Supplementary File 1

to

Social disparities in Disease Management Programmes for coronary heart disease in Germany: A cross-classified multilevel analysis

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Methods

Statistical Analysis – Model specification

We tested the model fit of the cross-classified null-models (main manuscript) by means of likelihood-ratio tests (LR tests) against three alternative models. These were a single-level logistic regression model on the one hand, and "naive" two-level null-models on the other hand. In the latter, patients were nested in (i) municipalities alone (Alternative 1) or (ii) GP practices alone (Alternative 2).

We assessed if the effect of GP practices and patients' residential areas is non-additive by introducing a random interaction classification between regional deprivation tertiles of GPs' and patients' residential areas. In this model (Alternative 3), patients at level 1 were nested in the cross-classified interaction of regional deprivation (level 2) of "GPs-by-municipalities" (level 3).

Statistical Analysis – Regression diagnostics

We performed regression diagnostics to check whether the random effects at municipality- and practice-level are normally distributed. To this end, we predicted the residuals at each level respectively from the unconditional models of Tables 3-5 (main manuscript) and plotted them using quantile-quantile plots.

Results

Model specification

The test statistics of the LR test indicated that the unconditional cross-classified model (N=1241, N Practice=382) was significantly preferred over a single-level logistic regression (chi^2(2)= 19.69, p=0.0001), and over the "naive" two-level models with patients nested in municipalities (Alternative 1: chi^2(1)= 6.15, p= 0.0132) or practices alone (Alternative 2: chi^2(1)= 4.72, p= 0.0298). We found no evidence that the effect of GP practices and patients' residential areas are independent of each other by introducing a random interaction classification (Alternative 3) between regional deprivation tertiles of GPs' and patients' residential areas (chi^2 (1)= 0.08, p= 0.7816).

Regression diagnostics

As illustrated in Figures 1-3, the assumption of normality of residuals were widely met both at municipality- and practice-level.

Figure 1: Random effects for unconditional model M0-RISK

A: Municipality   **B: GP-practice**

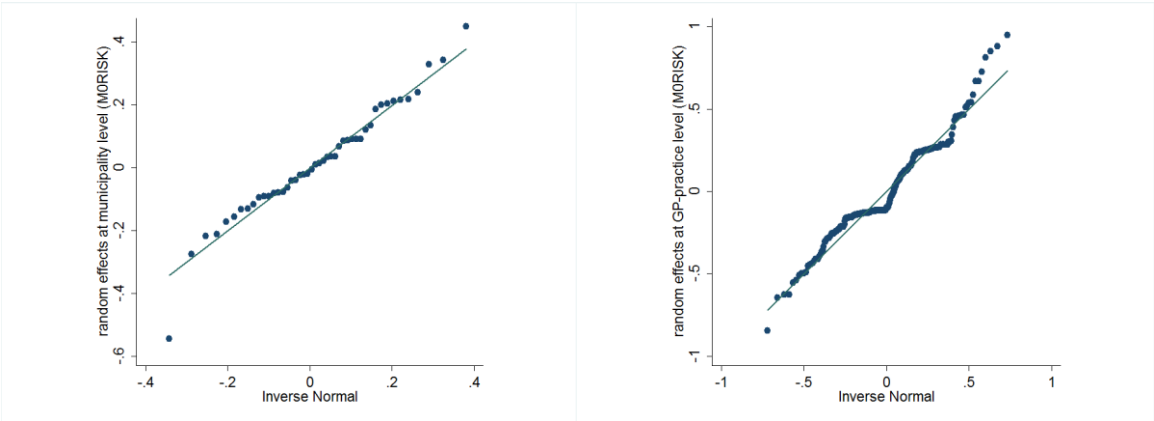**Figure 2: Random effects for unconditional model M0-COMORB**
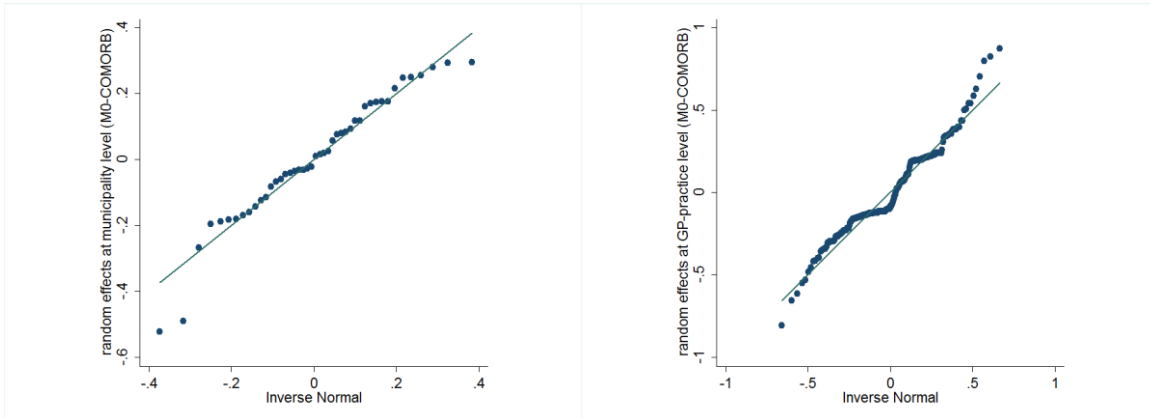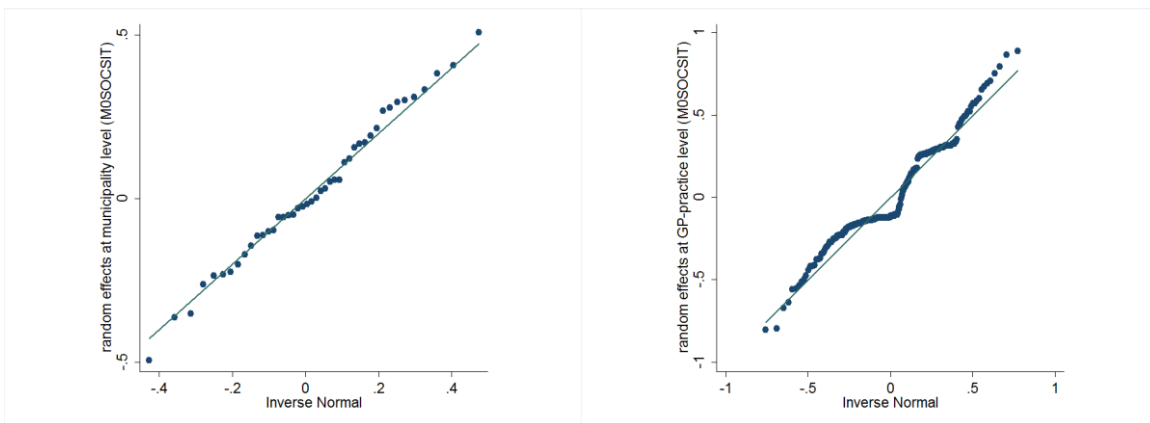
A: Municipality   **B: GP-practice**

Figure 3: Random effects for unconditional model M0-SOCSIT

A: Municipality   **B: GP-practice**

Regression results

Models adjusted for individual-level behavioural risk factors and higher-level variables

Table S1: Effect estimates of individual-level behavioural risk factors, practice-level, and area-level variables on the enrolment in the disease management program for coronary heart disease obtained from cross-classified multilevel logistic regression models

	M0-RISK		M1-RISK		M2-RISK		M3-RISK		M4-RISK	
			Measures of association/fixed effects - OR [95%CI]							
Individual level variables										
Education (Ref: I, lowest)										
II			0.97	[0.59 - 1.59]	0.97	[0.59 - 1.59]	1.01	[0.62 - 1.65]	1.01	[0.62 - 1.65]
III (highest)			1.11	[0.69 - 1.78]	1.11	[0.69 - 1.78]	1.12	[0.70 - 1.80]	1.14	[0.71 - 1.82]
Socio-demographics										
Age group (Ref: 55-64)										
65-74			**1.65**	**[1.01 - 2.71]**	**1.65**	**[1.01 - 2.71]**	**1.68**	**[1.03 - 2.75]**	**1.71**	**[1.04 - 2.79]**
75-84			1.68	[0.98 - 2.87]	1.67	[0.98 - 2.87]	1.68	[0.98 - 2.87]	1.69	[0.98 - 2.89]
Male (Ref: female)			**1.58**	**[1.07 - 2.35]**	**1.58**	**[1.07 - 2.35]**	**1.58**	**[1.07 - 2.33]**	**1.60**	**[1.08 - 2.36]**
Behavioural risk factors										
Hypercholesterolemia (Yes vs. No)			1.11	[0.78 - 1.58]	1.11	[0.78 - 1.58]	1.14	[0.80 - 1.61]	1.14	[0.80 - 1.62]
Body Mass Index (Ref: normal/underweight)										
Overweight/Pre-obese			1.20	[0.80 - 1.79]	1.20	[0.80 - 1.79]	1.20	[0.80 - 1.79]	1.19	[0.80 - 1.79]
Obese class I+II			1.04	[0.65 - 1.67]	1.04	[0.65 - 1.67]	1.02	[0.64 - 1.64]	1.01	[0.63 - 1.63]
Obese class III			1.37	[0.46 - 4.13]	1.37	[0.46 - 4.12]	1.40	[0.47 - 4.19]	1.49	[0.49 - 4.50]
Smoking status (Ref: Never Smoker)										
Former			1.20	[0.84 - 1.73]	1.20	[0.84 - 1.73]	1.19	[0.83 - 1.71]	1.19	[0.83 - 1.71]
Current			1.26	[0.68 - 2.33]	1.26	[0.68 - 2.33]	1.23	[0.66 - 2.27]	1.26	[0.68 - 2.33]
Alcohol consumption † (Ref: Abstainers)										
DI			**1.46**	**[1.02 - 2.09]**	**1.46**	**[1.02 - 2.09]**	**1.48**	**[1.04 - 2.12]**	**1.51**	**[1.06 - 2.16]**
DII			1.25	[0.53 - 2.97]	1.25	[0.53 - 2.97]	1.24	[0.52 - 2.94]	1.26	[0.53 - 3.01]
DIII			1.63	[0.44 - 6.07]	1.63	[0.44 - 6.10]	1.67	[0.45 - 6.17]	1.80	[0.48 - 6.77]
Contextual variables										
Practice-level										
Male general practitioner (vs. female)					1.03	[0.67 - 1.56]	1.03	[0.68 - 1.56]	1.05	[0.69 - 1.60]
Area-level										
Regional Deprivation § (Ref.:T1 - least deprived)										
T2							0.42	[0.23 - 0.76]	0.41	[0.24 - 0.71]
T3 (most deprived)							0.59	[0.32 - 1.08]	0.70	[0.40 - 1.21]
Degree of Urbanisation ǂ (Ref: rural)										
Urban cluster									0.97	[0.63 - 1.51]
High-density cluster									**0.46**	**[0.24 - 0.88]**
Intercept	**0.59 [0.47 - 0.75]**		**0.16**	**[0.08 - 0.34]**	**0.16**	**[0.08 - 0.34]**	**0.28**	**[0.12 - 0.65]**	**0.28**	**[0.12 - 0.64]**
			Measures of variation/random effects							
Practice-variance	0.24		0.30		0.30		0.28		0.37	
MOR-Practice	1.60		1.69		1.69		1.65		1.79	
PCV (%) Practice	-		25.0+		0.0++		-6.7++		23.3++	
Municipality-variance	0.20		0.18		0.18		0.10		0.00	
MOR-Municipality	1.53		1.50		1.50		1.35		1.00	
PCV (%) Municipality	-		-10.0+		0.0++		-44.4++		-100.0++	
			Model fit and sample size							
Wald-chi2 (df)	16.8# (2)		22.67 (14)		22.67 (15)		30.32 (17)		38.56 (19)	
Model-sig. (p-value)	**0.0002**		0.066		0.0913		**0.0242**		**0.0050**	
N	822		822		822		822		822	
Practice N	307		307		307		307		307	

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Outcome in all models: Enrolment in the disease management program for coronary heart disease (Yes vs. No). **M0**: Null-model without predictors. **M1**: Final model with individual level covariables. **M2**: Extension of M1 with practice-level variable „sex of general practitioner". **M3**: Extension of M2 with the area-level variable „Regional deprivation". **M4**: Extension of M3 additionally adjusted for the area-level variable „Degree of urbanisation". **MOR**: Median odds ratio. **PCV**: proportional change in variance. **PCV+**: Compares the change in variance on municipality-/practice-level between M1 and M0 (reference is the M0 variance on municipality-/practice-level). **PCV++**: compares the change in variance on municipality-/practice-level between the models with contextual variables (M2-M4) and with the final model containing individual variables (M1) respectively (reference is the M1 variance on municipality-/practice-level). [†] **Alcohol consumption in g/d:** DI: female: 0-19.99; male: 0-39.99. DII: female: 20-39.99; male: 40-59.99. DIII: female: > 40.0; male: > 60.0. **§**: Regional deprivation tertiles (T1-T3) refer to the deprivation of the patient-residential area. ǂ **Degree of Urbanisation:** Rural: < 300 inhabitants/km^2 or less than 5.000 inhabitants. Urban cluster: ≥ 300 inhabitants/km^2 and minimum population of 5.000 inhabitants, but less than 50.000. High-density cluster: ≥ 1000 inhabitants/km^2 and minimum population of 50.000 inhabitants. #Test statistic of a likelihood-ratio test, testing the fit of the null-model against a single-level logistic regression model.

Models adjusted for individual-level social situation and higher-level variables

Table S2: Effect estimates of individual-level social situation, practice-level, and area-level variables and the enrolment in the disease management program for coronary heart disease obtained from cross-classified multilevel logistic regression models

	M0-SOC		M1-SOC		M2-SOC		M3-SOC		M4-SOC	
			Measures of association/fixed effects – OR [95%CI]							
Individual level variables										
Education (Ref. I - lowest)										
II			0.92	[0.55 - 1.53]	0.92	[0.55 - 1.53]	0.96	[0.58 - 1.59]	0.98	[0.59 - 1.62]
III (highest)			0.95	[0.58 - 1.57]	0.95	[0.58 - 1.57]	0.96	[0.59 - 1.57]	0.99	[0.60 - 1.62]
Socio-demographics										
Age group (Ref: 55-64)										
65-74			1.55	[0.93 - 2.57]	1.55	[0.93 - 2.57]	1.57	[0.95 - 2.59]	1.56	[0.94 - 2.58]
75-84			1.35	[0.79 - 2.30]	1.35	[0.79 - 2.30]	1.35	[0.79 - 2.29]	1.33	[0.78 - 2.25]
Male (vs. female)			**1.80**	**[1.23 - 2.62]**	**1.80**	**[1.23 - 2.62]**	**1.78**	**[1.22 - 2.59]**	**1.79**	**[1.23 - 2.61]**
Ethnicity										
Immigration background[†] (Yes vs. No)			1.48	[0.81 - 2.74]	1.48	[0.80 - 2.74]	1.51	[0.83 - 2.77]	1.55	[0.84 - 2.84]
Social situation										
Certified and approved need of long-term care (Yes vs. No)			0.70	[0.28 - 1.74]	0.70	[0.28 - 1.74]	0.69	[0.28 - 1.70]	0.67	[0.27 - 1.65]
Living in a partnership (Yes vs. No)			0.92	[0.61 - 1.38]	0.92	[0.61 - 1.38]	0.92	[0.62 - 1.38]	0.91	[0.61 - 1.37]
Social contacts[x] (Ref.: 0-1 contacts)										
2-4			1.32	[0.81 - 2.17]	1.32	[0.81 - 2.17]	1.32	[0.81 - 2.15]	1.37	[0.84 - 2.23]
5-10 and more			1.13	[0.67 - 1.92]	1.13	[0.67 - 1.92]	1.16	[0.69 - 1.95]	1.20	[0.72 - 2.02]
Contextual variables										
Practice-level										
Male general practitioner (vs. female)					1.01	[0.65 - 1.55]	1.02	[0.67 - 1.56]	1.03	[0.67 - 1.59]
Area level										
Regional Deprivation (Ref.:T1 - least deprived)										
T2							**0.44**	**[0.23 - 0.82]**	**0.45**	**[0.26 - 0.78]**
T3 (most deprived)							0.56	[0.30 - 1.07]	0.68	[0.38 - 1.19]
Degree of Urbanisation [ǂ] (Ref: rural)										
Urban cluster									0.87	[0.55 - 1.35]
High-density cluster									**0.47**	**[0.25 - 0.90]**
Intercept	**0.55**	**[0.43 - 0.71]**	0.24	[0.11 - 0.50]	0.24	[0.11 - 0.50]	0.42	[0.18 - 1.02]	0.44	[0.18 - 1.06]
			Measures of variation/random effects							
Practice-variance	0.30		0.31		0.31		0.27		0.38	
MOR-Practice	1.69		1.71		1.71		1.65		1.80	
PCV (%) Practice	-		3.3[+]		0.0[++]		-12.9[++]		22.6[++]	
Municipality-variance	0.22		0.23		0.23		0.14		0.00	
MOR-Municipality	1.56		1.58		1.58		1.42		1.00	
PCV (%) Municipality	-		4.5[+]		0.0[++]		-39.1[++]		-100[++]	
			Model fit and sample size							
Wald-chi2 (df)	16.59# (2)		15.34 (10)		15.34 (11)		21.72 (13)		28.69 (15)	
Model-sig.	0.0002		0.12		0.17		0.060		0.020	
N	788		788		788		788		788	
Practice N	305		305		305		305		305	

Outcome in all models: Enrolment in the disease management program for coronary heart disease (yes vs. no). **M0**: Null-model without predictors. **M1-SOC**: Final model with individual level covariables. **M2-SOC**: Extension of M1-SOC additionally adjusting for practice-level variable „sex of general practitioner". **M3-SOC**: Extension of M2-SOC with the area-level variable „Regional deprivation". **M4-SOC**: Extension of M3-SOC additionally adjusted for the area-level variable „Degree of urbanisation". Further adjustment for differences in "current economic activity" (data not shown) did not change the point estimates or significance of the exposure variables (education/regional deprivation) in any of the models. [†] **Immigration background**: defined as having

(i) a foreign nationality or (ii) a German nationality and a place of birth outside of Germany. ^{x}**Social contacts**: the number of social contacts was included as a proxy of loneliness and was captured by the question "How many family members/relatives/friends do you have which whom you can discuss any problems and on why you can rely?". **§: Regional deprivation tertiles** (T1-T3) refer to the deprivation of the patient-residential area. $\ddagger$ **Degree of Urbanisation:** Rural: < 300 inhabitants/km^2 or less than 5.000 inhabitants. Urban cluster: $\geq$ 300 inhabitants/km^2 and minimum population of 5.000 inhabitants - but less than 50.000. High-density cluster: $\geq$ 1000 inhabitants/km^2 and minimum population of 50.000 inhabitants. **MOR**: Median odds ratio. **PCV**: proportional change in variance. **PCV^{+}**: Compares the change in variance on municipality-/practice-level between M1-SOC and M0 (reference is the M0 variance on municipality-/practice-level). **PCV^{++}**: compares the change in variance on municipality-/practice-level between the models with contextual variables (M2-M4-SOC) and the final model containing individual variables (M1-SOC) respectively (reference is the M1-SOC variance on municipality-/practice-level). #Test statistic of a likelihood-ratio test, testing the fit of the model against a single-level logistic regression model.

Results of the covariable selection process and reasons for not including all variables in one model:

1. Of the risk factors analysed, only the DI category of alcohol consumption compared to abstainers was significantly associated with DMP enrolment (Table S1). At first glance, and from the point of view of variable selection aimed at merging models, this variable would qualify for being included in the comorbidity model. But including comorbidities and behavioural risk factors (smoking, alcohol, etc.) in one model would in our opinion run the risk of over-adjustment, since effects of the risk factors (if any) are likely to be mediated via the CIRS-G severity index, which provides a comprehensive assessment of 14 organ systems. In light of the negligible effects of behavioural risk factors on propensity of DMP enrolment, and due to the conceptual risk of over-adjustment, we kept these two models as separate entities.

2. None of the social factors were significantly associated with the outcome, neither in the crude models (main text, Table 2) nor in the adjusted models (Table S2). Thus, none of the variables would actually qualify to be included. We nevertheless calculated a joint model with comorbidities. This turned out to be not very robust (judged by the standard errors of variance parameters), and did not change any of the relevant effect estimates (for education, GIMD, CIRS-G, or social contacts) to a relevant extent.