Supplemental Online Content

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This supplemental material has been provided by the authors to give readers additional information about their work.

eMethods

Neighborhood disadvantage index

Refugees initially lived in Red Cross reception centers while their asylum application was processed, but within 10 days of receiving their residence permit they were assigned temporary housing in one of Denmark's 15 counties.[1] Following this, local placement officers assigned them to one of the municipalities within the county and found permanent housing for the family in this municipality. Administrative statistics on the length of stay in temporary housing shows that across the policy years between 72% and 87% of refugee families were relocated to permanent housing within 9 months.[2] To identify the neighborhood to which refugee families were quasi-randomly assigned in residential history data, we therefore used the second place of residence as the neighborhood of assignment if there were records of families moving during the first year to another neighborhood within the same county. We used parish borders to define neighborhoods and excluded parishes with fewer than 50 family units, to avoid unstable statistical estimates. Parishes ranged from 0.1 to 159 km^2 (median 16 km^2), with populations of 101 to 20,848 (median 1,133). To construct a socioeconomic neighborhood disadvantage index for the initial neighborhood of assignment among the refugee families, we conducted a principal component analysis (PCA). Because we are examining a relatively long time period, the same neighborhood may be more or less disadvantaged at different time points. For this reason, we elected to create the neighborhood disadvantage index using PCA separately for each year that the dispersal policy was in place (1986-1998), allowing the disadvantage level of a neighborhood to vary over time. Refugees were assigned a time-invariant index value at the year of their resettlement. We did not consider later values of the index, as only this initial exposure measure was assumed quasi-random and free of bias due to confounding.

eTable3 contains detailed information on the four aggregated socioeconomic variables included in the PCA. eTable4 shows the eigenvalues and the proportion of variance explained for each of the four principal components for every year. The first principal component is the linear combination of the variables that explains the largest amount of variation, in our case between 50% and 58% of the variance depending on the year. We used the variable loading from this first principal component, shown in eTable5, to calculate a composite neighborhood disadvantage index. To give an indication of socioeconomic differences between neighborhoods at the top and the bottom of the index, eTable6 provides summary statistics for each of the aggregated socioeconomic variables by disadvantage level. For example, the unemployment rate among adults in the labor force was 5% and 10%, respectively, in

neighborhoods in the lowest and highest quartiles of the disadvantage index. Finally, eFigure1 shows where the socioeconomically disadvantaged neighborhoods were located in the country and how the pattern remained quite stable between the first and last year of the dispersal policy (*i.e.*, 1986 and 1998).

Sensitivity analysis

In sensitivity analyses, we analyzed the data excluding all children and adolescents who experienced the outcome, died, or emigrated within the first two years of resettlement. This wash-out period reduced the likelihood of capturing pre-existing cases. In another analysis, we used age as the indicator of time instead of years since resettlement. We also ran an analysis excluding all refugees who resettled before 1995, when diagnoses from outpatient psychiatric clinics and emergency care units started being included in the Psychiatric Central Register. Further, we analyzed the data excluding those arriving from former Yugoslavia because special regulations applied to them. Yugoslavs were granted provisional asylum for up to two years, during which they were accommodated in special refugee centers across the country.[3] They also were covered by a dispersal policy allowing settlement in more rural areas. Finally, we examined the association in two subsamples with more extended exposure to the assigned neighborhood: a subsample of 9037 (48%) children and adolescents who stayed in the neighborhood of assignment for a minimum of five years and a subsample of 5701 (30%) children and adolescents who stayed for a minimum of ten years.

eResults

Sensitivity analysis

Sensitivity analyses excluding study participants who were diagnosed with a psychiatric disorder, died, or emigrated within the first two years after resettlement (N=17,504) yielded findings similar to those of the main analysis (HR: 1.11, 95% CI: 1.02-1.20) and so did analyses using age as the underlying time scale instead of time since resettlement (HR: 1.11, 95% CI: 1.03-1.21). Estimates were similar but less precise when only including the smaller sample of refugees resettling during 1995-1998 (N=9,600), when follow-up data from both psychiatric inpatient and outpatient clinics, and emergency care services were available (HR: 1.11, 95% CI: 0.99-1.26). The same was seen when children and adolescents from former Yugoslavia (N=12,950) were excluded (HR: 1.09, 95% CI: 0.99-1.21). Results from Cox regression analysis in the subsample of 9037 children and adolescents who stayed in the

neighborhood of assignment for a minimum of five years, showed that an increase of one standard deviation in neighborhood disadvantage was associated with a 16% increase in the hazard of psychiatric disorders (HR: 1.16, 95% CI: 1.04-1.29). Using the subsample who stayed in the neighborhood of assignment for a minimum of 10 years (N = 5701) an increase of one standard deviation in neighborhood disadvantage was associated with a 22% increase in the hazard of psychiatric disorders (HR: 1.22, 95% CI: 1.02-1.45). Thus, we find that the association is stronger in subsamples with a more extended exposure to the assigned neighborhood. However, as soon as we limit the analytical sample to include refugee children and adolescents who stayed in the assigned neighborhood for a number of years we lose the advantage of the quasi-experiment, because whether you stay or move can be expected to be influenced by characteristics of the individuals in the family. These stronger effect estimates are therefore more likely to be contaminated by residential selection.

eReferences

1. Damm AP, Dustmann C. Does Growing Up in a High Crime Neighborhood Affect Youth Criminal Behavior? *Am Econ Rev*. 2014;104(6):1806-1832. doi:10.1257/aer.104.6.1806

2. Damm AP. *The Danish Dispersal Policy on Refugee Immigrants 1986-1998: A Natural Experiment?* 2005. Working Paper no. 05-03, Department of Economics, Aarhus School of Business, University of Aarhus.

3. Ankestyrelsen. *Bosniske krigsflygtninge fra medio 90'erne: Fakta om integration, 2014* [Bosnian war refugees from the mid-90s: Facts about integration, 2014]. 2014. Copenhagen: Ankestyrelsen.

eTable 1. Data sources

Data Element	Register	Years	Variables
Neighborhood characteristics	Statistics Denmark registers	1986-1998	Income, unemployment, education, and welfare benefits at the parish level[a]
Baseline characteristics of children and adolescents	Statistics Denmark registers	1986-1998	Country of origin, year of arrival, age, sex, parental marital status, parental age, and number of children in the household
Inpatient psychiatric hospital stays	Psychiatric Central Register	1986-2019, February	ICD-8 and ICD-10 codes and diagnosis dates
Contacts with outpatient psychiatric clinics and emergency care units	Psychiatric Central Register	1995-2019, February	ICD-8 and ICD-10 codes and diagnosis dates
Prescription of psychiatric medications	Prescription Drug Register	1995-2019, February	ATC codes and dates of prescription redemption

Abbreviation: ICD, *International Classification of Diseases;* ATC, *Anatomical Therapeutic Chemical*

[a] The specific operationalization of each neighborhood-level variable is described in eTable3

eTable 2. Residence permits granted to refugees from 1986 to 1998

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Total
Total number	7,281	4,193	3,905	4,465	3,044	4,014	3,782	3,424	2,818	20,347	8,253	5,925	4,758	76,209
By country of citizenship														
Former Yugoslavia	2	0	0	18	42	41	36	18	88	16,729	4,272	1,450	595	23,291
Somalia	14	33	56	201	138	559	641	1,232	897	1,180	1,470	1,741	946	9,108
Afghanistan	65	27	42	51	72	149	92	144	143	201	284	261	324	1,855
Sri Lanka	2,381	597	449	574	85	109	104	107	150	203	81	51	79	4,970
Iraq	363	233	481	540	435	476	1,225	774	560	974	945	1,283	1,749	10,038
Iran	1,040	925	914	544	495	523	270	250	137	126	254	260	232	5,970
Vietnam	274	195	457	634	659	621	276	68	29	79	44	25	26	3,387
Lebanon	2,626	1,648	1,145	1,337	727	1,262	856	461	488	456	353	564	349	12,272

Source: Data for 1986-1996 are available from the 1991 and 2001 Statistical Yearbook published by Statistics Denmark (https://www.dst.dk/da/Statistik/Publikationer/VisPub?cid=2179) and data for 1997 and 1998 are available from StatBank Denmark (https://www.statistikbanken.dk/VAN77).

eTable 3. Description of the aggregated socioeconomic variables included in the neighborhood disadvantage index, 1986-1998

Variable	Description	Median	Minimum	Maximum
Income	Median inflation-adjusted equivalized disposable family income, Danish kroner (DKK)	117,269	38,080	254,831
Education	Percent of inhabitants aged 25-69 years with low educational status (<10 years of formal schooling)	41.18	10.35	77.94
Unemployment	Percent of inhabitants aged 18-59 years in the labour force who had been unemployed for more than half a year	6.53	0.00	27.16
Welfare benefits	Percent of families receiving welfare benefits due to unemployment, sickness, or parental leave	36.42	11.76	67.11

eTable 4. Results from the principal component analyses: Eigenvalues and proportion of variance explained

Year	Component 1		Component 2		Component 3		Component 4	
	Eigenvalue	Proportion of variance explained	Eigenvalue	Proportion of variance explained	Eigenvalue	Proportion of variance explained	Eigenvalue	Proportion of variance explained
1986	2.12	0.53	0.86	0.21	0.79	0.20	0.23	0.06
1987	2.18	0.54	0.80	0.20	0.78	0.20	0.24	0.06
1988	2.30	0.58	0.75	0.19	0.70	0.18	0.24	0.06
1989	2.33	0.58	0.73	0.18	0.67	0.17	0.27	0.07
1990	2.32	0.58	0.71	0.18	0.69	0.17	0.27	0.07
1991	2.30	0.58	0.75	0.19	0.67	0.17	0.28	0.07
1992	2.25	0.56	0.79	0.20	0.67	0.17	0.29	0.07
1993	2.26	0.56	0.79	0.20	0.63	0.16	0.32	0.08
1994	2.08	0.52	0.91	0.23	0.69	0.17	0.32	0.08
1995	1.99	0.50	0.97	0.24	0.71	0.18	0.32	0.08
1996	2.07	0.52	0.94	0.24	0.66	0.17	0.32	0.08
1997	2.10	0.53	0.92	0.23	0.65	0.16	0.33	0.08
1998	2.10	0.53	0.92	0.23	0.66	0.16	0.32	0.08

Note: Separate analyses were conducted for each year from 1986 to 1998.

eTable 5. Results from the principal component analyses: Variable loadings for the first component

Year	Income	Education	Unemployment	Welfare benefits
1986	-0.57	0.58	0.38	0.43
1987	-0.56	0.57	0.42	0.43
1988	-0.55	0.55	0.45	0.43
1989	-0.54	0.54	0.47	0.45
1990	-0.53	0.54	0.47	0.46
1991	-0.52	0.53	0.48	0.46
1992	-0.53	0.53	0.47	0.45
1993	-0.53	0.54	0.49	0.44
1994	-0.56	0.55	0.46	0.41
1995	-0.58	0.56	0.42	0.41
1996	-0.57	0.56	0.44	0.41
1997	-0.56	0.56	0.44	0.42
1998	-0.56	0.57	0.39	0.45

Note: Separate analyses were conducted for each year from 1986 to 1998.

eTable 6. Descriptive neighborhood-level socioeconomic characteristics by disadvantage level, 1986-1998

Neighborhood characteristics	Neighborhood disadvantage index				
	Q1 (low disadvantage)	Q2	Q3	Q4	Q5 (high disadvantage)
Median household income	135.139	121.682	116.778	113.197	108.762
Low educational status	28.3	37.8	42.1	45.6	50.1
Unemployment rate	5.0	5.8	6.5	7.5	10.1
Welfare support rate	30.4	34.9	36.6	38.3	41.0

eTable 7. Standardized differences of baseline characteristics by neighborhood disadvantage level among refugee children and adolescents

| | Tertile of neighborhood disadvantage at resettlement | | | | | | Standardized differences | | |
| | Low (N = 6,519) | | Moderate (N = 5,732) | | High (N = 6,458) | | Low and moderate | Low and high | Moderate and high |
Baseline characteristics	N/Mean	(%)/SD	N/Mean	(%)/SD	N/Mean	(%)/SD	Std. diff.	Std. diff.	Std. diff.
Female	3014	(46.2)	2696	(47.0)	3071	(47.6)	0.016	0.026	0.010
Age at resettlement, categorical									
0-4	1379	(21.2)	1118	(19.5)	1229	(19.0)	0.041	0.053	0.012
5-8	1990	(30.5)	1838	(32.1)	1981	(30.7)	0.033	0.003	0.030
9-12	1650	(25.3)	1470	(25.6)	1642	(25.4)	0.008	0.003	0.005
13-16	1500	(23.0)	1306	(22.8)	1606	(24.9)	0.005	0.044	0.049
Age at resettlement, continuous	8.13	4.39	8.24	4.34	8.40	4.39	0.024	0.060	0.037
Number of children in the family at resettlement									
1	808	(12.4)	775	(13.5)	801	(12.4)	0.034	0.000	0.033
2	2051	(31.5)	1832	(32.0)	2057	(31.9)	0.011	0.008	0.002
3	1442	(22.1)	1231	(21.5)	1445	(22.4)	0.016	0.006	0.022
≥4	2218	(34.0)	1894	(33.0)	2155	(33.4)	0.021	0.014	0.007
Primary parent not married at resettlement	818	(12.5)	612	(10.7)	738	(11.4)	0.058	0.034	0.024
Primary parents' age at resettlement, categorical									
17-23	293	(4.5)	212	(3.7)	251	(3.9)	0.040	0.030	0.010
24-30	1774	(27.2)	1536	(26.8)	1723	(26.7)	0.009	0.012	0.003
31-37	2466	(37.8)	2289	(39.9)	2479	(38.4)	0.043	0.012	0.032
≥38	1986	(30.5)	1695	(29.6)	2005	(31.0)	0.020	0.013	0.032
Primary parents' age at resettlement, continuous	33.97	7.41	34.13	7.37	34.27	7.69	0.022	0.040	0.018
Country of origin									
Former Yugoslavia	1698	(26.0)	1961	(34.2)	2100	(32.5)	0.179	0.143	0.036
Somalia	856	(13.1)	710	(12.4)	1164	(18.0)	0.022	0.135	0.157
Afghanistan	251	(3.9)	196	(3.4)	218	(3.4)	0.023	0.025	0.002
Sri Lanka	511	(7.8)	543	(9.5)	255	(3.9)	0.058	0.166	0.222
Iraq	980	(15.0)	649	(11.3)	924	(14.3)	0.110	0.021	0.089
Iran	707	(10.8)	446	(7.8)	461	(7.1)	0.106	0.130	0.024
Vietnam	244	(3.7)	308	(5.4)	425	(6.6)	0.078	0.129	0.051
Lebanon (Palestinians)	1272	(19.5)	919	(16.0)	911	(14.1)	0.091	0.145	0.054

Abbreviations: SD, standard deviation; Std. diff., standardized difference

eTable 8. Association between neighborhood disadvantage and emigration from Denmark among refugee children and adolescents

	HR (95% CI)
Neighborhood disadvantage index. increase per SD	0.99 (0.96 to 1.03)

Abbreviations: HR, hazard ratio; CI, confidence interval

Hazard ratio and 95% confidence intervals from Cox proportional hazard models adjusted for sex, age, number of children in the family, parental marital status, parental age, year at time of resettlement, and initial municipality. Standard errors are clustered by neighborhood. N = 18.709.

eTable 9. Tests for differences in associations between neighborhood disadvantage and first-time diagnosis with a psychiatric disorder by subgroups among refugee children and adolescents
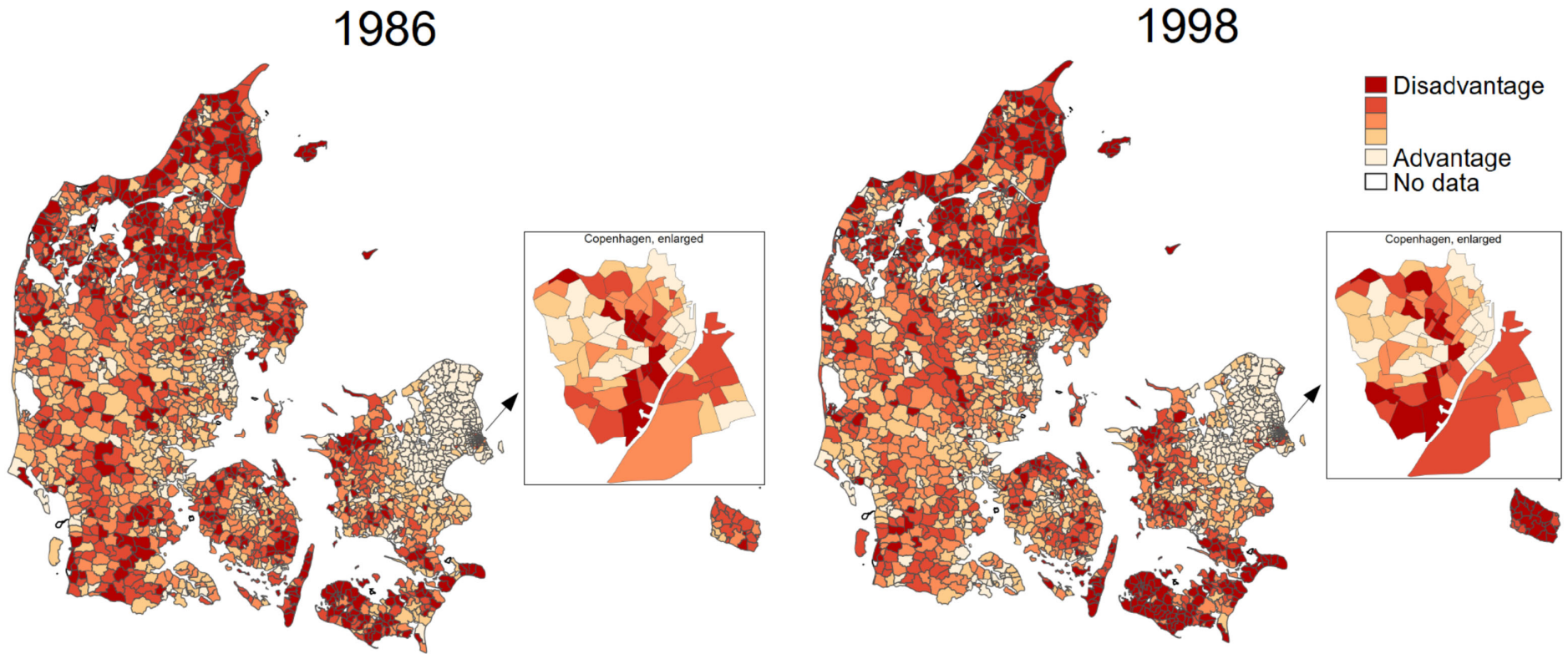
Neighborhood disadvantage	Results from stratified models		Test for difference in associations		
	Coef. (95% CI)		Observed difference	Bootstrap Std. Err.	P-value
Sex					
Boys	0.10 (0.00 to 0.20)				
Girls	0.13 (0.02 to 0.25)		0.03	0.13	0.784
Baseline age, years					
0-4	0.06 (-0.11 to 0.23)				
5-8	0.16 (0.02 to 0.31)		0.10	0.18	0.579
9-12	0.04 (-0.10 to 0.17)		-0.03	0.19	0.887
13-16	0.19 (0.03 to 0.34)		0.12	0.20	0.533
Household structure					
Dual-parent	0.09 (0.00 to 0.17)				
Single-parent	0.33 (0.07 to 0.59)		0.24	0.31	0.424

Abbreviations: Coef., coefficient; CI, confidence interval; Std. Err., standard error

Estimates from Cox proportional hazard models adjusted for sex, age, and parental marital status - if not the stratifying variable - and number of children in the family, parental age, year of resettlement, and initial municipality. Standard errors are clustered by neighborhood.

To test for differences in associations by subgroups p-values were calculated based on bootstrapped standard errors for the observed difference using 1,000 replications.

eFigure 1. Neighborhood socioeconomic disadvantage index classified into quintiles in the first and last year of the dispersal policy

Note: Neighborhoods (i.e., parishes) with fewer than 50 family units were excluded from the analysis and account for the "No data" category.