

## Supplementary Material

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# Mediating pathways between neighborhood disadvantage and cardiovascular disease risk: Quasi-experimental evidence from a Danish refugee dispersal policy

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## Appendix S1. Supplemental Methods

### Causal mediation analysis, product method formulas, and assumptions.

For causal mediation analysis, we employed product methods that are easily implemented across a broad range of potential applications (1), such as mediation analysis under the discrete-time survival analysis framework. Specifically, we decomposed total effect (TE) into a direct effect (NDE) or controlled direct effect (CDE) and a natural indirect effect (NIE). This was accomplished in three steps. First, we ran regression models with each mediator as the dependent variable while including the same set of covariates and model specifications used in the total effect model (i.e., no time-updated confounders were included) (Equation 1; mediator model). Second, we ran regression models that adjusted for all confounders and the mediator to evaluate the NDE of neighborhood disadvantage on each outcome (Equation 2; outcome model). Third, we calculated CDE, NDE, and NIE, whereby NDE is  $\alpha_1$  and NIE is the product of multiplication of two coefficients ( $\alpha_1 \times \gamma_1$ ).

$$E(M|X) = \gamma_0 + \gamma_1 X \quad (1)$$

$$E(Y|X, M) = \alpha_0 + \alpha_1 X + \alpha_0 M \quad (2)$$

Mediation analysis based on counterfactuals allows for a causal interpretation of the mediated effect. CDE are estimated by setting the mediator to a fixed level through conditioning in the regression model; this assesses how much the outcome would change on average if the mediator were set to level  $m$  uniformly in the population, but the treatments were changed from level  $a^* = 0$  to level  $a = 1$  (or one-unit increment of values in case of the continuous treatment variable). NDE expresses how much the outcome would change if the exposure were set at level  $a = 1$  versus level  $a^* = 0$ , but for each individual the mediators were kept at the level they would have had in the absence of the exposure. NIE expresses how much the outcome would change on average if the exposure were controlled at level  $a = 1$ , but the mediators were changed from the level it would have if  $a^* = 0$  to the level it would have if  $a = 1$ .

#### *Product Method Formulas*

The formulas below describe how NDE and NIE were derived in the linear probability models with a continuous mediator and with the presence of exposure-mediator interaction. We first fit the outcome model:

$$E[Y|X = x, M = m, C = c] = \theta_0 + \theta_1 X + \theta_2 M + \theta_3 (X \times M) + \theta_4' C,$$

Followed by the mediator model:

$$E[M|X = x, C = c] = \beta_0 + \beta_1 X + \beta_2' C.$$

We estimated CDE, NDE, and NIE using the following expressions.

$$DE = \{\theta_1 + \theta_3(\beta_0 + \beta_1 a^* + \beta_2' c)\}(a - a^*)$$

$$IE = \{(\beta_1 \theta_2 + \beta_1 \theta_3 a)(a - a^*)\}$$

The formulas below show how natural direct and indirect effects were derived in the logistic regression models with a continuous mediator and with the presence of exposure-mediator interaction. We first fitted an outcome model for CVD risk (Y), conditional on neighborhood disadvantage at arrival (X), potential mediator (i.e., household income, unstable employment, poor mental health conditions) (M), and neighborhood disadvantage-mediator interaction (X × M), and a set of confounders (C):

$$\log [\Pr(Y = 1|X = x, M = m, C = c)] = \theta_0 + \theta_1 X + \theta_2 M + \theta_3 (X \times M) + \theta_4' C.$$

Then we fitted a model for mediator, household income (M), conditional on neighborhood disadvantage (X), and a set of confounders (C):

$$\log [\Pr(M = 1|X = x, C = c)] = \beta_0 + \beta_1 X + \beta_2' C.$$

Finally, we estimated odd ratios of controlled direct effects (equivalent to the hazard ratios under the discrete-time survival models),  $HR_{CDE}$ , natural direct effects,  $HR_{NDE}$ , and natural indirect effects,  $HR_{NIE}$ , for an exposure using the following expressions. They include exposure-mediator interaction terms, which would be canceled out in models without them:

$$HR_{NDE} = \exp \{ \{ \theta_1 + \theta_3(\beta_0 + \beta_1 a + \beta_2' c + \theta_2 \sigma^2) \} (a - a^*) + 0.5 \theta_3^2 \sigma^2 (a^2 - a^{*2}) \}$$

$$HR_{NIE} = \exp \{ (\theta_2 \beta_1 + \theta_3 \beta_1 a) (a - a^*) \}$$

where  $\sigma^2$  is the variance of the error term in the regression for the mediator. *Assumptions*  
Causal mediation analysis requires several sequential ignorability assumptions (50, 53). The first is that treatment assignment is statistically independent of potential outcome values for the mediator and outcome given the observed confounders; this assumption is met in our case by the quasi-experimental study design. The second assumption is that no unobserved variables confound the relationship between the mediator and outcome, conditioned on observed treatment status and observed covariates. This ignorability of mediator implies that among refugees assigned to neighborhoods with the same disadvantage level, the mediator can be regarded as if it were randomized. Finally, causal mediation analysis requires an assumption that confounders (measured or unmeasured) of the mediator-outcome relationships are unaffected by the exposure. While these sequential ignorability assumptions are unverifiable, we assessed the second assumption (i.e., confounder bias) by evaluating estimates when all three mediators (income, unstable employment, and mental health) were modeled simultaneously.

## Reference

1. VanderWeele TJ. Mediation analysis: a practitioner's guide. Annual review of public health. 2016;37:17-32.

**Table S1. Register data used in the study.**

Data element	Register	Years	Variables
Neighborhood characteristics	Statistics Denmark Registers	1986-1998	Income, unemployment, education, and receipt of welfare benefits at the parish level
Baseline characteristics of individuals	Statistics Denmark Registers	1986-1998	Country of origin, year of arrival, age, sex, marital status, and number of children
Inpatient hospital stays & outpatient clinic contacts	Danish National Patient Registry	Inpatient: 1986-February 2019 Outpatient: 1995-February 2019	ICD-8 codes through 1994 and subsequently ICD-10 codes
Inpatient hospital stays & outpatient clinic contacts	Danish Psychiatric Central Register	Inpatient: 1986-February 2019 Outpatient: 1995-February 2019	ICD-8 codes through 1994 and subsequently ICD-10 codes
Prescription medications	Danish National Prescription Registry	1995-2020	Anatomical Therapeutic Chemical codes and dates of prescription redemption

Abbreviation: ICD, *International Classification of Diseases*

**Table S2. Socioeconomic variables included in the neighborhood disadvantage index.**

Variable	Description	Median/ %	Minimum	Maximum
Income	Median inflation-adjusted equivalized disposable family income in 2020 USD	117,269	38,080	254,831
Education	Percent inhabitants (aged 25-69 years) with less than 10 years of schooling	41.2	10.4	77.9
Unemployment	Percent inhabitants aged 18-59 years in the labour force who had been unemployed for more than half a year	6.5	0.0	27.2
Welfare benefits	Percent families receiving welfare benefits due to unemployment, sickness, or parental leave	36.4	11.8	67.1

Note: This includes 2,097 parishes nested within 271 municipalities for the years 1986-1998, which were used in the creation of the disadvantage index using principal component analysis.

**Table S3. Correlation between neighborhood-level variables in selected years.**

Year	Income	Education	Unemployment	Welfare benefits
<b>1986</b>				
Income	1.00			
Education	-0.65	1.00		
Unemployment	-0.36	0.19	1.00	
Welfare benefits	-0.23	0.40	0.24	1.00
<b>1991</b>				
Income	1.00			
Education	-0.56	1.00		
Unemployment	-0.45	0.28	1.00	
Welfare benefits	-0.27	0.43	0.31	1.00
<b>1996</b>				
Income	1.00			
Education	-0.51	1.00		
Unemployment	-0.37	0.30	1.00	
Welfare benefits	-0.21	0.41	0.29	1.00

Note: This includes 2,097 parishes nested within 271 municipalities for selective years. We created a composite neighborhood disadvantage index for each year using principal component analysis.

**Table S4. Principal component analyses: eigenvalues and proportion of variance explained.**

Year	Component 1		Component 2		Component 3		Component 4	
	Eigenvalues	Proportion of variance explained	Eigenvalues	Proportion of variance explained	Eigenvalues	Proportion of variance explained	Eigenvalues	Proportion of variance explained
1986	2.12	0.53	0.86	0.21	0.79	0.20	0.23	0.06
1987	2.17	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	2.00	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: Eigenvalues and proportion of variance explained were obtained from principal component analyses, with separate analyses conducted for each year during 1986-1998.

**Table S5. Principal component analyses: variable factor loadings.**

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	0.40	0.45

Note: Variable loadings from the first component calculated in the principal component analysis, with separate analyses conducted for each year during 1986-1998.



**Table S6. Neighborhood socioeconomic characteristics by tertile of neighborhood disadvantage.**

Neighborhood characteristics	Neighborhood disadvantage index			
	Total	Low-level disadvantage	Mid-level disadvantage	High-level disadvantage
Median household income	119,105	130,141	116,877	110,298
Proportion with education <10 years (%)	36.24	31.73	42.12	48.55
Proportion unemployed (%)	6.98	5.27	6.51	9.15
Proportion receiving welfare support (%)	40.80	32.08	36.58	40.06

Note: We included 2,097 parishes nested within 271 municipalities for the years between 1986 and 1998 to create the disadvantage index using principal component analysis. The neighborhood disadvantage index has been reversed, so higher values equal a higher disadvantage level. The index has been divided into tertiles for descriptive purposes.

**Table S7. Codes used for identifying cardiovascular risk factors.**

<b>Risk factors</b>	<b>ICD-8</b>	<b>ICD-10</b>	<b>Medication (ATC code)</b>
Hypertension	400-404	I10-I15	C02, C03, C07, C08, C09
Hyperlipidemia	272.00	E78.0-E78.5	C10AA, C10B, B04AB
Type 2 diabetes	249-250	E10-E14, O24 (except O24.4), H36.0	A10A, A10B
Any psychiatric condition: Schizophrenia and related disorders; Affective/Mood disorders; Neurotic and stress-related disorders	F20-29; F30-39; F40-48	295.x9, 296.89, 297.x9, 298.29-298.99, 299.04, 299.05, 299.09, 301.83; 296.x9 (excluding 296.89), 298.09, 298.19, 300.49, 301.19; 300.x9 (excluding 300.49), 305.x9, 305.68, 307.99	N05A (Antipsychotics) N05B (Anxiolytics) N06A (Antidepressants)

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

**Table S8. Associations between neighborhood disadvantage and risk of hypertension, adjusting for exposure and mediator interaction.**

Cohorts	Measures of mediators	Coefficient	95% CI	P value
Hypertension	Neighborhood disadvantage	-0.01	[-0.14, 0.12]	0.91
	Household income	-0.01	[-0.01, -0.00]	<0.001
	Disadvantage × Cumulative household income	0.00	[-0.00, 0.00]	0.36
	Neighborhood disadvantage	0.07	[-0.00, 0.15]	0.05
	Household poverty	0.24	[0.11, 0.37]	<0.001
	Disadvantage × Cumulative poverty	-0.06	[-0.16, 0.04]	0.26
	Neighborhood disadvantage	0.04	[-0.02, 0.10]	0.21
	Unstable employment	-0.23	[-0.38, -0.09]	0.002
	Disadvantage × Unstable employment	0.06	[-0.11, 0.23]	0.47
	Neighborhood disadvantage	0.04	[-0.02, 0.09]	0.22
	Poor mental health	2.30	[2.10, 2.60]	<0.001
	Disadvantage × Poor mental health	0.18	[-0.08, 0.44]	0.17

Note: We ran linear probability models separately for the hypertension outcome, with neighborhood disadvantage, each mediator, and neighborhood disadvantage-mediator interaction as predictors, adjusting for age, sex, country of origin, number of children, marital status, and fixed effects (i.e., indicator variables) for year of arrival and municipality. We multiplied coefficients by 100 to be equivalent with estimates from logistic regression models.

**Table S9. Decomposition of the association between neighborhood disadvantage and cardiovascular risk factor outcomes to examine the role of mediators, in the presence of exposure-mediator interaction.**

Health outcomes	Mediation with	Household income		Household poverty		Unstable employment		Poor mental health	
		Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Hypertension	Controlled direct effect	-0.007	[-0.137, 0.122]	0.073	[-0.001, 0.147]	0.039	[-0.025, 0.104]	0.035	[-0.021, 0.091]
	Natural direct effect	0.044	[-0.012, 0.099]	0.056	[-0.002, 0.114]	0.054	[-0.002, 0.11]	0.036	[-0.020, 0.092]
	Natural indirect effect	0.003	[0.001, 0.004]	0.001	[0.000, 0.002]	0.000	[0.000, 0.000]	-0.002	[-0.004, 0.000]
Hyperlipidemia	Controlled direct effect	-0.026	[-0.121, 0.068]	0.049	[-0.007, 0.105]	0.012	[-0.037, 0.061]	0.020	[-0.022, 0.063]
	Natural direct effect	0.023	[-0.017, 0.063]	0.035	[-0.009, 0.078]	0.036	[-0.007, 0.080]	0.021	[-0.021, 0.063]
	Natural indirect effect	0.003	[0.002, 0.004]	0.000	[-0.001, 0.001]	0.000	[0.000, 0.000]	-0.001	[-0.002, 0.000]
Type 2 diabetes	Controlled direct effect	0.018	[-0.059, 0.095]	0.002	[-0.040, 0.045]	0.005	[-0.034, 0.043]	0.003	[-0.032, 0.038]
	Natural direct effect	0.007	[-0.027, 0.041]	0.006	[-0.028, 0.041]	0.001	[-0.024, 0.044]	0.004	[-0.031, 0.038]
	Natural indirect effect	0.002	[0.002, 0.003]	0.001	[0.000, 0.001]	0.000	[-0.000, 0.000]	0.000	[-0.001, 0.000]

Abbreviations: CI, confidence interval.

Note: Estimates were derived from the linear probability models using a pooled logistic regression framework, whereby each health outcome was modeled as a function of neighborhood disadvantage, mediator, and the interaction between exposure and mediator, while adjusting for age, sex, country of origin, number of children, marital status, and fixed effects (i.e., indicator variables) for year of arrival and municipality. We multiplied coefficients by 100 to be equivalent with estimates from logistic regression models. CIs for natural direct effect and natural indirect effect were bootstrapped 1000 times.

**Table S10. Total, controlled direct, and natural indirect effects of neighborhood disadvantage through different types of mediators, pooled logistic regressions.**

Health outcomes	Mediation with	Household income			Household Poverty			Unstable employment			Poor mental health
		OR	[95% CI]	% Mediated	OR	[95% CI]	% Mediated	OR	[95% CI]	OR	[95% CI]
Hypertension	TE	1.027	[1.001, 1.054]	4.25	1.027	[1.001, 1.054]	1.36	1.027	[1.001, 1.054]	1.027	[1.001, 1.054]
	NDE	1.026	[0.998, 1.054]		1.027	[0.998, 1.055]		1.027	[0.999, 1.056]	1.027	[0.999, 1.055]
	NIE	1.001	[1.001, 1.002]		1.000	[1.000, 1.001]		1.000	[1.000, 1.000]	0.999	[0.999, 1.000]
Hyperlipidemia	TE	1.023	[1.007, 1.054]	5.15	1.023	[1.007, 1.054]	NA	1.023	[1.007, 1.054]	1.023	[1.007, 1.054]
	NDE	1.021	[0.990, 1.052]		1.023	[0.992, 1.054]		1.023	[0.990, 1.056]	1.023	[0.992, 1.054]
	NIE	1.001	[1.001, 1.002]		1.000	[0.999, 1.000]		1.000	[1.000, 1.000]	1.000	[0.999, 1.000]

Abbreviations: TE, Total effect; NDE, Natural direct effect; NIE, Natural indirect effect; CI, confidence interval; OR, Odds Ratios.

Notes: TE estimates were derived from the pooled logistic regression models, whereby each health outcome was modeled as a function of neighborhood disadvantage, while adjusting for age, sex, country of origin, number of children, marital status, fixed effects (i.e., indicator variables) for year of arrival and municipality, and observed years since arrival. NDE and NIE were derived using product methods formulas. CIs were bootstrapped 1000 times. The proportion mediated on a risk difference scale by  $OR\_NDE(OR\_NIE - 1) / (OR\_NDE \times OR\_NIE - 1)$ .

**Table S11. Controlled direct, natural direct, and natural indirect effects of neighborhood disadvantage through different types of mediators, pooled logistic regressions with the presence of exposure-mediator interaction.**

		Household income		Household Poverty		Unstable employment		Poor mental health	
Mediation with		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
<b>Health outcomes</b>									
Hypertension	CDE	1.006	[0.944, 1.068]	1.035	[0.997, 1.072]	1.018	[0.987, 1.050]	1.025	[0.995, 1.056]
	NDE	1.024	[0.996, 1.053]	1.029	[0.999, 1.058]	1.033	[1.003, 1.063]	1.026	[0.996, 1.055]
	NIE	1.001	[1.001, 1.002]	1.000	[1.000, 1.001]	1.000	[1.000, 1.000]	0.999	[0.999, 1.000]
Hyperlipidemia	CDE	0.996	[0.923, 1.070]	1.031	[0.989, 1.073]	1.003	[0.966, 1.041]	1.020	[0.984, 1.055]
	NDE	1.018	[0.987, 1.050]	1.025	[0.992, 1.057]	1.036	[1.001, 1.071]	1.020	[0.986, 1.054]
	NIE	1.001	[1.001, 1.002]	1.000	[0.999, 1.000]	1.000	[1.000, 1.000]	1.000	[0.999, 1.000]

Abbreviations: CDE, Controlled direct effect; NDE, Natural direct effect; NIE, Natural indirect effect; CI, confidence interval; OR, Odds Ratios.

Notes: Estimates were derived from the pooled logistic regression models. CDE, NDE and NIE were derived using product methods formulas. CIs were bootstrapped 1000 times.

**Table S12. Association between neighborhood disadvantage and a given mediator, adjusting for other mediators.**

	Cohorts	Household income		Unstable employment		Poor mental health	
		Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
Neighborhood disadvantage	Hypertension	-0.62	[-0.92, -0.32]	-0.001	[-0.004, 0.002]	-0.002	[-0.005, 0.003]
	Hyperlipidemia	-0.65	[-0.94, -0.36]	-0.001	[-0.004, 0.002]	0.000	[-0.004, 0.003]
	Diabetes	-0.66	[-0.94, -0.39]	-0.001	[-0.003, 0.002]	-0.001	[-0.005, 0.003]

Abbreviation: CI, confidence interval

Note: We ran linear regression models separately for each mediator as an outcome and neighborhood disadvantage as an exposure, while also adjusting for other time-updated mediators in each CVD cohort. For example, we included unstable employment and poor mental health as covariates in the mediator model for household income. Household income was measured as inflation-adjusted annual equivalized disposable family income in Danish Krone (dKr) divided by 1,000, which was then averaged across preceding years. Unstable employment and poor mental health condition were measured as the proportion of observed years in which an individual experiences unemployment or poor mental health condition, respectively, from arrival up to the year of observation.

**Table S13. Associations of the multiple mediators with CVD risk outcome.**

Cohorts	Measures of mediators (cumulative)	Coefficient	95% CI
Hypertension	Household income	-0.003	[-0.005, -0.002]
	Unstable employment	-0.150	[-0.290, -0.000]
	Poor mental health	2.30	[2.00, 2.60]
Hyperlipidemia	Household income	-0.004	[-0.005, -0.002]
	Unstable employment	-0.260	[-0.36, -0.15]
	Poor mental health	1.40	[1.2, 1.6]
Type 2 Diabetes	Household income	-0.003	[-0.004, -0.002]
	Unstable employment	-0.140	[-0.22, -0.054]
	Poor mental health	0.47	[0.34, 0.60]

Abbreviations: CI, confidence interval.

Note: We ran linear probability models for each outcome with all three mediators as predictors, adjusting for neighborhood disadvantage. Household income was measured as inflation-adjusted annual equivalized disposable family income in Danish Krone (dKr) divided by 1,000, which was then averaged across years, from arrival up to the year of observation. Unstable employment and poor mental health condition were measured as the proportion of observed years in which the individual experience unemployment or poor mental health condition, respectively, from arrival up to the year of observation. We multiplied the coefficients by 100 to express changes in risk as percentage-points.



**Table S14. Correlation between mediators.**

	Household income	Poverty	Unstable employment	Poor mental health
Household income	1.00			
Household poverty	-0.68	1.00		
Unstable employment	0.06	-0.09	1.00	
Poor mental health	0.05	-0.01	-0.05	1.00

Note: We reported Pearson's correlation coefficient between mediator variables for the Hypertension cohort (Observations = 648,003). The cumulative poverty mediator was derived from the household income variable. Correlation coefficients between mediators in Hyperlipidemia and Diabetes cohorts were similar to these estimates.

**Table S15. Association between 5-year cumulative neighborhood disadvantage and cardiovascular risk factors.**

	Estimate	95% CI
Hypertension	0.07	[0.01, 0.13]
Hyperlipidemia	0.05	[0.00, 0.10]
Type 2 diabetes	0.04	[-0.00, 0.08]

Abbreviations: CI: Confidence Interval

Notes: The exposure variable captured the mean of the neighborhood disadvantage index across the first five years upon resettlement during 1986-1998. For each outcome, estimates with 95% C.I.s were obtained from linear probability models in a pooled regression framework adjusted for age, sex, country of origin, number of children, marital status, and fixed effects (i.e., indicator variables) for the year of arrival and municipality. We adjusted standard errors clustered at individual and municipality levels. We multiplied the coefficients by 100 to express as percentage-point changes in annual risk. We excluded individuals who had outcome incidence within the first 5 years since the year of resettlement. Number of observations used in each model varied (N = 462,914 for the hypertension cohort; N = 528,811 for the hyperlipidemia cohort; N = 547,483 for the type 2 diabetes cohort)

**Table S16. Association between cumulative neighborhood disadvantage and mediator in 5-year disadvantage exposure samples**

		Household income		Household poverty		Unstable employment		Poor mental health	
Cohort		Coefficien t	95% CI	Coefficien t	95% CI	Coefficien t	95% CI	Coefficient	95% CI
Neighborhood disadvantage	Hypertension	-1.940	[-2.44, - 1.43]	0.022	[0.017, 0.028]	-0.007	[-0.012, - 0.002]	0.004	[0.001, 0.007]
	Hyperlipidemia	-1.910	[-2.39, - 1.42]	0.022	[0.017, 0.027]	-0.007	[-0.011, - 0.002]	0.004	[0.001, 0.006]
	Diabetes	-1.910	[-2.38, - 1.44]	0.021	[0.016, 0.026]	-0.007	[-0.011, - 0.002]	0.004	[0.002, 0.006]

Abbreviations: CI. Confidence Interval.

Note: We ran linear regression models separately for each mediator as an outcome and 5-year cumulative neighborhood disadvantage as an exposure in person-year observations for each outcome. All mediators were measured as the cumulative mean from the 6<sup>th</sup> year up to the observational year or the proportion of observed years in which the individual experienced the respective hardship (i.e., poverty, unemployment, or poor mental health condition) from the 6<sup>th</sup> year up to the observational year until outcome incidence, emigration, death, or the end of the study period, whichever comes first.

**Table S17. Associations of the mediator with CVD risk outcome in 5-year disadvantage exposure samples.**

Cohorts	Measures of mediators	Coefficient	95% CI
Hypertension	Household income	-0.005	[-0.007, -0.003]
	Household poverty	0.110	[-0.051, 0.260]
	Unstable employment	-0.310	[-0.450, -0.170]
	Poor mental health	2.9	[2.4, 3.3]
Hyperlipidemia	Household income	-0.006	[-0.008, -0.004]
	Household poverty	-0.034	[-0.150, 0.082]
	Unstable employment	-0.240	[-0.360, -0.130]
	Poor mental health	2.4	[2.1, 2.8]
Type 2 Diabetes	Household income	-0.004	[-0.005, -0.003]
	Household poverty	0.120	[0.029, 0.210]
	Unstable employment	-0.190	[-0.290, -0.092]
	Poor mental health	0.8	[0.600, 0.100]

Abbreviations: CI. Confidence Interval.

Note: We ran linear probability models separately for each mediator as a predictor, adjusting for 5-year neighborhood disadvantage, and outcome. We multiplied the coefficients by 100 to express as percentage-point changes in risk. All mediators were measured as the cumulative mean from the 6<sup>th</sup> year up to the observational year or the proportion of observed years in which the individual experienced the respective hardship (i.e., poverty, unemployment, or poor mental health condition) from the 6<sup>th</sup> year up to the observational year until outcome incidence, emigration, death, or the end of the study period, whichever comes first.

**Table S18. Association between neighborhood disadvantage and cardiovascular risk factors among refugees who did not move in the follow-ups.**

	Estimate	95% CI
Hypertension	0.04	[-0.09, 0.17]
Hyperlipidemia	0.09	[-0.26, 0.21]
Type 2 diabetes	-0.01	[-0.07, 0.05]

Abbreviations: CI: Confidence Interval

Notes: We restricted refugee sample to those who did not change the neighborhood/parish from the initial observation up to the outcome incidence (Hypertension cohort: 9,570; Hyperlipidemia cohort: 11,002; Diabetes cohort: 10,680). For each outcome, estimates with 95% CIs were obtained from linear probability models in a pooled regression framework, adjusted for age, sex, country of origin, number of children, marital status, and fixed effects (i.e., indicator variables) for year of arrival and municipality. We clustered standard errors at individual and municipality levels. We multiplied the coefficients by 100 to express changes in annual risk as percentage points. Number of observations used in each model varied (N = 122,393 for the hypertension cohort; N = 148,153 for the hyperlipidemia cohort; N = 157,071 for the type 2 diabetes cohort).

**Table S19. Association between neighborhood disadvantage and mediator among refugees who did not move in the follow-ups.**

Cohort	Cumulative income		Cumulative poverty		Unstable employment		Cumulative poor mental health		
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI	
Neighborhood disadvantage	Hypertension	-1.60	[-2.39, -0.80]	0.018	[0.008, 0.029]	0.004	[-0.003, 0.011]	0.008	[0.001, 0.015]
	Hyperlipidemia	-1.67	[-2.51, -0.83]	0.021	[0.012, 0.029]	0.004	[-0.002, 0.010]	0.009	[0.003, 0.014]
	Diabetes	-1.67	[-2.55, -0.79]	0.019	[0.009, 0.030]	0.003	[-0.003, 0.009]	0.008	[0.002, 0.014]

Abbreviations: CI. Confidence Interval.

Note: We ran linear regression models separately for each mediator as an outcome and neighborhood disadvantage at arrival as an exposure in person-year observations for each outcome. Household income was measured as inflation-adjusted annual equivalized disposable family income in Danish Krone (dKr) divided by 1,000, which was then averaged across cumulated years. Poverty, unemployment and poor mental health condition were measured as the proportion of observed years in which the individual experience poverty, unemployment, or poor mental health condition, respectively, from an arrival up to the observational year. Number of observations used in each model varied (N = 122,393 for the hypertension cohort; N = 148,153 for the hyperlipidemia cohort; N = 157,071 for the type 2 diabetes cohort).

**Table S20. Associations of the mediator with CVD risk outcome among refugees who did not move in the follow-ups.**

Cohorts	Measures of mediators	Coefficient	95% CI
Hypertension	Cumulative income	-0.003	[-0.009, 0.004]
	Cumulative poverty	-0.150	[-0.61, 0.32]
	Cumulative unemployment	-0.240	[-0.73, 0.25]
	Cumulative poor mental health	2.8	[2.1, 3.4]
Hyperlipidemia	Cumulative income	-0.004	[-0.008, -0.000]
	Cumulative poverty	-0.400	[-0.710, -0.080]
	Cumulative unemployment	-0.280	[-0.74, 0.19]
	Cumulative poor mental health	1.9	[1.4, 2.4]
Type 2 Diabetes	Cumulative income	-0.006	[-0.008, -0.003]
	Cumulative poverty	0.200	[-0.10, 0.51]
	Cumulative unemployment	-0.180	[-0.49, 0.12]
	Cumulative poor mental health	0.5	[0.2, 0.8]

Abbreviations: CI. Confidence Interval.

Note: We ran linear probability models separately for each mediator as a predictor, adjusting for neighborhood disadvantage, and outcome. We multiplied the coefficients by 100 to express as percentage-point changes in risk. Cumulative poverty, cumulative unemployment, and cumulative poor mental health condition were measured as the proportion of observed years in which the individual experience poverty, unemployment, or poor mental health condition, respectively, from an arrival up to the observational year. Number of observations used in each model varied (N = 122,393 for the hypertension cohort; N = 148,153 for the hyperlipidemia cohort; N = 157,071 for the type 2 diabetes cohort).