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Neighborhood socioeconomic status and its associations with stroke incidence and severity in Berlin.

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INTRODUCTION

- The burden of CVD is the highest among all disease groups on a global scale, and stroke is one of the **two leading causes of mortality and disability in the world**. [1]
- SES does not have one single universally accepted definition, but is classically measured as a composite of 3 variables: **income, occupation, and education** [2, 3], which in turn are associated to factors like knowledge, prestige, access to resources, and power. [4]
- Stroke affects **lower-income populations more frequently**, both **between and within countries**, in terms of risk factor prevalence, disease incidence, short-and-long-term consequences and death-rate. [5–8]
- Group-level factors have received much attention in epidemiology over the past years, and have prompted the recent interest and debate on the **potential health effects of group-level constructs**, such as income inequality, social capital, and neighborhood characteristics. [9]
- Group-level variables can be an important **source of confounding** when making **causal inference** analyses in healthcare. [9-11] Not controlling for relevant group-level variable in an individual-level analysis would lead to a **psychologistic fallacy** (falsely assuming that individual level outcomes are explained exclusively by individual-level variables). [12]

CURRENT STATE OF RESEARCH

- There is an ever-growing body of literature that aims to understand the **effects of nSES on stroke**. It has been shown that **areas with lower neighborhood SES (nSES)** have [14–21]:

- higher stroke incidence; mortality risk (up to 3 times)
- costs of treating, need for long-term care, and depression rates
- events occur at a younger age, education-level about risk factors and warning signs is lower.

These areas with higher risk of stroke have been reported to be spatially clustered [22].

- A systematic review (2021) examining the effect of nSES on stroke incidence, **considering only studies that controlled for individual SES (iSES)**, showed that in some contexts, the effects remain statistically significant after the individual measurement in the models, and in others, they don’t.[25]
- The causal effect of nSES on stroke can only be assessed by **controlling for all potential confounders, including iSES**. Otherwise, <u>we would be committing an ecological fallacy</u>.
- **Literature in Germany about this topic is scarce**, and I couldn’t find **any studies** contrasting nSES and stroke-related parameters **in Berlin**.

OBJECTIVES

- **Primary objectives:**

- Contribute to the current understanding on the relationship between **nSES and stroke incidence**

- Assess the association between **nSES and functional outcomes (mRS at 3 months)**

- **Secondary objective**

- Create an adapted variable to estimate nSES in Berlin at the postal (ZIP) code level.

METHODS (1) – DATA SOURCES

- This is a **descriptive**, registry-based study, with analyses at the **ecological (group) level**.
- I obtained stroke data from the **B_SPATIAL registry**, which has collected information about **14.429 stroke patients** in Berlin since the year 2016. It's administered by the Center for Stroke Research (CSB) at the Charité in Berlin and includes **information of the 15 hospitals with stroke units** in the city.
- I defined a neighborhood as **the postal (ZIP) code in which patients were picked** by the ambulance. I obtained the official list of ZIP codes in Berlin (190) from the FIS-Broker, a collection of cartographically relevant information published by the Berlin Senate.
- To assign a nSES value to each postal code, I used the **Social-structure atlas of Berlin** (SSAB), updated in January 2022 by the Berlin Senate. The SSAB splits Berlin in several **geographic regions (called LORs)** and **assigns a nSES value,** called ESIx-value (Employment and Social Index) to each of them.
- I **matched every postal code with one LOR**, and consequently, with its corresponding ESIx

METHODS (2.1) – STATISTICAL ANALYSIS

- All statistical analyses were conducted using **Rstudio** (version 1.3.1093). I cleaned, merged and grouped the data using the ***dplyr* package** (version 1.1.0). I used the ***ggplot2* package** (version 3.4.1) to graphically assess all the associations and to plot maps. I applied Generalized Linear Models (GLM) to do the analyses.

Objective 1 – nSES and stroke incidence

- I used the *pois.exact* function of the *epitools* package (version 0.5-10.1) to compute **incidence rates (IR)** per postal code, as the <u>ratio of new cases and the total population multiplied by the number of years observed</u>.
- Initially, I used a **Poisson regression** to model my data. Eventually, I had to change this to a **Negative binomial regression**.
- To do this, I used the *glm* function of the ***stats* package** (version 3.6.2), where nSES was the independent variable, the logarithm of person-time was the offset, and the number of cases was the dependent variable. I also included covariates such as age and sex distribution per neighborhood

METHODS (2.2) – STATISTICAL ANALYSIS

Objective 2 – nSES and functional outcome (mRS)

- I measured the association between nSES and the mRS at 3 months by using an **ordinal logistic regression**. Low mRS values are better then high values.
- I used the *polr* function of the ***MASS* package** (version 7.3-58.1), as well as the *orm* function of the **rms package** (version 6.3-0) and compared their results. I made this analysis with the rounded-up median mRS, and I also repeated it using the rounded-down median, to make sure that this wouldn't condition my results.
- The assessment of the proportion of neighborhoods with different median mRS values was made using **quintiles of the ESIx variable**.

RESULTS

The final sample included 5414 patients (53% female). The most common age period of events was between 73 and 85 years, with males suffering from stroke at a younger age.

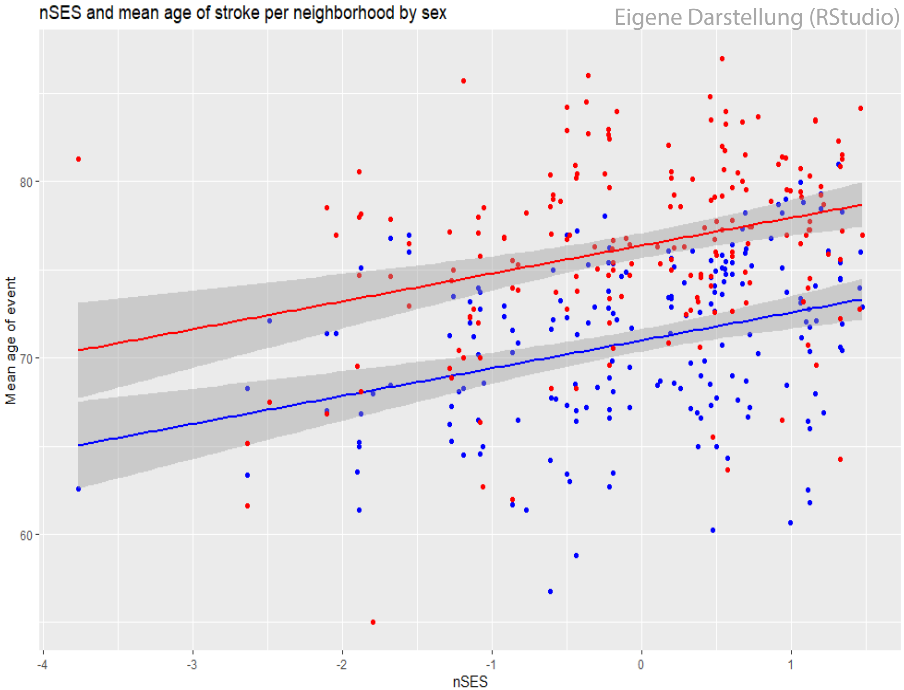


Figure 1. nSES and mean age of stroke by nSES. (Men in blue, women in red). Each dot is a neighborhood.

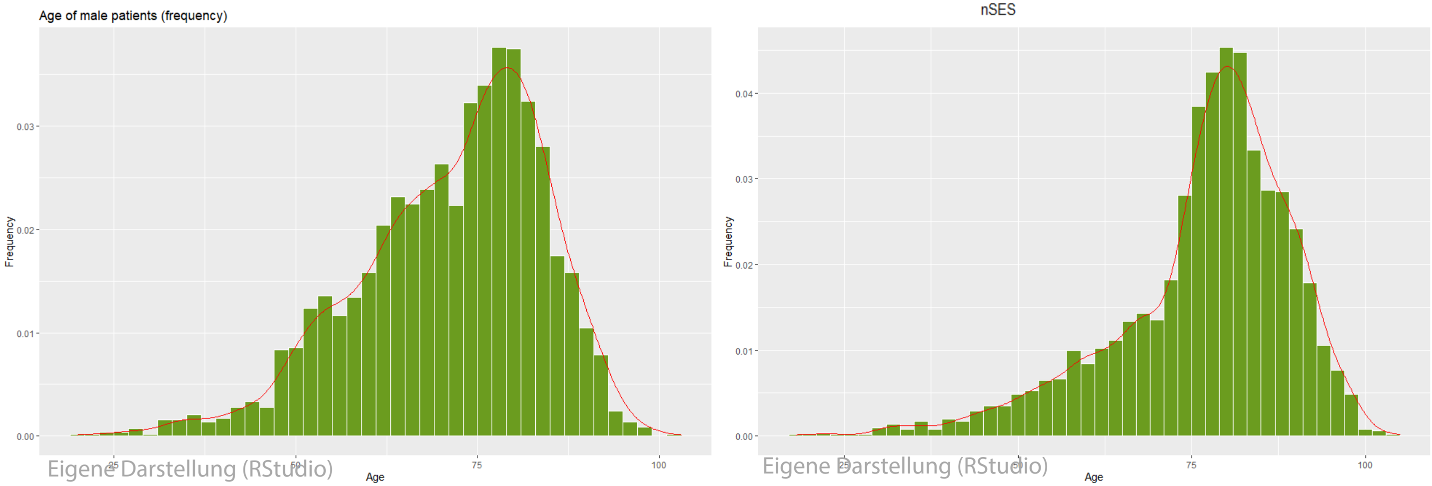
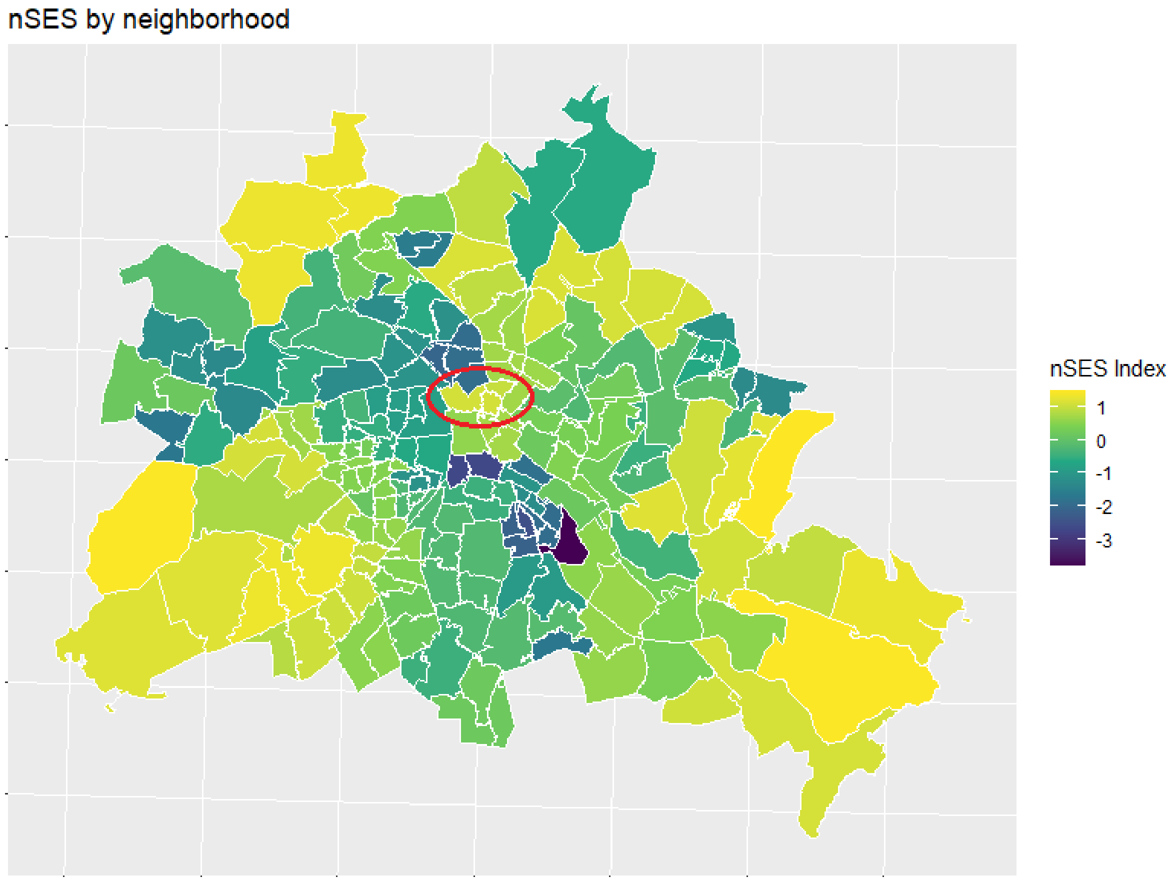


Figure 2. Age distribution of cases by sex: Men (left), women (right)

RESULTS



Eigene Darstellung (RStudio)

Figure 3. ESIx/SES index by ZIP code.

- Clusters of neighborhoods with **higher nSES (yellow)** tend to be more **on the periphery of the city**, while the center has, on average, lower nSES. In the middle of the city, there is a very small cluster of neighborhoods with SES above the center's average (red oval).

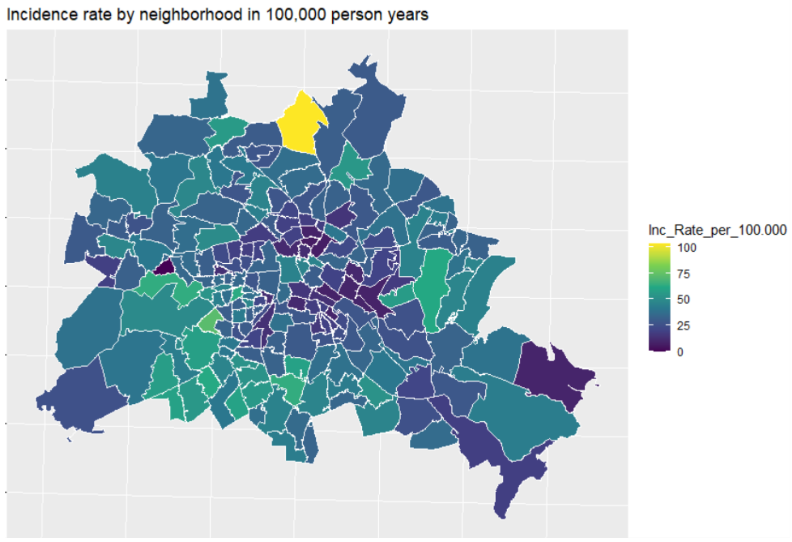
RESULTS

Objective 1

- At first, with the Poisson regression, I unexpectedly found a **positive significant association** between nSES and stroke incidence (**IRR=1.035**, p-value=<0.02) without controlling for age distribution. This suggested that people living in neighborhoods with higher nSES could suffer more from stroke.
- However, after controlling for the percentage of older people in every neighborhood (>65 and 35-64), **the effect was inverted** and remained statistically significant (**IRR=0.95**; p-value=0.006). This means that for every unit increase in nSES, there is a 5% decrease in the incidence rate of stroke in Berlin's neighborhoods.
- Later, when checking the models' assumptions, I noticed clear evidence of **overdispersion**. The variance exceeded the mean and **the dispersion parameter, which should be close to 1, was 2.64.**
- I solved this by using a **Negative binomial regression** instead, with which the dispersion parameter **went down to a more adequate 1.1**. The effect on the IR became slightly stronger (**IRR=0.94**, p-value = 0.042). After using a **multilevel model with random effects**, these results still held.

RESULTS

Alle Abbildungen: Eigene Darstellung (RStudio)



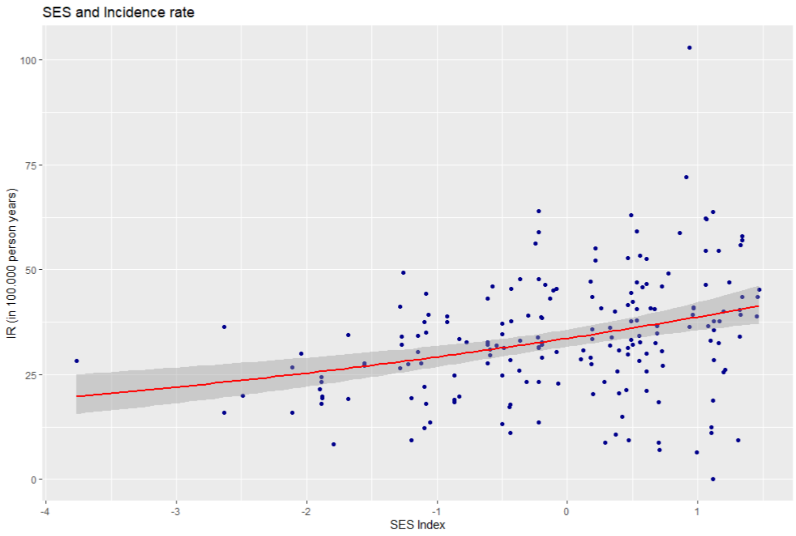
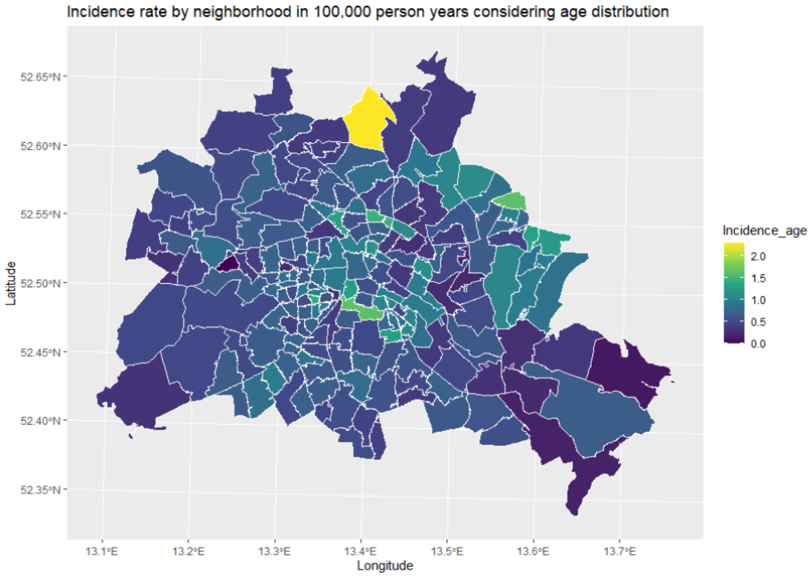


Figure 4. Incidence rate per 100.000 person years by nSES. Richer neighborhoods tend to be more green (poor health) (left). The correlation is positive (right).



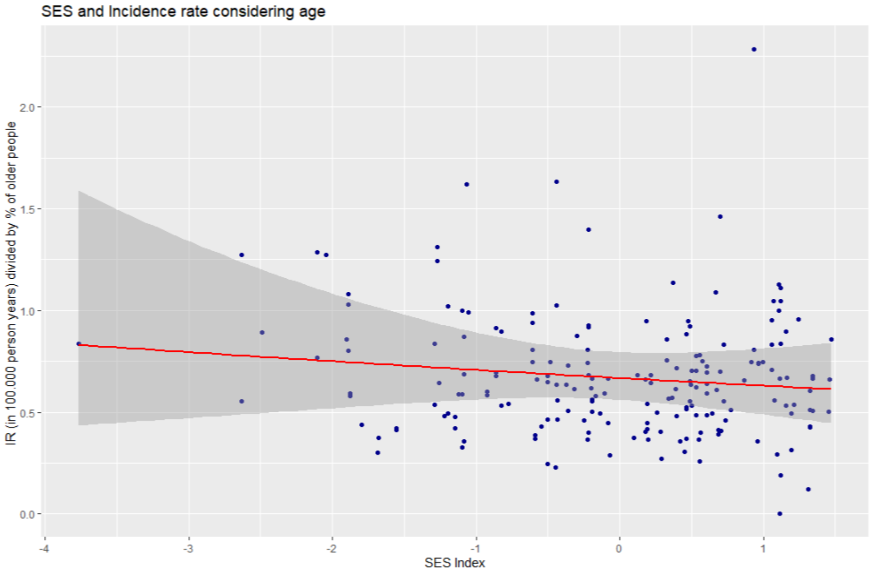


Figure 5. Incidence rate per 100.000 person years by nSES (considering age). Richer neighborhoods are now more blue (good health) (left). The correlation became negative (right).

RESULTS

NEG. BINOMIAL 1	Male				Female				Total			
	Coeff	*Exp.*	*CI 95%*	*p-value*	*Coeff*	*Exp.*	*CI 95%*	*p-value*	*Coeff*	*Exp.*	*CI 95%*	*p-value*
Intercept	-10.9464	0.00001	0.0000 - 0.0002	*<0.00001*	-9.6441	0.000064	0.0000 - 0.0010	*<0.00001*	-9.77	0.000056	0.000005 - 0.0005	*<0.00001*
nSES	-0.0393	0.9614	0.8991 - 1.0280	*0.2409*	-0.0813	0.9219	0.8567 - 0.9918	*0.02804*	- 0.060	0.940	0.886- 0.999	*0.042*
Mean age (Stroke patients)	0.0099	1.009	0.9965 - 1.0235	*0.1443*	0.0184	1.0186	1.0059 - 1.0315	*0.00377*	0.0150	1.015	1.000- 1.029	*0.0374*
Age 65+ (% of patients in neighborhood)	0.0338	1.0344	1.0213 - 1.0477	*<0.00001*	0.0378	1.0385	1.0245 - 1.0527	*<0.00001*	0.0356	1.036	1.024- 1.048	*<0.00001*
Age 34-64 (% of patients in neighborhood)	0.0400	1.0407	1.0254 - 1.0564	*<0.00001*	0.0253	1.0256	1.0091 - 1.0424	*0.00230*	0. 0322	1.033	1.019- 1.046	*<0.00001*
Proportion of men (% in neighborhood)	-0.0161	0.9840	0.9428 - 1.0271	*0.4630*	-0.0488	0.9524	0.9088 - 0.9979	*0.04167*	-0.029	0.970	0.934 - 1.008	*0.127*
Dispersion parameter	1.114				1.082				1.098			
AIC	1157.2				1126.9				1346.4			

Table 1. Effect measures of nSES on stroke incidence rate using a negative binomial regression and stratified by sex. No overdispersion is present.

RESULTS

Explanation to the initial (unexpected) results:

Richer neighborhoods **are also older** (see how young neighborhoods are clustered in the city center, and the (richer) periphery is, on average, older)

This means, the initial apparent higher risk in richer neighborhoods was not because of their higher nSES, but because they have more old people (who suffer more from stroke).

This is a classic example of **confounding**.

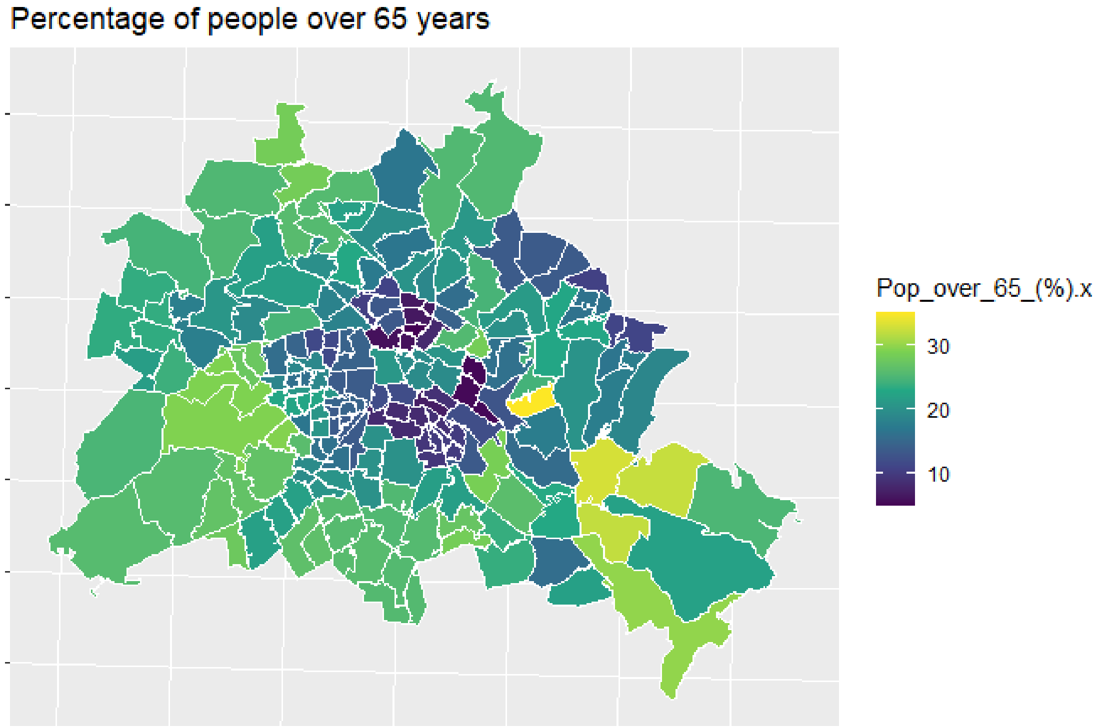


Figure 5. Percentage of people over 65 year per ZIP code
Eigene Darstellung (RStudio)

RESULTS

Objective 2

- I found a statistically significant association between nSES and mRS at 3 months at the individual level (**OR=0.885**, p-value=<0.00001). This means that, for every unit the nSES increases, the odds of the mRS increasing (getting worse) decline by 11.5%.

Ordinal regression	Total			
	Coeff	*Exp.*	*CI 95%*	*p-value*
nSES	-0.1219	**0.8852**	**0.839 - 0.933**	<0.00001
Age	0.047	1.048	1.04 - 1.05	<0.00001
Sex (Male)	-0.286	0.750	0.676 - 0.833	<0.00001

Table 2. mRS at 3 months using data at different levels

RESULTS

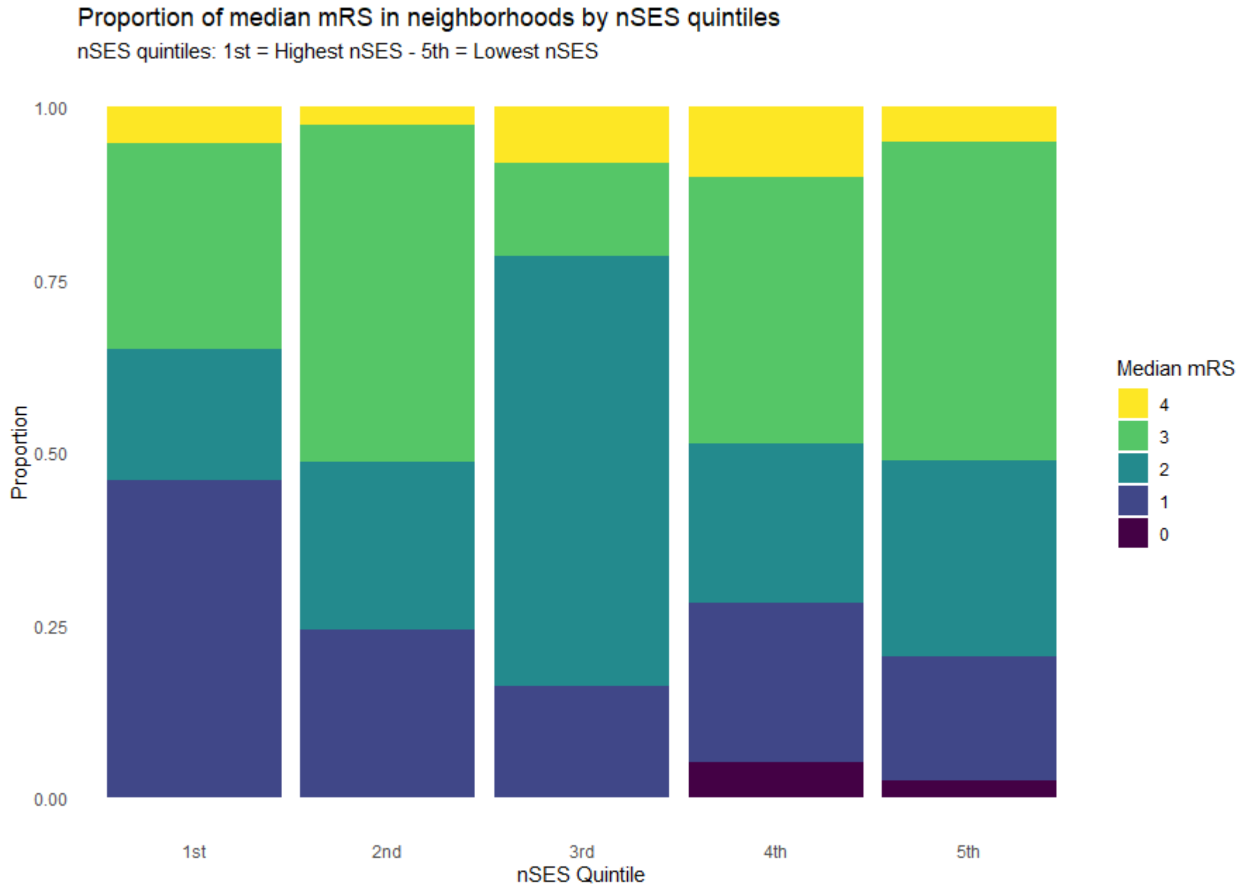


Figure 6. nSES (in quintiles) and median mRS at 3 months. Notice how good mRS values (blue) are much more frequent in the 1st (richest) quintile.

Eigene Darstellung (RStudio)

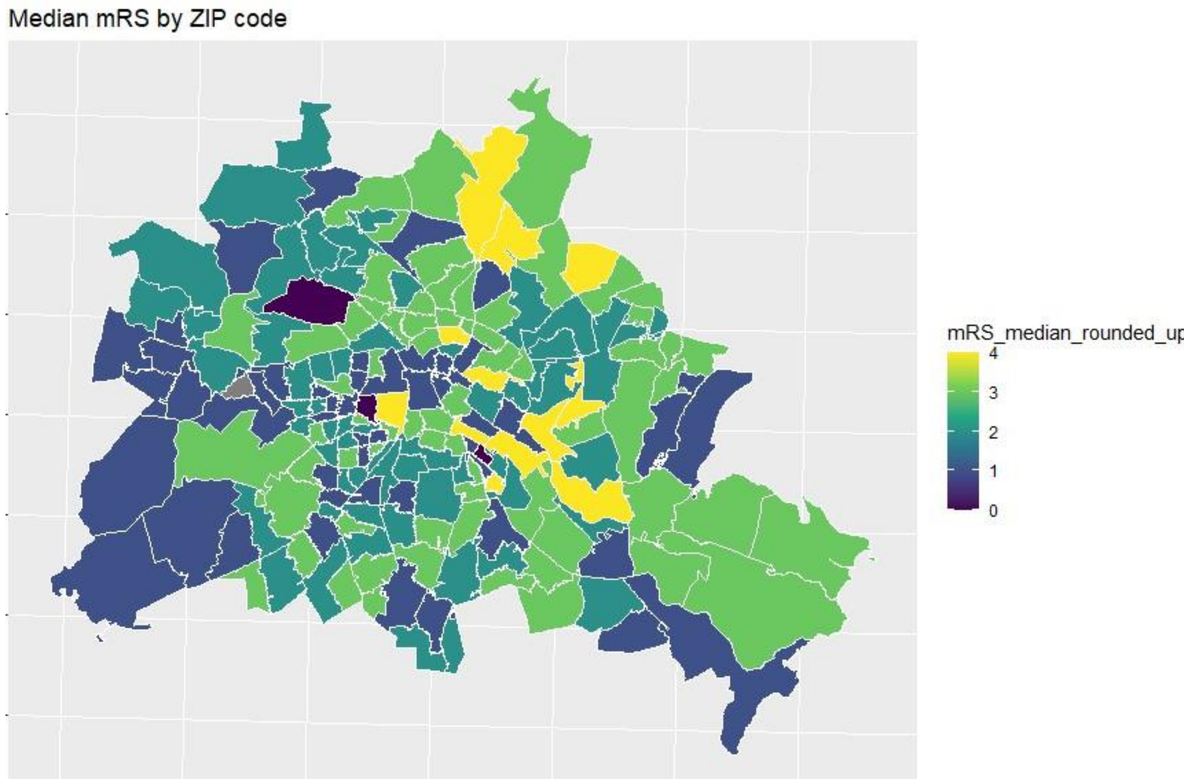


Figure 7. Median mRS at 3 months by ZIP code. Regions in the north-west and south-west have clusters of low mRS.

Eigene Darstellung (RStudio)

CONCLUSIONS AND DISCUSSION

- More deprived neighborhoods have **higher stroke incidence** than richer ones. At the individual level, patients living in deprived neighborhoods had statistically significant **worse functional outcomes** (3-month-mRS).
- Neighborhoods with low nSES are clustered in Berlin, and stroke parameters follow that spatial pattern to a certain extent. These results are **in conformity with most findings in national and international literature**.
- This is the first time that the associations between nSES and stroke outcomes in Berlin are assessed. Moreover, I have contributed with the creation of an ESIx variable adapted to the postal code level.
- This work was **not designed within a causal inference framework.** Therefore, one should not assume that the associations that I am presenting are of a causal nature. I cannot make inferences about the effects of nSES on individual stroke outcomes (ecological fallacy) because I don’t have information about iSES.
- Policy makers should be aware of these results, and use them to plan the allocation of healthcare resources accordingly. They should also find solutions to make data about individual SES more accessible for research purposes, to help improve our understanding of this topic in Berlin.

“*True understanding of the presence and magnitude of neighborhood health effects will emerge from multidisciplinary work, using diverse methodological approaches, with their strengths and its limitations. Partnership across disciplines, and among health researchers, communities, urban planners, and policy experts will be key.*” [13]

- Ana Diez-Roux

REFERENCES

[1] Roth GA, Mensah GA, Johnson CO, et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990-2019: Update From the GBD 2019 Study. J Am Coll Cardiol 2020; 76(25): 2982–3021 [https://doi.org/10.1016/j.jacc.2020.11.010][PMID: 33309175]

[2] Baker EH. Socioeconomic Status, Definition. In: Cockerham WC, Dingwall R, Quah S, editors. The Wiley Blackwell Encyclopedia of Health, Illness, Behavior, and Society. Chichester, UK: John Wiley & Sons, Ltd 2014; 2210–4.

[3] Winkleby MA, Jatulis DE, Frank E, Fortmann SP. Socioeconomic status and health: how education, income, and occupation contribute to risk factors for cardiovascular disease. Am J Public Health 1992; 82(6): 816–20 [https://doi.org/10.2105/ajph.82.6.816][PMID: 1585961]

[4] Link-Gelles R, Westreich D, Aiello AE, et al. Bias with respect to socioeconomic status: A closer look at zip code matching in a pneumococcal vaccine effectiveness study. SSM Popul Health 2016; 2: 587–94 [https://doi.org/10.1016/j.ssmph.2016.08.005][PMID: 27668279]

[5] Kerr GD, Slavin H, Clark D, Coupar F, Langhorne P, Stott DJ. Do vascular risk factors explain the association between socioeconomic status and stroke incidence: a metaanalysis. Cerebrovasc Dis 2011; 31(1): 57–63 [https://doi.org/10.1159/000320855][PMID: 20980755]

[6] Marshall IJ, Wang Y, Crichton S, McKevitt C, Rudd AG, Wolfe CDA. The effects of socioeconomic status on stroke risk and outcomes. The Lancet Neurology 2015; 14(12): 1206–18 [https://doi.org/10.1016/S1474-4422(15)00200-8]

[7] Cox AM, McKevitt C, Rudd AG, Da Wolfe C. Socioeconomic status and stroke. The Lancet Neurology 2006; 5(2): 181–8 [https://doi.org/10.1016/S1474-4422(06)70351-9]

[8] Addo J, Ayerbe L, Mohan KM, et al. Socioeconomic status and stroke: an updated review. Stroke 2012; 43(4): 1186–91 [https://doi.org/10.1161/STROKEAHA.111.639732][PMID: 22363052]

[9] Diez Roux AV. The study of group-level factors in epidemiology: rethinking variables, study designs, and analytical approaches. Epidemiol Rev 2004; 26: 104–11 [https://doi.org/10.1093/epirev/mxh006][PMID: 15234951] }

[10] Courgeau D. Methodology and Epistemology of Multilevel Analysis. Dordrecht: Springer Netherlands 2003.

[11] Blakely TA. Ecological effects in multi-level studies. Journal of Epidemiology & Community Health 2000; 54(5): 367–74 [https://doi.org/10.1136/jech.54.5.367]

[12] Diez Roux AV. Ecological variables, ecological studies, and multilevel studies in public health research. In: Detels R, Gulliford M, Karim QA, Tan CC, editors. Oxford Textbook of Global Public Health. Oxford University Press 2015; 411–29.

[13] Diez Roux A-V. Neighborhoods and health: where are we and were do we go from here? Rev Epidemiol Sante Publique 2007; 55(1): 13–21 [https://doi.org/10.1016/j.respe.2006.12.003][PMID: 17320330]

[14] Kaup AO, Dos Santos BFC, Victor ES, et al. Georeferencing deaths from stroke in São Paulo: an intra-city stroke belt? Int J Stroke 2015; 10 Suppl A100: 69–74 [https://doi.org/10.1111/ijs.12533][PMID: 26061637]

[15] Vastagh I, Szőcs I, Oberfrank F, Ajtay A, Bereczki D. A szocioökonómiai helyzet és a stroke kapcsolata a fôvárosban. Ideggyogy Sz 2020; 73(11-12): 389–97 [https://doi.org/10.18071/isz.73.0389][PMID: 33264536]

[16] Stack K, Robertson W, Blackburn C. Does socioeconomic position affect knowledge of the risk factors and warning signs of stroke in the WHO European region? A systematic literature review. BMC Public Health 2020; 20(1): 1473 [https://doi.org/10.1186/s12889-020-09580-x][PMID: 32993624]

[17] Yu AYX, Smith EE, Krahn M, et al. Association of Neighborhood-Level Material Deprivation With Health Care Costs and Outcome After Stroke. Neurology 2021 [https://doi.org/10.1212/WNL.0000000000012676][PMID: 34408072]

REFERENCES

[18] Stulberg EL, Twardzik E, Kim S, et al. Association of Neighborhood Socioeconomic Status With Outcomes in Patients Surviving Stroke. Neurology 2021; 96(21): e2599- E2610 [https://doi.org/10.1212/WNL.0000000000011988][PMID: 33910941]

[19] Brown AF, Liang L-J, Vassar SD, et al. Neighborhood socioeconomic disadvantage and mortality after stroke. Neurology 2013; 80(6): 520–7 [https://doi.org/10.1212/WNL.0b013e31828154ae][PMID: 23284071]

[20] Chen R, Crichton S, McKevitt C, Rudd AG, Sheldenkar A, Wolfe CDA. Association between socioeconomic deprivation and functional impairment after stroke: the South London Stroke Register. Stroke 2015; 46(3): 800–5 [https://doi.org/10.1161/STROKEAHA.114.007569][PMID: 25649807]

[21] Arrich J, Lalouschek W, Müllner M. Influence of socioeconomic status on mortality after stroke: retrospective cohort study. Stroke 2005; 36(2): 310–4 [https://doi.org/10.1161/01.STR.0000152962.92621.b5][PMID: 15625296]

[22] Pedigo A, Aldrich T, Odoi A. Neighborhood disparities in stroke and myocardial infarction mortality: a GIS and spatial scan statistics approach. BMC Public Health 2011; 11: 644 [https://doi.org/10.1186/1471-2458-11-644][PMID: 21838897]

Poster:

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