:** We compared billing data from DRG statistics (2008–2017) and quality assurance data (2017) for acute ischemic stroke with the German Index of Multiple Deprivation 2010 (GIMD 2010) for the 36 districts (Landkreise) and independent cities (i.e., cities not belonging to a district) in Rhineland–Palatinate using correlation analyses, a Poisson regression analysis, and logistic regression analyses.

**Results:** The age-standardized stroke rates (ASR) ranged from 122 to 209 per 100 000 inhabitants, while the GIMD 2010 ranged from 4.6 to 47.5; the two values were positively correlated (Spearman's  $\rho = 0.47$ ; 95% confidence interval [0.16; 0.85]). In 2017, mechanical thrombectomies were performed more commonly (5.7%) in the first GIMD 2010 quartile of the regional areas (i.e., in the least deprived areas) than in the remaining quartiles (4.2–4.6%). The intravenous thrombolysis rates showed no differences from one GIMD 2010 quartile to another. Severe neurological deficits (National Institutes of Health Stroke Scale  $\geq 5$ ) on admission to the hospital were slightly more common in the fourth quartile (i.e., in the most deprived areas), while antiplatelet drugs and statins were somewhat less commonly ordered on discharge in those areas than in the first quartile.

**Conclusion:** These findings document a relationship between regional deprivation and the occurrence of acute ischemic stroke. Poorer GIMD 2010 scores were associated with worse care outcomes in a number of variables, but the absolute differences were small

### Cite this as:

Grau AJ, Dienlin S, Bartig D, Maier W, Buggle F, Becher H: Regional deprivation, stroke incidence, and stroke care—an analysis of billing and quality assurance data from the German state of Rhineland–Palatinate.

Dtsch Arztebl Int 2021; 118: 397–402. DOI: 10.3238/arztebl.m2021.0149

Regional deprivation, i.e., deficiencies in material and social resources at the regional level, can have substantial negative consequences for the health status of different segments of the population and is associated with a large number of diseases (1, 2). Multidimensional indexes of multiple deprivation (IMD) have proved to be suitable instruments for the analysis of regional inequalities in health. In our country, the German Index of Multiple Deprivation (GIMD) has been used to analyze a number of epidemiological issues and questions of healthcare research (2).

At the level of the individual and at the level of region of residence, unfavorable socioeconomic conditions are associated with an elevated risk of stroke (3). A person's socioeconomic circumstances as early as childhood are linked to their risk of stroke later in life (4–6). Furthermore, studies have shown connections between regional deprivation and poorer care after a stroke (7, 8). No research into regional deprivation, stroke incidence and stroke care has yet been carried out in Germany.

We used data from diagnosis-related groups (DRG) statistics (9) and the “Acute Stroke” quality assurance project in the German state of Rhineland–Palatinate to investigate whether multiple deprivation at the level of districts and independent cities (i.e., cities not belonging to a district) in this state correlates with the rate of hospital admissions for treatment of ischemic stroke and with elements of a lower quality of care for acute ischemic stroke.

## Material and methods

The state of Rhineland–Palatinate is made up of 12 independent cities and 24 districts (hereinafter referred to collectively as districts). We analyzed the DRG data of all patients resident in Rhineland–Palatinate who were assigned a main diagnosis of ischemic stroke (ICD-10 code I63: cerebral infarction) in the period 2008 to 2017. Patients with “discharge code 06” (transfer to another hospital) were excluded to avoid multiple documentation. For patients admitted to more than one hospital, only the last hospital was counted. The code I63 includes patients with a first or subsequent ischemic stroke. Recurrent strokes during inpatient treatment were coded as secondary diagnoses and

Department of Neurology, Ludwigshafen Hospital, Ludwigshafen: Prof. Dr. med. Armin J. Grau

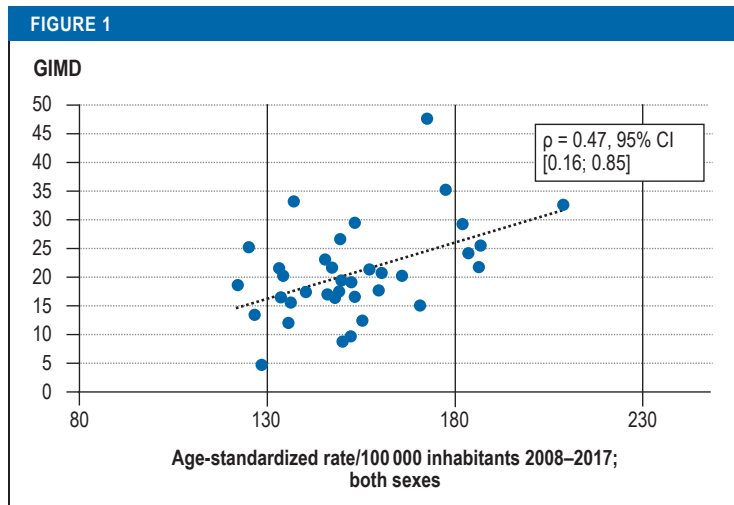
Quality Assurance Agency of Rhineland–Palatinate, Mainz: Dr. med. Sieghard Dienlin

DRG Market, Osnabrück: Dr. rer. nat. Dirk Bartig

Helmholtz Center Munich – German Research Center for Health and the Environment (Ltd), Institute for Health Economics and Management in Healthcare, Neuherberg: Dr. rer. biol. hum. Werner Maier

Oberwallis Hospital Center, Visp, Switzerland: Dr. med. Florian Buggle

Institute for Medical Biometry and Epidemiology, University Medical Center Hamburg-Eppendorf, Hamburg: Prof. Dr. rer. nat. Heiko Becher



**FIGURE 1**  
**GIMD**  
 Association between the age-standardized rates of ischemic stroke and the German Index of Multiple Deprivation 2010 (GIMD)  
 ρ, Spearman correlation coefficient; 95% CI, 95% confidence interval

were not included for analysis. Treatments in stroke units (code 8.981/8–98b in the German catalog of operations and procedures [OPS]) and recanalization therapy (systemic thrombolysis: OPS 8–020.8; mechanical thrombectomy: OPS 8–836.80) were identified from the DRG data.

Quality assurance procedures for all inpatients with acute stroke have been mandatory in Rhineland–Palatinate since 2006. The details documented are age, sex, postal code of place of residence (since 2017), vascular risk factors, previous strokes, investigation and treatment delays, diagnostic and therapeutic procedures, secondary prophylactic measures, severity of neurological deficit (National Institute of Health Stroke Scale, NIHSS), and degree of functional deficit (Barthel index) (10). The districts were identified on the basis of the postal codes; if the same postal code was used for more than one district, the patient was assigned to the district with the higher population. A total of 10 071 patients with ischemic stroke were documented in 2017. Of these, 624 were excluded because of a missing or erroneous postal code or residence outside Rhineland–Palatinate and a further 419 owing to double registration (eight criteria identical). The population for analysis thus comprised 9028 patients (recurrent strokes: 25.2%).

The study was approved by the ethics committee of the Rhineland–Palatinate Medical Association (application number: 2019–14656, retrospective).

The GIMD 2010 is based on data from 2010 (exception: data on the *Bundestag* election 2009) and comprises seven domains: income, unemployment, education, district revenue, social capital, environment, and security (11–14). The GIMD 2010 scores relate to the districts in which the patients’ residence is located.

### Statistical analyses

The 36 districts were divided into four quartiles according to GIMD 2010, with the lowest GIMD 2010 scores in the first quartile (least deprivation; reference).

The calculation of stroke incidence was age-standardized to the European Standard Population (15) (age-standardized rates). The Spearman correlation coefficient (ρ) with 95% confidence intervals (95% CI) was used for correlation analyses.

A Poisson regression analysis was carried out to establish the association between the incidence of stroke and the GIMD 2010 quartiles, with the incidence rate modeled at district level depending on the GIMD 2010 adjusted for age (10-year age classes) and sex, calendar year, and a binary variable “independent cities/districts”. For analysis of the OPS data, available only in aggregated form, differences between GIMD 2010 quartiles were calculated with 95% CI.

Logistic regression, adjusted for age, sex, and the parameters for which univariate analysis revealed associations (stroke severity [NIHSS] and diabetes mellitus), was performed to analyze the quality assurance data, which were available in the form of individual data sets. The analyses of the DRG statistics were conducted using the statistical package SAS, version 9.4, and the quality assurance data were evaluated with the statistics software R (version 3.1.1.).

### Results

The number of ischemic strokes treated in hospital increased by 10.9% between 2008 (n = 10 151) and 2017 (n = 11 259). The age-standardized rate (2008: 148; 2017: 152 per 100 000 inhabitants) went up by 2.7% (women –1.7%; men +6.9%; *eTable 1*).

Across the 36 districts the age-standardized stroke rate (means 2008–2017) ranged from 122 to 209 (women 95–155, men 151–245) per 100 000 inhabitants. The mean GIMD 2010 was 20.7 (range 4.6–47.5; range for Germany as a whole: 2.0–71.0). The GIMD 2010 and the district stroke rate showed a statistically significant positive association (ρ = 0.47; 95% CI: [0.16; 0.85]) (men ρ = 0.52 [0.23; 0.91]; women ρ = 0.43 [0.11; 0.80]) (*Figures 1 and 2*). The age-standardized rate increased steadily with the ascending quartiles of the GIMD 2010 and was 1.28 [1.22; 1.35] times higher in the fourth quartile than in the first quartile (*Table 1*). Poisson regression showed a lower stroke rate in independent cities than in districts (relative risk: 0.86 [0.81; 0.91]). Interaction analyses of the associations among individual variables demonstrated a slight decrease in the effect of the GIMD 2010 with increasing age and a somewhat stronger influence of the GIMD 2010 in independent cities than in districts, but no change in the magnitude of the association between GIMD 2010 and stroke rate over the 10-year period (*eTable 2*).

The rate of treatment in stroke units was somewhat higher in the first and fourth quartiles than in the intermediate quartiles. For intravenous thrombolysis

there was no difference among the GIMD 2010 quartiles. In respect of mechanical thrombectomy, the rates in the first quartile were somewhat higher than in the other quartiles (Table 2).

With regard to the DRG data, the documentation rate of ischemic strokes by quality assurance was lower in the fourth quartile of 2017 than in the other quartiles. The severity of the neurological (NIHSS) and functional (Barthel index) deficits at admission increased marginally with increasing degree of deprivation; severe deficits were statistically significantly more frequent in the fourth quartile than in the first quartile. There were no relevant differences in the time from stroke occurrence to admission. The 7-day mortality was non-significantly higher in the fourth quartile (3.3%) than in the first quartile (2.2%). Apart from a slightly lower rate of platelet aggregation inhibitors and statins on discharge in the fourth quartile, the regions did not differ with respect to secondary prophylaxis and rehabilitation procedures (eTable 3).

### Discussion

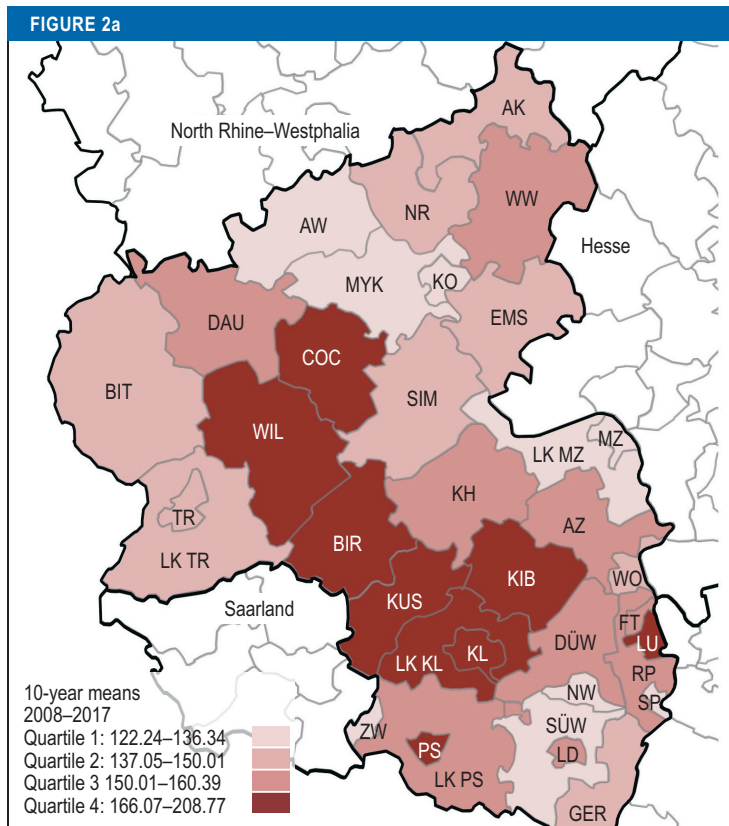
Our analyses show a statistically significant association between regional deprivation and hospital treatment of ischemic stroke in the German state of Rhineland-Palatinate.

Similar associations have been found in studies from various countries (7, 16–18). The stroke rate was 28% higher in the quartile of districts with the greatest deprivation than in the districts with the least deprivation. In an English study in which the territorial units considered were small, the differences were more clearly aligned with regional deprivation (7). The districts and cities of Rhineland-Palatinate are not homogeneous in their socioeconomic structure. The actual effect sizes may be underestimated owing to socioeconomic heterogeneity of the territorial entities. Our study concerned itself purely with the perspective of regional deprivation and did not look at individual socioeconomic status. However, various studies have shown a statistically significant and independent effect of regional deprivation on health even after controlling for individual socioeconomic factors (19).

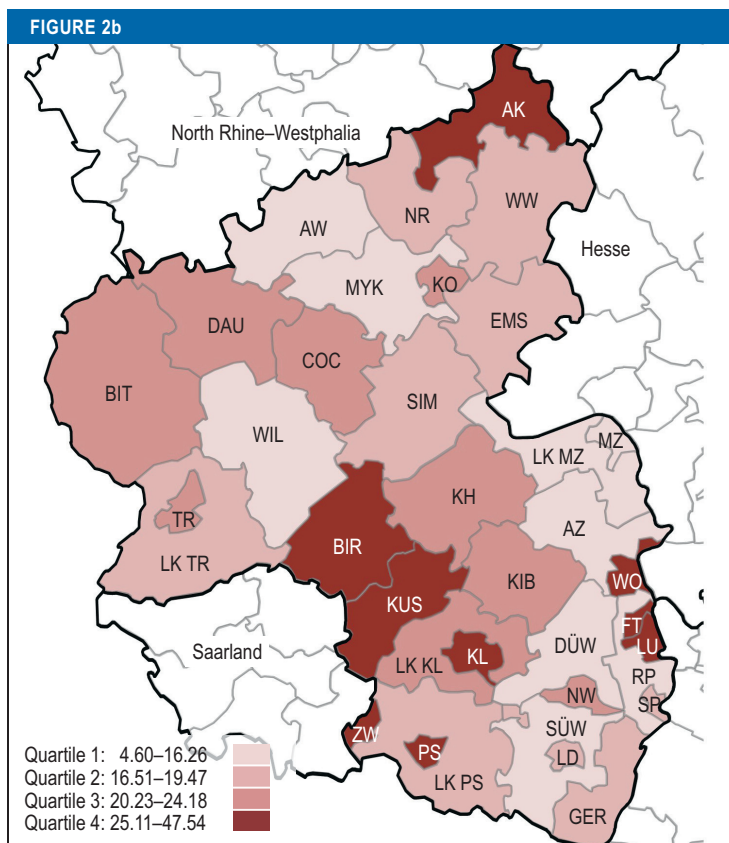
#### Abbreviations in Figures 2a and 2b:

(LK = district): AK (LK Altenkirchen), AW (LK Ahrweiler), AZ (LK Alzey-Worms), BIR (LK Birkenfeld), BIT (Eifelkreis Bitburg-Prüm), COC (LK Cochem-Zell), DAU (LK Vulkaneifel), DÜW (LK Bad Dürkheim), EMS (Rhein-Lahn-Kreis), FT (Frankenthal), GER (LK Germersheim), KH (LK Bad Kreuznach), KIB (Donnersberg-Kreis), KL (Kaiserslautern), KO (Koblenz), KUS (LK Kusel), LD (Landau), LK KL (LK Kaiserslautern), LK MZ (LK Mainz-Bingen), LK PS (LK Südwestpfalz), LK TR (LK Trier-Saarburg), LU (Ludwigshafen a. Rh.), MZ (Mainz), MYK (LK Mayen-Koblenz), NR (LK Neuwied), NW (Neustadt Weinstraße), PS (Pirmasens), RP (Rhein-Pfalz-Kreis), SIM (Rhein-Hunsrück-Kreis), SP (Speyer), SÜW (LK Südliche Weinstraße), TR (Trier), WIL (LK Bernkastel-Wittlich), WO (Worms), WW (Westerwald-Kreis), ZW (Zweibrücken)

Maps produced by Dr. Dirk Bartig using his own software based on OpenStreetMap; classification by official municipality code (allgemeine Gemeindegchlüssel, AGS) as of 2016



Quartiles of the age-standardized rates of ischemic stroke in Rhineland-Palatinate



Quartiles of the German Index of Multiple Deprivation 2010 (GIMD) in Rhineland-Palatinate

TABLE 1

**Association between the quartiles of the German Index of Multiple Deprivation 2010 (GIMD) and the age-standardized stroke rates 2008–2017 in the 36 independent cities and districts of Rhineland–Palatinate**

	Age-standardized rates/100 000 inhabitants			
	Quartile 1 (4.6–16.3)	Quartile 2 (16.5–19.5)	Quartile 3 (20.2–24.2)	Quartile 4 (25.1–47.5)
Women	114	117	126	137
Men	173	175	191	203
Overall	143	145	157	169
Incidence ratio* [95% CI]	1.00	1.05 [1.02; 1.08]	1.16 [1.12; 1.21]	1.28 [1.22; 1.35]

\* Poisson analysis for both sexes together (for further results of Poisson analysis see *eTable 2*)  
 Quartile 1 (least deprivation) is the reference quartile.  
 95% CI, 95% Confidence interval

TABLE 2

**Association between the GIMD 2010 quartiles and care data from the DRG statistics 2017**

Hospital statistics	Overall	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Number of patients	11 259	3738	2918	2347	2256
Treatment in stroke unit (%)	69.5%	72.4%	65.3%	68.3%	71.2%
Difference (%) from quartile 1 [95% CI]			-7.1 [-4.0; -9.4]*	-4.1 [-1.7; -6.5]*	-1.3 [1.1; -3.6]
Intravenous thrombolysis (%)	15.1%	14.6%	14.9%	15.2%	16.3%
Difference (%) from quartile 1 [95% CI]			0.33 [-1.4; 2.1]	0.63 [-1.2; 2.5]	1.7 [-0.2; 3.6]
Mechanical thrombectomy (%)	4.9%	5.7%	4.6%	4.2%	4.6%
Difference (%) from quartile 1 [95% CI]			-1.10 [-0.03; -2.2]*	-1.55 [-0.5; -2.7]*	-1.12 [0.03; -2.3]

\*  $p < 0.05$   
 DRG, Diagnosis-related groups; GIMD, German Index of Multiple Deprivation; 95% CI, 95% confidence interval

The increasing overall number of ischemic strokes corresponds with the general epidemiological trend against the backdrop of higher life expectancy. However, the age-standardized incidence of first strokes is decreasing in the western industrialized countries (20). Consideration of our finding of a slight rise in the age-standardized stroke rate must be tempered by the fact that our analysis included both first and recurrent strokes. We used DRG data because these, in contrast to the figures from the State Statistical Office, avoid double registration of transferred patients. The gold standard for the calculation of stroke incidence is a population-based stroke register like the one maintained for Rhineland–Palatinate in Ludwigshafen (21). The incidences derived from billing data are higher than those from population-based stroke registers. One reason for this is the misplaced incentive, in the DRG system, to assign the diagnostic code for stroke even in the case of doubt. However, this effect is presumably constant across regions and thus can be assumed to have no influence on the association we observed. The hospitalization rate for acute stroke is around 95%, so hospital data embrace nearly all patients.

One essential factor in the association between regional deprivation and stroke incidence is that vascular risk factors such as diabetes mellitus, obesity, and high blood pressure are found more frequently in deprived areas (22, 23). As found in other studies (7, 8, 18, 19), diabetes mellitus was over-represented in the more greatly deprived regions of our study

The severity of the neurological and functional deficits increased slightly, yet significantly, with the degree of regional deprivation. Some (24, 25) but not all of the studies on this topic (8) report similar associations. The documentation of the NIHSS by large numbers of physicians has to be treated with caution; however, agreement with the results of the Barthel index, which is assessed by nursing staff, supports the present findings.

The studies to date have shown varying results with regard to the impact of socioeconomic factors on the quality of care in acute stroke (3, 7, 8, 26–28). Even in prosperous countries (7, 26–28), associations have been found between regional deprivation and lower standards of care, e.g., a lower lysis rate (7, 27) or a lower rate of prescription of oral anticoagulants in the event of atrial fibrillation (28).



In contrast to intravenous thrombolysis, mechanical thrombectomy was carried out more frequently in the least deprived regions; the absolute differences, however, were small. It may be that medical innovations are implemented sooner in socioeconomically advantaged areas. The time from symptom onset to inpatient admission did not increase in line with the deprivation index—a sign that spatial distance from the treatment center is probably not an important parameter. Patients in regions belonging to the fourth GIMD 2010 quartile were given thrombocyte aggregation inhibitors and statins somewhat less frequently than those in the first quartile; the absolute differences were, however, small.

The strengths of our study include the high case numbers and the analysis of both billing data and quality assurance data. The limitations comprise the lack of data on risk factors such as smoking and on the quality of treatment of risk factors; the lower documentation rate of patients in more deprived regions for quality assurance purposes; the inclusion of both first strokes and recurrences; and the relatively large size of the territorial units considered.

In summary, our study both demonstrates a statistically significant association between regional deprivation and the incidence of ischemic stroke and suggests an association between regional deprivation and stroke severity. Stroke prevention programs should thus pay particular attention to disadvantaged regions. However, our results show that there is no strong association between regional deprivation and stroke care in Rhineland–Palatinate.

**Acknowledgments**

We are grateful to Dr. med. Christoph Burmeister, MPH, director of the SQMed Quality Assurance Agency of Rhineland–Palatinate, for his support of the project and to Cornelius Grau for his assistance in data evaluation.

**Conflict of interest statement**

Dr. Bartig has been contracted by Boehringer Ingelheim to perform analyses of the German Diagnosis-Related Groups system. The remaining authors state that no conflict of interest exists.

Manuscript received on 7 December 2020, revised version accepted on 4 February 2021

Translated from the original German by David Roseveare

**References**

1. Hofmeister C, Maier W, Mielck A, Stahl L, Breckenkamp J, Razum O: Regionale Deprivation in Deutschland: bundesweite Analyse des Zusammenhangs mit Mortalität unter Verwendung des „German Index of Multiple Deprivation“ (GIMD). *Gesundheitswesen* 2016; 78: 42–8.
2. Maier W: Indizes multipler Deprivation zur Analyse regionaler Gesundheitsunterschiede in Deutschland: Erfahrungen aus Epidemiologie und Versorgungsforschung. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 2017; 60: 1403–12.
3. Marshall J, Wang Y, Crichton S, McKeivitt C, Rudd AG, Wolfe CD: The effects of socioeconomic status on stroke risk and outcomes. *Lancet Neurol* 2015; 14: 1206–18.
4. McHutchison CA, Backhouse EV, Cvoro V, Shenkin SD, Wardlaw JM: Education, socioeconomic status, and intelligence in childhood and stroke risk in later life: a meta-analysis. *Epidemiology* 2017; 28: 608–18.
5. Becher H, Palm F, Aigner A, et al.: Socioeconomic conditions in childhood, adolescence, and adulthood and the risk of ischemic stroke. *Stroke* 2016; 47: 173–9.

6. Grau AJ, Aigner A, Urbanek C, et al.: Socioeconomic decline and advancement within and between generations and the risk of stroke—a case-control study. *Neurol Res Pract* 2019; 1: 8.
7. Bray BD, Paley L, Hoffman A, et al.: Socioeconomic disparities in first stroke incidence, quality of care, and survival: a nationwide registry-based cohort study of 44 million adults in England. *Lancet Public Health* 2018; 3: e185–e93.
8. Kapral MK, Fang J, Chan C, et al.: Neighborhood income and stroke care and outcomes. *Neurology* 2012; 79: 1200–7.
9. Statistisches Bundesamt (Destatis), DRG-Statistik Berichtsjahre 2008–2017; aus dem Krankenhaus entlassene vollstationäre Patienten (einschl. Sterbe- und Stundenfälle), 2020. [www.destatis.de/DE/Methoden/Qualitaet/Qualitaetsberichte/Gesundheit/fallpauschalebezogene-krankenhausstatistik.pdf?\\_\\_blob=publicationFile](http://www.destatis.de/DE/Methoden/Qualitaet/Qualitaetsberichte/Gesundheit/fallpauschalebezogene-krankenhausstatistik.pdf?__blob=publicationFile) (Daten im Bestand der Autoren).
10. Grau AJ, Eicke M, Biegler MK, et al.: Quality monitoring of acute stroke care in Rhineland-Palatinate, Germany, 2001–2006. *Stroke* 2010; 41: 1495–500.
11. Noble M, Wright G, Smith G, et al.: Measuring multiple deprivation at the small-area level. *Environment and Planning* 2006; 38: 169–85.
12. Maier W, Fairburn J, Mielck A: Regionale Deprivation und Mortalität in Bayern. Entwicklung eines „Index Multipler Deprivation“ auf Gemeindeebene. *Gesundheitswesen* 2012; 74: 416–25.
13. Bauer H, Maier W: GIMD 2010 – Ein Update des „German Index of Multiple Deprivation“. *Berichte des Helmholtz Zentrums München* 2018; doi:10.15134/2018M0001.
14. Schederecker F, Kurz C, Fairburn J, Maier W: Do alternative weighting approaches for an Index of Multiple Deprivation change the association with mortality? A sensitivity analysis from Germany. *BMJ Open* 2019; 26: e028553.
15. Revision of the European Standard Population – Report of Eurostat’s task force – 2013 edition. [www.ec.europa.eu/eurostat/de/web/products-manuals-and-guidelines/-/KS-RA-13-028](http://www.ec.europa.eu/eurostat/de/web/products-manuals-and-guidelines/-/KS-RA-13-028) (last accessed on 12 June 2020).
16. Grimaud O, Béjot Y, Heritage Z, et al.: Incidence of stroke and socioeconomic neighborhood characteristics: an ecological analysis of Dijon stroke registry. *Stroke* 2011; 42: 1201–6.
17. Heeley EL, Wei JW, Carter K, et al.: Socioeconomic disparities in stroke rates and outcome: pooled analysis of stroke incidence studies in Australia and New Zealand. *Med J Aust* 2011; 195: 10–4.
18. Andersen KK, Steding-Jessen M, Dalton SO, Olsen TS: Socioeconomic position and incidence of ischemic stroke in Denmark 2003–2012. A nationwide hospital-based study. *J Am Heart Assoc* 2014; 3: e000762.
19. Maier W, Holle R, Hunger M, et al.: The impact of regional deprivation and individual socio-economic status on the prevalence of Type 2 diabetes in Germany. A pooled analysis of five population-based studies. *Diabet Med* 2013; 30: e78–86.
20. Feigin VL, Forouzanfar MH, Krishnamurthi R, et al.: Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet* 2014; 383: 245–54.
21. Palm F, Urbanek C, Rose S, et al.: Stroke incidence and survival in Ludwigshafen am Rhein, Germany: the Ludwigshafen stroke study (LuSt). *Stroke* 2010; 41: 1865–70.
22. Maier W, Scheidt-Nave C, Holle R, et al.: Area level deprivation is an independent determinant of prevalent type 2 diabetes and obesity at the national level in Germany. Results from the national telephone health interview surveys „German Health Update“ GEDA 2009 and 2010. *PLoS One* 2014; 9: e89661.
23. Siegel M, Mielck A, Maier W: Individual income, area deprivation, and health: Do income-related health inequalities vary by small area deprivation? *Health Econ* 2015; 24: 1523–30.
24. Béjot Y, Guilleateau A, Joux J, et al.: Social deprivation and stroke severity on admission: a French cohort study in Burgundy and the West Indies–Guyana region. *Eur J Neurol* 2017; 24: 694–702.
25. Marshall J, Wang Y, Crichton S, McKeivitt C, Rudd AG, Wolfe CD: The effects of socioeconomic status on stroke risk and outcomes. *Lancet Neurol* 2015; 14: 1206–18.
26. Langagergaard V, Palnum KH, Mehnert F, et al.: Socioeconomic differences in quality of care and clinical outcome after stroke: a nationwide population-based study. *Stroke* 2011; 42: 2896–902.
27. Stecksén A, Glader EL, Asplund K, Norrving B, Eriksson M: Education level and inequalities in stroke reperfusion therapy: observations in the Swedish stroke register. *Stroke* 2014; 45: 2762–8.
28. Sjölander M, Eriksson M, Asplund K, Norrving B, Glader EL: Socioeconomic Inequalities in the prescription of oral anticoagulants in stroke patients with atrial fibrillation. *Stroke* 2015; 46: 2220.

**Corresponding author**

Prof. Dr. med. Armin J. Grau  
 Neurologische Klinik  
 Klinikum der Stadt Ludwigshafen am Rhein  
 Bremsersstr. 69  
 67063 Ludwigshafen am Rhein, Germany  
 grau@klllu.de

**Cite this as:**

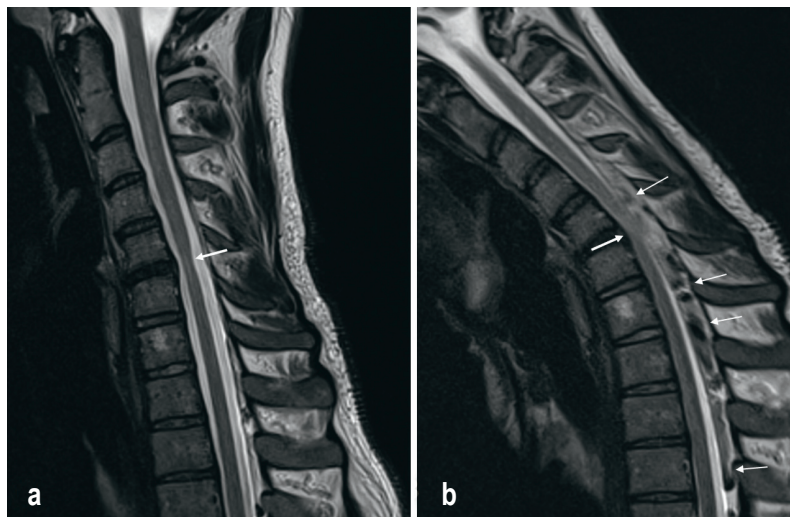
Grau AJ, Dienlin S, Bartig D, Maier W, Bugge F, Becher H:  
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 Dtsch Arztebl Int 2021; 118: 397–402. DOI: 10.3238/arztebl.m2021.0149

► **Supplementary material**

**eTables:**

[www.aerzteblatt-international.de/m2021.0149](http://www.aerzteblatt-international.de/m2021.0149)

**CLINICAL SNAPSHOT**



**Figure:**

- a) T2-weighted MRI in a neutral head position showing segmental myelopathy signals and myelonatrophy at the level of C5–C6 (white arrow).
- b) T2-weighted MRI during maximum head flexion with evidence of massive anterior displacement of the dorsal dura and secondary enlarged dorsal epidural space with venous congestion (thin arrows). This resulted in high-grade spinal canal stenosis at the level of C5–C6 (thick arrow).

**Male Adolescent with Left-Sided Muscle Atrophy of the Hand—The Rare Entity of Cervical Flexion Myelopathy (Hirayama disease)**

A 19-year-old male presented with painless atrophic paralysis of the left-hand muscles (grade of muscle strength, 3/5) with no sensory impairment and normal muscle stretch reflexes. Magnetic resonance imaging (MRI) of the cervical spine in the supine position showed segmental myelopathy with cervical spinal cord atrophy of cervical vertebrae C5–C6 in the absence of mechanical spinal cord compression (*Figure a*). Dynamic cervical spine MRI while the patient performed maximum head flexion revealed massive ventral displacement of the dorsal dura with subsequent high-grade spinal canal stenosis and congestion of the epidural veins in the corresponding spinal motion segment C5–C6. Based on this, cervical flexion myelopathy (Hirayama disease) was diagnosed (*Figure b*), an extremely rare differential diagnosis of both autoimmune inflammatory multifocal motor neuropathy (MMN) and monomelic-onset amyotrophic lateral sclerosis (ALS). This leads (usually in young males) to

progressive degeneration of the motor anterior horn cells of the cervical spinal cord and atrophic hand muscle paralysis as a result of head flexion-related spinal canal stenosis and secondary venous congestion. Conservative treatment with a cervical collar in order to avoid continued spinal cord compression from head flexion resulted in long-term clinical stabilization.

**Dr. med. Filipp Maximilian Filippopolos**, Klinik und Poliklinik für Neurologie, Ludwig-Maximilians-Universität München

**Dr. med. Maximilian Patzig**, Institut für Diagnostische und Interventionelle Neuroradiologie, Ludwig-Maximilians-Universität München

**Dr. med. Florian Schöberl**, Klinik und Poliklinik für Neurologie, Ludwig-Maximilians-Universität München, Florian.Schoeberl@med.uni-muenchen.de

**Conflict of interest statement:** The authors declare that no conflict of interest exists.

Translated from the original German by Christine Rye.

**Cite this as:** Filippopolos FM, Patzig M, Schöberl F: Male adolescent with left-sided muscle atrophy of the hand—the rare entity of cervical flexion myelopathy (Hirayama disease). Dtsch Arztebl Int 2021; 118: 402. DOI: 10.3238/arztebl.m2021.0102

Supplementary material to:

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eTABLE 1

**Frequency and age-standardized rates (ASR)\* of ischemic stroke in Rhineland–Palatinate 2008–2017; data from DRG statistics**

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>Number</b>	<b>Overall</b>	<b>10 151</b>	<b>10 251</b>	<b>10 645</b>	<b>10 757</b>	<b>11 098</b>	<b>11 191</b>	<b>11 267</b>	<b>11 365</b>	<b>11 386</b>	<b>11 259</b>
	Women	5165	5072	5303	5359	5549	5339	5526	5375	5310	5256
	Men	4986	5179	5342	5398	5549	5852	5741	5990	6076	6003
<b>ASR</b>	<b>Overall</b>	<b>148</b>	<b>147</b>	<b>149</b>	<b>150</b>	<b>151</b>	<b>155</b>	<b>154</b>	<b>154</b>	<b>154</b>	<b>152</b>
	Women	122	119	120	123	122	122	127	122	120	120
	Men	174	175	178	178	183	191	184	190	191	186

\* Per 100 000 inhabitants and year  
DRG, Diagnosis-related groups

eTABLE 2

**Association between the GIMD 2010 quartiles and the age-standardized rates of ischemic stroke\***

	Relative risk	95% Confidence interval	p-Value
GIMD 2010 districts			
Quartile 1	1.00	–	–
Quartile 2	1.05	[1.02; 1.08]	0.0002
Quartile 3	1.16	[1.12; 1.21]	<0.0001
Quartile 4	1.28	[1.22; 1.35]	<0.0001
Men versus women	1.76	[1.71; 1.80]	<0.0001
Cities versus districts	0.86	[0.81; 0.91]	<0.0001
Change in incidence/year (2008–2017)	1.004	[0.997; 1.010]	0.30
Interaction terms to explore associations between variables			
GIMD 2010 × age	0.999	[0.998; 0.999]	<0.0001
GIMD 2010 × city	1.02	[1.00; 1.04]	0.043
GIMD 2010 × year	1.000	[0.998; 1.003]	0.68
Sex × age	0.988	[0.987; 0.989]	<0.0001
Intercept	0.001	[0.001; 0.001]	<0.0001

\* Adjusted for sex, cities/districts including interaction terms (Poisson analysis)  
GIMD, German Index of Multiple Deprivation

eTABLE 3

**Association between the GIMD 2010 quartiles and the quality assurance project “Acute Stroke” 2017**

	Overall	Quartile 1	Quartile 2	Quartile 3	Quartile 4
<b>Number of patients</b>	9028	3193	2216	1996	1623
Proportion of all patients relative to DRG statistics (%)	80.2	85.4	85.4	85.0	71.9
<b>Demographic variables</b>					
Age (years; mean and SD)	73.7 ±13.3	73.8 ±12.9	73.4 ±13.4	73.9 ±13.5	73.7 ±13.6
Women (%)	47.0	45.5	46.4	47.2	50.4
<b>Relevant prior morbidity</b>					
Arterial hypertension (%)	85.2	84.6	87.1	84.8	84.3
Diabetes mellitus (%)	29.3	28.6	29.1	27.9	32.4
Atrial fibrillation (%)	27.9	28.0	26.4	28.4	28.8
Previous stroke (%)	25.2	25.7	27.6	22.2	24.6
<b>Variables on admission</b>					
Time to admission <4 h* <sup>5</sup> (%) (OR [95% CI]) <sup>*4</sup>	36.9	37.81	35.3; 0.88 [0.78; 0.98] <sup>*1</sup>	36.3; 0.91 [0.81; 1.03]	38.1; 1.02 [0.90; 1.16]
Severe neurological deficit on admission; NIHSS > 5 (%) (OR [95% CI]) <sup>*3</sup>	33.1	32.01	32.1; 1.02 [0.92; 1.15]	33.7; 1.06 [0.94; 1.20]	36.1; 1.25 [1.09; 1.43] <sup>*1</sup>
Severe functional deficit on admission; Barthel index <60 (%) <sup>*6</sup> (OR [95% CI]) <sup>*3</sup>	36.3	34.71	36.5; 1.10 [0.97; 1.25]	36.6; 1.07 [0.95; 1.22]	38.7; 1.19 [1.04; 1.35] <sup>*1</sup>
Dysphagia screening <sup>*7</sup> (%) (OR [95% CI])	90.6	92.31	87.9; 0.62 [0.51; 0.76] <sup>*2</sup>	91.0; 0.83 [0.67; 1.03]	90.3; 0.75 [0.60; 0.94] <sup>*1</sup>
<b>Mortality</b>					
Mortality after 7 days <sup>*8</sup> (%) <sup>*4</sup> (OR [95% CI])	2.7	2.21	3.0; 1.33 [0.91; 1.95]	2.8; 1.18 [0.80; 1.75]	3.3; 1.43 [0.96; 2.13]
<b>Treatment on discharge</b>					
Platelet aggregation inhibitors <sup>*9</sup> (%) (OR [95% CI]) <sup>*4</sup>	96.6	96.91	96.4; 0.85 [0.57; 1.26]	97.1; 1.07 [0.70; 1.64]	95.6; 0.66 [0.44; 0.98] <sup>*1</sup>
OAC in AF <sup>*10</sup> (%) (OR [95% CI]) <sup>*4</sup>	92.2	91.91	94.1; 1.38 [0.75; 2.53]	92.4; 1.07 [0.61; 1.86]	90.1; 0.80 [0.46; 1.39]
Antihypertensives <sup>*11</sup> (%) (OR [95% CI]) <sup>*4</sup>	73.1	71.81	73.1; 1.50 [1.05; 2.13]	75.7; 1.16 [0.83; 1.63]	72.6; 1.23 [0.85; 1.77]
Statins <sup>*12</sup> (%) (OR [95% CI]) <sup>*4</sup>	87.6	88.41	88.6; 1.03 [0.85; 1.24]	86.8; 0.88 [0.73; 1.06]	85.8; 0.79 [0.66; 0.96] <sup>*1</sup>
Rehab treatment <sup>*13</sup> (%) (OR [95% CI]) <sup>*4</sup>	73.1	71.81	73.1; 1.12 [0.91; 1.37]	75.7; 1.23 [1.00; 1.53]	72.6; 1.03 [0.83; 1.28]

Definitions and explanations:

\*1 p <0.05

\*2 p <0.005

\*3 Adjusted for age, sex, diabetes mellitus

\*4 Additionally adjusted for NIHSS on admission

\*5 Time from symptom onset to hospital admission <4 h

\*6 Barthel index: 0–100 points; low score corresponds to more severe functional deficit

\*7 Dysphagia screening performed according to standard protocol in the hospital concerned

\*8 Proportion of patients who died in the first 7 days, excluding patients who were transferred to other departments, hospitals, or rehabilitation/care facilities

\*9 Patients with platelet aggregation inhibitor at discharge, related to all patients with ischemic cerebral infarction after exclusion of patients with anticoagulation, palliative treatment, or length of stay <1 day

\*10 Patients with oral coagulation recommended or given at discharge, related to all patients with ischemic cerebral infarction and atrial fibrillation who were discharged to their own home or a rehab facility and were slightly or moderately immobilized (operationalized by means of two items from the Barthel index or the Rankin scale at discharge)

\*11 Patients with antihypertensive treatment at discharge, related to all patients with arterial hypertension after exclusion of patients with palliative treatment or length of stay <1 day

\*12 Patients with statins at discharge, related to all patients with ischemic cerebral infarction after exclusion of patients with palliative treatment or length of stay <1 day

\*13 Patients registered for outpatient or inpatient rehabilitation treatment, related to all patients not resident in a care home before their stroke and a score of 2–5 on the modified Rankin scale at discharge, after exclusion of patients with palliative treatment goal or transfer to another hospital

AF, Atrial fibrillation; DRG, diagnosis-related groups; GIMD, German Index of Multiple Deprivation; NIHSS, National Institute of Health Stroke Scale (higher scores correspond to more pronounced neurological deficits); OAC, oral anticoagulants; OR, odds ratio; SD, standard deviation; 95% CI, 95% confidence interval