**Online Supporting Material**

**Supplemental Figure 1.**Test non- linear effect of lutein intake

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There is no evidence against a linear effect (Included covariates from Model 2; n of splines4; Chi211·05; p- value 0·05)

**Table 1.** Characteristics of participants in The Rotterdam Study (n= 4402)

|  |  |  |  |
| --- | --- | --- | --- |
|  | RS I-5n= 1133 | RS II-3n= 1320 | RS III-2n= 1949 |
| Age (y, mean and SD) | 79 | 4 | 72 | 5 | 56 | 6 |
| Female (n,%)  |  638 | 56·3 |  731  | 55·4 |  1130  | 58·0 |
| Height (cm, mean and SD) | 166·1 | 9·1 | 168·3 | 9·1 | 171·2 | 9·2 |
| *Missing values* | 0 |  | 1 |  | 0 |  |
| Weight (kg, mean and SD) | 75·9 | 13·4 | 78·0 | 13·6 | 80·5 | 15·4 |
| *Missing values* | 0 |  | 1 |  | 0 |  |
| Caucasian ethnicity (n,%)  | 1097 | 96·8 |  1172 | 88·8 |  1832 | 94·0 |
| *Missing values* | 14  | 1·2 | 114  | 8·6 | 21  | 1·1 |
| FEV1(L, mean and SD) | 2·22 | 0·65 | 2·48 | 0·70 | 2·92  | 0·77 |
| FEV1 (%, mean and SD)  | 103·5  | 22·9 | 101·81 | 20·7 | 103·6 | 17·7 |
| FVC (L, mean and SD) | 2·96 | 0·82 | 3·26 | 0·88 | 3·82 | 0·99 |
| FEV1/FVC (%, median and IQR) | 76·4  | 71·3, 79·9 | 77·1  | 72·5, 81·0 | 77·5  | 73·0, 81·3 |
| Dietary intake |  |  |  |
|  Lutein intake (mg/d, median and  IQR ) | 2·09  | 1·20, 3·57 | 2·50  | 1·41, 4·12 | 3·12 | 1·87, 5·09 |
|  Total energy intake (kJ/d, median and  IQR) | 8096 | 6477, 9979 | 8234 | 6573, 9920 | 9301 | 7724, 11343 |
|  Total energy intake (kcal/d, median  and IQR) | 1935  | 1548, 2385 | 1968  | 1571, 2371 | 2223  | 1846, 2711 |
|  α-carotene intake (mg/d, median and  IQR) | 0·57  | 0·23, 1·06 | 0·61  | 0·25, 1·28 | 0·82  | 0·36, 1·62 |
|  β-carotene intake (mg/d, median and  IQR) | 3·10  | 1·66, 5·19 | 3·46  | 1·86, 6·15 | 4·43  | 2·55, 7·38 |
|  β-cryptoxanthin intake mg/d, median and IQR)  | 0·30  | 0·11, 0·68 | 0·28  | 0·10, 0·56 | 0·27  | 0·11, 0·50 |
|  Lycopene intake (mg/d, median and  IQR) | 0·95  | 0·43, 1·89 | 1·25  | 0·59, 2·38 | 1·73  | 0·90, 2·92 |
|  Zeaxanthin intake (mg/d, median and  IQR) | 0·13  | 0·09, 0·18 | 0·13  | 0·09, 0·18 | 0·14  | 0·01, 0·18 |
|  Total fat intake (g/d, median and  IQR) | 65·4  | 50·5, 86·4 | 68·1  | 51·4, 86·4 | 77·9  | 60·2, 100·0 |
|  Ratio N3:N6 (g/d, median and IQR) | 6·8  | 5·9, 7·7 | 6·8  | 6·0, 7·6 | 7·1  | 6·3, 7·9 |
|  Dietary fibre intake (g/d, median and  IQR) | 24·2  | 18·1, 31·6 | 24·3  | 19·0, 31·1 | 28·0  | 21·8, 35·8 |
| Physical activity (MET hours/ per week, median and IQR) | 30·3  | 12·0, 67·8 | 43·7  | 17·9, 83·1 | 46·5  | 19·6, 82·2 |
| *Missing values* | 131 |  | 91 |  | 187 |  |
| Smoking status (n,%) |  |  |  |
|  Never  | 378 | 33·4 | 441 | 33·4 | 691 | 35·5 |
|  Former | 668 | 59·0 | 749 | 56·7 | 1000 | 51·3 |
|  Current | 87 | 7·7 | 130 | 9·8 | 258 | 13·2 |
| Education level (n,%) |  |  |  |
|  Lower education  | 573 | 50·6 | 621 | 47·0 | 815 | 41·8 |
|  Higher education  | 555 | 49·0 | 658 | 49·9 | 1130 | 58·0 |
| *Missing values* |  5 | 0·4 |  41 | 3·1 |  4 | 0·2 |
| Diabetes Mellitus type 2 (n,%) | 135 | 11·9 | 51 | 3·9 | 97 | 5·0 |
| *Missing values* |  12 | 1·1 |  3 | 0·2 |  5 | 0·3 |
| CVD (n,%) | 60 | 5·3 | 33 | 2·5 | 60 | 3·1 |
| *Missing values* |  14 | 1·2 |  25 | 1·9 | 7 | 0·4 |
| Asthma (n,%) | 61 | 5·4 | 75 | 5·7 | 102 | 5·2 |
| COPD (n,%) | 224 | 19·8 | 211 | 16·0 | 266  | 13·6 |
| Lung cancer (n,%) | 17 | 1·5 | 11 | 0·8 | 1 | 0·1 |

Values are means, SD, numbers with valid percentages (numbers), or medians with interquartile range.
Abbreviations: n= number of participants; kg= kilogram; cm= centimetres; FEV1= Forced Expiratory volume per second; FVC= Forced Vital Capacity; L= litre; IQR= interquartile range; y=years; kJ= Kilojoules; kcal= kilo calories; mg= milligram; N3:N6-ratio= omega 3: omega 6 fatty acids ratio; MET= Metabolic Equivalent of TASK; COPD= Chronic Obstructive Pulmonary Disease; CVD= cardiovascular diseases (i.e. treatment for narrowed blood vessels, myocardial infarction, stroke, cerebral hemorrhage and cerebro vascular accident).

**Supplemental Table 2.** Specification of the multiple imputation procedure

|  |  |
| --- | --- |
| Software | IBM SPSS Statistics for Windows (Release 21,0,0,1) |
| Imputation method | Fully conditional specification (Markov chain Monte Carlo method) |
| Key settings | Maximum iterations: 20 |
| Imputed data sets  | 10 |
| Variables included in the  | Lutein intake (ug/d); FEV1 predicted (%); FEV1 (L); FVC (L); Ratio  |
|  | FEV1/FVC; ethnicity; gender; age; height (cm); weight (kg); |
|  imputation procedure  | education; household income; smoking; pack years of smoking; |
|  (imputed or used as  | physical activity measured in MET (h); energy intake (kcal); |
|  predictors of missing  | alpha carotene intake (ug/d); zeaxanthin intake (ug/d); |
|  data): | betacrypotoxanthin intake (ug/d); beta carotene intake (ug/d); |
|  | lycopene intake (ug/d); total fat intake (g/d); saturated fat intake (g/d) |
|  | mono unsaturated fat intake (g/d); poly unsaturated fat intake (g/d); |
|  | linoleic acid intake (g/d); trans fatty acid intake (g/d); |
|  | alpha linoleinic acid intake (g/d); eicosapentaenoic acid intake (g/d); |
|  | docosahexaenoic acid intake (g/d); fiber intake (g/d); alcohol intake (g/d); |
|  | serum cholesterol (mmol/l); asthma; COPD; diabetes; CVD (treatment for  |
|  | narrowed date blood vessels/ CVA); lungfunction test; lung cancer |
|  |  |
|  |  |
| Additionally added  | waist circumference (cm) (RS I-3, RS II-1, RS III-1); hip circumference  |
| predictive variables to  | (cm); (RS I-3, RS II-1, RS III-1); height (cm) (RS I-3, RS II-1, RS III-1);  |
| increase plausibility of | weight (kg) (RS I-3, RS II-1, RS III-1); energy intake (kcal) extremes (RS I-5, RS II-1, RS III-1); dietary supplement intake in summer and/ or winter |
| missing at random | (RS I-5, RS II-3, RS III-1); MET/h sport, MET/h walk, MET/h cycling,  |
| assumption: | MET/h gardening, MET/h domestic activities (RS I-3, RS II-1) |
|  | Dutch Healthy Diet Index – score (RS I-5, RS II-3, RS III-1); |
|  | protein intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | vegeterian protein intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | animal protein intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | cholesterol intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | total carbohydrate intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | mono/disaccharides intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | polysaccharides intake (g/d) (RS I-5, RS II-3, RS III-1); |
|  | occupational situation (RS I-1, RS II-1, RS III-1); |
|  | last occupational situation (RS I-1, RS II-1, RS III-1); |
|  | highest attained education (RS I-1, RS II-1, RS III-1); |
|  | number of persons living from net income (RS I-1, RS II-1, RS III-1); |
|  | date of retirement/discontinuing occupation (RS I-4, RS II-1, RS III-1) |
|  |  |
| Not normally distributed  | Predictive mean matching |
| variables were treated with: |  |
|  |  |
| Binary/categorical  | Logistic regression models |
| variables were treated with: |  |