Supplementary Method

NOVA system classification

Overall, four categories were established per the NOVA classification system as follows: 1) **UNPFs**, such as fruits, vegetables, milk, and meat; 2) **processed culinary ingredients** comprising vegetable oils obtained by crushing seeds, nuts, and fruits; 3) **processed foods**, such as canned or bottled vegetables and legumes in brine; and 4) **UPFs**, including soft drinks, packaged snacks, confectionery, breakfast cereals, flavored yogurts, industrially processed bread and buns, and processed meat products [1].

Covariate classification

Individual sociodemographic and behavioral covariates were collected through a questionnaire at baseline, including age, sex, ethnicity (White, others), body mass index (<18.5kg·m^2, 18.5–25kg·m^2, 25–30kg·m^2, ≥30kg·m^2), total energy intake, highest qualification (none, O levels or General Certificate of Secondary Education or Certificate of Secondary Education or equivalent, A levels/AS levels or equivalent, National Vocational Qualification or Higher National Diploma or Higher National Certificate or other professional, College or University degree), annual before-tax household income (<GBP 31 000, ≥GBP 31 000), smoking status (never smokers, current or past occasional smokers, pack years<10, pack years 10–19, pack years≥20), passive smoking exposure (none, any) and family history of chronic lung disease. Physical activity was expressed as total Metabolic Equivalent Task (MET) hours per week for all activities including walking, moderate and vigorous activity. MET score: low (< 600 MET-min/week), moderate (600 to 3000 MET-min/week), and high (≥ 3000 MET-min/week) [2]. Townsend deprivation

index (TDI) combined information on social class, employment, car availability, and housing. Higher scores represent higher levels of area-based socioeconomic deprivation [3]. The healthy diet score was adopted from previously published studies by estimating adherence to the main items of the Mediterranean diet, which was calculated in reference to the following elements: vegetables, fruits, fish, unprocessed red meat, and processed meat [4-6]. Healthy diet score is calculated based on the following factors: vegetable intake of at least four tablespoons each day; fruit intake of at least three pieces each day; fish intake of at least twice each week; unprocessed red meat intake of no more than twice each week; and processed meat intake of no more than twice each week. One point was given for each favorable dietary factor and the total diet score ranged from 0 to 5. A higher score indicates a much healthier diet.

Reference

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Table S1. UPF items in the UK Biobank

Data field	Food item	Portion size (g/serving)	Energy (KJ/100 g)	Energy for one serving (KJ/serving)
100160	Low calorie drink intake	330	43	141.90
100170	Fizzy drink intake carbonated (fizzy) drinks	330	174	574.20
100180	Squash intake	250	159	397.50
100250	Instant coffee intake	190	8	15.20
100380	Intake of artificial sweetener added to coffee [c]	6	200	12.00
100500	Intake of artificial sweetener added to tea [d]	6	200	12.00
100530	Flavoured milk intake	250	270	675.00
100720	Fortified wine intake	50	481	240.50
100730	Spirits intake	23	919	211.37
100770	Porridge intake	203.5	195	396.83
100800	muesli intake	100	1540	1540.00
100810	Oat crunch intake	100	1639	1639.00
100820	Sweetened cereal intake	38	1632	620.16
100830	Plain cereal intake	30	1601	480.30
100840	Bran cereal intake	50	1406	703.00
100850	Whole-wheat cereal intake	44	1474	648.56
100860	Other cereal intake	44	1566	689.04
101090	Bap intake	90	1065	958.50
101160	Bread roll intake	60	1084	650.40
101230	Naan bread intake	160	1206	1929.60
101250	Crispbread intake	10	1591	159.10
101260	Oatcakes intake	13	1737	225.81
101270	Other bread intake	45	1661	747.45
101310	Number of bread slices with butter/margarine	Thin 10/ Medium 12/	3061	306.10/367.32/459.15

101350	Number of baguettes with butter/margarine	Thick 15		306.10/367.32/459.15
101390	Number of baps with butter/margarine			306.10/367.32/459.15
101430	Number of bread rolls with butter/margarine			306.10/367.32/459.15
101470	Number of crackers/crispbreads with butter/margarine			306.10/367.32/459.15
101510	Number of oatcakes with butter/margarine			306.10/367.32/459.15
101550	Number of other bread types with butter/margarine			306.10/367.32/459.15
101970	Double crust pastry intake	60	1060	636.00
101980	Single crust pastry intake	30	1310	393.00
101990	Crumble intake	70	924	646.80
102000	Pizza intake	150	1036	1554.00
102010	Pancake intake	110	1065	1171.50
102020	Scotch pancake intake	41	1138	466.58
102030	Yorkshire pudding intake	25	881	220.25
102040	Indian snacks intake	40	975	390.00
102050	Croissant intake	60	1563	937.80
102060	Danish pastry intake	110	1441	1585.10
102070	Scone intake	48	1378	661.44
102120	Ice-cream intake	120	1229	1474.80
102140	Milk-based pudding intake	200	494	988.00
102150	Other milk-based pudding intake	60	518	310.80
102170	Soya dessert intake	125	309	386.25
102180	Fruitcake intake	70	1478	1034.60
102190	Cake intake	60	1617	970.20
102200	Doughnut intake	60	1414	848.40
102210	Sponge pudding intake	120	1116	1339.20
102220	Cheesecake intake	110	1231	1354.10
102230	Other dessert intake	60	696	417.60
102260	Chocolate bar intake	50	2081	1040.50

102270	White chocolate intake	50	2212	1106.00
102280	Milk chocolate intake	50	2177	1088.50
102290	Dark chocolate intake	50	2273	1136.50
102300	Chocolate-covered raisin intake	25	1159	289.75
102310	Chocolate sweet intake	36	1922	691.92
102320	Diet sweets intake	18	975	175.50
102330	Sweets intake	36	1793	645.48
102340	Chocolate-covered biscuits intake	17	2076	352.92
102350	Chocolate biscuits intake	24	2071	497.04
102360	Sweet biscuits intake	17	1842	313.14
102370	Cereal bar intake	28	1525	427.00
102380	Other sweets intake sweet snacks	40	1793	717.20
102460	Crisp intake	40	2186	874.40
102470	Savoury biscuits intake	40	2168	867.20
102480	Cheesy biscuits intake	40	1366	546.40
102500	Other savoury snack intake	40	2099	839.60
102530	Powdered/instant soup intake	200	270	540.00
102760	Snackpot intake (snack pot, noodles/rice	280	1541	4314.80
102770	Couscous intake	150	1440	2160.00
102850	Low fat cheese spread intake	40	733	293.20
102860	Cheese spread intake	15	1106	165.90
103010	Sausage intake	30	1218	365.40
103050	Crumbed or deep-fried poultry intake (chicken or turkey in breadcrumbs or deep fried	100	1111	1111.00
103070	Bacon intake	46	891	409.86
103080	Ham intake	23	891	204.93
103260	Vegetarian sausages/burgers intake	90	748	673.20
103280	Quorn intake	90	389	350.10
103290	Other vegetarian alternative intake	90	1386	1247.40

104000	Baked bean intake	135	335	452.25
104020	Fried potatoes intake	180	796	1432.80
104050	Mashed potato intake	60	438	262.8

Abbreviations: UPF, ultra-processed food.

Table S2. Definition of COPD Diagnosis

Code type	Codes
UK Biobank Self Report information	Field ID 20002 (1112, 1113, 1472)
ICD-9 information	492, 492.0, 492.8, 492.9, 496.X
ICD-10 information	J43, J43.0, J43.1, J43.2, J43.8, J43.9, J44, J44.0, J44.1, J44.8, J44.9
Read V2 information	663K., 66YB., 66YD., 66Yg., 66Yh., 66YL., 66YM., 66YS., 66YT., 679V., 8CR1., 9Oi.., 9Oi0., 9Oi1., 9Oi2., 9Oi3., 9Oi4., H3..., H3121, H312z, H32.., H320., H320z, H322., H32z., H36.., H37.., H38.., H39.., H3y.., H3z..

Abbreviations: COPD, chronic obstructive pulmonary disease.

Table S3. Multivariable-adjusted linear regression models for the association between UPF consumption and biomarker levels [a].

Biomarkers	UPF consumption							
	Model 1				Model 2			
	β	Lower 95% CI	Upper 95% CI	P-value	β	Lower 95% CI	Upper 95% CI	P-value
Glycemic control								
HbA1c (mmol/mol)	0.055	0.0506	0.0593	<0.0001	0.0309	0.0266	0.0352	<0.0001
Inflammation								
C-reactive protein (mmol/L)	0.7198	0.6882	0.7514	<0.0001	0.1829	0.1529	0.213	<0.0001
Erythrocyte distribution width (%)	0.0148	0.0129	0.0168	<0.0001	0.0117	0.0096	0.0137	<0.0001
Leukocyte count (10^9 cells/L)	0.1372	0.1296	0.1447	<0.0001	0.0529	0.0451	0.0606	<0.0001
NLR	0.0932	0.0809	0.1056	<0.0001	0.0372	0.0243	0.0501	<0.0001
PLR	-0.0531	-0.0641	-0.042	<0.0001	-0.0153	-0.0268	-0.0039	0.0088
SII	0.1147	0.1002	0.1293	<0.0001	0.0521	0.0369	0.0673	<0.0001
Lipid profile								
Apolipoprotein A (g/L)	-0.1619	-0.1671	-0.1567	<0.0001	-0.0908	-0.0958	-0.0858	<0.0001
Apolipoprotein B (g/L)	0.0142	0.0072	0.0212	0.0001	-0.0076	-0.0149	-0.0003	0.0412
Total cholesterol (mmol/L)	-0.0589	-0.0649	-0.0528	<0.0001	-0.0401	-0.0464	-0.0339	<0.0001
HDL-C (mmol/L)	-0.2748	-0.2823	-0.2672	<0.0001	-0.1345	-0.1414	-0.1276	<0.0001
LDL-C (mmol/L)	-0.0096	-0.017	-0.0021	0.0119	-0.0125	-0.0202	-0.0047	0.0017
Triglycerides (mmol/L)	0.3315	0.3161	0.347	<0.0001	0.0682	0.0534	0.083	<0.0001

Abbreviations: UPF, ultra-processed food; HR, hazard ratio; CI, confidence interval; HbA1c, glycated hemoglobin; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

Model 1 unadjusted.

Model 2 adjusted for age, sex, ethnicity, Townsend deprivation index, education levels, income, BMI, physical activity, total energy intake, healthy diet score, smoking status, passive smoking exposure, and family history of chronic lung diseases.

a The multivariable-adjusted linear regression models were used to explore the association between UPF consumption and the biomarkers.

The levels of biomarkers were nature log-transformed before analyses.

Table S4. Risk estimates of COPD with the selected biomarkers (1-SD increment) [a]

Biomarkers	COPD					
	Model 1		Model 2		Model 3	
	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
Glycemic control						
HbA1c (mmol/mol)	1.37 (1.34-1.4)	<0.0001	1.35 (1.33-1.38)	<0.0001	1.14 (1.11-1.16)	<0.0001
Inflammation						
C-reactive protein (mmol/L)	1.56 (1.52-1.61)	<0.0001	1.54 (1.5-1.58)	<0.0001	1.32 (1.28-1.36)	<0.0001
Erythrocyte distribution width (%)	1.24 (1.22-1.27)	<0.0001	1.24 (1.21-1.26)	<0.0001	1.20 (1.17-1.23)	<0.0001
Leukocyte count (10^9 cells/L)	1.55 (1.51-1.58)	<0.0001	1.53 (1.5-1.56)	<0.0001	1.35 (1.32-1.39)	<0.0001
NLR	1.21 (1.18-1.25)	<0.0001	1.21 (1.17-1.24)	<0.0001	1.14 (1.11-1.18)	<0.0001
PLR	0.84 (0.81-0.86)	<0.0001	0.84 (0.82-0.86)	<0.0001	0.95 (0.92-0.97)	0.0001
SII	1.18 (1.15-1.22)	<0.0001	1.17 (1.14-1.21)	<0.0001	1.15(1.12-1.18)	<0.0001
Lipid profile						
Apolipoprotein A (g/L)	0.87 (0.85-0.9)	<0.0001	0.9 (0.87-0.93)	<0.0001	0.95 (0.92-0.98)	0.0005
Apolipoprotein B (g/L)	0.9 (0.87-0.92)	<0.0001	0.89 (0.87-0.92)	<0.0001	0.90 (0.88-0.93)	<0.0001
Total cholesterol (mmol/L)	0.79 (0.77-0.82)	<0.0001	0.8 (0.78-0.83)	<0.0001	0.87 (0.85-0.89)	<0.0001
HDL-C (mmol/L)	0.8 (0.77-0.82)	<0.0001	0.82 (0.8-0.85)	<0.0001	0.93 (0.90-0.96)	<0.0001
LDL-C (mmol/L)	0.81 (0.79-0.83)	<0.0001	0.81 (0.79-0.83)	<0.0001	0.87 (0.85-0.90)	<0.0001
Triglycerides (mmol/L)	1.23 (1.19-1.26)	<0.0001	1.2 (1.17-1.24)	<0.0001	0.98 (0.95-1.02)	0.3298

Abbreviations: UPF, ultra-processed food; HR, hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; HbA1c, glycated hemoglobin; NLR, neutrophil-to-lymphocyte ratio; PLR, platelet-to-lymphocyte ratio; SII, systemic immune-inflammation index; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol.

Model 1 unadjusted.

Model 2 adjusted for UPF consumption.

Model 3 adjusted for age, sex, ethnicity, Townsend deprivation index, education levels, income, BMI, physical activity, total energy intake, healthy diet score, smoking status, passive smoking exposure, family history of chronic lung diseases, and UPF consumption.

a HRs (95% CIs) and *P*-values were obtained by using the multivariable Cox regression model.

The levels of biomarkers were nature log-transformed before analyses.

Table S5. Sensitivity analysis of the association of UPF consumption with incidence of COPD.

	UPF consumption					Per SD increase	*P*-trend
	Q1	**Q2**	**Q3**	**Q4**	**Q5**		
The association between absolute UPF consumption (grams per day) and the risk of COPD							
Cases	844	745	807	941	1333		
Person-years	538193	539423	539188	537538	533424		
Fully adjusted HR	Reference	0.88 (0.79 - 0.97)	0.90 (0.81 - 0.99)	0.99 (0.90 - 1.09)	1.24 (1.13 - 1.36)	1.14 (1.10 - 1.17)	<0.0001
The association between energy contribution of UPF and the risk of COPD							
Cases	858	843	849	933	1187		
Person-years	537325	538689	539076	537870	534807		
Fully adjusted HR	Reference	0.99 (0.90 - 1.09)	1.01 (0.91 - 1.11)	1.06 (0.96 - 1.17)	1.24 (1.13 - 1.36)	1.09 (1.06 - 1.13)	<0.0001
Excluded participants with inappropriate energy intake							
Cases	795	731	829	943	1287		
Person-years	533424	534148	533472	533092	528863		
Fully adjusted HR	Reference	0.92 (0.83 - 1.01)	0.95 (0.86 - 1.05)	1.03 (0.94 - 1.14)	1.23 (1.13 - 1.35)	1.11 (1.08 - 1.14)	<0.0001
Additionally adjusted for baseline health conditions (Diabetes, hypertension, asthma, cardiovascular disease, and cancer)							
Cases	812	747	844	964	1303		
Person-years	538307	539132	538485	538026	533815		
Fully adjusted HR	Reference	0.92 (0.83 - 1.02)	0.95 (0.86 - 1.05)	1.04 (0.95 - 1.14)	1.23 (1.12 - 1.35)	1.11 (1.08 - 1.14)	<0.0001
Excluded participants who developed COPD within the first 2 years of the follow-up							
Cases	762	705	804	892	1222		
Person-years	538163	538879	538214	538162	534047		
Fully adjusted HR	Reference	0.92 (0.83 - 1.02)	0.96 (0.87 - 1.06)	1.02 (0.92 - 1.12)	1.22 (1.11 - 1.34)	1.11 (1.08 - 1.14)	<0.0001
Excluded participants who developed COPD within the first 5 years of the follow-up							
Cases	616	573	662	739	991		
Person-years	537433	538046	537421	537512	534126		
Fully adjusted HR	Reference	0.93 (0.83 - 1.04)	0.98 (0.87 - 1.09)	1.04 (0.93 - 1.16)	1.24 (1.11 - 1.37)	1.11 (1.07 - 1.14)	<0.0001
Excluding cases with missing covariables							
Cases	433	423	472	550	638		
Person-years	390555	390620	390064	389946	388348		
Fully adjusted HR	Reference	0.94 (0.82 - 1.07)	0.98 (0.86 - 1.12)	1.09 (0.96 - 1.24)	1.18 (1.04 - 1.34)	1.09 (1.05 - 1.13)	0.0004
Adjusting for waist circumference instead of BMI							

	Cases	812	747	844	964	1303		
	Person-years	538307	539132	538485	538026	533815		
	Fully adjusted HR	Reference	0.92 (0.83 - 1.01)	0.94 (0.85 - 1.04)	1.01 (0.92 - 1.12)	1.19 (1.08 - 1.3)	1.10 (1.07 - 1.12)	<0.0001

Abbreviations: UPF, ultra-processed food; COPD, chronic obstructive pulmonary disease; HR, hazard ratio; SD, standard deviation.

HR was calculated by the Cox model adjusted for age, sex, ethnicity, Townsend deprivation index, education levels, income, BMI, physical activity, total energy intake, healthy diet score, smoking, passive smoking exposure and family history of chronic lung diseases.

HRs (95% CIs) and *P*-values were obtained by using the multivariable Cox regression model.

Table S6. Substitution models replacing 50g/day, 100g/day and 200g/day UPF with equivalent amount of UNPF and their effect on COPD risk.

	COPD	
	HR (95% CI)	*P*-value
Replacing 50g/day of UPF weight in diet for an equivalent proportion of UNPF	0.985 (0.982 - 0.988)	<0.0001
Replacing 100g/day of UPF weight in diet for an equivalent proportion of UNPF	0.970 (0.964 - 0.977)	<0.0001
Replacing 200g/day of UPF weight in diet for an equivalent proportion of UNPF	0.941 (0.929 - 0.954)	<0.0001

Abbreviations: HR, hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; UNPF, unprocessed or minimally processed foods; UPF, ultra-processed foods.

The models included ultra-processed foods, unprocessed or minimally processed foods, processed culinary ingredients, processed foods, total energy intake, healthy diet score, age, sex, ethnicity, Townsend deprivation index, education levels, income, BMI, physical activity, smoking status, passive smoking exposure, and family history of chronic lung diseases.

HRs (95% CIs) and *P*-values were obtained by using the multivariable Cox regression model.

Table S7 Substitution models replacing 5%, 10% and 20% UPF with equivalent amount of UNPF and their effect on COPD risk.

	COPD	
	HR (95% CI) [a]	*P*-value
Replacing 5% of UPF energy in diet for an equivalent proportion of UNPF	0.973 (0.96 2- 0.984)	<0.0001
Replacing 10% of UPF energy in diet for an equivalent proportion of UNPF	0.947 (0.926 - 0.968)	<0.0001
Replacing 20% of UPF energy in diet for an equivalent proportion of UNPF	0.897 (0.857 - 0.937)	<0.0001

Abbreviations: HR, hazard ratio; CI, confidence interval; COPD, chronic obstructive pulmonary disease; UNPF, unprocessed or minimally processed foods; UPF, ultra-processed foods.

a The models included ultra-processed foods, unprocessed or minimally processed foods, processed culinary ingredients, processed foods, total energy intake, healthy diet score, age, sex, ethnicity, Townsend deprivation index, education levels, income, BMI, physical activity, smoking status, passive smoking exposure, and family history of chronic lung diseases.

HRs (95% CIs) and *P*-values were obtained by using the multivariable Cox regression model.

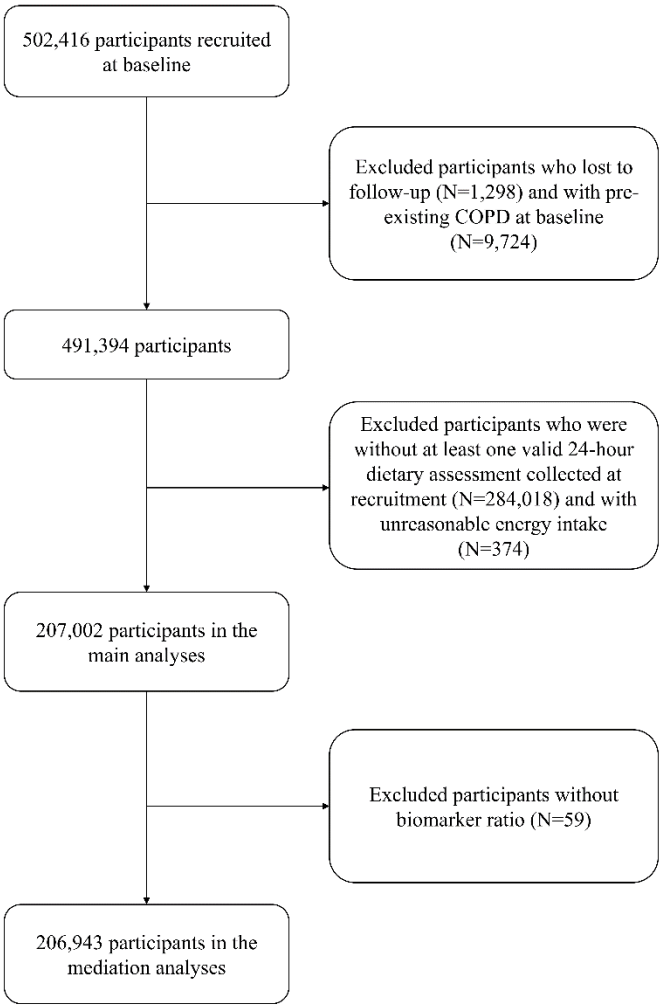

Figure S1. Flowchart of the study participants selection in the UK Biobank. Abbreviations: COPD, chronic obstructive pulmonary disease.

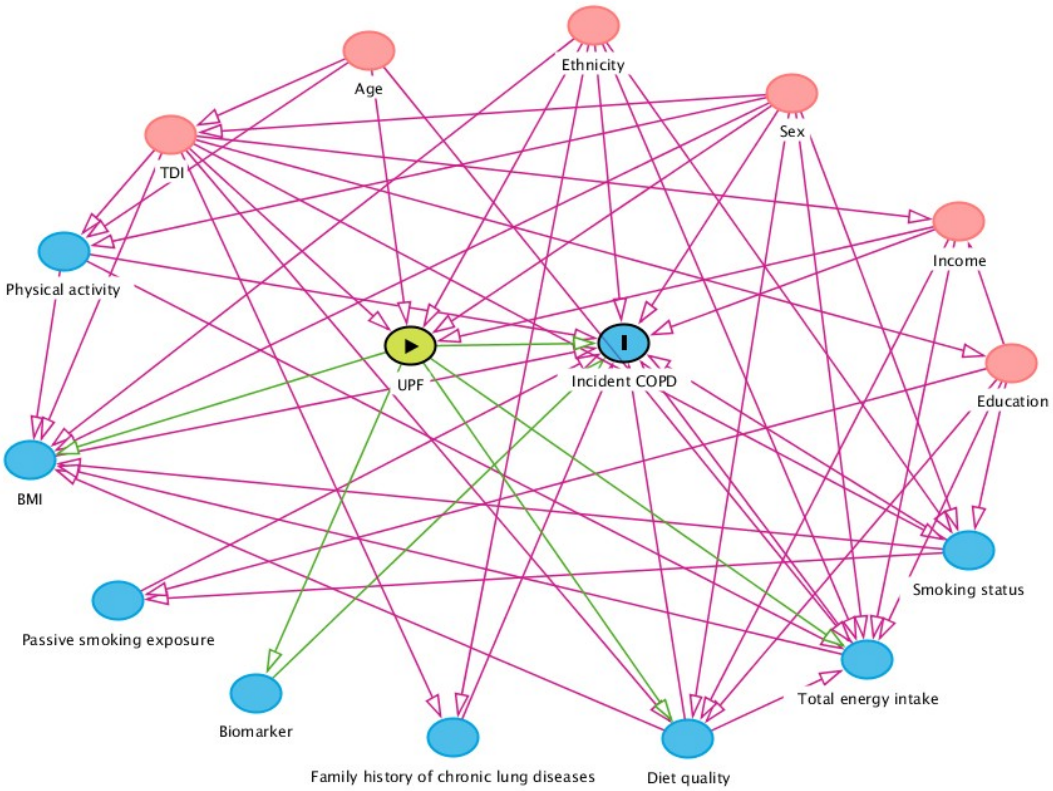

Figure S2. Direct acyclic graph of the relation between UPF consumption and COPD. The green circle represents exposure, the blue circle with a rectangle in the middle represents the outcome, and the blue circles represent the confounding variables. Abbreviations: COPD, chronic obstructive pulmonary disease; UPF, ultra-processed foods; BMI, body mass index; TDI, Townsend deprivation index.