Supplementary Material of “Healthy nutrition in Germany: A survey analysis of social causes, obesity and socio-economic status”

***Model specification***

The hybrid model(45,46) can be written as

$y\_{it}=\left(x\_{it}- \overbar{x}\_{i}\right)β\_{W}+ \overbar{x}\_{i}β\_{B }+ c\_{i}β\_{R}+z\_{t}γ+u\_{i}+ε\_{it}$. (1)

*yit* denotes the dependent variable of individual *i* at time *t*. $x\_{it}$ stands for the vector of all exogenous time-varying variables for *i* at time *t*, and $\overbar{x}\_{i}$ for the mean of the whole observation period. $c\_{i}$ variables only vary between clusters but are time-invariant. The model also comprises a vector of dummy variables (***z***) for every point in time, which controls period effects for all individuals. $u\_{i}$ denotes the random intercept, and an individual’s time varying stochastic error term is represented by $ε$*it*.

***Sensitivity analyses***

All the reported regression results were tested for robustness: First, all models were recalculated by performing fixed effects regression with individual slopes and constants to allow for heterogeneous growth (FEIS)(42,43,72) only for NEMONIT, as FEIS regression is only executable for at least three-waves panel data. Second, all models were rerun excluding influential cases from the regression dropping individuals with Cook’s D>1. The robustness of standard errors was investigated via non-parametric bootstrapping. None of these checks had any substantial influence on the estimates. Moreover, all parameters were tested for linearity including penalized splines FE models(73). Further sensitivity checks comprise the implementation of different operationalizations of different constructs depending on data availability. For KiGGS, physical exercise, single parent status, and psychological problems were available as further control variables. These were not included in the main analyses, because of comparatively low number of person years (see Table S2 in the Supplement). However, none of these variations affected the reported results in any substantial way. In addition, the robustness of all estimates with respect to model specification was assessed using the procedure suggested by Young and Holsteen (2017)(74). Furthermore, the potential influence of omitted variables was examined using the method suggested by Frank (2000)(75). Also, all these checks detected no fundamental deviations from the reported results. All models comprise the analysis of complete cases (CC). Being aware of the potential benefits of multiple imputation (MI; more efficient and less biased estimates), we reran the models with multiply imputed data. The results of CC and MI analyses are the same. This is due to the small differences in the number of missings between outcomes and independent variables (see Tables S1-S4). In this case, the potential benefits of MI are negligible, since CC performs equally well(76). All the analyses were conducted using the statistical software package STATA 15.1.

Table S1: KiGGS: Variable description of all Outcomes

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Description | Mean/ Share  | within ($\overbar{x}\_{i}$) | between($x\_{it}- \overbar{x}\_{i}+ ̿)$ | *N*(*n* x *T*) | *n* |
| sd | min. | max. | sd  | min. | max. |
| Amply Recommended Food Groups (g/d) | Summed intake (g/d and kcal/d) of amply recommended (fruits, vegetables, and juice) and tolerated (sweets, and sweetened beverages) food group intake. Food group specific intake in g/d is calculated from intake frequencies and amount/portion per intake (ref. 77: 19f) and kcal/d as calculated from g/d and food group specific consumption(78) weighted average energy densities(79-81). | 797.6 | 328.3 | -1416.7 | 3011.9 | 497.7 | 0 | 4571.4 | 26722 | 16416 |
| Amply Recommended Food Groups (kcal/d) | 370.1 | 158.2 | -545.9 | 1286.0 | 238.6 | 0 | 1993.3 | 26722 | 16416 |
| Tolerated Food Groups (g/d) | 368.1 | 227.6 | -1175.8 | 1912.1 | 428.3 | 0 | 3881.5 | 26657 | 16390 |
| Tolerated Food Groups (kcal/d) | 521.3 | 323.8 | -2901.7 | 3944.3 | 530.4 | 0 | 8280.6 | 26657 | 16390 |
| HuSKY | Healthy Nutrition Score for Kids and Youth (HuSKY) following Kleiser et al.(31) based on intake of fruits, vegetables, juice, sweets, and sweetened beverages in g/d, standardized between 0 and 100. | 49.1 | 12.8 | .4 | 97.8 | 17.4 | 0 | 100 | 26058 | 16136 |
| HFD Index | Healthy Food Diversity (HFD) Index following Drescher et al.(34) based on intake in g/d and relative recommended intake ratio of amply recommended to tolerated food groups according to the Optimized Mixed Diet(32,33); standardized between 0 and 100. | 46.5 | 13.7 | -1.0 | 93.4 | 23.7 | 0 | 100 | 26056 | 16135 |
| ED1 (non-beverages and caloric beverages) | Average energy density (ED) of caloric food intake excluding non-caloric beverages and drinking water in kcal/g(40). | .79 | .20 | -.50 | 2.09 | .29 | .28 | 3.21 | 26056 | 16135 |
| ED2 (non-beverages only) | Average energy density of non-beverage food intake excluding all beverages in kcal/g(40). | 1.12 | .33 | -.27 | 2.52 | .49 | .27 | 3.21 | 26296 | 16228 |

Note: data source: KiGGS Panel: Robert Koch-Institute. KiGGS = German Health Interview and Examination Survey for Children and Adolescents.

Table S2: KiGGS: Variable description of all Covariates

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Description | Mean/ Share  | within ($\overbar{x}\_{i}$) | between($x\_{it}- \overbar{x}\_{i}+ ̿)$ | *N*(*n* x *T*) | *n* |
|  |  | sd | min. | max. | sd  | min. | max. |  |
| Equivalence Income (micro level) | Calculated according to German Council for Economic Experts(82) as ratio of household net income and square root of household size. Unit: EUR per year. | 16609.2 | 4114.0 | -89876.4 | 123094.7 | 7736.4 | 1341.6 | 138564.1 | 24311 | 16820 |
| County Level Disposable Income per Capita (p.c.) | Average disposable income p.c. of county of residence appended to the KiGGS data from the Regional Database Germany (RDG) of the statistical offices of the confederation and the federal states (1=10000-<15000, 2=15000-<20000, 3=20000-<38000 EUR per year). It represents the mean of the years 2003-2006, and 2009-2012 according to the 2 waves of KiGGS. | 2.1 | .4 | 1.6 | 2.6 | .4 | 1 | 3 | 32572 | 16286 |
| State Level Disposable Income p.c. | Average disposable income p.c. of federal state of residence appended to the KiGGS data from the RDG. Unit: EUR per year. | 18050.4 | 952.4 | 13886.4 | 22214.4 | 1935.4 | 14131.8 | 21739.9 | 29632 | 17640 |
| Eastern Germany | Binary, 1, if place of residence in Eastern Germany. | .33 | .05 | -.17 | .83 | .47 | 0 | 1 | 29632 | 17640 |
| Large City | Binary, 1, if place of residence with more than 100000 inhabitants. | .23 | .10 | -.27 | .73 | .41 | 0 | 1 | 29632 | 17640 |
| Retail Firms and Hospitality Industry p.c. | Number of retail firms and firms in the food service industry per capita of county of residence (data source: RDG). Binary, 1, if 15<=nr./1000c<28. | .10 | .10 | -.40 | .60 | .28 | 0 | 1 | 33792 | 16896 |
| Factory Area p. c. | Factory area of trade and industry (excl. mining area) of county of residence (data source: RDG; 1=0-<10, 2=10-<20, 3=20-<80 ha/10000c). | 1.6 | .2 | 1.1 | 2.1 | .7 | 1 | 3 | 33792 | 16896 |
| Mother: Education  | Five-point scale according to ISCED97 of the mother’s/father’s educational attainment (school+vocation). | 3.6 | .3 | 1.6 | 5.6 | 1.0 | 1 | 5 | 24710 | 16700 |
| Father: Education  | 3.8 | .3 | 1.8 | 5.8 | 1.0 | 1 | 5 | 23096 | 16038 |
| Parental Job Position | Seven-point scale of the socio-economic status of the job position of the household’s main breadwinner(77). | 3.4 | .5 | .4 | 6.3 | 1.3 | 1.1 | 7 | 24903 | 17185 |
| Mother: Employment Status | 1=unemployed, 2=part-time employed, 3=full-time employed; | 1.8 | .3 | .8 | 2.8 | .7 | 1 | 3 | 25521 | 17285 |
| Father: Employment Status | 2.8 | .2 | 1.8 | 3.8 | .6 | 1 | 3 | 23908 | 16604 |
| Single Parent\* | Binary, 1, if single parent responsible for child. | .13 | .05 | -.37 | .63 | .33 | 0 | 1 | 15175 | 14522 |
| Household Size | Nr. of people living in the same household. | 3.9 | .3 | 1.9 | 5.9 | .8 | 1 | 5 | 25665 | 17294 |
| Sex: female | Binary. | .50 | 0 | .50 | .50 | .50 | 0 | 1 | 29632 | 17640 |
| Age  | In complete years. | 10.8 | 2.7 | 6.8 | 14.8 | 5.1 | 0 | 24 | 29632 | 17640 |
| Birth Cohort | In 2 year groups (1985-1986=1,…,2005-2006=11) | 6.2 | 0 | 6.2 | 6.2 | 2.5 | 1 | 11 | 23984 | 11992 |
| Migration Background  | Binary. | .22 | 0 | .22 | .22 | .41 | 0 | 1 | 35120 | 17560 |
| Physical Exercise\* | Binary, 1, if physical activity level is high. | .68 | .09 | .18 | 1.18 | .46 | 0 | 1 | 14816 | 14205 |
| Psychological Problems\* | Binary (ref. 83: 110). | .10 | .14 | -.40 | .60 | .27 | 0 | 1 | 22938 | 16473 |

Note: variables with ‘\*’ are only included in the robustness analyses, as N is comparatively low. Data source: KiGGS Panel: Robert Koch-Institute. KiGGS = German Health Interview and Examination Survey for Children and Adolescents.

Table S3: NEMONIT: Description of all nutrition variables

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Description | Mean/ Share  | within ($\overbar{x}\_{i}$) | between($x\_{it}- \overbar{x}\_{i}+ ̿)$ | *N*(*n* x *T*) | *n* |
| sd | min. | max. | sd  | min. | max. |
| Amply Recommended Food Groups (g/d) (1) | Sum of food group specific intake in g/d and kcal/d as calculated from g/d and food group specific consumption(78) weighted average energy densities(79-81). (1) = fruits + vegetables + cereal products + potatoes + coffee + tea (+ water (g/d only)). (2) = dairy products + meat products + fish + eggs. (3) = edible fats. (4) = alcoholic beverages + sweetened soft drinks + juices + sweets + snacks. | 2422.6 | 462.6 | -561.6 | 5170.0 | 732.4 | 483.7 | 5523.2 | 9462 | 2610 |
| Amply Recommended Food Groups (kcal/d) (1) | 743.9 | 167.6 | -199.2 | 2287.3 | 224.6 | 126.9 | 2380.4 | 9462 | 2610 |
| Moderately Recommended Food Groups (g/d) (2) | 375.0 | 128.1 | -538.5 | 1973.9 | 164.1 | 13 | 1343.5 | 9462 | 2610 |
| Moderately Recommended Food Groups (kcal/d) (2) | 512.6 | 156.3 | -230.6 | 1920.7 | 190.3 | 29.3 | 2131.9 | 9492 | 2610 |
| Sparsely Recommended Food Groups (g/d) (3) | 27.6 | 14.4 | -77.2 | 150.7 | 17.5 | 0 | 160.4 | 9462 | 2610 |
| Sparsely Recommended Food Groups (kcal/d) (3) | 196.1 | 95.9 | -488.7 | 879.6 | 123.0 | 0 | 952.4 | 9462 | 2610 |
| Tolerated Food Groups (g/d) (4)  | 642.6 | 301.7 | -1578.4 | 3396.6 | 461.9 | 1 | 3158.0 | 9454 | 2610 |
| Tolerated Food Groups (kcal/d) (4) | 663.3 | 256.0 | -634.6 | 2472.0 | 310.4 | 2.2 | 2490.3 | 9454 | 2610 |
| Overall Intake (g/d) | Sum of intake (1) + (2) + (3) + (4) in g/d and kcal/d. | 3467.8 | 498.4 | 917.7 | 6211.5 | 741.6 | 1569.2 | 8046.6 | 9454 | 2610 |
| Overall Intake (kcal/d) (5) | 2115.7 | 367.0 | 62.3 | 4452.0 | 571.2 | 460.2 | 5488.7 | 9454 | 2610 |
| Carbohydrate Intake (g/d) | Macronutrient intake in g/d and energy percent. | 233.8 | 46.6 | 18.5 | 570.0 | 71.3 | 61.0 | 697.2 | 9462 | 2610 |
| Carbohydrate Intake (% of kcal/d) | 45.9 | 5.7 | 21.7 | 78.0 | 6.9 | 21.9 | 70.4 | 9462 | 2610 |
| Fat Intake (g/d) | 81.8 | 20.7 | -41.7 | 226.7 | 28.4 | 15.6 | 228.7 | 9462 | 2610 |
| Fat Intake (% of kcal/d) | 35.6 | 5.2 | 10.1 | 59.2 | 5.6 | 14.5 | 58.1 | 9462 | 2610 |
| Protein Intake (g/d) | 73.4 | 16.0 | -4.5 | 191.8 | 21.0 | 26.2 | 188.4 | 9462 | 2610 |
| Protein Intake (% of kcal/d) | 14.6 | 2.4 | 4.4 | 29.5 | 2.5 | 7 | 28.7 | 9462 | 2610 |
| Alcohol Intake (g ethanol/d) | 12.3 | 10.5 | -92.4 | 143.1 | 15.2 | 0 | 138.0 | 9462 | 2610 |
| Alcohol Intake (% of kcal/d) | 3.9 | 3.0 | -15.2 | 37.5 | 4.6 | 0 | 35.4 | 9462 | 2610 |
| Dietary Fibre Intake (g/d) | 20.9 | 5.1 | -18.9 | 60.7 | 7.2 | 3.5 | 71.7 | 9462 | 2610 |
| O-HEI-NVSII(0-100) | Optimized HEI-NVSII according to relative food group and gender specific intake recommendations after Gedrich and Karg (2001)(37). | 58.2 | 6.3 | 30.9 | 81.9 | 7.7 | 35.5 | 84.7 | 9454 | 2610 |
| HEI-MAC(0-100) | HEI based on the macronutrient (MAC) intake recommendations of DGE et al. (2013)(38). | 67.4 | 9.0 | 31.0 | 101.7 | 9.9 | 38.9 | 99.0 | 9462 | 2610 |
| HEI-EN(0-100) | HEI based on overall energy (EN) intake recommendations of DGE (2015)(39).  | 84.3 | 10.0 | 26.4 | 125.9 | 9.8 | 28.5 | 100 | 9454 | 2610 |
| HFD Index(0-100) | Healthy Food Diversity (HFD) Index following Drescher et al. (2007)(34) (based on intake in g/d). | 73.8 | 10.2 | 3.7 | 123.8 | 13.0 | 12.3 | 97.0 | 9462 | 2610 |
| ED1 (non-beverages and caloric beverages) | Average energy density (ED) of caloric food intake excluding non-caloric beverages and drinking water in kcal/g(40). | 1.34 | 0.20 | 0.23 | 2.50 | 0.26 | 0.61 | 2.54 | 9454 | 2610 |
| ED2 (non-beverages only) | Average energy density of non-beverage food intake excluding all beverages in kcal/g(40). | 1.68 | 0.22 | 0.73 | 2.90 | 0.29 | 0.78 | 2.76 | 9454 | 2610 |

Note: The intake of all food groups is based on the mean of the two 24h-recall measurements. Data source: NEMONIT: Max Rubner-Institute (2016)(25). NEMONIT = German National Nutrition Monitoring.

Table S4: NEMONIT: Description of all health, socio-economic, socio-demographic, and control variables

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | Description | Mean/ Share  | within ($\overbar{x}\_{i}$) | between($x\_{it}- \overbar{x}\_{i}+ ̿)$ | *N*(*n* x *T*) | *n* |
|  |  | sd | min. | max. | sd  | min. | max. |  |
| BMI | Body mass index (BMI). | 25.6 | .9 | 16.7 | 34.7 | 4.4 | 16.4 | 62.7 | 9769 | 2610 |
| Obese | Binary, 1, if BMI ≥ 30. | .14 | .14 | -.66 | .94 | .32 | 0 | 1 | 9769 | 2610 |
| Good Health Condition  | Binary, 1, if self-rated health condition good or very good. | .81 | .24 | .01 | 1.61 | .32 | 0 | 1 | 9774 | 2610 |
| Equivalence Income (micro level) | Calculated according to German Council for Economic Experts (ref. 82: 262) as ratio of household net income and square root of household size. Unit: EUR per year. | 21063.3 | 4224.0 | -10616.8 | 48963.3 | 8599.4 | 1697.1 | 66000 | 8286 | 2504 |
| Eastern Germany | Binary, 1, if place of residence in Eastern Germany. | .18 | .01 | -.32 | .98 | .38 | 0 | 1 | 9783 | 2610 |
| Education | Five-point scale according to ISCED97 of the educational attainment (school+vocation). | 3.9 | .4 | 2.3 | 5.9 | .9 | 1 | 5 | 9447 | 2590 |
| Job Position | Seven-point scale of the socio-economic prestige of the job position(77). | 4.5 | .9 | .1 | 8.5 | 1.5 | 1 | 7 | 9217 | 2587 |
| Employment Status | Binary, 1, if employed. | .58 | .21 | -.22 | 1.41 | .45 | 0 | 1 | 9593 | 2608 |
| Single | Binary, 1, if single  | .38 | .18 | -.42 | 1.18 | .41 | 0 | 1 | 6094 | 2609 |
| Household Size | Nr. of people living in the same household. | 2.6 | .5 | -.6 | 6.6 | 1.1 | 1 | 7 | 9773 | 2610 |
| Sex: female | Binary. | .57 | 0 | .57 | .57 | .49 | 0 | 1 | 13050 | 2610 |
| Age  | In complete years. | 51.6 | 2.2 | 46.9 | 55.6 | 15.9 | 15.5 | 81.7 | 9783 | 2610 |
| Birth Cohort | In 2 year groups (1927-1928=0, …, 1991-1992=32). | 15.0 | .3 | 14.2 | 15.8 | 7.9 | 0 | 32 | 9783 | 2610 |
| Physical Exercise  | In hours per week of light sports activities. Middle sports activities are doubled and heavy sports activities are quadrupled according to caloric influence(84). | 8.3 | 6.6 | -62.2 | 82.3 | 9.7 | 0 | 158.5 | 9648 | 2610 |
| Season | Season of interviews (Spring=1, Summer=2, Fall=3, Winter=4). Included as season dummies into the models (reference: Winter). | 2.5 | .9 | .1 | 4.9 | .6 | 1 | 4 | 9783 | 2610 |
| Weekend | Binary, 1, if interviews on weekends (Saturday and Sunday). | .18 | .33 | -.62 | .98 | .22 | 0 | 1 | 9462 | 2610 |
| Special Day | Binary, 1, if interviews on a special day (holiday, vacation, illness, shift work).  | .20 | .32 | -.60 | 1.00 | .26 | 0 | 1 | 8572 | 2586 |

Note: data source: NEMONIT: Max Rubner-Institute (2016)(25). NEMONIT = German National Nutrition Monitoring.

**Additional References**

72. Polachek SW & Kim MK (1994) Panel estimates of the gender earnings gap: individual-specific intercept and individual-specific slope models. *J Econometrics* **61**, 23–42.

73. Ruppert D, Wand MP & Carroll RJ (2003) *Semiparametric Regression*. Cambridge, UK: Cambridge University Press.

74. Young C & Holsteen K (2017) Model Uncertainty and Robustness: A Computational Framework for Multimodel Analysis. *Sociol Method Res* **46**, 3-40.

75. Frank KA (2000) Impact of a confounding variable on a regression coefficient. *Sociol Method Res* **29**, 147-194.

76. Karahalios A, Baglietto L, Lee KJ *et al.* (2013) The impact of missing data on analyses of a time-dependent exposure in a longitudinal cohort: a simulation study. *Emerging Themes in Epidemiology* **10**, 6.

77. RKI – Robert Koch-Institut (Ed.) (2008) *Public Use File KiGGS, Kinder- und Jugendgesundheitssurvey 2003-2006. Dokumentation des Datensatzes.* Berlin.

78. BMELV – Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (2008) *Statistisches Jahrbuch über Ernährung, Landwirtschaft und Forsten der Bundesrepublik Deutschland.* Bremerhaven: Wirtschaftsverlag NW.

79. Souci SW, Fachmann W & Kraut H (2000) *Die Zusammensetzung der Lebensmittel. Nährwert-Tabellen.* Stuttgart: medpharm Scientific Publishers.

80. BMELV – Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (2014) *Bundeslebensmittelschlüssel BLS 3.01*.

81. Nutri-Science GmbH (2014) *Prodi 6.2 Expert*.

82. SBGE – Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung (Ed.) (2000) *Jahresgutachten 2000/01*. Berlin: Deutscher Bundestag.

83. Woerner W, Becker A, Friedrich C *et al.* (2002) Normierung und Evaluation der deutschen Elternversion des Strengths and Difficulties Questionnaire (SDQ): Ergebnisse einer repräsentativen Felderhebung. *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie* **30**, 105-112.

84. Ainsworth BE, Haskell WL, Whitt MC *et al.* (2000) Compendium of Physical Activities: an update of activity codes and MET intensities. *Med Sci Sport Exer* **32**, 498-516.