Exposome Analysis with Bayesian Group Index Regression

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Bayesian Group Index Regression

- **Bayesian group index model**:

$$y_i \sim Bernoulli(p_i)$$

$$logit(p_i) = \beta_0 + \sum_{k=1}^{K} \beta_k \left(\sum_{j=1}^{C_k} w_{kj}\ q_{kij} \right) + \mathbf{z}_i^T \phi,$$

- Priors:

$$\beta_k \sim Normal(0, \tau_k)$$

$$\tau_k = 1/\sigma_k^2$$

$$\sigma_k \sim Uniform(0,100)$$

$$w_{k1}, \ldots, w_{kC_k} \sim Dirichlet(\alpha_{k1}, \ldots, \alpha_{kC_k}),\ \text{for } k=1,\ldots,K$$

- Dirichlet prior assures that the variable weights $w_{kj} \in (0,1)$ and $\sum_{j=1}^{C_k} w_{kj} = 1.$

Exposome Data Analysis

- Modeled child asthma risk with predictors from the air pollution, indoor air, metal, organochlorine, pesticide, PBDE, PFAS, phenol, phthalate, traffic, natural space, meteorological, lifestyle, and built environment families using positive and negative association groups when mixed.

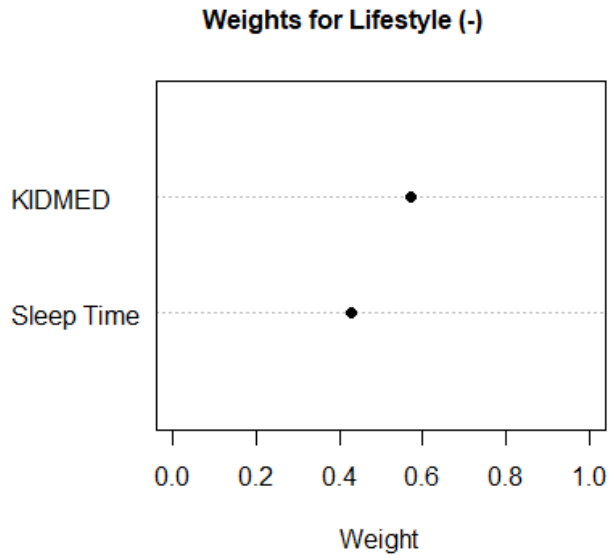
Parameter	Index	Predictors
β_1	Air Pollution	NO2 (yr), PM10 (yr), PM25 (yr), PM25 Abs (yr)
β_2	Indoor Air (-)	Absorbance, NO2
β_3	Indoor Air (+)	PM, Benzene
β_4	Metals (-)	As, Co, Cs, Cu, Pb
β_5	Metals (+)	Cd, Hg, Mn, Mo
β_6	Organochlorines	DDE, DDT, HCB, PCB138, PCB153, PCB170, PCB180
β_7	Pesticides	DEP, DETP, DMP
β_8	PBDEs	PBDE153, PBDE 47
β_9	PFASs	PFHXS, PFOA, PFOS, PFUNDA
β_{10}	Phenols	BPA, BUPA, ETPA, MEPA, OXBE, PRPA
β_{11}	Phthalates (-)	MBZP, MECPP, MEHHP, MEHP, MEOHP, OXOMINP
β_{12}	Phthalates (+)	MEP, MIBP, MNBP, OHMINP
β_{13}	Traffic	Traffic Load, Traffic Density
β_{14}	Natural Spaces	NDVI (h), NDVI (s)
β_{15}	Meteorological	Humidity (month), UV dose (month)
β_{16}	Lifestyle (-)	Sleep Time, KIDMED
β_{17}	Lifestyle (+)	Sedentary Time, MVPA
β_{18}	Built Environment (-)	Access Points (h), Building Density (h), Population Density (h), Building Density (s), Population Density (s)
β_{19}	Built Environment (+)	Access Points (s), Connectivity (h), Connectivity (s), Facility Density (h), Facility Density (s), SEI (h), SEI (s)

Exposome Data Analysis

Main Model - OR estimates for family groups and covariates

Variable	Odds Ratio	2.5% CI	97.5% CI
Family Groups			
Air Pollution	0.69	0.41	1.12
Indoor Air (-)	1.08	0.81	1.43
Indoor Air (+)	1.23	0.97	1.57
Metals (-)	0.74	0.50	1.02
Metals (+)	1.28	0.93	1.72
Organochlorines	1.14	0.86	1.55
Pesticides	**0.77**	**0.60**	**0.98**
PBDEs	**0.72**	**0.56**	**0.92**
PFASs	1.07	0.82	1.44
Phenols	0.95	0.71	1.28
Phthalates (-)	0.84	0.61	1.12
Phthalates (+)	1.36	0.99	1.94
Traffic	0.94	0.74	1.17
Natural Spaces	0.74	0.53	1.03
Meteorological	1.00	0.71	1.42
Lifestyle (-)	**0.77**	**0.59**	**0.99**
Lifestyle (+)	1.06	0.84	1.35
Built Environment (-)	0.69	0.47	1.16
Built Environment (+)	1.23	0.84	1.93

Variable	Odds Ratio	2.5% CI	97.5% CI
Cohort			
Cohort 1	**5.89**	**1.99**	**18.31**
Cohort 2	**4.31**	**1.22**	**15.77**
Cohort 4	1.92	0.57	7.46
Cohort 5	2.39	0.68	9.21
Cohort 6	1.16	0.33	4.36
Other Covariates			
Child Sex (Male)	**1.63**	**1.06**	**2.49**
Maternal Age	0.86	0.71	1.05



Exposome Data Analysis

- The significant cohort covariates indicated effect modification.
- Cohorts 3 and 6 had few asthma cases.
- Family indices were once again split when containing mixed associations with the outcome, so while similar to the main model the stratified model specifications are not identical.

Main Model:

- N=1301
- 19 indices
- Air Pollution predictors together in one index

Cohort 1 Model:

- N=202
- 20 indices
- Air Pollution (-) contains PM25 and PM25 Abs
- Air Pollution (+) contains N02 and PM10

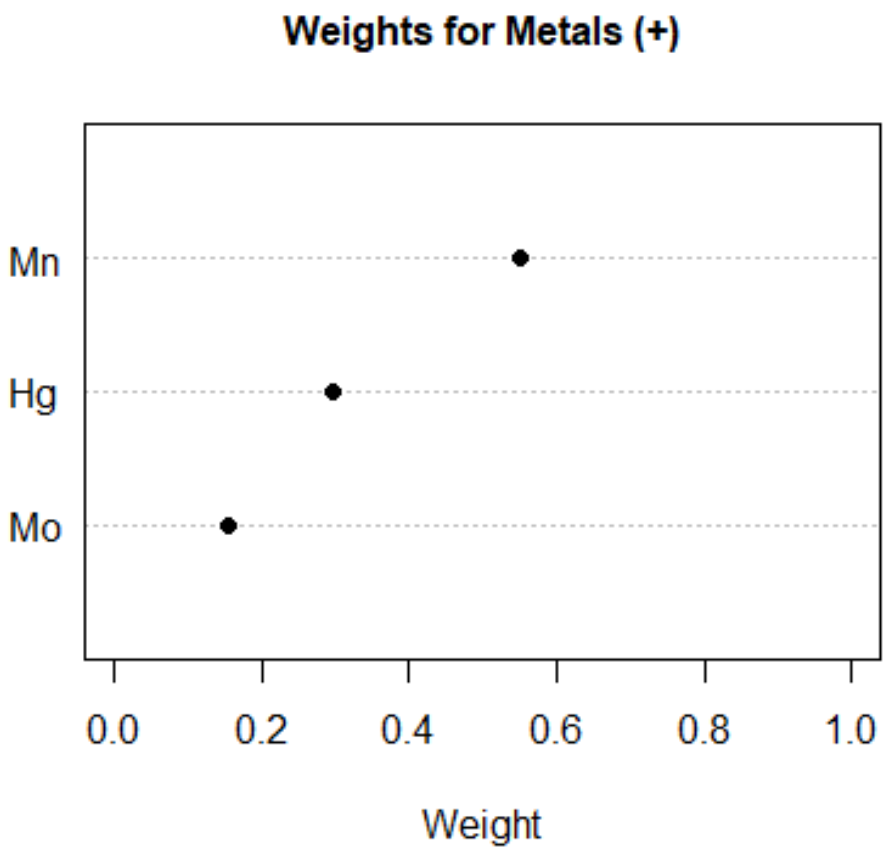
Exposome Data Analysis

Significant Cohort Findings

Model	Significant Parameters	OR (95% CI)	Important Predictors (Weight)
Cohort 1			
Negative Effects:	Metals (-)	0.17 (0.04, 0.60)	Copper (0.21), Arsenic (0.21)
	Phthalates (-)	0.37 (0.12, 0.94)	OXOMINP (0.28)
Positive Effects:	Phthalates (+)	2.99 (1.27, 8.18)	MEP (0.51), OHMINP (0.49)
	Metals (+)	**2.39 (1.02, 6.05)**	**Manganese (0.55)**
	Phenols (+)	**2.23 (1.01, 5.26)**	**OXBE (0.75)**
	Child Sex (Male)	4.11 (1.22, 15.20)	
Cohort 2			
Positive Effects:	Organochlorines (+)	2.50 (1.04, 6.85)	PCB 138 (0.42)
Cohort 4			
Negative Effects:	Built Environment (-)	0.10 (0.01, 0.59)	Home and School Connectivity Density (0.27 and 0.26)
	Metals (-)	0.11 (0.01, 0.79)	Cadmium (0.23)
	Phenols (-)	0.14 (0.01, 0.82)	BPA (0.26)
	Natural Spaces	0.21 (0.04, 0.65)	Home NDVI (0.64)
	PBDEs	0.27 (0.06, 0.80)	PBDE 153 (0.58)
Positive Effects:	Pesticides (+)	2.80 (1.01, 10.96)	DMTP (0.60)
Cohort 5			
Negative Effects:	**Built Environment (-)**	**0.17 (0.05, 0.43)**	**Home Access Points (0.67)**
Positive Effects:	**Traffic**	**2.03 (1.01, 4.12)**	**Traffic Density (0.79)**

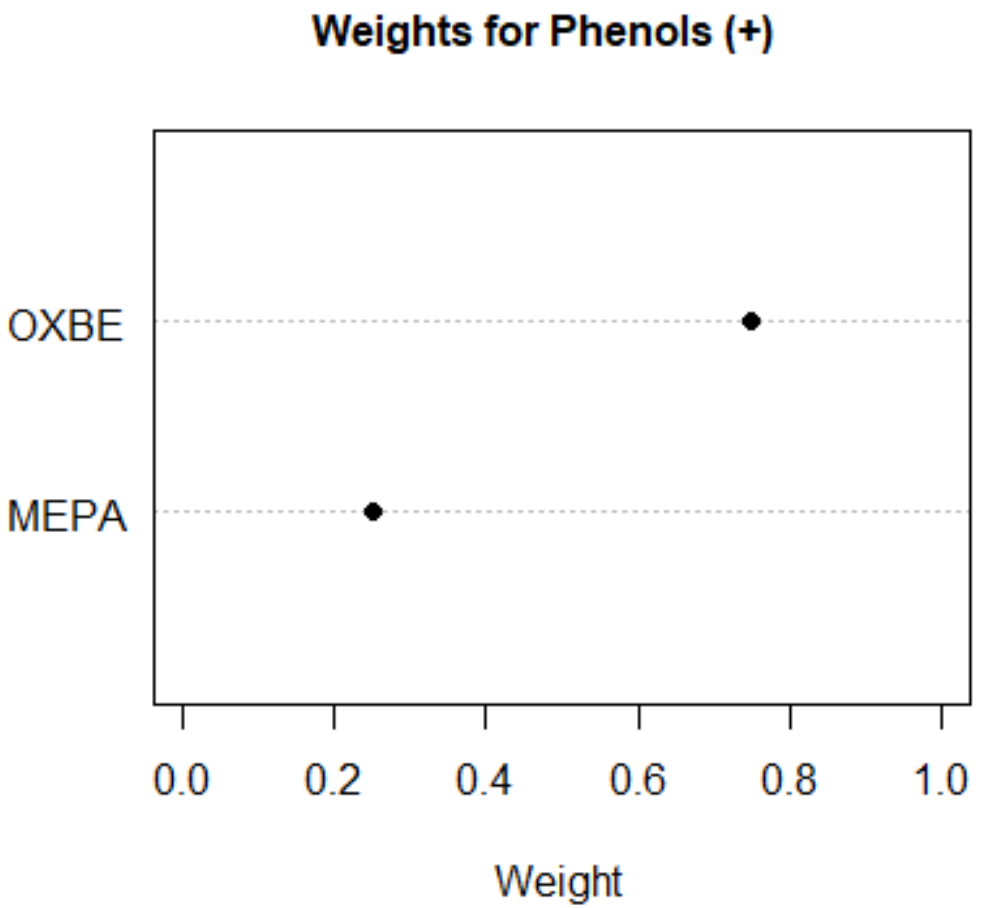
Exposome Data Analysis

Cohort 1: OR = 2.39 (1.02, 6.05)



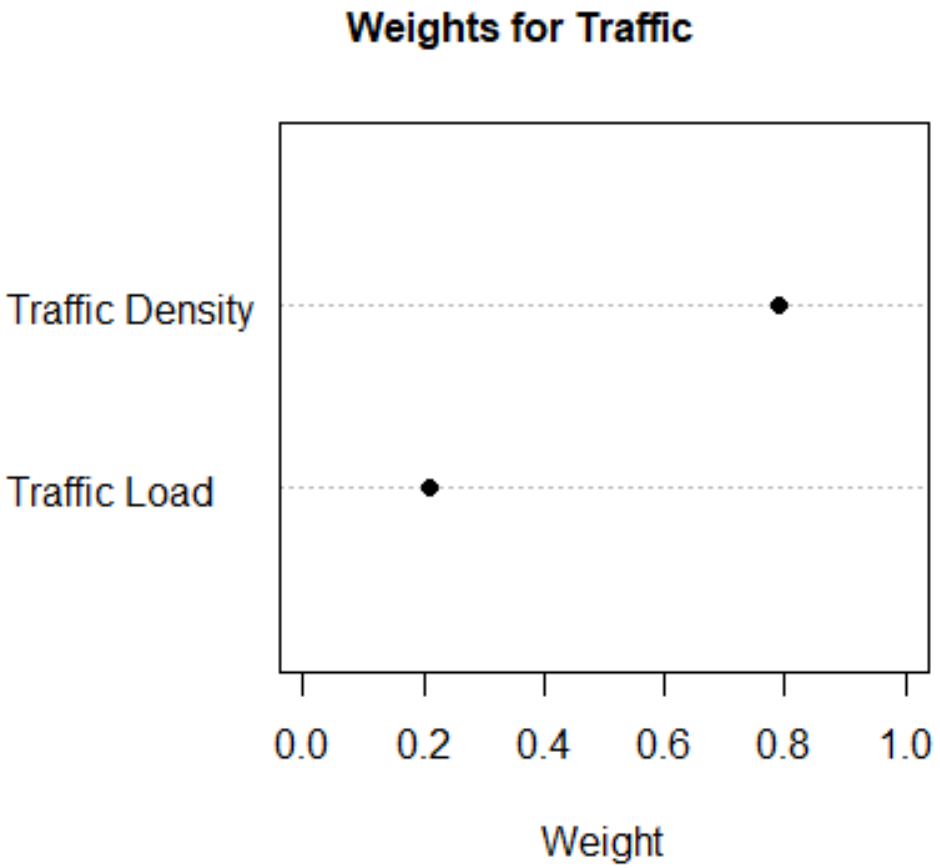
Exposome Data Analysis

Cohort 1: OR = 2.23 (1.01, 5.26)



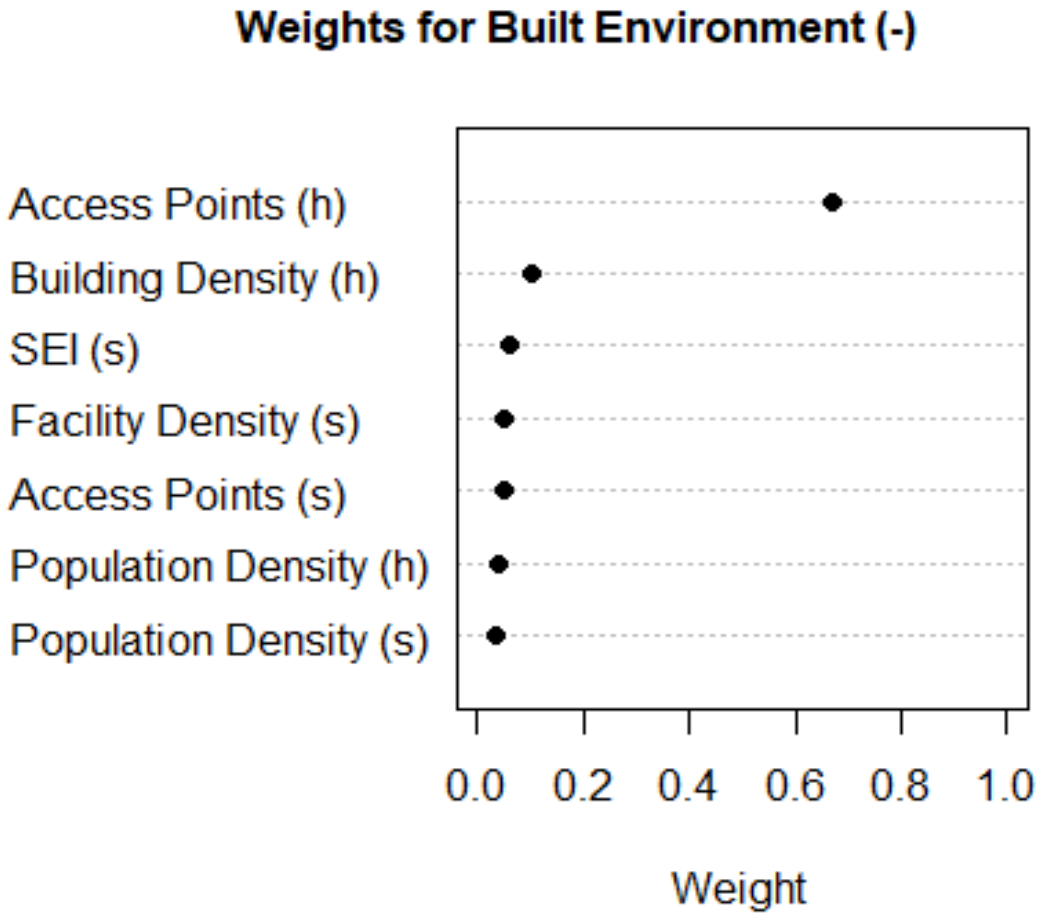
Exposome Data Analysis

Cohort 5: OR = 2.03 (1.01, 4.12)



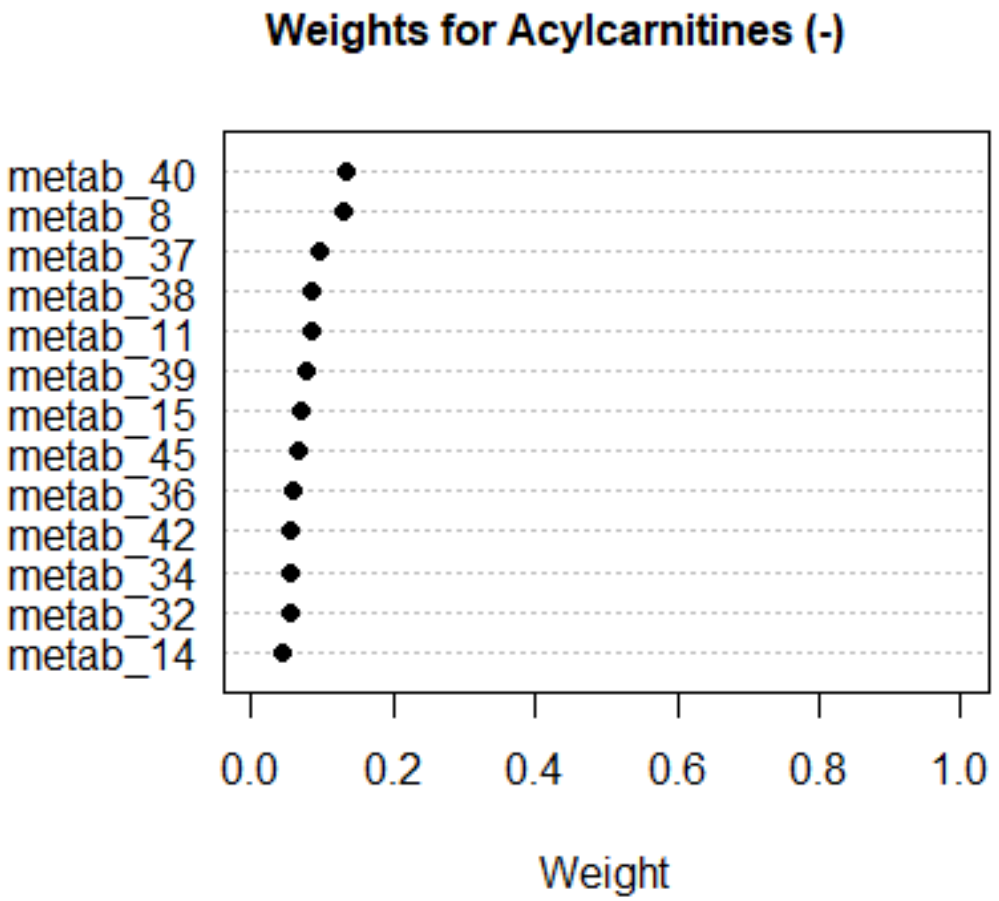
Exposome Data Analysis

Cohort 5: OR = 0.17 (0.05, 0.43)



Incorporating -omics Data

- Took the Main Model from Challenge 1 and incorporated the serum metabolomics data.
- In addition to original 19 family indices this model included Biogenicamines (-), Biogenicamines (+), Aminoacids (-), Aminoacids (+), Acylcarnitines (-), Acylcarnitines (-), Glycerophospholipids (-), Glycerophospholipids (+), Sphingolipids (-),and Sphingolipids (+) indices.
- Acylcarnitines (-) was significant with OR = 1.52 [1.02, 2.34].



Related References

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Thank you!

Any questions?

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