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Effect of area-level socioeconomic deprivation on mental and physical health: A longitudinal natural experiment among refugees in Germany

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ABSTRACT

Existing studies on contextual health effects struggle to account for compositional bias, limiting causal interpretation. We use refugee dispersal in Germany as a natural experiment to study the effect of area-level socioeconomic deprivation on mental and physical health, while considering the potential mediating role of neighbourhood characteristics. Refugees subject to dispersal (n = 1466) are selected from a nation-wide longitudinal refugee study (IAB-SOEP-BAMF Panel; 2016–2018). Multi-level linear regression models, adjusted for age, sex, education, country of origin, federal state, asylum status and length of residence in Germany, are fitted to the change in mental and physical health subscales of the SF-12 depending on quintiles (Q1 – Q5) of commune-level socioeconomic deprivation (German Index of Socioeconomic Deprivation, GISD). This is followed by sensitivity analyses and mediation analyses for housing, social cohesion, proportion of non-citizens in the neighbourhood, access to green space, population density and primary care physician density. Residency in districts with moderate-high deprivation (Q4) has a negative impact on physical health (coef.: -2.2, 95%CI: -4.1;-0.2) compared to lowest deprivation (Q1). Moderate-high deprivation (Q4) has a positive impact on mental health, but the effect is statistically insignificant (coef.: 1.6, 95%CI: -0.7; 3.9). Comparisons with other deprivation quintiles are statistically insignificant. Sensitivity analyses confirm results of the final models, while no mediating factors show a substantial impact on the observed relationship. The results point to gaps in health and social service provision for refugees living in the most deprived regions, but further research is required to understand the precise mechanisms behind the observed relationships. Further research using longer timeframes and larger sample sizes are required to confirm results.

1. Background

Understanding the health impacts of the places where people live has fascinated researchers for decades. Contextual factors of the place of residence can include such varied factors as regional inequality, education, infrastructure development, green space, social capital or walkability (Diez Roux & Mair, 2010), but also more intangible factors such as the "social space" created by digital technologies (Balsa-Barreiro et al., 2022). In social epidemiology, contextual factors are frequently operationalised as socioeconomic deprivation indices at small-area level (Carstairs, 1995). This allows for the joint assessment of multiple relevant factors which are often colinear. The effects of area-level socioeconomic deprivation on health have been widely documented. For example, several seminal studies have shown the impact on mortality, but also physical health outcomes such as self-rated health, cardiovascular disease, respiratory illness and health behaviours (Carstairs, 1995; Diez Roux & Mair, 2010; Eames et al., 1993; Pickett & Pearl, 2001; Riva et al., 2007). Since the 1990s, the development of more sophisticated statistical methods in the field of social epidemiology allowed for the analysis of regional-level factors in individual-level health outcomes through the use of multi-level regression models (Diez Roux & Mair, 2010; Pickett & Pearl, 2001). Such analyses have produced a more nuanced picture of the effects of area-level deprivation on health, with some varied and/or inconclusive results for some health outcomes such

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as mental health (Fone et al., 2007; Pickett & Pearl, 2001). Despite the methodological benefits conferred by these approaches, issues with their interpretation remain: the decision to live in or move to a particular neighbourhood is invariably shaped by individual agency as well as social, economic and cultural factors, which result in systematic differences between individuals in different regions (compositional bias).

To overcome these issues, natural experiments are needed (Biddle et al., 2023; Diez Roux & Mair, 2010). Since the place of residence is not readily amenable to experimentation, situations where individuals are (quasi-)randomly distributed into neighbourhoods provide an opportunity to study contextual effects on health (Biddle et al., 2023). The dispersal of refugees provides such opportunities, as it is organised in a quota-based system in several countries, allocating individuals to contexts at national or sub-national level based on factors such as population size or tax revenue, but independent of socio-demographic characteristics of the refugee population (Dustmann et al., 2017). In some countries, such dispersal policies are accompanied by residence requirements which oblige individuals to reside in the assigned region for the duration of their asylum claim or for several years following a successful asylum claim (Brücker et al., 2019; Schikora, 2019). Existing studies from Denmark and Sweden which use refugee dispersal processes as natural experiments confirm the negative impacts of area-level socioeconomic deprivation on physical health, with mixed results for mental health (Biddle et al., 2023). However, as these studies use register-based approaches with identification of refugees by nationality, they are subject to misclassification bias. Furthermore, they are carried out in contexts *without* residence requirements, and thus cannot ensure treatment adherence. This study will use national- and regional-level refugee dispersal policies adopted by the German government to study the effect of area-level socioeconomic deprivation on physical and mental health. The strict enforcement of the dispersal process in Germany, and the accompanying residence rule, provides an ideal policy context to study the effects of context on health.

Refugee health is not a singularity and other marginalised populations may be subject to the same contextual exposures (Biddle et al., 2023). Studying their health in natural experiments may thus serve as a lens, allowing us to explore the effects of area-level socioeconomic deprivation for the health of other population groups. This must, however, be done with careful consideration of the causal mechanisms and potential mediators at play. In particular, previous studies have shown that the type of accommodation and accommodation size can have a direct impact on mental and physical health of refugees (Bozorgmehr & Razum, 2015; Dudek et al., 2022). The social context into which refugees are dispersed may further mediate the relationship between area-level deprivation and health: Regions with lower deprivation may have more resources to invest in infrastructure conducive to social participation and engagement such as local parks, libraries, community centres and activity groups (Fone et al., 2007; Kawachi & Berkman, 2014; Kress et al., 2020). Alternatively, areas of high deprivation may in fact be beneficial for migrant health through the existence of co-ethnic social networks which act as buffers for "acculturative stress" (Bécares et al., 2012; Hynie et al., 2011; Sierau et al., 2019). The neighbourhood type, in terms of urban/rural characteristics, population density as well as access to available green space, have also been shown to have important health effects (Erdmann et al., 2022; Twohig-Bennett & Jones, 2018). Finally, aspects of the health system, such as better availability of primary care physicians, might have health benefits for individuals living in areas of low deprivation.

Given the above, the primary aim of this analysis is to investigate what impact living in an area of high deprivation has on the mental and physical health of refugees. The secondary aim is to assess whether key contextual factors, namely social cohesion, accommodation characteristics, proportion of non-citizens, access to green space, population density and primary care physician density, mediate the relationship between area-level socioeconomic deprivation and health.

2. Methods

This study employs a natural experiment design using longitudinal data from three waves of the IAB-SOEP-BAMF Refugee Panel (M3-M5; 2016–2018) in Germany (Kroh et al., 2017) to conduct a difference-in-difference (DiD) analysis. The analysis follows the simplest form of the DiD approach, namely the observation of the change in outcome in individuals over two time periods (t0 vs. t1), but for five exposure groups (area-level socioeconomic deprivation quintiles, Q1-Q5) (Wing et al., 2018). Assignment to exposure (area-level deprivation) is exogenous due to the allocation of refugees to different geographical contexts based on quasi-random administrative quotas.

2.1. Study setting

Germany continues to host the highest number of refugees in Europe, with an estimated 2.1 million refugees residing in Germany in 2022 (UNHCR, 2023). Recently arrived refugees in Germany show a high burden of mental ill health, with prevalence estimates of 20–45% for symptoms of depression and anxiety (Biddle et al., 2021; Hoell et al., 2021). Mental illness is compounded by structural factors and housing conditions following arrival, including insecure asylum status, unemployment, loneliness and dissatisfaction with living conditions (Nutsch & Bozorgmehr, 2020; Schönfeld et al., 2022). At the same time, newly arriving refugees report a high number of chronic conditions and disabilities (Biddle et al., 2021), with many of these likely exacerbated due to long flight journeys without adequate access to health care (Abubakar et al., 2018). Worryingly, health care utilisation remains low after arrival in Germany, pointing to structural, linguistic, geographic and other barriers to accessing adequate care (Biddle et al., 2021).

Upon arrival in Germany, refugees are dispersed into communes (Local Administrative Unit - 2) based on a three-level dispersal process at federal, regional and communal levels. First, refugees are assigned to one of Germany's 16 federal states based on an administrative quota ("Königsteiner Schlüssel") based on population size and tax revenue (Bozorgmehr et al., 2017). In this process, the nationality of refugees is taken into account, since different regional offices of the Federal Ministry for Migration and refugees (BAMF) have specialisations for processing asylum seekers from different countries of origin (Müller, 2013). This applies mostly to countries of origin with smaller numbers of applications, with the 22 most common nationalities (as of 2019, see Appendix S1) being processed in all 16 federal states (Flüchtlingsrat Niedersachsen, 2019).

The process for dispersal *within* federal states differs from state to state. After the asylum claim is formally lodged, some states disperse asylum seekers on to further reception centres within the state (second-level dispersal) before transferring them to communes (third-level dispersal), while others disperse refugees directly to communes. This process happens quasi-randomly, that is, without taking individual characteristics of refugees into account, with two notable exceptions: 1) Refugees may be housed in state reception centres without third-level dispersal until the end of the asylum process for refugees from so-called "safe" countries of origin; 2) some federal states have specially designated accommodation facilities for single women, families, or refugees with special needs or health issues.

While the dispersal of refugees is not entirely random, it remains exogenous as self-selection into communes by the refugees themselves is not possible. Furthermore, the deviations from random dispersal (i.e. nationality at the national level, gender/family status at the sub-national level) are unrelated to the exposure of interest for the present analysis (area-level deprivation). We therefore utilise this quasi-random dispersal as a natural experiment which allows for causal interpretation of results.

A further feature of the asylum system in Germany which makes it a unique natural experiment is the residence requirement policy ("Wohnsitzauflage") (Schikora, 2019). The policy requires asylum seekers to remain resident in the region to which they were assigned for the duration of their asylum application and up to 3 years following a decision. The policy applies to the following individuals: (i) those who have not yet received a decision on their asylum decision, (ii) those who have received a negative asylum decision but have not yet left the country, (iii) those who have received a negative asylum decision but have been granted a temporary right to remain and (iv) those who have a positive asylum decision but are dependent on state benefits for a period of 3 years following the asylum decision (Brücker et al., 2019). The latter category was introduced as an extension to the prior residential policy in several federal states, but the introduction of the policy change was not uniform (Schikora, 2019). This residency requirement policy effectively minimises selective (secondary) migration into new or other districts.

2.2. Data source

The IAB-SOEP-BAMF Panel (Kroh et al., 2017) is an extension of the German Socio-Economic Panel specifically tailored to the refugee population. The survey collects detailed information on social, economic, psychological and health indicators from a representative sample of refugees living in Germany. Sampling of households is based on all refugees listed in the central register of foreign nationals ("Ausländerzentralregister") who arrived in Germany between January 2013 and December 2016. Sampling is conducted via a stratified, multi-stage, clustered sampling design, using immigration offices as clusters and randomly selecting 130 out of 369 immigration offices as primary sampling units (Kroh et al., 2017) The total adult sample (N = 6897) consists of three waves (M3-M5), which were recruited between 2016 and 2017. The overall response rate was high at 48.7% (Kroh et al., 2017). All waves were followed up in 2018 and thus have slightly different follow-up periods (1 vs. 2 years).

2.3. Sample selection

In order to comply with criteria for the residence requirement policy, individuals were excluded who fulfilled one or more of the exemption criteria detailed in Supplementary File S2. The sample for this analysis hence includes a total of 1466 individuals, who were subject to the residence requirement policy at both t0 and t1 (n = 1145), and those who are no longer subject to the policy at t1 (but were at t0) (n = 321).

Analyses of the complete dataset show a loss follow-up of 49.4%, with slightly higher proportions lost to follow up in individuals not subject to residential assignment (53.6%) compared to those subject to residential assignment (45.2%) at baseline.

2.4. Variables

Our primary outcome measures are change (t1-t0) in mental health score (mcs) and physical health score (pcs) derived from the SF-12v2. The SF-12 was originally developed by the RAND Corporation to study health-related quality of life and has since been extensively used and validated worldwide as a measure of subjective health status (Ware et al., 1996). It has been shown to have cross-cultural validity, which has also recently been attested for migrants in Germany (Schulz, 2012). The scores are calculated using explorative factor analysis (PCA, varimax rotation) using the mean value of the SOEP 2004 population (Andersen et al., 2007). Scores are standardised for a population mean of 50 and a standard deviation of 10, with higher values indicating better health.

Our exposure is area-level socioeconomic deprivation in quintiles, with Q1 indicating lowest and Q5 highest deprivation. We use the 2014 German Index of Socioeconomic Deprivation (GISD) (Kroll et al., 2017) on the level of communes (LAU-2). In 2014, Germany was comprised of n = 11 116 communes, with a highly variable population size of 9–3.5million inhabitants. The GISD combines eight indicators on unemployment, education, income, tax revenue and debtors from the INKAR (indicators and maps on spatial and urban development in Germany and Europe) database using factor analysis (Kroll et al., 2017).

Covariates were selected based on the directed acyclic graph (DAG) displayed in Fig. 1. Despite the natural experiment design, the uneven dispersal based on nationality at the national (and partly sub-national) level may result in potential confounding through socio-demographic and asylum-related characteristics which need to be taken into account. In baseline models, we adjust for characteristics which influence the first-level dispersal process: federal state and country of origin. We used country of origin for individuals from Syria, Afghanistan and Iraq and regional groupings for less common nationalities. Adjusting for country of origin also allows, as a proxy measure, for potential differences in pre-migration experiences to be taken into account, especially in absence of data on pre-migration health status. Absolute mcs/pcs values at baseline assessment (t0) are also included in the baseline models. Given existing evidence on the uneven socio-demographic distribution of refugees across Germany (Bozorgmehr et al., 2017), we further adjust for age, gender, highest educational attainment (as a proxy for individuals resources to navigate through the health and social system and health literacy aspects), asylum status and time since arrival in Germany in a second model.

2.5. Statistical methods

We use linear regression to model the relationship between area-level socioeconomic deprivation in quintiles and change in mcs/pcs. Due to comparatively small sample sizes in the more deprived quintiles, robust variances are estimated using bootstrapping with 1000 replications on all models. Baseline and socio-demographic variables are introduced one at a time. Multicollinearity is assessed using variance inflation factors (VIF). Missing variables are handled by listwise deletion.

We then use multi-level models, fitting random intercepts at the level of the communes, to account for clustering at the contextual level. Intraclass correlation (ICC) and likelihood ratio tests (clustered vs. linear models) are used to judge relevance of clustering; Akaike's and Bayesian information criterion (AIC/BIC) are used to judge model fit. Further mediation and sensitivity analyses are carried out with multi-level models if there is substantial evidence for clustering (LR-test of clustered vs. linear model $p < 0.05$) or on linear models if there is no evidence of clustering in order to avoid unnecessarily inflating estimate precision (these are deemed to be the "final models"). The detailed specification of the models can be found in Supplementary File S3.

In the case of statistically significant findings, we conduct several exploratory mediation analyses to test causal pathways between exposure and outcome.

1) Reported level of social cohesion, captured by the perceived safety of the neighbourhood and worries about hostility to foreigners, as suggested by Kress et al. (Kress et al., 2020).
2) Type of accommodation (private vs. shared)
3) Total and same-nationality proportion of non-citizens at regional (NUTS-3) level, with data captured 12/2017 and taken from the Database of the German Statistical Office (GENESIS) (Statistisches Bundesamt (Destatis), 2023a)
4) Proportion of non-green space at communal level (proxied by proportion of land used for industry, traffic and residential areas, minus parks and recreational spaces), captured 12/2017 and taken from the Database of the German Statistical Office (GENESIS) (Statistisches Bundesamt (Destatis), 2023b)
5) Population density at regional (NUTS-3) level (population/km^2)
6) Primary care physician density as a proxy for health care accessibility at regional (NUTS-3) level for the year 2019 (Kassenärztliche Bundesvereinigung, 2023)

For mediation analyses, potential mediating variables were included

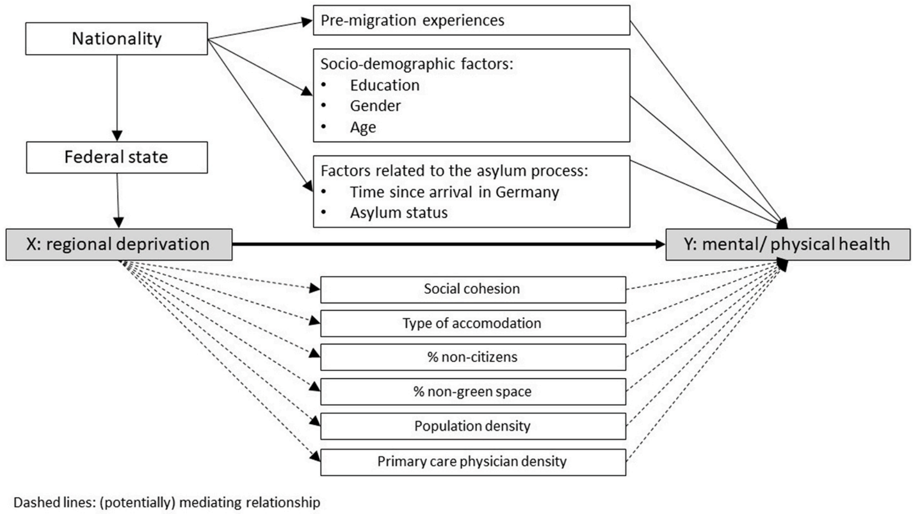

Fig. 1. Directed Acyclic Graph depicting causal relationships between exposure, outcome and covariates used to guide the analysis.

in the final models and the resulting change in coefficients assessed (see equations in Supplementary File S3).

Sensitivity analyses were carried out to check robustness of results, as listed in Supplementary File S4.

All analyses were conducted using Stata Version 18.

3. Results

A higher proportion of the sample lived in the less deprived quintiles (Q1-Q2) compared to the more deprived quintiles (Q3-Q5) (Table 1). The sample is young, with 44.6% between 17 and 29 years, and 63.2% of the sample is male. The largest share of participants was from Syria (43.5%), followed by Iraq (17.6%) and Afghanistan (15.4%). The majority of participants entered the survey between 1 and 2 years after arrival in Germany (60.6%), with the remaining participants being approximately equally spread between having arrived under 1 year ago and over 2 years ago. On entry into the survey, 37.4% had obtained a refugee status, while half of participants (52.5%) were still waiting for the outcome of their asylum application. The federal state of North Rhine-Westphalia contributes the largest number of participants to the sample (29.2%), followed by Baden-Württemberg (18.0%) and Bavaria (14.5%), as could be expected based on the administrative dispersal quota. The distribution of the sample across federal states is markedly different by deprivation quintile. Socio-economic differences across deprivation quintiles are statistically significant for country of origin, months since arrival, asylum status and federal state. Differences in accommodation and social cohesion variables across quintiles were statistically significant for type of accommodation, perception of neighbourhood safety and worries about hostility to foreigners (see Supplementary File S5).

The sample covers 553 communes. While the lowest deprivation quintiles are covered with a substantial number of communes, participants in the higher deprivation quintiles are concentrated in fewer communes (Supplementary File S6). Descriptively, a small improvement in mcs score (0.9, sd: 14.9) can be observed between t0 and t1 across the sample, but there is a substantial improvement in the highest deprivation quintiles (Fig. 2). With regard to the pcs score, there is a small decline (−0.7, sd: 10.4) between t0 and t1 across the sample, but no discernible pattern can be observed between quintiles (see also Supplementary File S7).

Single-level linear regression models show an improvement in mental health (mcs score) in the most deprived quintiles. However, these effects are not statistically significant (Table 2). When applying a multi-level model to the mental health outcome, the null model provides evidence of clustering at community level (ICC: 0.077; LRtest $p < 0.001$). The final multi-level model, adjusted for baseline and socio-demographic variables, confirms the results of the linear models: while there is a greater improvement in mental health in areas of moderate-high deprivation (Q4: coef.: 1.6, 95%CI: -0.7; 3.9) compared to individuals living in areas of lowest deprivation (Q1), none of the comparisons are statistically significant (Table 2) (see Fig. 3).

For physical health (pcs score), single-level regression models show a dose response relationship, with individuals in quintiles with higher deprivation reporting worse physical health (Table 2). The strength of this relationship increases as baseline and sociodemographic variables are introduced (see Fig. 3). However, only the decline in physical health for individuals living in areas of moderate-high deprivation (Q4) compared to lowest deprivation (Q1) is statistically significant once socio-demographic characteristics have been adjusted for (Q4: coef.: -2.2, 95%CI: -4.1;-0.2). When applying multi-level modelling to the physical health outcome, the null model does not suggest that clustering is occurring at the community level (ICC: 0.02; LRtest $p = 0.08$). Fully adjusted multi-level models shows near-identical results to the simple linear regression (Table 2). Given these results, multi-level modelling will be applied for mental health, but not physical health final models. VIF were small for all variables included in the final mental and physical models (see Supplementary File S8).

Given the non-significant results for mental health, mediation analyses were carried out only for the physical health outcome. Introducing variables for social cohesion, regional proportion of non-citizens and primary care physician density had negligible effects on results (see Supplementary File S9). Introducing variables on the type of accommodation (Q4vsQ1: -2.1, 95%CI: -3.9;-0.2) and proportion of land used for infrastructure (Q4vsQ1: -2.1, 95%CI: -3.9;-0.2) had a slight dampening effects on the observed relationship between area-level deprivation and physical health, whereas including the proportion of same-nationality foreigners and (Q4vsQ1: -2.3, 95%CI: -4.3;-0.3) and population density (Q4vsQ1: -2.3, 95%CI: -4.2;-0.5) slightly increased the observed coefficient.

Results remained stable through all sensitivity analyses. For mental health, no statistically significant differences could be observed for the deprivation quintiles, although coefficients tended towards a stronger mental health decline in the more deprived quintiles (see Supplementary File S10, S12 & S14). For physical health, the dose-response relationship continued to be evident and was statistically significant for Q4 vs. Q1 in all sensitivity analyses. Applying no mobility restrictions (S8) further rendered the health disadvantage in the most deprived quintile statistically significant (Q5vsQ1: -2.2, 95%CI: -3.7; -0.7)) (see Supplementary

Table 1
Socio-demographic characteristics of participants.

	Area-level Socioeconomic Deprivation (GISD)						
	Q1 (lowest)	**Q2** (moderate-low)	**Q3** (moderate)	**Q4** (moderate-high)	**Q5** (highest)	**Total**	**chi2-test (p-value)**
Total Sample	452 (100.0%)	430 (100.0%)	244 (100.0%)	174 (100.0%)	166 (100.0%)	1466 (100.0%)	
Age group							
17–29 years	204 (45.1%)	188 (43.7%)	107 (43.9%)	80 (46.0%)	75 (45.2%)	654 (44.6%)	0.992
30–49 years	216 (47.8%)	216 (50.2%)	118 (48.4%)	81 (46.6%)	80 (48.2%)	711 (48.5%)	
50+ years	32 (7.1%)	26 (6.0%)	19 (7.8%)	13 (7.5%)	11 (6.6%)	101 (6.9%)	
Total	*452 (100.0%)*	*430 (100.0%)*	*244 (100.0%)*	*174 (100.0%)*	*166 (100.0%)*	*1466 (100.0%)*	
Gender							
male	288 (63.7%)	263 (61.2%)	169 (69.3%)	110 (63.2%)	96 (57.8%)	926 (63.2%)	0.151
female	164 (36.3%)	167 (38.8%)	75 (30.7%)	64 (36.8%)	70 (42.2%)	540 (36.8%)	
Total	*452 (100.0%)*	*430 (100.0%)*	*244 (100.0%)*	*174 (100.0%)*	*166 (100.0%)*	*1466 (100.0%)*	
Country of origin							
Syria	193 (42.7%)	182 (42.3%)	123 (50.4%)	90 (51.7%)	50 (30.1%)	638 (43.5%)	<0.001
Iraq	71 (15.7%)	98 (22.8%)	45 (18.4%)	24 (13.8%)	20 (12.0%)	258 (17.6%)	
Afghanistan	73 (16.2%)	57 (13.3%)	30 (12.3%)	19 (10.9%)	47 (28.3%)	226 (15.4%)	
other Asia	35 (7.7%)	33 (7.7%)	21 (8.6%)	27 (15.5%)	17 (10.2%)	133 (9.1%)	
Africa	64 (14.2%)	48 (11.2%)	15 (6.1%)	11 (6.3%)	18 (10.8%)	156 (10.6%)	
other	16 (3.5%)	12 (2.8%)	10 (4.1%)	3 (1.7%)	14 (8.4%)	55 (3.8%)	
Total	*452 (100.0%)*	*430 (100.0%)*	*244 (100.0%)*	*174 (100.0%)*	*166 (100.0%)*	*1466 (100.0%)*	
Months since arrival							
1–12 months	86 (19.8%)	69 (16.5%)	51 (21.6%)	30 (17.9%)	33 (21.7%)	269 (19.1%)	<0.001
13–24 month	273 (62.8%)	240 (57.4%)	131 (55.5%)	122 (72.6%)	88 (57.9%)	854 (60.6%)	
>24 months	76 (17.5%)	109 (26.1%)	54 (22.9%)	16 (9.5%)	31 (20.4%)	286 (20.3%)	
Total	*435 (100.0%)*	*418 (100.0%)*	*236 (100.0%)*	*168 (100.0%)*	*152 (100.0%)*	*1409 (100.0%)*	
Asylum status (simplified)							
Asylum seeker	227 (50.4%)	238 (55.7%)	126 (51.9%)	72 (41.9%)	103 (62.0%)	766 (52.5%)	<0.001
Asylum status	185 (41.1%)	149 (34.9%)	83 (34.2%)	96 (55.8%)	33 (19.9%)	546 (37.4%)	
Temporary protection status	38 (8.4%)	40 (9.4%)	34 (14.0%)	4 (2.3%)	30 (18.1%)	146 (10.0%)	
Total	*450 (100.0%)*	*427 (100.0%)*	*243 (100.0%)*	*172 (100.0%)*	*166 (100.0%)*	*1458 (100.0%)*	
Level of education (ISCED11)							
low	289 (64.1%)	280 (65.1%)	156 (63.9%)	112 (64.4%)	110 (66.3%)	947 (64.6%)	0.430
medium	77 (17.1%)	90 (20.9%)	40 (16.4%)	33 (19.0%)	25 (15.1%)	265 (18.1%)	
high	85 (18.8%)	60 (14.0%)	48 (19.7%)	29 (16.7%)	31 (18.7%)	253 (17.3%)	
Total	*451 (100.0%)*	*430 (100.0%)*	*244 (100.0%)*	*174 (100.0%)*	*166 (100.0%)*	*1465 (100.0%)*	
Federal state							
Schleswig-Holstein	18 (4.0%)	21 (4.9%)	16 (6.6%)	1 (0.6%)	11 (6.6%)	67 (4.6%)	<0.001
Hamburg	11 (2.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	11 (0.8%)	
Lower Saxony	3 (0.7%)	70 (16.3%)	18 (7.4%)	9 (5.2%)	24 (14.5%)	124 (8.5%)	
Bremen	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	7 (4.2%)	7 (0.5%)	
Northrhine-Westphalia	65 (14.4%)	109 (25.3%)	123 (50.4%)	106 (60.9%)	25 (15.1%)	428 (29.2%)	
Hessia	59 (13.1%)	70 (16.3%)	6 (2.5%)	0 (0.0%)	0 (0.0%)	135 (9.2%)	
Rheinland-Palatinate	4 (0.9%)	4 (0.9%)	11 (4.5%)	4 (2.3%)	0 (0.0%)	23 (1.6%)	
Baden-Wuerttemberg	155 (34.3%)	93 (21.6%)	16 (6.6%)	0 (0.0%)	0 (0.0%)	264 (18.0%)	
Bavaria	136 (30.1%)	48 (11.2%)	12 (4.9%)	17 (9.8%)	0 (0.0%)	213 (14.5%)	
Saarland	0 (0.0%)	7 (1.6%)	2 (0.8%)	7 (4.0%)	0 (0.0%)	16 (1.1%)	
Berlin	0 (0.0%)	0 (0.0%)	38 (15.6%)	0 (0.0%)	0 (0.0%)	38 (2.6%)	
Brandenburg	0 (0.0%)	3 (0.7%)	0 (0.0%)	12 (6.9%)	25 (15.1%)	40 (2.7%)	
Mecklenburg Western Pomerania	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	18 (10.8%)	18 (1.2%)	
Saxony	0 (0.0%)	5 (1.2%)	1 (0.4%)	14 (8.0%)	16 (9.6%)	36 (2.5%)	
Saxony-Anhalt	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (12.0%)	20 (1.4%)	
Thuringia	1 (0.2%)	0 (0.0%)	1 (0.4%)	4 (2.3%)	20 (12.0%)	26 (1.8%)	
Total	*452 (100.0%)*	*430 (100.0%)*	*244 (100.0%)*	*174 (100.0%)*	*166 (100.0%)*	*1466 (100.0%)*	

File S11, S13 & S14).

4. Discussion

This study demonstrates the negative impact of area-level socioeconomic deprivation on the physical health of residents. This result is robust to sensitivity analyses, with no substantial impact of potential mediating variables considered. However, we find no evidence of a statistically significant relationship between area-level deprivation and mental health, a result which is also robust to sensitivity analysis.

The results of this study confirm the existing evidence (Diez Roux & Mair, 2010), including other natural experiments (Biddle et al., 2023; Hamad et al., 2020; White et al., 2016), on the relationship between area-level socioeconomic deprivation and physical health. Area-level deprivation may have effects on the physical health status of residents through diminished neighbourhood resources such as access to green

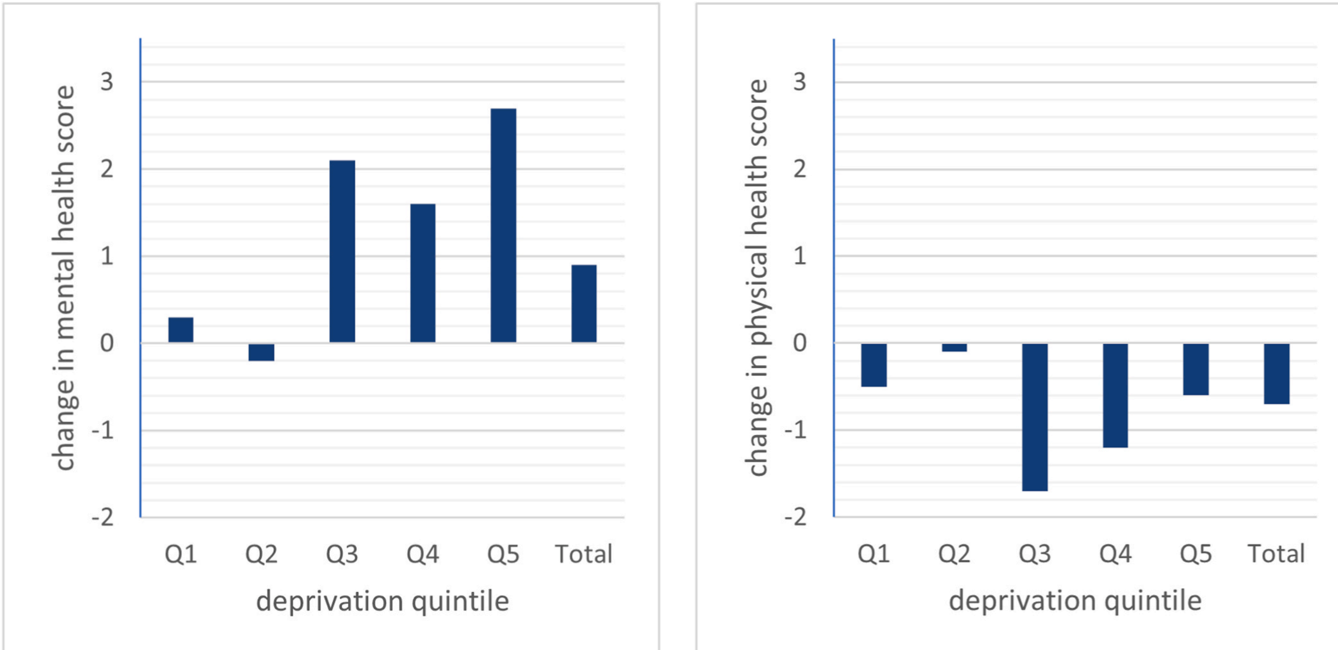

Fig. 2. Change in mcs (mental health) and pcs (physical health) between baseline and follow-up by area-level socioeconomic deprivation quintile.
2a: Change in mcs (mental health)
2b: Change in pcs (physical health)
Q1: lowest deprivation; Q2: moderate-low deprivation; Q3: moderate deprivation; Q4: moderate-high deprivation; Q5: highest deprivation.

space, food availability, walkability and environmental pollution (Diez Roux & Mair, 2010). Previous research for Germany has pointed particularly to the importance of air quality in explaining the relationship between area-level deprivation and physical health (Voigtländer et al., 2010). The present study used the proportion of land used for infrastructure as a proxy for the (lack of) access to green space and found no substantial mediating effects on the observed relationship. Unfortunately, data on important aspects such as walkability and food availability is not nationally available in Germany. Further research should consider whether these factors play a role in explaining the relationship observed in the present study.

In contrast to previous studies, which considered the effects over long time periods, our analysis shows that the negative effects of area-level deprivation are evident even after 1–2 years of follow-up. This suggests that availability and accessibility of health and social care structures, which can have immediate effects exacerbating or improving existing health conditions, play an important role in determining refugee health in more deprived regions. The present study did not find a mediating effect of physician density. However, physician density is a poor proxy of health service accessibility among the refugee population, especially as the distribution of primary care physicians is relatively equitable across districts in Germany (Ozegowski & Sundmacher, 2014). While recognised refugees are integrated into regular healthcare and social service infrastructure, important access barriers, including language skills, a lack of awareness of services and difficulties navigating complex bureaucratic systems have been documented (Spura et al., 2017). Adequate provision of interpreting services, support navigating systems through social workers and accessible information is therefore crucial in supporting accessibility and ensuring adequate coverage of services. Areas with higher deprivation may have less expendable resources to invest in services and their accessibility for refugees. In order to avoid further deterioration of health in the more deprived regions, the delivery of health and social services in these regions should be supported at the level of the federal states, for example by using area-level socioeconomic deprivation as a criterion in the allocation of available integration budgets.

The results of our study further contribute to the growing body of literature which shows complex effects of area-level deprivation on mental health. While some studies have reported a negative impact of area-level deprivation on symptoms of depression and anxiety (Fone et al., 2007; Visser et al., 2021), our study and other natural experiments using strict dispersal policies among refugees (Raphael et al., 2020) suggest that this may be due to selection effects. Robust evidence from other natural experiments does, however, provide support for the negative effects of area-level deprivation on psychiatric diagnoses and prescriptions (Boje-Kovacs et al., 2023; Foverskov et al., 2023). In fact, our study shows suggestive evidence of a positive impact of area-level deprivation on mental health. A possible explanation for this effect is the relative income hypothesis (Wilkinson, 1997), which suggests that the *relative* inequality experienced by refugees residing in areas of low deprivation might incur higher levels of stress compared to those living in areas with higher deprivation, where wealth and status differentials between the resident population and newly arriving refugees are less pronounced. The effect may also be explained by the social context in more deprived regions if social attributes of these areas, such as the level of social interaction, are supportive for mental health (Fone et al., 2007; Kress et al., 2020).

The fact that our study mirrors findings from other natural experiments among refugees in Europe suggests that the mechanisms at play are not purely specific to one locality. Rather, similar effects might be in operation in other similar geographical contexts, even if they cannot be uncovered because the dispersal policies required for natural experimental approaches are not in place. Furthermore, refugee migration is not a singularity, as many of the structural conditions which create and exacerbate health inequalities for refugees might affect other marginalised populations, such as ethnic minorities, people living in poverty, people with disabilities or sexual and gender minorities (Biddle et al., 2023). However, in order to judge whether the observed effects of area-level socioeconomic deprivation on health holds for these population groups, further analysis of potential pathways and mechanisms is required. This includes consideration of the effects which act beyond geopolitical boundaries, including international social networks and

Table 2
Results of single-level and multi-level regression models for mental (mcs) and physical (pcs) health outcomes.

Clustering	Mcs (t0-t1)				Pcs (t0-t1)			
	crude	baseline	sociodemo	**Multi-level**	crude	baseline	**sociodemo**	Multi-level
	None	None	None	**commune**	None	None	**None**	commune
Q1 (lowest)	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Q2 (moderate low)	−0.50127	−0.75324	−0.65064	−0.79811	0.32600	−0.15467	−0.37882	−0.37819
	(-2.49084–1.48831)	(-2.42165–0.91517)	(-2.35010–1.04881)	(-2.34261–0.74639)	(-1.05879–1.71078)	(-1.40125–1.09190)	(-1.57830–0.82066)	(-1.51849–0.76212)
Q3 (moderate)	1.74285	1.25732	0.84761	0.72053	−1.22763	−1.07762	−1.39302 +	−1.39029+
	(-0.51096–3.99665)	(-0.84046–3.35511)	(-1.29738–2.99259)	(-1.25040–2.69145)	(-2.86243–0.40717)	(-2.72499–0.56976)	(-3.01694–0.23089)	(-2.93689–0.15631)
Q4 (moderate high)	1.25611	2.26323+	1.43071	1.62770	−0.74277	−1.82380+	−2.18030*	−2.17586*
	(-1.44027–3.95250)	(-0.08235–4.60881)	(-0.99137–3.85280)	(-0.68440–3.93980)	(-2.62103–1.13550)	(-3.71413–0.06653)	(-4.13708 - -0.22352)	(-3.95693 to −0.39479)
Q5 (highest	2.32923+	1.03105	0.29193	0.49907	−0.10897	−1.55074	−1.69936	−1.69727
	(-0.41426–5.07273)	(-2.10481–4.16690)	(-2.89800–3.48187)	(-2.43803–3.43617)	(-1.91416–1.69622)	(-3.86986–0.76838)	(-4.04041–0.64168)	(-4.00218–0.60763)
mcst0		−0.77460**	−0.80670**	−0.80364**		−0.53900**	−0.64767**	−0.64764**
		(-0.82529 to −0.72392)	(-0.85728 to −0.75612)	(-0.85469 - -0.75259)		(-0.59126 to −0.48675)	(-0.70635 - -0.58898)	(-0.70467 to −0.59060)
Syria		*ref*	*ref*	*ref*		*ref*	*ref*	*ref*
Iraq		0.42450	1.11572	1.16221		−1.02644	−0.96299	−0.96526
		(-1.26303–2.11204)	(-0.59687–2.82831)	(-0.62459–2.94902)		(-2.42875–0.37587)	(-2.42283–0.49684)	(-2.47666–0.54615)
Afghanistan		−1.98632*	−1.44005	−1.33101		0.40057	0.37876	0.37662
		(-3.89181 to −0.08083)	(-3.61314–0.73303)	(-3.54921–0.88719)		(-1.03585–1.83698)	(-1.16118–1.91870)	(-1.19872–1.95197)
other Asia		−2.46411*	−1.34425	−1.33617		0.79758	−0.19544	−0.19698
		(-4.76889 to −0.15932)	(-3.92678–1.23828)	(-3.80064–1.12829)		(-0.88759–2.48276)	(-1.96692–1.57605)	(-2.00480–1.61085)
Africa		−0.31678	0.96725	1.08513		1.36869+	0.84263	0.84017
		(-2.25064–1.61708)	(-1.23029–3.16479)	(-1.11888–3.28914)		(-0.13068–2.86805)	(-0.74965–2.43491)	(-0.78122–2.46156)
other		2.56795	4.94647**	5.21193**		0.60896	0.81110	0.80673
		(-0.55351–5.68941)	(1.37299–8.51994)	(1.52090–8.90297)		(-1.50849–2.72640)	(-1.61185–3.23405)	(-1.65784–3.27131)
Schleswig-Holstein		*ref*	*ref*	*ref*		*ref*	*ref*	*ref*
Hamburg		−2.99813	−3.34634	−3.77142		−3.58719	−5.02498*	−5.02692*
		(-15.19942–9.20317)	(-15.49162–8.79894)	(-16.08110–8.53827)		(-7.91386–0.73948)	(-9.67931 - -0.37066)	(-9.62788 to −0.42595)
Lower Saxony		0.00513	1.15511	0.88686		−0.15978	0.96376	0.96303
		(-3.24069–3.25095)	(-2.16189–4.47211)	(-2.29248–4.06620)		(-2.74113–2.42156)	(-1.71991–3.64743)	(-1.57248–3.49855)
Bremen		−10.91682**	−10.56423**	−11.25464**		1.97876	0.39863	0.39535
		(-15.56983 to −6.26382)	(-15.21309 to −5.91537)	(-15.89118 - -6.61810)		(-4.22012–8.17763)	(-6.44334–7.24060)	(-6.28337–7.07406)
Northrhine-Westphalia		0.47871	−0.12859	−0.48130		0.12922	−0.31877	−0.32068
		(-2.43454–3.39196)	(-3.04408–2.78689)	(-3.33257–2.36997)		(-2.11463–2.37307)	(-2.61365–1.97612)	(-2.50996–1.86859)
Hessia		0.34884	0.13470	−0.21050		0.73186	0.88769	0.88580
		(-3.16169–3.85937)	(-3.34236–3.61175)	(-3.62579–3.20478)		(-1.81608–3.27979)	(-1.74260–3.51798)	(-1.66981–3.44141)
Rheinland-Palatinate		−1.57630	−2.18993	−2.33983		−1.42270	−1.58692	−1.59122
		(-6.94676–3.79416)	(-7.20194–2.82208)	(-7.02863–2.34897)		(-5.04431–2.19890)	(-5.49048–2.31663)	(-5.34826–2.16582)
Baden-Wuerttemberg		−1.85005	−2.79684+	−3.20978*		0.17156	−0.30546	−0.30658
		(-4.75682–1.05671)	(-5.90107–0.30739)	(-6.17921 - -0.24034)		(-2.04981–2.39293)	(-2.61676–2.00583)	(-2.47102–1.85787)
Bavaria		1.34118	0.24065	−0.22190		−0.15065	−0.76068	−0.76419
		(-1.87601–4.55836)	(-3.04951–3.53082)	(-3.29990–2.85610)		(-2.57636–2.27506)	(-3.27286–1.75150)	(-3.11469–1.58630)
Saarland		−2.93125	−4.81130	−5.35011 +		5.60788*	4.84319*	4.84013*
		(-8.48843–2.62592)	(-10.82225–1.19964)	(-11.13013–0.42992)		(1.20261–10.01314)	(0.53482–9.15157)	(0.75687–8.92339)
Berlin		−5.72262**	−4.86092*	−5.07860*		−1.94746	−1.93762	−1.94286
		(-10.05416 to −1.39108)	(-9.16030 to −0.56154)	(-9.46537 - -0.69183)		(-5.92636–2.03144)	(-6.11960–2.24436)	(-6.06191–2.17619)
Brandenburg		1.75662	1.07419	0.55473		1.72793	2.67059	2.66703
		(-3.04170–6.55495)	(-3.66984–5.81821)	(-3.95093–5.06039)		(-1.86027–5.31614)	(-1.31168–6.65285)	(-1.06147–6.39552)

(*continued on next page*)

Table 2 (*continued*)

Clustering	Mcs (t0-t1)				Pcs (t0-t1)			
	crude	baseline	sociodemo	Multi-level	crude	baseline	sociodemo	Multi-level
	None	None	None	commune	None	None	None	commune
Mecklenburg Western Pomerania		0.07665	0.77937	0.28296		2.52918	1.75601	1.75101
		(-7.60588–7.75918)	(-7.37907–8.93782)	(-6.47647–7.04238)		(-2.55660–7.61496)	(-4.14633–7.65835)	(-3.51936–7.02138)
Saxony		−0.49940	−0.33026	−0.58567		−0.41508	0.00108	0.00122
		(-5.55963–4.56082)	(-5.36209–4.70157)	(-5.16643–3.99508)		(-4.38833–3.55817)	(-4.17347–4.17564)	(-3.55921–3.56164)
Saxony-Anhalt		0.78317	1.39673	0.83631		0.45726	1.58173	1.58045
		(-4.47002–6.03635)	(-3.93924–6.73270)	(-4.63029–6.30292)		(-4.42391–5.33844)	(-3.34924–6.51270)	(-3.09549–6.25638)
Thuringia		−0.94015	−0.78338	−1.18171		5.25399**	4.31938*	4.31501**
		(-6.10007–4.21976)	(-6.30901–4.74225)	(-6.15955–3.79612)		(1.44387–9.06411)	(0.61694–8.02182)	(1.05863–7.57140)
male			*ref*	*ref*			*ref*	*ref*
female			−2.39329**	−2.44284**			−2.30777**	−2.30763**
			(-3.65866 to −1.12792)	(-3.69505 - -1.19062)			(-3.36401 - -1.25153)	(-3.37973 to −1.23553)
Days since arrival			−0.00140	−0.03713			−0.22106**	−0.22107**
			(-0.00306–0.00027)	(-0.09747–0.02321)			(-0.27195 - -0.17017)	(-0.27135 to −0.17079)
Education: low			*ref*	*ref*			*ref*	*ref*
Education: medium			−0.85088	−0.79004			1.78191**	1.78222**
			(-2.50812–0.80635)	(-2.44944–0.86937)			(0.57998–2.98384)	(0.54223–3.02222)
Education: high			−0.27577	−0.19783			2.49724**	2.49732**
			(-1.93901–1.38747)	(-1.83203–1.43637)			(1.22557–3.76892)	(1.26260–3.73204)
Age in years			−0.03180	−0.00138			0.00002	0.00002
			(-0.09061–0.02700)	(-0.00306–0.00030)			(-0.00147–0.00151)	(-0.00153–0.00157)
Asylum seeker			*ref*	*ref*			*ref*	*ref*
Asylum status			2.17449*	2.26814*			0.45784	0.45629
			(0.44156–3.90742)	(0.48387–4.05241)			(-0.78539–1.70107)	(-0.76578–1.67835)
Temporary protection status			−1.68967	−1.74457			0.21540	0.21548
			(-4.12615–0.74681)	(-4.21394–0.72480)			(-1.43711–1.86790)	(-1.44531–1.87626)
Observations	1466	1466	1400	1400	1466	1466	1400	
R-squared	0.00483	0.41944	0.43855		0.00283	0.28434	0.34023	
adjusted R-squared	0.00210	0.40936	0.42541		0.00010	0.27191	0.32478	
model degrees of freedom	4	25	32	32	4	25	32	
Number of clusters				539				539
Aikikes information criterion (AIC)				10816.96				10039.14
Bayes information criterion (BIC)				11000.51				10222.69
Intra-class correlation coefficient (ICC)				0.04873				0.00073
Neighbourhood intercept variance				6.18383				0.05259
Residual variance				120.718				72.4004
Likelihood-ratio test vs. linear model				0.0296				0.4863

Mcs = mental health component summary scale; pcs = physical health component summary scale; Significance levels: + $p < 0.1$; *$p < 0.05$; **$p < 0.01$.

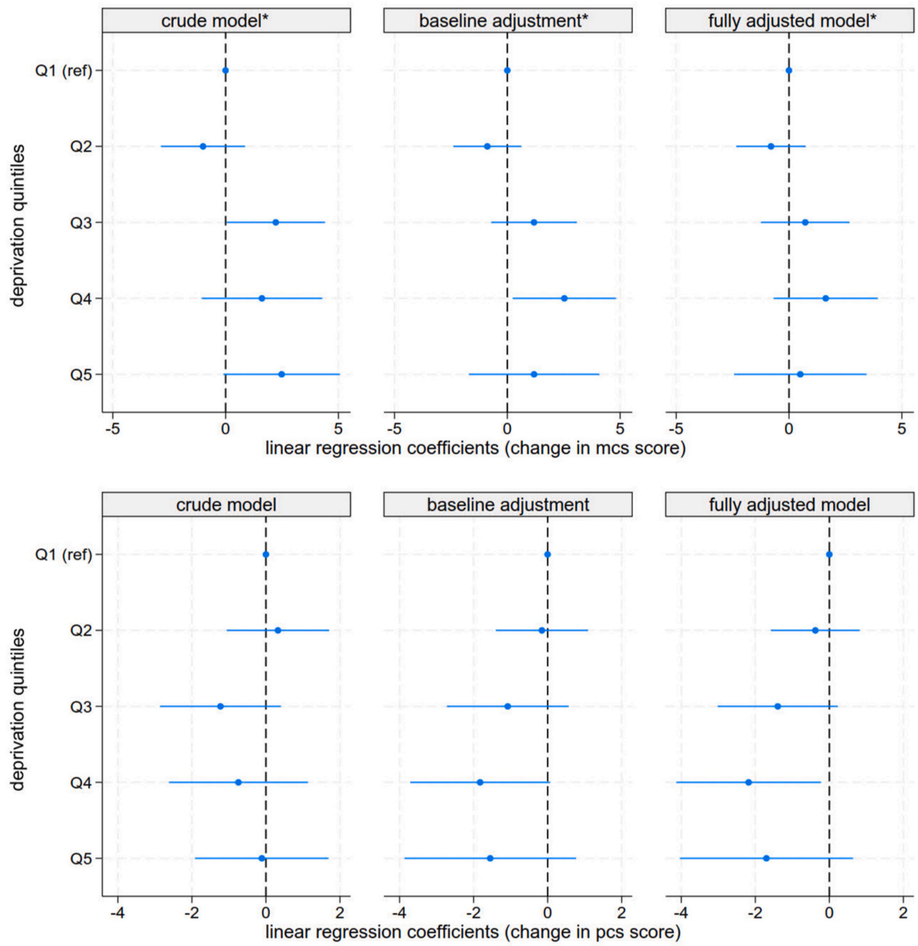

Fig. 3. Coefficient plots for baseline and fully adjusted models.
3a) Effect of area-level deprivation on mental health.
3b) Effect of area-level deprivation on physical health.
* Multi-level model accounting for random slopes at the commune level.
mcs = mental health component scale of the SF-12; pcs = physical health component scale of the SF-12.

communities (Balsa-Barreiro et al., 2022).

Strengths of this study are the natural experiment design with robust, multi-level DiD analysis which allows for causal interpretation. The dispersal of refugees across Germany is quasi-random, with important exemptions particularly relating to nationality at the national, and family status at the sub-national levels. However, we believe that refugee dispersal in Germany remains a valid and valuable natural experiment for the following reasons: 1) despite the partially uneven dispersal of individuals in Germany, individuals are unable to select their living environment reducing compositional bias; 2) deviations from random dispersal are unrelated to the exposure of interest for the present analysis; 3) the most common nationalities, representing over 90% of the current sample, are dispersed to all federal states; 4) the analysis applies the exposure at a highly granular level, meaning that potential confounding introduced by (partial) sorting of other nationalities at the level of federal states is further diffused by the variation in exposure achieved after sub-national dispersal.

The study benefits from robust survey data which allows for the direct identification of refugees as well as analysis of potential causal pathways. However, the causal interpretation of results is limited by the short follow-up time of 1–2 years and relatively small sample size, especially in the more deprived quintiles. Combined with the fact that surveys take place relatively soon after arrival in Germany, this means that changes in mental health status may reflect secular trends rather than responses to contextual characteristics. Further research with larger sample sizes and longer follow-up is required to further evaluate and study the impact of area-level socioeconomic deprivation on mental and physical health outcomes. A further limitation is the drop out of half the sample between t0 and t1. The use of subjective health outcomes is a further benefit of the analysis, as previous studies considering the effect of area-level deprivation on health have typically used diagnosis data from medical registries. However, further research should test whether the effects hold for more specific health outcomes. Due to the clustered sampling approach and identification strategy, this analysis only covers a small proportion of geographical areas in Germany. However, these communes represent a broad range of communes in terms of area-level deprivation, population density, federal state and socioeconomic characteristics (Supplementary File S6). While the study uses small-area level contextual variables, these constitute political boundaries which may or may not represent refugees' actual experienced communities (Pickett & Pearl, 2001). Alternative approaches which centres individuals' experiences of their communities, such as social network modelling, is encouraged.

5. Conclusions

This study finds a negative impact of area-level socioeconomic deprivation on the self-reported physical health of refugees in Germany. In contrast to previous studies, which considered the effects over long time periods, our analysis shows that the negative effects of area-level socioeconomic deprivation are evident even after 1–2 years of follow-up. This suggests that availability and accessibility of health and social care structures play an important role in determining refugee health in more deprived regions. Further efforts should be made to support resource-poor regions to improve integration of refugees into health and social systems. Further research using longer timeframes and larger sample sizes are required to confirm the results of this study. These should further explore the mechanisms through which area-level socioeconomic deprivation acts on health in order to guide policy efforts and assess generalisability of results to other marginalised population groups.

Ethical approval and data availability

The present study is a secondary data analysis of publicly available data and thus did not require ethical approval. Data of the Socioeconomic Panel is publicly available for individuals at research institutions subject to eligibility requirements and data sharing agreements. Requests can be made via soepmail@diw.de. Details of the data protection statement and mission of the Socioeconomic Panel can be accessed here (in German): https://www.diw.de/documents/dokumentenarchiv/17/diw_01.c.347090.de/soep_datenschutzverfahren.pdf.

Data sharing

Data of the Socioeconomic Panel is publicly available for individuals at research institutions subject to eligibility requirements and data sharing agreements. Requests can be made via soepmail@diw.de.

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CRediT authorship contribution statement

Louise Biddle: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft. **Kayvan Bozorgmehr:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: LB and KB report funding from the German Federal Ministry of Education and Research (BMBF) and the Robert Koch-Institute. KB additionally reports funding from the German Ministry of Health, the German Agency for Health Education, the Global Health Academy of the German Alliance for Global Health Research (GLOHRA), the WHO European Regional Office Europe, and the International Organization for Migration and the German Centre for Migration and Integration (DeZIM). KB is registered co-inventor (issued) for the Refugee care manager Software (RefCare) and sits on the board of the German Alliance for Global Health research.

Data availability

Data of the Socioeconomic Panel is publicly available for individuals at research institutions subject to eligibility requirements and data sharing agreements. Requests can be made via soepmail@diw.de.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101596.

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