BMJ Open

Primary care in Germany: access and utilisation—a cross-sectional study with data from the German Socio-Economic Panel (SOEP)

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To cite: Greiner GG, Schwettmann L, Goebel J, *et al*. Primary care in Germany: access and utilisation—a cross-sectional study with data from the German Socio-Economic Panel (SOEP). *BMJ Open* 2018;**8**:e021036. doi:10.1136/bmjopen-2017-021036

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2017-021036).

Received 6 December 2017
Revised 11 July 2018
Accepted 24 July 2018

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ABSTRACT

Objectives (1) To describe the accessibility of general practitioners (GPs) by the German population; (2) to determine factors on individual and area level, such as settlement structure and area deprivation, which are associated with the walking distance to a GP; and (3) to identify factors that may cause differences in the utilisation of any doctors.

Design Cross-sectional study using individual survey data from the representative German Socio-Economic Panel (SOEP) linked with area deprivation data from the German Index of Multiple Deprivation for 2010 (GIMD 2010) and official data for settlement structure (urban/rural areas) at district level. Logistic regression models were estimated to determine the relationship of individual and area factors with the distance to a GP. Negative binomial regressions were used to analyse the association with utilisation.

Setting Germany.

Population n=20 601 respondents from the SOEP survey data 2009.

Primary outcome measure Walking distance to a GP.

Secondary outcome measure Doctor visits.

Results Nearly 70% of the sample lives within a 20 min walk to a GP. People living in the most deprived areas have a 1.4-fold (95% CI 1.3 to 1.6) increased probability of a greater walking distance compared with the least deprived quintile, even after controlling for settlement structure and individual factors. In rural districts, people have a 3.1-fold (95% CI 2.8 to 3.4) higher probability of a greater walking distance compared with those in cities. Both area deprivation and rurality have a negative relationship with the utilisation of physicians, whereas the distance to a GP is not associated with the utilisation of physicians.

Conclusion Walking distance to a GP depends on individual and area factors. In Germany, area deprivation is negatively correlated with the accessibility of GPs while controlling for settlement structure and individual factors. Both area factors are negatively associated with the utilisation of doctors. This knowledge could be used for future GP requirement plans.

Strengths and limitations of this study

- New approach linking individual survey data with self-reported travel times to a general practitioner (GP), administrative data for settlement structure and data for area deprivation.
- Data from a large representative survey of the German population considering an individual's capability and circumstances in terms of walking.
- Data could be biased because of self-reported distances to GPs and differences in time perception.

BACKGROUND

To ensure an adequate supply of healthcare services for the population, health policymakers need valid information which enables them to identify areas with an insufficient supply and to correspondingly plan or adjust the distribution of medical facilities. This paper focuses on access to healthcare. Certainly, the decision to consult a doctor is mainly based on health status. However, consultation rates are also influenced by demographic, socioeconomic and psychological factors which may constitute barriers of access to healthcare, for example, language barriers, ethnicity, occupational status, car ownership, anxiety or bad experiences with side effects of drugs or treatment.[1 2] Penchansky and Thomas defined access as a concept consisting of five different dimensions including *accessibility*, *availability*, *acceptability*, *affordability* and *accommodation*.[3] Hence, it covers local conditions, the ratio of supply and demand, the acceptance of healthcare services by consumers, different financial aspects and the necessary organisation, that is, adequate services. This concept of access is enlarged by the new dimension *awareness*, which describes whether people even know about the services and possibilities they can access, for example, in their neighbourhood.[4] It is therefore obvious that access is determined by both individual and contextual, that is, area, factors.

Recent research has focused on the social and built environment and its impact on health and healthcare. Particularly, maldistribution, often leading to a lack of physicians in rural areas, is a frequently reported problem in many countries.[5–7] It is known that monetary and non-monetary incentives exist to encourage practice in more urban areas, especially for young general practitioners (GPs). Less income, lower career opportunities and less infrastructure are often named as personal barriers to working and living in more rural areas. Consequently, many recently introduced programmes to recruit and retain physicians in rural areas focus on these factors.[8–10] Nevertheless, demographic change, leading to an ageing population, will exacerbate this situation.[11] Hence, a shortage of GPs also exists in rural areas in Germany, with the prognosis getting worse.[12 13] Thus, the first objective of this paper is to describe the accessibility of GPs by the German population.

Accessibility of healthcare facilities is often measured in terms of travel time or walking distance. For example, Voigtländer and Deiters showed in their review that a minimum standard for an acceptable travel time to reach a doctor is below 30 min with local public transport, tending to be lower in urban areas.[14] Todd and colleagues assumed that up to 20 min is a reasonable travel time for good accessibility.[15]

The impact of area deprivation and settlement structure, that is, the distinction between rural and urban areas, on the accessibility of healthcare facilities such as GP surgeries is often examined with the help of geographic information systems (GIS).[15 16] Buffer zones are often used to estimate accessibility.[15] However, they are based on Euclidean (straight line) distances. In contrast, real travel distances could be examined by network analyses and have also been conducted on reaching the GP by car or public transport.[17] Generally, evidence shows that the spatial accessibility of GPs in rural areas is lower than in urban areas.[15 16] However, the difference is not only relevant for the regional distribution of healthcare services. The number of studies analysing the impact of area deprivation on health and healthcare systems has increased successively in recent years. Several studies suggest that area deprivation has a negative effect on health,[18–20] and that there is greater need for healthcare services in more deprived areas.[21 22]

Nevertheless, the effect of area deprivation on access and accessibility remains unclear. The findings of Todd *et al*,[15] for example, suggest a positive primary care law (more deprived areas with better accessibility), whereas Teljeur *et al*[16] show a negative effect of area deprivation on accessibility in some settlement structures. They report inconsistent effects of area deprivation on the proportion of the population living within walking distance of a GP as well as for median travel times in different settlement types.

Hence, the second objective of this paper is to shed further light on factors, which may be associated with the walking distance to a GP.

Furthermore, as a third objective, we evaluate whether accessibility correlates with the utilisation of healthcare services in terms of visits to any doctor and identify factors that are interrelated with these differences in utilisation. Features of the social environment may constitute important determinants in their own right.[21]

In contrast to previous studies, we combine individual data taken from a large representative population-based survey with data for area deprivation and for settlement structure. This allows us to determine factors at both individual and area level which may be associated with the walking distance to a GP and the utilisation of healthcare services. To the best of our knowledge, our paper is the first to describe these interrelations for the German population by using a new methodological approach.

METHODS

Population and study design

We used data from the German Socio-Economic Panel (SOEP) for our cross-sectional study.[23] The SOEP is an annual, representative, multiwave study commissioned by the German Institute for Economic Research (DIW Berlin), ongoing since 1984 and sampling nearly 11 000 households and 30 000 individuals.[24 25] Data are collected using different questionnaires for individuals, households or specific subgroups by face-to-face interviews. Information available includes household composition, living conditions and personal information such as the biography of the individual and socioeconomic status (SES) with information on education, employment and earnings. Further data are collected for indicators such as health and life satisfaction as well as for social and political aspects.

In the household questionnaires of the SOEP, walking distance to GPs is ascertained every 5 years. Therefore, we used data from the individual and household datasets for the year 2009 as for this year there is temporal proximity to other data, particularly area deprivation, used in this analysis. After excluding all participants with missing answers on the question about the distance to a GP (n=191), the final sample for descriptive analyses consisted of n=20 601 people older than 17 years. Further missing values in explanatory variables reduced the sample available for statistical analyses to n=19 638.

Outcomes

The question for the main outcome of interest was, 'How long does it take you on foot to reach the following facilities in your residential area?—general practitioner' with four categories of answer: 'under 10 min', '10–20 min', 'more than 20 min' and 'not available, cannot be reached on foot'. We dichotomised this variable and cumulated the first two and the last two categories creating two different groups. Group 1 ('close') consisted of those respondents who reported very good or good accessibility because of a walking time of ≤ 20 min. Group 2 ('distant') comprised those with a walking time of >20 min and those who could not reach their GP on foot.

Utilisation of doctors, as the secondary outcome measure, was ascertained by the question, 'Have you gone to a doctor within the last three months? If yes, please state how often'. It should be remarked that this question concerns any visit to a doctor (GPs and/or specialists).

Explanatory variables and confounders

Predictors and potential confounders were taken from the literature.[1 2] We controlled for demographic factors as well as for individual SES, health status and area factors.

We categorised age into three groups: younger adults (age <40 years), middle-aged (40–64 years) and older adults (age ≥65 years). Furthermore, we analysed the association of sex (male or female) and migration background (German or not German) with the distance to a GP. Additionally, we controlled for whether having a child under 18 years living in the household could be associated with the distance to a GP, as awareness and preferences regarding the place of residence may change when having a child.

To characterise the individual SES, we used educational level, type of health insurance and the equivalised disposable income of the household. The education level is stated in respect of high school, the (upper) secondary education level that is required to enter university, in three characteristic values (more than, equal to and less than high school).

The healthcare system in Germany is universal and mandatory. However, there are two types of health insurance (private vs compulsory/statutory health insurance). Employees exceeding a certain income limit, for example, can choose a private health insurance which may have a number of advantages for both patients (eg, reduced waiting time) and physicians (eg, higher remuneration). This may induce differences regarding access as some practices are not accepting patients covered by the statutory insurance system. The equivalised disposable income was calculated using the household post-government income (combined income after taxes and government transfers of all individuals in the household) reported by the respondents. The square root scale of the Organisation for Economic Co-operation and Development[26 27] was used for equivalisation, and we created quintiles for the sample with quintile 1 (Q1) representing the highest equivalised disposable income and quintile 5 (Q5) representing the lowest equivalised disposable income.

Different aspects of health were taken into account: the current self-reported health status on a 5-point Likert scale (from 1='very good' to 5='bad'), the number of certain morbidities ever diagnosed by a doctor ('diabetes, asthma, cardiac disease (also cardiac insufficiency, weak heart), cancer, apoplectic stroke, migraine, high blood pressure, depression, dementia and others') and concerns about own health status on a 3-point Likert scale (1='very concerned', 2='somewhat concerned' or 3='not concerned at all'). In order to evaluate the severity of multicollinearity, we controlled Spearman's rank correlation coefficients and calculated variance inflation factors (VIFs) in each case. A value >5 for a VIF would suggest a problem[28] but, in our case, they were always clearly below this threshold (<2).

In addition, we used quintiles of the German Index of Multiple Deprivation (GIMD)[29] for the year 2010 to identify the deprivation status of the region where the household was located as an area factor. The GIMD 2010 consists of seven domains, which represent different dimensions of deprivation: income, employment, education, municipal/district revenue, social capital, environment and security. Households were matched by official district codes (N=412 districts in 2010) to quintiles Q1–Q5 of the GIMD 2010, where Q1 represents the least deprived districts and Q5 the most deprived districts.

Supplementary data provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) for 2010 were used to characterise the settlement structure of the districts[30] where the households were located by official district codes. The corresponding classification is based on the share of the population living in large and medium-sized cities, the population density of the district region as well as the population density of the district region without consideration of the large and medium-sized cities in it. According to the BBSR, there are four different types of settlement structure:

1. Administratively independent major cities with >100 000 inhabitants (inhab.).
2. Urban districts: share of the population in large or medium-sized cities of minimum 50% and population density >150 inhab./km², or districts with population density >150 inhab./km² while not counting large or medium-sized cities.
3. Rural districts with population concentrations: share of the population in large or medium-sized cities of minimum 50% and a population density <150 inhab./km², or districts with share of the population in large or medium-sized cities <50% and a density >100 inhab./km² while not counting large or medium-sized cities.
4. Thinly populated rural districts: share of the population in large or medium-sized cities <50% and a density <100 inhab./km² while not counting large or medium-sized cities.

Area deprivation status and settlement structure were matched with the SOEP data via the official municipality keys (Amtliche Gemeindeschlüssel) of the households' district of residence.

Being unable to identify unique districts by a combination of federal state, settlement structure and area deprivation status, the DIW Berlin had to make some minor changes in four smaller districts in order not to violate data protection laws, which had no significant impact on the analysis (further information in online supplementary A).

Statistical analyses

In addition to our description of the full sample, we used multiple logistic regression to model our dichotomous outcome variable 'walking distance to GP' to obtain the odds modelled as a linear combination of our predictor variables. Here, because of missing values, we had to reduce our sample to n=19 638. These missing values occurred in current self-rated health status (n=42), concerns about own health (n=66) and type of health insurance (n=35). However, the largest number of missing values appeared in school education (n=856). OR estimators are reported with their 95% CIs.

We performed several robustness checks. First, we used the weighting factor provided by the SOEP[31] to check our analyses for a more representative population (sum of used weightings n=64 335 424; sum of normalised used weightings n=17 101). Using this, we also took into account the different likelihoods of being drawn into the different SOEP subsamples and the unequal probabilities of the households and individuals staying in the survey since the first interview. Second, we performed an ordered logistic regression modelling the outcome variable with all four characteristics available ('under 10 min', '10–20 min', 'more than 20 min' and 'not available, cannot be reached on foot'). Third, we performed a sensitivity analysis without administratively independent major cities (n=14 770 respondents) as it can be assumed from the literature that the supply rate of GP surgeries in cities is greater than in non-urban areas.

To analyse the associations of individual and area factors with utilisation, we performed negative binomial regressions modelling the count variable as the number of doctor visits is zero-inflated (n=5750; 27.9%) in our sample. Two distinct models including the confounders described above were estimated: one with the distance to the GP as an additional covariate and one without. The second model including the distance to a GP allowed us to control for a possible endogeneity problem. Additionally, the question on utilisation could address different types of physicians (see 'Discussion'). We also used the weighting factor here to check for robustness.

Finally, in all tests, we categorised the missing values in school education as a new subgroup and checked their impact as an additional sensitivity analysis.

All data analyses were performed using SAS V.9.4 (SAS Institute).

Patient and public involvement

Patients and/or public were not involved in this study.

RESULTS

Descriptive results

Table 1 shows the sample characteristics. Participants in our sample had an average age of 49.9 years and consisted of 52.3% females. Overall, 39.5% reported living <10 min away from the GP, 30.1% between 10 and 20 min, 13.6% >20 min, and a GP was not reachable on foot for 16.8%. So, in total, 69.6% reported living within a self-reported walking distance of at most 20 min (group 1, 'close'), whereas 30.4% had to walk >20 min or could not reach a GP on foot (group 2, 'distant'). The vast majority (75.4%) of those who lived in cities and urban districts were able to reach a GP within 20 walking minutes. Considering urbanity, just 14.0% of group 1 reported living in a rural area, whereas the corresponding percentage of those in group 2 increased to 24.1%. Finally, participants in the 'distant' group visited a doctor on average more often than those in the 'close' group (mean 2.75 vs 2.56).

Regression results

Table 2 shows the results of the multiple logistic regressions modelling the risk of being in group 2, that is, not living within a 20 min walk of a GP. Model I shows the results of the unweighed sample, and model II displays the estimates for the weighted sample. Because of missing values, n=19 638 (95.3%) were included in the analyses. The largest share of missing values appeared for education level. Most of these cases are people in the youngest age group. Other missing values are reported in the footnotes to the tables.

Comparing group 1 with group 2 in model I, the probability of a greater walking distance to a GP is dependent on various individual and area factors. Living in the least deprived area quintile Q1 significantly decreased the risk of being in the 'distant' group (OR 1.38 for Q2; 95% CI 1.26 to 1.53 and OR 1.43 for Q5; 95% CI 1.29 to 1.59 with reference to Q1), whereas no linear rise in the probability is seen with increasing area deprivation. Living in the most rural settlement structure increased the probability of a longer walking distance to the GP, especially compared with cities (OR 3.06; 95% CI 2.76 to 3.40). Here, a continual rise in the probability can be witnessed with increasing levels of rurality.

Older people (aged >64 years) had a 13% higher probability of living >20 walking minutes away from a GP compared with the group <40 years of age (OR 1.13; 95% CI 1.02 to 1.25). The probability is significantly lower for those respondents with children <18 years in the household (OR 0.91; 95% CI 0.84 to 0.99) or a migration background (OR 0.67; 95% CI 0.57 to 0.78). Furthermore, individuals in lower equivalent disposable income quintiles were less likely to report a walking distance of >20 min. The poorest quintile had a 13% reduced probability (OR 0.87; 95% CI 0.78 to 0.98) compared with the quintile with the highest equivalent disposable income. However, having private instead of compulsory health insurance coverage showed no significant effect on the probability of a greater walking distance (OR 0.97; 95% CI 0.88 to 1.08).

No significant differences are seen in education level between the two groups; a higher education level even tends to produce a greater distance to the GP (OR 1.09; 95% CI 0.99 to 1.20 for high school against less than high school). Suffering bad health compared with a very good self-reported health status increased the probability by 60% (OR 1.60; 95% CI 1.29 to 2.00). However, the number of morbidities (OR 1.04; 95% CI 1.00 to 1.08) and concerns about own health (very concerned with

Table 1 Sample characteristics

	Total (n=20 601)		Group 1 (close)* (n=14 346)		Group 2 (distant)* (n=6255)	
	n/mean†	%/SD†	n/mean†	%/SD†	n/mean†	%/SD†
Sex						
Male	9824	47.7	6852	47.8	2972	47.5
Female	10 777	52.3	7494	52.2	3283	52.5
Age†	*49.93*	*17.69*	*49.35*	*17.66*	*51.25*	*17.69*
Young (age<40 years)	6089	29.6	4441	31.0	1648	26.3
Middle (40–64 years)	9437	45.8	6505	45.3	2932	46.9
Old (age>64 years)	5075	24.6	3400	23.7	1675	26.8
Walking distance to GP						
Less than 10 min	8146	39.5	8146	56.8	–	–
10–20 min	6200	30.1	6200	43.2	–	–
More than 20 min	2796	13.6	–	–	2796	44.7
None in the area/not reachable	3459	16.8	–	–	3459	55.3
Area deprivation GIMD 2010 (quintiles)						
Q1 least deprived	4633	22.5	3429	23.9	1204	19.2
Q2	4085	19.8	2792	19.5	1293	20.7
Q3	3584	17.4	2389	16.7	1195	19.1
Q4	4205	20.4	3080	21.5	1125	18.0
Q5 most deprived	4094	19.9	2656	18.5	1438	23.0
Settlement structure						
1 city	5138	24.9	4164	29.0	974	15.6
2 urban district	6277	30.5	4444	31.0	1833	29.3
3 rural district with pop. concentration	5679	27.6	3737	26.0	1942	31.0
4 rural district	3507	17.0	2001	14.0	1506	24.1
Children in household						
Yes	5570	27.0	4034	28.1	1536	24.6
No	15 031	73.0	10 312	71.9	4719	75.4
German						
Yes	19 456	94.4	13 427	93.6	6029	96.4
No	1145	5.6	919	6.4	226	3.6
Equivalent household disposable income (quintiles)						
Q1 (high; >€32 564)	4122	20.0	2932	20.4	1190	19.0
Q2 (>€24 031–32 564)	4119	20.0	2825	19.7	1294	20.7
Q3 (>€18 552–24 031)	4119	20.0	2793	19.5	1326	21.2
Q4 (>€13 829–18 552)	4121	20.0	2901	20.2	1220	19.5
Q5 (low; ≤€13 829)	4120	20.0	2895	20.2	1225	19.6
Education‡						
Less than high school	2843	14.4	2014	14.7	829	13.8
High school	12 343	62.5	8411	61.3	3932	65.3
More than high school	4559	23.1	3296	24.0	1263	21.0
Health status‡						
Very good	1841	9.0	1385	9.7	456	7.3
Good	8039	39.1	5761	40.3	2278	36.5
Satisfactory	6995	34.0	4767	33.3	2228	35.7

Continued

Table 1 Continued

	Total (n=20 601)		Group 1 (close)* (n=14 346)		Group 2 (distant)* (n=6255)	
	n/mean†	%/SD†	n/mean†	%/SD†	n/mean†	%/SD†
Poor	2882	14.0	1883	13.2	999	16.0
Bad	802	3.9	515	3.6	287	4.6
Number of morbidities†	*0.79*	*1.01*	*0.76*	*0.99*	*0.87*	*1.05*
Concerns about own health‡						
Very concerned	3765	18.3	2535	17.7	1230	19.8
Somewhat concerned	10 654	51.9	7376	51.6	3278	52.6
Not concerned at all	6116	29.8	4395	30.7	1721	27.6
Type of health insurance‡						
Compulsory health ins.	17 608	85.6	12 213	85.3	5395	86.4
Private health ins.	2958	14.4	2109	14.7	849	13.6
Doctor visits (3 months)†	*2.62*	*3.86*	*2.56*	*3.77*	*2.75*	*4.05*

Source: SOEP.v32, own calculations.
*Group 1: walking distance to GP less or equal 20 minutes, Group 2: walking distance to GP more than 20 minutes.
†continuous variable – mean and SD (standard deviation) reported in italics.
‡Missing values in total: education (n=856), health status (n=42), concerns about own health (n=66), and type of health insurance (n=35).
GIMD, German Index of Multiple Deprivation; ins., insurance; pop., population; Q, quintile.

reference to not concerned at all OR 0.90; 95% CI 0.81 to 1.02) had a very small or no significant effect on the distance to the GP.

Regarding the robustness of the general findings, the observed association of area deprivation with the distance to a GP is supported by the other two models reported in table 2. Model II, with the number of weighted observations used of n=64 335 424, shows an even stronger effect of area deprivation (OR 1.60 comparing the most deprived quintile with the least deprived) and settlement structure (OR 3.14 comparing the most rural with the most urban structure) on the distance to a GP. Also, the results of the ordered logistic regression model validated these results (see online supplementary B). Similarly, even excluding respondents living in cities (model III) did not change the general finding of a remarkable association of area deprivation (OR 1.45; 95% CI 1.29 to 1.62 comparing the most deprived quintile with the least deprived) with the distance to a GP.

In order to identify associations with utilisation at the individual and area level, we performed two negative binomial regressions reported in table 3. The model controlling for the distance to a GP as a confounder for utilisation shows the same results as the model without the distance to a GP precisely up to the second decimal place (not given in the table). Therefore, we just report the full model (model I) containing the distance to a GP as an explanatory variable. Also, because of the very similar results, we do not expect to have an endogeneity problem.

Living >20 min away from a GP had no significant effect on the number of doctor visits within the last three months, while holding the other variables in the model constant (incident rate ratio (IRR)=1.00; 95% CI 0.97 to 1.04). In rural settlements (IRR=0.90, 95% CI 0.86 to 0.94 compared with big cities) and very deprived areas (IRR=0.84, 95% CI 0.80 to 0.88 compared with least deprived areas), the utilisation is significantly lower. Using the weighting factor (model II) supports our results showing robustness for a more representative sample.

Finally, testing the missing values of school education as a subgroup in a further robustness check (not reported in the tables) did not change the estimators or the significance levels of our results substantially.

DISCUSSION

Principal findings of this study

First, in our cross-sectional analysis, we found that nearly 70% of the sample lives within 20 min walking time of a GP surgery. Second, in our results, a strong and robust association exists between higher area deprivation and higher rurality, on the one hand, and worse accessibility to GPs, on the other. This link appeared while controlling for area factors, but also for demographic characteristics, as well as for individual SES and health status. Third, area deprivation and rurality also show a negative relationship with the utilisation of physicians, whereas the distance to a GP is not associated with utilisation.

Strengths and weaknesses

In our study based on a large representative survey from Germany, we adopt a new approach to link individual data, self-reported travel times to a GP and number of visits to a doctor with administrative data for settlement structure and data for area deprivation. This approach

Table 2 Results of multiple logistic regression: effects of individual and area factors on worse general practitioner accessibility (>20 min)

	Model I (n=19638)		Model II* (n=17101)		Model III (n=14770)	
	OR	95% CI	OR	95% CI	OR	95% CI
Sex [female]	1.02	0.96 to 1.09	**1.08**	1.05 to 1.15	1.01	0.94 to 1.08
Age [ref=young (age<40 years)]						
Middle (40–64 years)	1.08	1.00 to 1.17	1.05	0.96 to 1.14	1.07	0.98 to 1.17
Old (age>64 years)	**1.13**	1.02 to 1.25	1.06	0.95 to 1.17	1.11	0.99 to 1.24
Area deprivation GIMD 2010 [ref=Q1, least deprived]						
Q2	**1.38**	1.26 to 1.53	**1.32**	1.19 to 1.46	**1.41**	1.27 to 1.56
Q3	**1.45**	1.31 to 1.61	**1.31**	1.18 to 1.46	**1.49**	1.34 to 1.66
Q4	**1.34**	1.20 to 1.49	**1.22**	1.09 to 1.37	**1.21**	1.07 to 1.36
Q5 (most deprived)	**1.43**	1.29 to 1.59	**1.60**	1.42 to 1.80	**1.45**	1.29 to 1.62
Settlement structure [ref=1 city]						
2 urban district	**1.88**	1.71 to 2.07	**2.11**	1.91 to 2.34	–†	–†
3 rural district with population concentration	**2.40**	2.18 to 2.65	**2.44**	2.21 to 2.70	**1.28**†	1.19 to 1.39†
4 rural district	**3.06**	2.76 to 3.40	**3.14**	2.81 to 3.52	**1.63**†	1.48 to 1.79†
Children in household [yes]	**0.91**	0.84 to 0.99	**0.76**	0.70 to 0.83	**0.91**	0.84 to 0.99
German [no]	**0.67**	0.57 to 0.78	**0.78**	0.68 to 0.89	**0.59**	0.49 to 0.71
Equivalent household disposable income [ref=Q1 high; >€32 564]						
Q2 (>€24 031–32 564)	1.01	0.91 to 1.11	**1.18**	1.05 to 1.33	1.05	0.94 to 1.18
Q3 (>€18 552–24 031)	1.00	0.90 to 1.11	1.03	0.91 to 1.16	1.06	0.94 to 1.19
Q4 (>€13 829–18 552)	**0.87**	0.78 to 0.97	0.91	0.80 to 1.03	0.93	0.82 to 1.06
Q5 (low; ≤€13 829)	**0.87**	0.78 to 0.98	0.93	0.82 to 1.06	0.90	0.80 to 1.03
Education [ref=less than high school]						
High school	1.09	0.99 to 1.20	**1.11**	1.01 to 1.23	1.08	0.97 to 1.20
More than high school	0.99	0.88 to 1.12	1.07	0.94 to 1.21	0.98	0.86 to 1.12
Health status [ref=very good]						
Good	**1.14**	1.01 to 1.30	1.15	1.00 to 1.33	**1.20**	1.04 to 1.39
Satisfactory	**1.31**	1.14 to 1.50	**1.34**	1.14 to 1.56	**1.37**	1.17 to 1.61
Poor	**1.50**	1.28 to 1.76	**1.59**	1.33 to 1.89	**1.62**	1.35 to 1.95
Bad	**1.60**	1.29 to 2.00	**1.61**	1.27 to 2.03	**1.64**	1.28 to 2.10
Number of morbidities	**1.04**	1.00 to 1.08	**1.05**	1.01 to 1.09	1.02	0.98 to 1.06
Concerns about own health [ref=not concerned at all]						
Somewhat concerned	0.96	0.88 to 1.04	0.92	0.84 to 1.01	0.97	0.89 to 1.07
Very concerned	0.90	0.81 to 1.02	1.00	0.88 to 1.13	0.91	0.80 to 1.04
Type of health insurance [private health insurance]	0.97	0.88 to 1.08	0.97	0.86 to 1.09	0.99	0.88 to 1.10
Max re-scaled R^2 (percentage)	5.92		6.89		3.69	

Models I to III are full models.
Missing values in total: education (n=856), health status (n=42), concerns about own health (n=66) and type of health insurance (n=35).
*Weighting factor was used: calculation with normalised weights.
†Reference=2 urban district, sensitivity analysis without big major cities.
OR in bold, statistically significant at the 5% level;
[], category tested in a dichotomous variable; [ref=], reference category for more than two characteristics; GIMD, German Index of Multiple Deprivation; Q, quintile.

clearly extends previous approaches, which did not take personal factors into account that may influence the place of residence.[15 16] Other approaches had already controlled for individual health and social factors, but were lacking area information.[32] Thus, as far as we know, this is the first study to control for both individual characteristics and area factors when looking at the accessibility of GPs.

Table 3 Results of negative binomial regressions: effects on utilisation (number of doctor visits)

	Model I (n=19638)		Model II* (n=17101)	
	IRR	95% CI	IRR	95% CI
Sex [female]	**1.25**	1.22 to 1.29	**1.23**	1.20 to 1.27
Age [ref=young (age<40 years)]				
Middle (40–64 years)	**0.92**	0.88 to 0.95	**0.94**	0.90 to 0.97
Old (age>64 years)	1.00	0.95 to 1.05	1.04	0.99 to 1.09
Area deprivation GIMD 2010 [ref=Q1, least deprived]				
Q2	0.96	0.92 to 1.01	**0.96**	0.91 to 1.00
Q3	0.97	0.92 to 1.02	1.00	0.95 to 1.05
Q4	**0.92**	0.88 to 0.97	**0.95**	0.90 to 0.99
Q5 (most deprived)	**0.84**	0.80 to 0.88	**0.86**	0.82 to 0.90
Settlement structure [ref=1 city]				
2 urban district	**0.93**	0.89 to 0.97	**0.93**	0.89 to 0.97
3 rural district with population concentration	**0.90**	0.86 to 0.94	**0.89**	0.86 to 0.93
4 rural district	**0.90**	0.86 to 0.94	**0.90**	0.86 to 0.94
Children in household [yes]	1.00	0.96 to 1.04	1.03	0.99 to 1.07
GP within 20 minutes [yes]	1.00	0.97 to 1.04	0.99	0.96 to 1.02
German [no]	1.03	0.96 to 1.11	0.97	0.91 to 1.03
Equivalent household disposable income [ref=Q1 high; >€32 564]				
Q2 (>€24 031–32 564)	0.99	0.94 to 1.04	0.99	0.95 to 1.04
Q3 (>€18 552–24 031)	**0.94**	0.89 to 0.99	**0.94**	0.90 to 0.99
Q4 (>€13 829–18 552)	**0.91**	0.87 to 0.96	**0.90**	0.85 to 0.94
Q5 (low; ≤€13 829)	**0.87**	0.82 to 0.92	**0.86**	0.82 to 0.91
Education [ref=less than high school]				
High school	**1.12**	1.07 to 1.17	**1.15**	1.10 to 1.20
More than high school	**1.18**	1.12 to 1.25	**1.19**	1.13 to 1.26
Health status [ref=very good]				
Good	**1.39**	1.30 to 1.49	**1.43**	1.33 to 1.54
Satisfactory	**1.93**	1.80 to 2.08	**1.97**	1.82 to 2.14
Poor	**2.91**	2.68 to 3.15	**2.91**	2.67 to 3.17
Bad	**4.09**	3.70 to 4.52	**3.91**	3.54 to 4.32
Number of morbidities	**1.28**	1.26 to 1.30	**1.25**	1.24 to 1.27
Concerns about own health [ref=not concerned at all]				
Somewhat concerned	**1.18**	1.13 to 1.23	**1.21**	1.16 to 1.26
Very concerned	**1.47**	1.39 to 1.55	**1.54**	1.46 to 1.63
Type of health insurance [private health insurance]	**1.05**	1.01 to 1.11	1.04	0.99 to 1.10
Intercept	**1.24**	1.11 to 1.39	**1.23**	1.09 to 1.38
Goodness of fit (value deviance/DF)	1.09		1.24	

Incidence rate ratio in bold=statistically significant at 5% level.
Missing values in total: education (n=856), health status (n=42), concerns about own health (n=66) and type of health insurance (n=35).
Models I and II are full models.
*Weighting factor was used: calculation with normalised weights.
[], category tested in a dichotomous variable; [ref=], reference category for more than two characteristics; DF, degrees of freedom; GIMD, German Index of Multiple Deprivation; GP, general practitioner; Q, quintile.

A further strength of the present study is that we also consider the individual's walking capability. Certain groups of people are not able to walk within 20 min to a GP because of a number of physical and mental factors, whereas other groups may be able to do so. Differences in gait speed are, for example, associated with differences in height and body weight.[33] Certainly, working with a GIS would allow us to locate the GPs in the region of interest, creating heat maps and performing network analysis. But this would not consider individual capabilities. Hence, we see a big strength in our study that respondents answered the question by taking their personal capabilities and circumstances such as the terrain into account.

Finally, this study examined factors of access to and utilisation of primary care in Germany using a large dataset.

We do, however, acknowledge that we used self-reported data, which may have led to some bias. One problem could be that respondents did not exactly understand the question. There is a chance that respondents mean the GP whom they are consulting and not the nearest one, especially if they are not aware of the nearest GP. This would bias the results, especially as we did not use a GIS to locate the places of residence of respondents and GP surgeries. Also, differences in time perception may lead to a bias in the results.

Another potential limitation deserves to be mentioned. A possible bias could have resulted from missing information on education level for n=856 respondents. The vast majority of the missing values were for those younger than 25 years. A possible explanation might be that corresponding individuals are still in education, for example, at university, so that their final education level is not yet clear. Consequently, we systematically analysed the distribution of missing values and concluded that these missing values could be excluded without distorting the results for several reasons, especially as they showed no impact after testing them as a subgroup. Additionally, the total number of missing values is not high compared with the entire sample. Finally, we want to mention that the vast majority of people in the youngest age group do not usually have the possibility of freely choosing their place of residence at this age.

What is already known and what did we find

Our findings of a negative association of area deprivation with access and accessibility are consistent with and supportive of studies by Teljeur *et al* in Ireland[16] and especially Bauer *et al* in Germany,[34] who reported an inverse care law (more highly deprived areas with worse accessibility). However, our findings are contrary to others who report either a positive effect[15] or no effect[35] of area deprivation on accessibility and also a negative effect of rurality. First, we have to take into account that the methods and approaches used are very different as we did not use GIS to locate the GPs and residents. This could also be one reason why our ratio of people living within 20 min of a GP (70%) is significantly lower than the 84.8% quoted in the work by Todd *et al*.[15]

One further result of our study is that household disposable income shows a negative association with the probability of living within 20 min of a GP. Some previous studies have already shown that a higher individual SES is associated with greater distance to a GP.[32] There are several possible explanations for these observations. People with the highest income could be much more flexible in their choice of GP or their place of residence. We can expect that this group is more likely to own a car,[36] which has a positive effect on access.[2] More generally, the positive association between individual SES and health is well known and has been reported in a large number of empirical studies.[37] If doctors are less needed and if there exist other ways of going to a doctor than on foot, the distance does not seem to be an essential decision-making factor on the place of residence or choice of doctor.

As explained in the introduction, awareness is a dimension of access.[4] This could be one reason why having a child <18 years at home is a significant predictor in our models. Awareness of medical facilities in the neighbourhood may arise with this factor.

There has been some inconsistency in our results regarding utilisation. We found a negative association of rurality and area deprivation with utilisation, whereas one might have expected a positive relationship because of the worse health of the population.[21] On the one hand, as mentioned above, health status in deprived areas is often worse than in less deprived areas.[22] On the other hand, the wording of the question for utilisation in our dataset could also refer to specialised physicians. It is known that, especially in rural areas or deprived areas, the distribution of specialised physicians is poor.[7] This may be one reason for lower utilisation in more rural and deprived areas as we cannot factor out the visits to GPs. Our result showing that the distance to a GP has no effect on utilisation seems to be supportive of the assumption that these opposing effects may cancel each other out, at least in part.

Unanswered questions and future research

In our study, we used area deprivation quintiles and settlement structure as confounders. For future research, the identification of certain districts and the application of multilevel analysis could increase knowledge about the associations between area deprivation and accessibility to GPs in Germany. The identification of districts with insufficient supply would generate valuable implications for policymakers regarding the reduction of barriers to healthcare access and the distribution of medical facilities.

CONCLUSION

The distance to a GP depends on individual and area factors. In Germany, area deprivation is negatively associated with accessibility, controlling for settlement structure and several individual factors. Area deprivation and settlement structure also have a significant negative association with utilisation. Identifying areas with the greatest lack of supply regarding their needs using survey data seems to be a helpful approach and could generate important implications for policymakers regarding the distribution of medical facilities.

Contributors GGG and WM designed the study. GGG performed the analysis and wrote the initial version of the manuscript. WM provided the German Index of Multiple Deprivation (GIMD), supervised the study and gave support preparing the

manuscript. LS advised on methodological aspects and gave support preparing the manuscript. JG linked the regional data with the survey data and advised on methodological aspects using the SOEP data. All authors read and approved the final manuscript. GGG has responsibility for the final content.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement All the data sources used for this study are referenced within the manuscript. We are unable to share the SOEP and settlement structure data, but information related to it is available at (https://www.diw.de/en/diw_02.c.222516.en/data.html) and (http://www.bbsr.bund.de/BBSR/DE/Raumbeobachtung/Raumabgrenzungen/Kreistypen4/kreistypen_node.html). Data from the GIMD 2010 is available by e-mailing WM (werner.maier@helmholtz-muenchen.de).

REFERENCES

1. Campbell SM, Roland MO. Why do people consult the doctor? *Fam Pract* 1996;13:75–83.
2. Comber AJ, Brunsdon C, Radburn R. A spatial analysis of variations in health access: linking geography, socio-economic status and access perceptions. *Int J Health Geogr* 2011;10:44.
3. Penchansky R, Thomas JW. The concept of access: definition and relationship to consumer satisfaction. *Med Care* 1981;19:127–40.
4. Saurman E. Improving access: modifying penchansky and thomas's theory of access. *J Health Serv Res Policy* 2016;21:36–9.
5. Hann M, Gravelle H. The maldistribution of general practitioners in England and Wales: 1974-2003. *Br J Gen Pract* 2004;54:894–8.
6. Rosenthal MB, Zaslavsky A, Newhouse JP. The geographic distribution of physicians revisited. *Health Serv Res* 2005;40(6 Pt 1):1931–52.
7. Rosenblatt RA, Hart LG. Physicians and rural America. *West J Med* 2000;173:348–51.
8. Günther OH, Kürstein B, Riedel-Heller SG, *et al*. The role of monetary and nonmonetary incentives on the choice of practice establishment: a stated preference study of young physicians in Germany. *Health Serv Res* 2010;45:212–29.
9. Curran V, Rourke J. The role of medical education in the recruitment and retention of rural physicians. *Med Teach* 2004;26:265–72.
10. Brooks RG, Walsh M, Mardon RE, *et al*. The roles of nature and nurture in the recruitment and retention of primary care physicians in rural areas: a review of the literature. *Acad Med* 2002;77:790–8.
11. Colwill JM, Cultice JM, Kruse RL. Will generalist physician supply meet demands of an increasing and aging population? *Health Aff* 2008;27:w232–41.
12. Kopetsch T. Ärztemangel trotz Zuwachsraten. *Deutsches Ärzteblatt* 2006:103–11.
13. Kassenärztliche Bundesvereinigung. Ärztemangel. http://www.kbv.de/html/themen_1076.php (accessed Nov 2017).
14. Voigtländer S, Deiters T. [Minimum standards for the spatial accessibility of primary care: a systematic review]. *Gesundheitswesen* 2015;77:949–57.
15. Todd A, Copeland A, Husband A, *et al*. Access all areas? An area-level analysis of accessibility to general practice and community pharmacy services in England by urbanity and social deprivation. *BMJ Open* 2015;5:e007328.
16. Teljeur C, O'Dowd T, Thomas S, *et al*. The distribution of GPs in Ireland in relation to deprivation. *Health Place* 2010;16:1077–83.
17. Stentzel U, Piegsa J, Fredrich D, *et al*. Accessibility of general practitioners and selected specialist physicians by car and by public transport in a rural region of Germany. *BMC Health Serv Res* 2016;16:587.
18. Meijer M, Röhl J, Bloomfield K, *et al*. Do neighborhoods affect individual mortality? A systematic review and meta-analysis of multilevel studies. *Soc Sci Med* 2012;74:1204–12.
19. Riva M, Gauvin L, Barnett TA. Toward the next generation of research into small area effects on health: a synthesis of multilevel investigations published since July 1998. *J Epidemiol Community Health* 2007;61:853–61.
20. Sánchez-Santos MT, Mesa-Frias M, Choi M, *et al*. Area-level deprivation and overall and cause-specific mortality: 12 years' observation on British women and systematic review of prospective studies. *PLoS One* 2013;8:e72656.
21. Kopetsch T, Maier W. [Analysis of the association between regional deprivation and utilization: an assessment of need for physicians in Germany]. *Gesundheitswesen* 2018;80:27–33.
22. Eibich P, Krekel C, Demuth I, *et al*. Associations between neighborhood characteristics, well-being and health vary over the life course. *Gerontology* 2016;62:362–70.
23. Berlin DIW. *Socio-Economic Panel (SOEP), data for years 1984–2015, International Scientific Use Version 32, SOEP*, 2017.
24. Deutsches Institut für Wirtschaftsforschung. Die Survey-Gruppe SOEP. 2017 http://www.diw.de/de/diw_02.c.221178.de/ueber_uns.html# (accessed Nov 2017).
25. Wagner GG, Frick JR, Schupp J. The German Socio-Economic Panel Study (SOEP) - evolution, scope and enhancements. *SSRN Electronic Journal* 2007:p. 139–69.
26. OECD. *Growing unequal?: Income distribution and poverty in OECD Countries*, 2008.
27. OECD. What Are Equivalence Scales – OECD Project on Income Distribution and Poverty. http://www.oecd.org/els/soc/OECD-Note-EquivalenceScales.pdf (accessed Nov 2017).
28. Sheskin DJ. *Handbook of Parametric and Nonparametric Statistical Procedures*. 5th edn. Taylor & Francis, 2011.
29. 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–e86.
30. Bundesinstitut für Bau-, Stadt- und Raumforschung (BBSR), Federal Institute for Research on Building, Urban Affairs and Spatial Development. *Laufende Raumbeobachtung – Raumabgrenzungen Siedlungsstrukturelle Kreistypen*, 2010.
31. Kroh M. *Short-documentation of the update of the SOEP-Weights, 1984–2008*: DIW Berlin: mimeo, 2009.
32. Knittel JR, Sutcliffe R, Djeudeu Deudjui DA, *et al*. Assoziationen zwischen räumlicher Entfernung zum Hausarzt und individuellen gesundheitlichen und sozialen Faktoren in der älteren Bevölkerung im Ruhrgebiet – Ergebnisse der Heinz Nixdorf Recall Studie. *Gesundheitswesen* 2016;78:A59.
33. Samson MM, Crowe A, de Vreede PL, *et al*. Differences in gait parameters at a preferred walking speed in healthy subjects due to age, height and body weight. *Aging* 2001;13:16–21.
34. Bauer J, Maier W, Müller R, *et al*. [Primary care in Germany - equal access for everyone?]. *Dtsch Med Wochenschr* 2018;143.
35. Bauer J, Müller R, Brüggmann D, *et al*. Spatial accessibility of primary care in England: a cross-sectional study using a floating catchment area method. *Health Serv Res* 2018;53.
36. Behrends S, Joachimiak W, Kott K, *et al*. Datenreport 2016 – Ausstattung mit Gebrauchsgütern. 2016 http://www.bpb.de/nachschlagen/datenreport- 2016/226236/ausstattung-mit-gebrauchsguetern (accessed Nov 2017).
37. Feinstein JS. The relationship between socioeconomic status and health: a review of the literature. *Milbank Q* 1993;71:279–322.