Environ Health Perspect

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Supplemental Material

Constituents of Household Air Pollution and Risk of Lung Cancer among Never-Smoking Women in Xuanwei and Fuyuan, China

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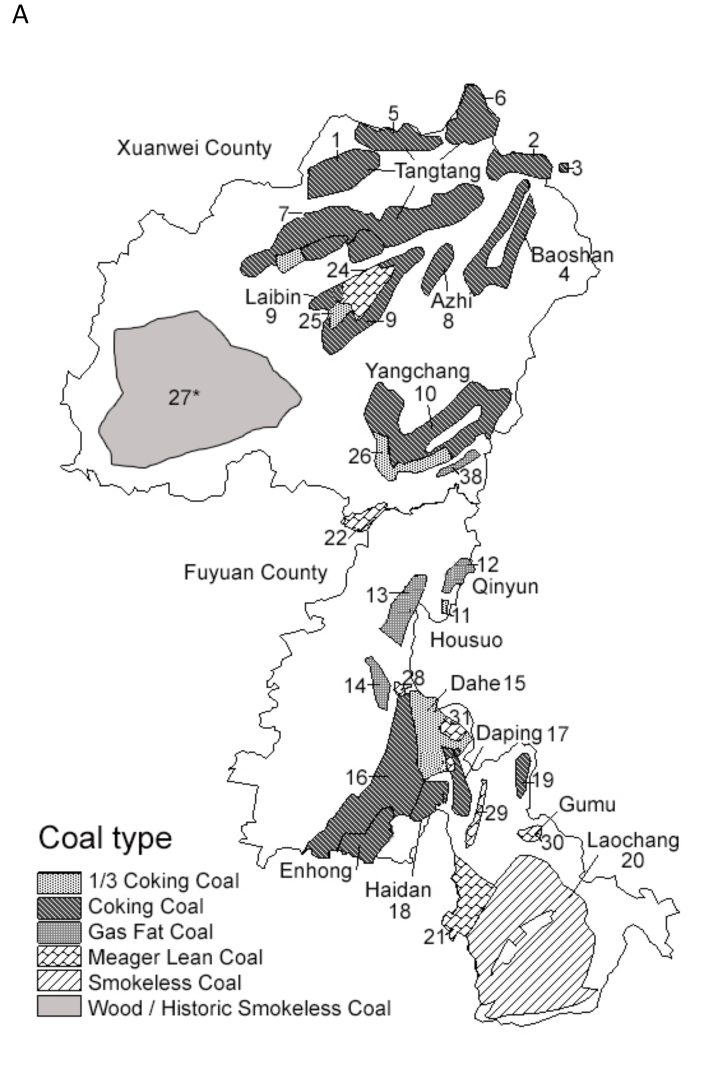


B

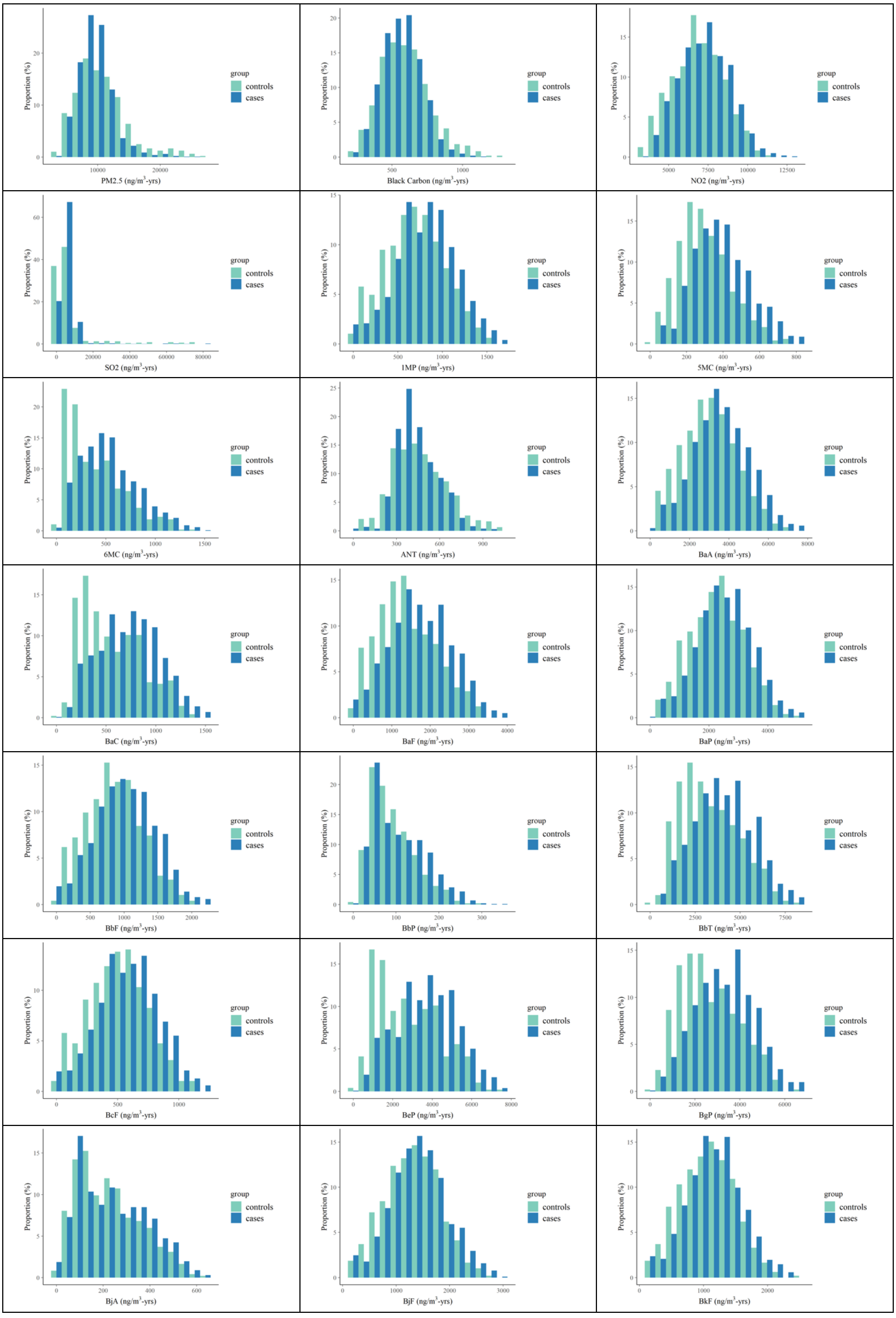
Coal Deposit Layer	Coal Region	OR [95%CI]
Never smoky coal users (Reference)	XW and FY	1
9	XW, Laibin	30.6 [12.0, 78.1]
24	XW, Laibin	19.0 [6.51, 55.4]
1,2,4,7,8	XW, North	9.13 [4.65, 17.9]
10	XW South	6.64 [3.03, 14.5]
12,13,14,38*	FY, North	15.0 [5.76, 39.2]
16,17,19	FY, South	13.1 [6.50, 26.4]
20, 27	XW and FY	4.83 [1.33, 17.5]
Wood/Feces Users	XW and FY	1.81 [0.85, 3.87]
Other/Outside/Unknown	Undefined	1.87 [0.95, 3.68]

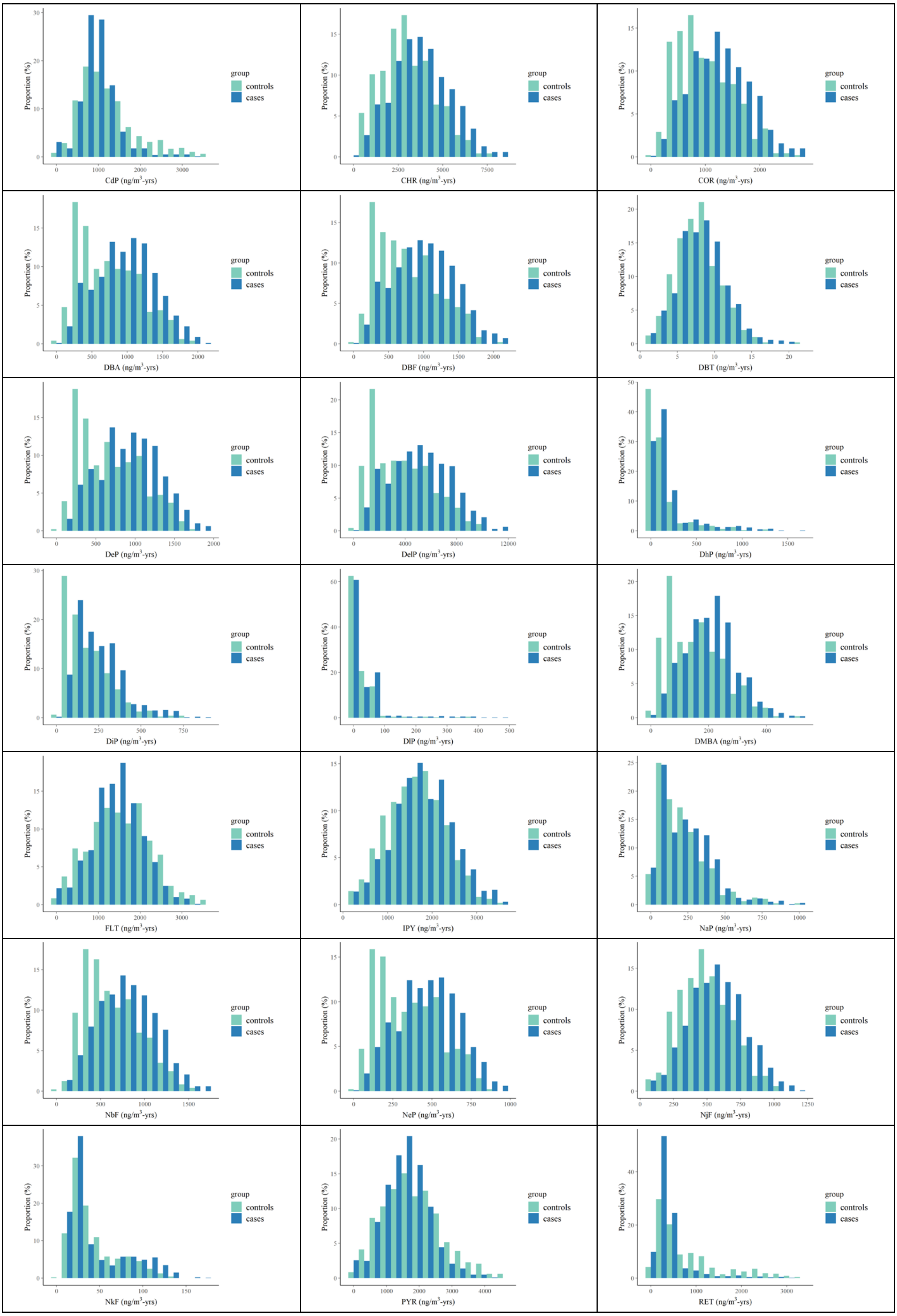
Figure S1. Map of Geological Coal Deposit Layers in Xuanwei and Fuyuan Counties of Yunnan, China (A) and associated lung cancer odds ratios for the most frequently used deposit (B).
Coal deposits are designated by numbers. Coal type is based on the Chinese State Standard coal classification.

Odds ratios are derived from the same population contributing to the current publication and are adjusted for age and food sufficiency before marriage/20 years of age. Strata groupings were derived by combining coals of the same type and number of women using coal from each deposit. Deposits with sufficient users to allow separate analysis (9, 10, 24) were kept as such.

Map and odds ratios are reproduced with permission from Wong JYY, Downward GS, Hu W, et.al. *Lung cancer risk by geologic coal deposits: A case-control study of female never-smokers from Xuanwei and Fuyuan, China*. Int J Cancer. PMID: 30511435, https://doi.org/10.1002/ijc.32034. 2018.

*: Deposit 38 is in Xuanwei, the other deposits of this geological type (gas fat coal) are in Fuyuan.


Proportion (%)
group
controls
cases
PM2.5 (ng/m³-yrs)
Black Carbon (ng/m³-yrs)
NO2 (ng/m³-yrs)
SO2 (ng/m³-yrs)
1MP (ng/m³-yrs)
5MC (ng/m³-yrs)
6MC (ng/m³-yrs)
ANT (ng/m³-yrs)
BaA (ng/m³-yrs)
BaC (ng/m³-yrs)
BaF (ng/m³-yrs)
BaP (ng/m³-yrs)
BbF (ng/m³-yrs)
BbP (ng/m³-yrs)
BbT (ng/m³-yrs)
BcF (ng/m³-yrs)
BeP (ng/m³-yrs)
BgP (ng/m³-yrs)
BjA (ng/m³-yrs)
BjF (ng/m³-yrs)
BkF (ng/m³-yrs)



Proportion (%)
group
controls
cases
CdP (ng/m3-yrs)
CHR (ng/m3-yrs)
COR (ng/m3-yrs)
DBA (ng/m3-yrs)
DBF (ng/m3-yrs)
DBT (ng/m3-yrs)
DeP (ng/m3-yrs)
DeIP (ng/m3-yrs)
DhP (ng/m3-yrs)
DiP (ng/m3-yrs)
DIP (ng/m3-yrs)
DMBA (ng/m3-yrs)
FLT (ng/m3-yrs)
IPY (ng/m3-yrs)
NaP (ng/m3-yrs)
NbF (ng/m3-yrs)
NeP (ng/m3-yrs)
NjF (ng/m3-yrs)
NkF (ng/m3-yrs)
PYR (ng/m3-yrs)
RET (ng/m3-yrs)

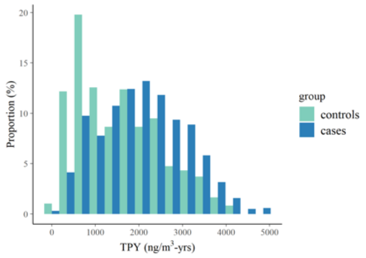


Figure S2. Comparative histograms comparing distribution of predicted exposure metrics by case/control status.

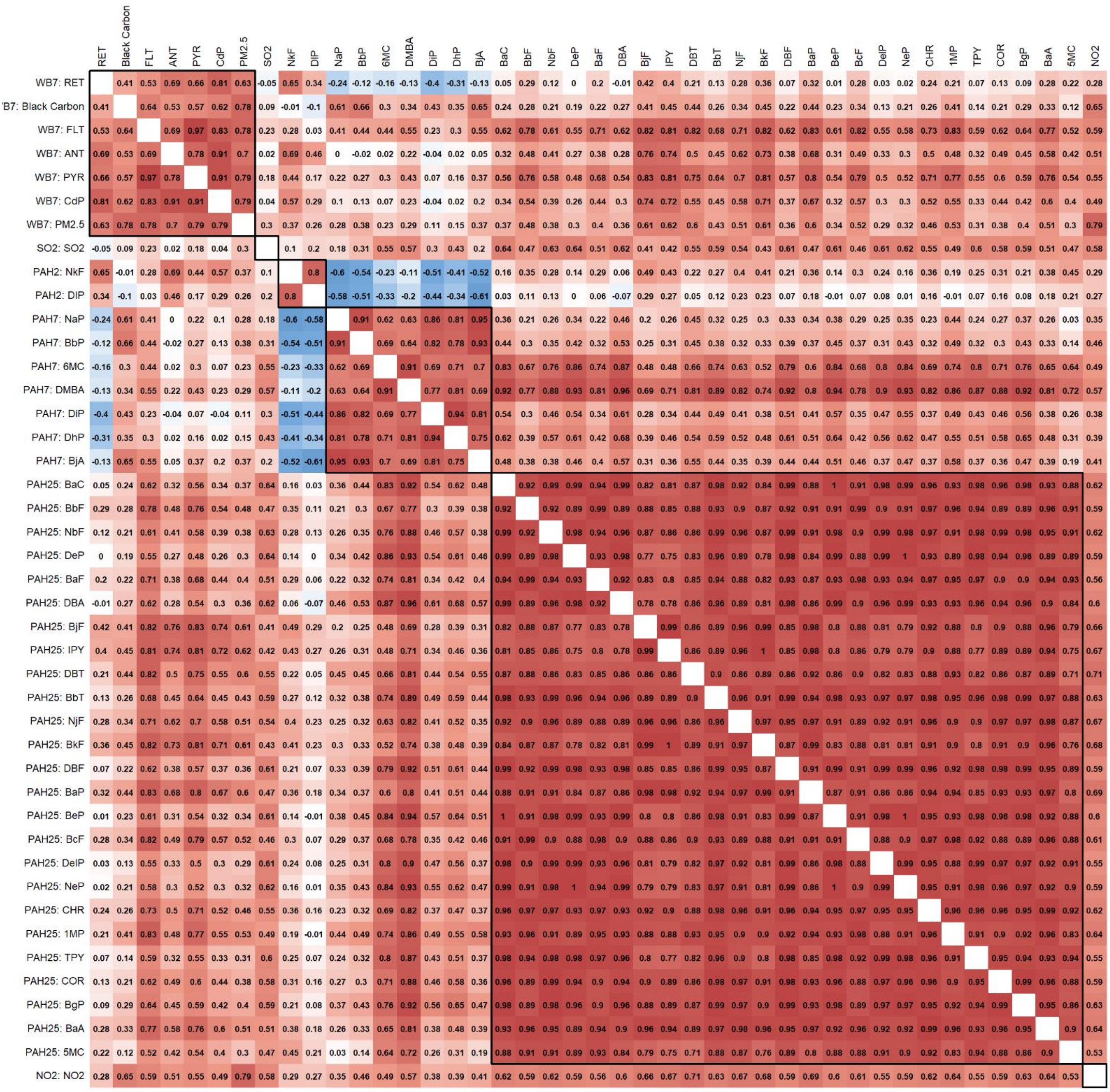


Figure S3. Correlation heatmap showing spearman correlations between exposures for the full population (including both cases and controls). Blue colours indicate negative correlations, red colours positive correlations. Exposures were ordered according to cluster membership (clusters were derived from the exposure data of controls) from the hierarchical clustering and sign and strength of the point estimate from the regularized regression model.

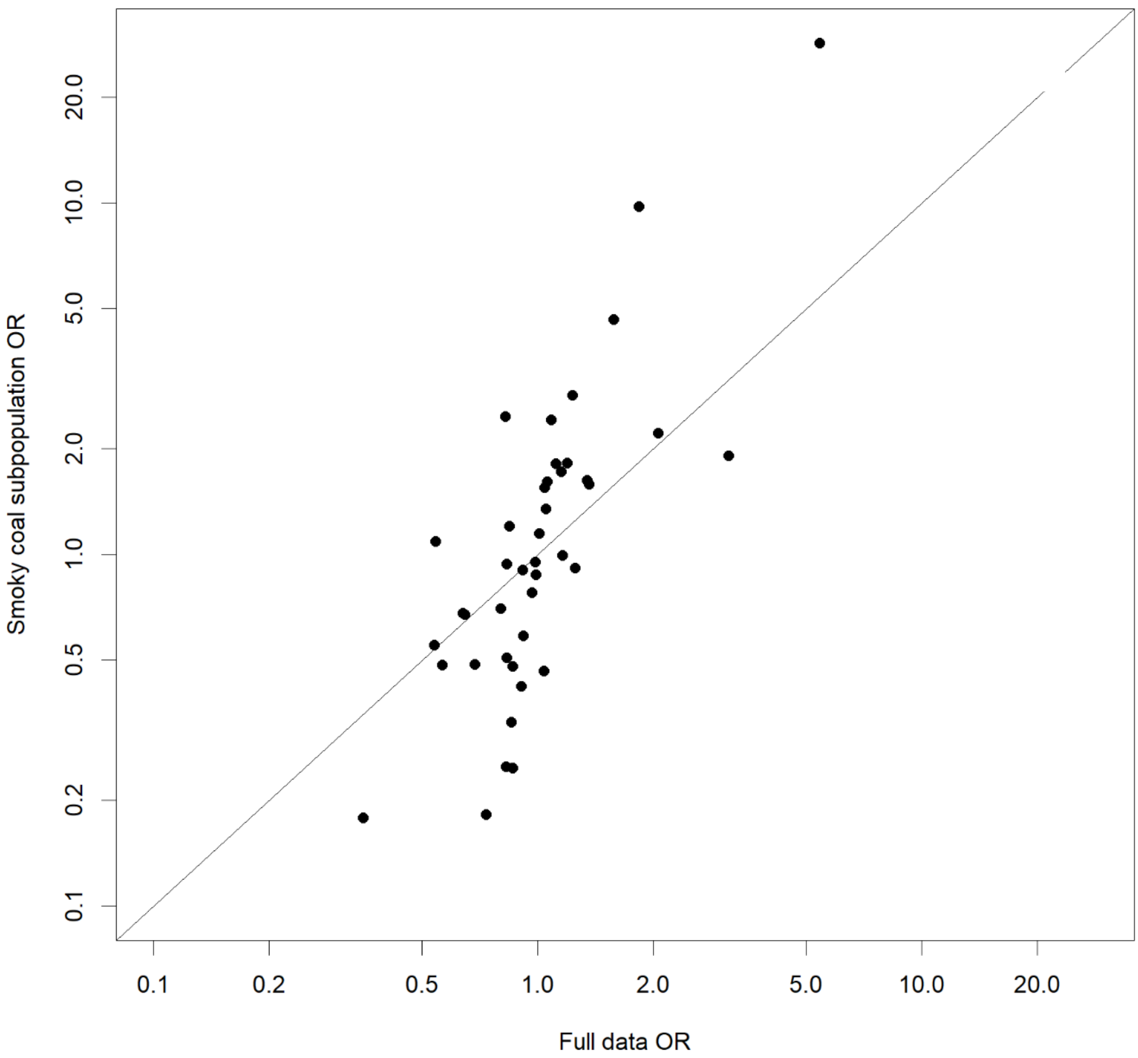


Figure S4. Comparison of coefficients for lung cancer risk from the regularized regression model fitted to lifetime cumulative exposure data for the full study population to those from a model fitted on data from subjects using almost exclusively smoky coal (used smokeless coal and/or for less than 2 years during their life). The (rescaled) point estimate for retene was off the (vertical) scale and is therefore not shown in the graph.

Table S1. $PM_{2.5}$, $PM_{2.5}$ absorbance, NO_2 and SO_2 by main fuel and stove

	$PM_{2.5}$		$PM_{2.5}$ absorbance		NO_2		SO_2	
	N	GM (GSD)	N	GM (GSD)	N	GM (GSD)	N	% Detected
Smoky Coal	206	148 (1.9)	202	12.0 (1.7)	191	111 (1.4)	191	40
Vented	110	134 (1.6)	108	13.0 (1.6)	105	102 (1.4)	105	31
Unvented	8	233 (1.3)	8	10.0(1.4)	6	113 (1.1)	6	67
Portable Stove	22	143 (1.9)	22	7.3 (2.0)	19	118 (1.6)	19	63
Firepit	15	277 (1.6)	13	13.7 (1.4)	15	132 (1.2)	15	73
Smokeless Coal	47	115 (1.9)	46	5.1 (1.7)	42	132 (1.6)	42	86
Vented	5	126 (2.0)	5	6.1 (2.0)	5	135 (1.5)	5	80
Unvented	18	109 (2.1)	17	4.8 (1.6)	15	134 (1.5)	15	93
Portable Stove	19	123 (1.9)	19	5.1 (1.9)	17	127 (1.7)	17	88
Firepit	3	102 (1.3)	3	3.7 (1.3)	3	139 (1.9)	3	100
Wood	24	289 (2.1)	23	16.3 (1.4)	24	110 (1.4)	24	29
Vented	8	183 (1.9)	8	13.5 (1.5)	8	104 (1.4)	8	38
Unvented	0	-	0	-	0	-	0	-
Portable Stove	6	320 (1.3)	6	17.2 (1.2)	5	90 (1.2)	5	0
Firepit	10	392 (2.4)	9	18.6 (1.4)	10	128 (1.4)	10	40

Values for "Mixed" fuels and stoves are not reported

N – number of samples collected

$PM_{2.5}$ (in $\mu g/m^3$) represents personal exposure from 163 women as reported by: Hu W, Downward GS, Reiss B, et.al. *Personal and indoor PM2.5 exposure from burning solid fuels in vented and unvented stoves in a rural region of China with a high incidence of lung cancer*. Environ Sci Technol 48:8456-8464, PMID: 25003800, https://doi.org/10.1021/es502201s (reprinted with permission)

$PM_{2.5}$ absorbance (in $1 \times 10^{-5} m^{-1}$) represents personal exposure from 163 women as reported by: Downward GS, Hu W, Rothman N, et.al. *Outdoor, indoor, and personal black carbon exposure from cookstoves burning solid fuels*. Indoor Air 26:784-795, PMID: 26452237, https://doi.org/10.1111/ina.12255 (reprinted with permission)

NO_2 (in $\mu g/m^3$) and SO_2 (in % detected samples) represent indoor measurements from 163 households as reported by: Seow WJ, Downward GS, Wei H, et.al. *Indoor concentrations of nitrogen dioxide and sulfur dioxide from burning solid fuels for cooking and heating in Yunnan province, China*. Indoor Air 26:776-783, PMID: 26340585, https://doi.org/10.1111/ina.12251 (reprinted with permission)

Table S2. Geometric mean (and GSD) for indoor measurements of expanded PAH analysis including methylated PAHs

	Smoky Coal					Smokeless Coal					Wood				
	Overall	Vented	Unvented	Portable Stove	Firepit	Overall	Vented	Unvented	Portable Stove	Firepit	Overall	Vented	Unvented	Portable Stove	Firepit
N	37	21	3	8	5	20	6	4	9	1	8	3	0	1	4
1MP	10.3 (4.4)	6.6 (2.9)	20.5 (3.3)	12.8 (9.4)	30.3 (3.2)	0.4 (4.3)	0.5 (6.6)	0.6 (3.5)	0.3 (4.1)	0.3 (-)	11 (3)	21.8 (1.4)	-	8.3 (-)	7.1 (4)
5MC	6.5 (3.4)	4.5 (2.5)	13.2 (2.5)	8 (6.4)	15.6 (2.2)	1.2 (3.2)	2.6 (4.0)	1.4 (2.3)	0.8 (2.7)	0.4 (-)	3.7 (2.0)	4.8 (1.9)	-	2.4 (-)	3.3 (2.3)
6MC	6.4 (4.2)	4.4 (2.8)	2.8 (10.6)	9.9 (6.2)	25.8 (2.0)	0.7 (3.7)	1 (6.8)	0.5 (1.9)	0.6 (3.3)	1.4 (-)	2.6 (2.2)	3.1 (1.2)	-	2.7 (-)	2.3 (3.1)
ANT	9.3 (2.9)	7 (2.6)	13.7 (2.8)	12.2 (4)	15.8 (2.4)	0.9 (5.9)	2.2 (5.7)	0.9 (8.1)	0.6 (4.6)	0.1 (-)	13.1 (2.4)	29.2 (1.5)	-	16.1 (-)	6.8 (2)
BaA	49.9 (3.5)	34.9 (2.6)	116 (3.4)	56.7 (6.5)	109.8 (2.1)	4.3 (6.4)	5.8 (8.8)	6 (4.5)	2.8 (7.5)	8.3 (-)	43.8 (2.5)	85 (1.6)	-	43.7 (-)	26.7 (2.8)
BaC	8.9 (3)	5.7 (2.3)	21.7 (2.9)	12 (4.4)	21.1 (1.8)	2.7 (4)	1.9 (4.6)	2.4 (2.1)	3.1 (4.9)	9.1 (-)	4.9 (2)	7.4 (1.5)	-	5.3 (-)	3.5 (2.3)
BaF	19.3 (5.1)	11.4 (3.4)	54 (6.1)	23.3 (10.1)	70.2 (3)	1.1 (3.1)	1.2 (4.4)	1.3 (2.3)	1 (3.2)	1.5 (-)	16.9 (2.8)	30.1 (1.4)	-	13.6 (-)	11.6 (3.8)
BaP	38 (2.9)	28.7 (2.3)	73.1 (2.6)	41.8 (5)	72.6 (2.1)	7.8 (3.9)	9.8 (6.1)	7.3 (3.7)	6.9 (3.6)	7.9 (-)	37.1 (2.3)	73.3 (1.7)	-	42.9 (-)	21.4 (2.2)
BbF	11.9 (5.1)	7.4 (3.5)	29.4 (7.3)	14.1 (9.8)	38.4 (3.2)	0.9 (2.6)	0.9 (3.7)	1.1 (2)	0.8 (2.7)	1.1 (-)	12.4 (2.8)	23.3 (1.5)	-	10.1 (-)	8.1 (3.8)
BbP	1.1 (3.7)	1.1 (3.2)	0.4 (1.1)	1.1 (6.5)	1.9 (3.5)	0.5 (2.1)	0.8 (2.7)	0.6 (2.4)	0.4 (1.1)	0.4 (-)	1.6 (2.8)	2 (4.3)	-	3.3 (-)	1.1 (2.2)
BbT	54 (3.0)	35.4 (2.4)	139 (2.5)	74.6 (4.2)	108.1 (1.9)	17.3 (4.4)	13 (5.5)	19.7 (2.5)	17.4 (5.4)	55.3 (-)	35.6 (2.2)	62.6 (1.6)	-	40.6 (-)	22.5 (2.2)
BcF	7.1 (4.9)	4.5 (3.3)	17 (5.8)	8.3 (10.1)	22.7 (3.1)	0.3 (3.9)	0.3 (5.6)	0.4 (3)	0.2 (4.1)	0.3 (-)	7.6 (3)	15.1 (1.4)	-	6.1 (-)	4.8 (4)
BeP	48.8 (3.1)	31.1 (2.5)	117.7 (2.2)	67.6 (4.5)	113 (1.7)	10.2 (4.2)	9.2 (6.1)	9.9 (2.3)	10.2 (4.8)	23.8 (-)	20.9 (2)	31.4 (1.5)	-	24.2 (-)	14.9 (2.4)
BgP	47.3 (2.9)	32.5 (2.4)	97.2 (2.2)	60.4 (4.5)	99.9 (1.9)	10.1 (3.3)	11.4 (4.8)	8.6 (2.6)	9.6 (3.3)	13.1 (-)	27.9 (2)	47 (1.5)	-	34.1 (-)	17.9 (2)
BjA	2.9 (5.9)	2.1 (4.7)	4.2 (8.9)	3.3 (10.7)	6.4 (5.2)	0.4 (1.8)	0.5 (2.8)	0.4 (1.1)	0.4 (1.5)	0.4 (-)	3.6 (4.5)	4.3 (8.3)	-	5.1 (-)	2.9 (4.4)
BjF	22.2 (2.9)	17.4 (2.3)	41.3 (2.6)	23.6 (5)	39.3 (2.1)	4.8 (3.8)	5.9 (5.8)	4.5 (3.9)	4.2 (3.5)	4.5 (-)	22.7 (2.3)	45.1 (1.8)	-	25.7 (-)	13.1 (2.1)
BkF	17.8 (2.9)	14.1 (2.3)	32.3 (2.9)	18.6 (5)	30.7 (2.1)	3.9 (3.7)	4.6 (5.4)	3.9 (3.5)	3.5 (3.6)	4.5 (-)	17.8 (2.3)	36 (1.7)	-	21.9 (-)	10 (2.1)
CdP	17 (4.2)	13.8 (3.2)	30.4 (4)	14.2 (8.6)	38.2 (3.1)	1 (6.9)	2 (8.9)	1.9 (6.6)	0.6 (5.8)	0.1 (-)	38.8 (4.3)	113.4 (1.6)	-	38.3 (-)	17.4 (5.3)
CHR	46.9 (3.3)	30.1 (2.5)	128.2 (3.2)	60 (5.3)	111.4 (2)	6.3 (7.3)	6.2 (8.8)	9 (4)	4.7 (10)	24 (-)	39.2 (2.4)	70.6 (1.6)	-	35.2 (-)	26 (2.7)
COR	16.8 (3)	11.1 (2.5)	35.8 (2.2)	22.9 (4.5)	37.2 (1.5)	3.6 (3.4)	3.7 (4.7)	3.2 (2.7)	3.5 (3.6)	6.3 (-)	9.9 (2.2)	17.8 (1.4)	-	12.7 (-)	6 (2.2)
DBA	11.8 (3.1)	7.9 (2.4)	26.7 (3.2)	14.6 (4.6)	27.3 (1.9)	2.8 (4.1)	2.3 (5.8)	2.2 (2.2)	3.1 (4.6)	8.5 (-)	5.8 (2)	8.6 (1.5)	-	7 (-)	4.2 (2.3)
DBF	12.1 (3.1)	8.2 (2.5)	26.9 (2.9)	14.6 (4.8)	28.1 (1.8)	2.7 (3.8)	2.6 (4.9)	2.1 (2.5)	2.8 (4.3)	7.2 (-)	6.9 (2.1)	10.5 (1.5)	-	8.7 (-)	4.7 (2.4)
DBT	0.1 (3.4)	0.1 (1.6)	0.4 (6.3)	0.2 (6.7)	0.3 (2.5)	0.1 (2.6)	0.1 (1.7)	0.1 (1.9)	0.1 (3.6)	0.2 (-)	0.1 (2.5)	0.1 (2.3)	-	0.1 (-)	0.1 (3.3)
DeP	12.2 (2.9)	8 (2.1)	26.3 (2.5)	16.4 (4.7)	28.9 (1.5)	3.4 (2.9)	3.4 (3.4)	2.5 (1.5)	3.7 (3.4)	7.1 (-)	4.6 (1.9)	5.9 (1.4)	-	6 (-)	3.5 (2.4)
DelP	64.1 (3.2)	39.9 (2.6)	142.6 (2.1)	89.8 (4.8)	168.6 (1.4)	11.6 (3.7)	11.2 (5.3)	9.1 (2.3)	12.1 (4.1)	28.2 (-)	22.4 (2.2)	33 (1.4)	-	29.5 (-)	15.6 (2.8)
DhP	1 (8.1)	0.9 (6.5)	0.6 (16.2)	0.6 (14.1)	4.2 (4.6)	0.1 (2.7)	0.2 (6.4)	0.1 (1.1)	0.1 (1.1)	0.1 (-)	0.4 (6)	0.4 (6.1)	-	3.1 (-)	0.3 (7.2)

DiP	3.5 (5.3)	3.5 (4.2)	4 (8.9)	1.9 (9.6)	8.2 (3.8)	0.7 (3.8)	1.3 (5.3)	0.3 (1.1)	0.6 (4)	0.3 (-)	1.4 (5.2)	0.9 (6.1)	-	6.4 (-)	1.4 (6)
DlP	0.4 (9.8)	0.3 (6.7)	4.4 (26.9)	0.7 (21.5)	0.2 (1.9)	1.3 (5.8)	2.8 (4.9)	0.7 (4.5)	0.8 (7.2)	4.2 (-)	0.2 (3.7)	0.1 (1.1)	-	0.1 (-)	0.3 (6.3)
DMBA	3.1 (3.5)	2.1 (2.6)	5.1 (1.8)	4 (6.9)	7.6 (2.8)	0.4 (3.2)	0.8 (6.5)	0.2 (1.1)	0.3 (1.9)	0.2 (-)	1.2 (2.1)	1.4 (1.3)	-	1 (-)	1.1 (2.9)
FLT	17 (4.8)	10.8 (3.1)	39.9 (7.1)	20.7 (9.5)	49.6 (3.4)	0.9 (2.3)	0.9 (2.1)	1.2 (2)	0.8 (2.7)	0.7 (-)	37.8 (4.4)	96.2 (1.5)	-	24.9 (-)	20.8 (6.6)
IPY	26.6 (2.7)	20.9 (2.2)	50.2 (2.7)	29.7 (4.3)	42.2 (2.1)	8.2 (3.1)	8.7 (4.2)	7.8 (3.1)	7.8 (3.1)	10.2 (-)	29 (2.1)	55.9 (1.7)	-	33.5 (-)	17.1 (1.7)
NaP	2.2 (5.8)	2.5 (4.9)	1.1 (6.9)	1.1 (9.8)	5.2 (4)	0.4 (1.6)	0.5 (2.4)	0.4 (1.1)	0.4 (1.1)	0.4 (-)	3 (3.9)	6.2 (1.2)	-	7.3 (-)	1.4 (5.3)
NbF	10.6 (2.8)	7.3 (2.1)	22.7 (2.7)	13.7 (4.4)	21.9 (1.6)	3.9 (2.8)	3.6 (2.9)	3.1 (2)	4.2 (3.4)	9 (-)	6.2 (1.9)	9.4 (1.6)	-	7.4 (-)	4.4 (2)
NeP	6.2 (2.9)	4.2 (2.2)	12.8 (2.8)	7.8 (4.9)	14.1 (1.6)	1.3 (3.1)	1.3 (4.4)	1.1 (1.6)	1.2 (3.3)	2.3 (-)	2.6 (2.5)	4.2 (1.5)	-	3.6 (-)	1.7 (3.3)
NjF	8.5 (2.7)	6.7 (2.1)	14.3 (2.8)	9.5 (4.7)	15.1 (1.8)	2.8 (2.3)	3.4 (2.5)	2.2 (2.4)	2.7 (2.4)	3.6 (-)	7.1 (2)	12 (1.7)	-	8.5 (-)	4.6 (1.8)
NkF	0.7 (3.1)	0.5 (2.2)	1.6 (11.2)	1 (4.4)	0.6 (1.9)	0.9 (3)	2.1 (3.1)	0.7 (3.2)	0.6 (2.4)	0.4 (-)	1 (4.2)	1.2 (8)	-	0.3 (-)	1.2 (3.4)
PYR	19.7 (4.5)	12.8 (2.9)	49.3 (6.1)	22.8 (9.3)	56.8 (3.5)	1 (2.6)	1 (2.3)	1.6 (2.7)	0.9 (3)	0.8 (-)	46.7 (3.7)	112.1 (1.5)	-	31.2 (-)	26.8 (5.2)
RET	6.1 (4.3)	4.4 (3.7)	10.4 (2.7)	7.6 (8.3)	11.3 (2.7)	1.3 (3.9)	2.4 (4.5)	1.4 (6.5)	0.9 (2.9)	0.6 (-)	33.1 (8)	54.4 (4)	-	2.7 (-)	42.5 (12.5)
TPY	23.7 (3.7)	13.7 (2.7)	70.4 (2.3)	33.6 (5.9)	70.6 (1.8)	2.6 (6.4)	2.6 (8.5)	3.2 (3.1)	2 (8.3)	10.4 (-)	10.7 (2.1)	15.2 (1.4)	-	11.4 (-)	8 (2.7)

N – number of samples

1MP – 1-methylpyrene , 5MC – 5-methyl chrysene, 6MC – 6-methylchrysene, ANT – anthanthrene, BaA – benz(a)anthracene, BaC – benzo(a)chrysene, BaF – benzo(a)fluorene, BaP – benzo(a)pyrene, BbF – benzo(b)fluorene, BbP – benzo(b)perylene, BbT – benzo(b)fluoranthene, BcF – benzo(c)fluorene, BeP – benzo(e)pyrene, BgP – benzo(g,h,i)perylene, BjA – benz(j,e)aceanthrylene, BjF – benzo(j)fluoranthene, BkF – benzo(k)fluoranthene, CdP – cyclopenta(c,d) pyrene, CHR – chrysene, COR – coronene, DBA – dibenzo(a,h)anthracene, DBF – dibenzo(a,e)fluoranthene, DBT – dibenzothiophene, DeP – dibenzo(a,e,)pyrene, DelP – dibenzo(e,l)pyrene, DhP – dibenzo(a,h)pyrene, DiP – dibenzo(a,i)pyrene, DlP – dibenzo(a,l)pyrene, DMBA – 7,12-dimethylbenz.a.anthracene, FLT – fluoranthene, IPY –indeno (1,2,3)pyrene, NaP – naphtho(2,3,a)pyrene, NbF – naphtho(1,2,b)fluoranthene, NeP – naphtho(2,3,e)pyrene, NjF – naphtho(2,3,j)fluoranthene, NkF – naphtho(2,3,k)fluoranthene, PYR – pyrene, RET – retene, TPY – triphenylene

Concentrations in ng/m^3

Samples were sourced from a subgroup of the population identified in Table S1 above. Selection was targeted towards representing stove and fuel variety in the study population

Text S1. Determinant-based modelling of exposure to household air pollutants

We enrolled 163 households and their never-smoking female heads, selected from 30 villages throughout Xuanwei and Fuyuan for an exposure survey in which multiple indoor and personal air samples were collected. Village and subject selection was targeted to represent the major geographical regions, solid fuels, and stove designs in use and to provide a population reflective of that within the case-control study. To that end, households that were at least ten years old and had not had any stove alterations undertaken in the past five years were preferentially selected.

Personal and indoor measurements were collected over 2 sequential 24-hour periods in 2008 and 2009. Samples of $PM_{2.5}$, black carbon (BC), quartz, trace elements, and particle bound PAHs and mPAHs were collected on 37mm teflon filters. Indoor measurements of NO_2 and SO_2 were collected using passively diffusing Ogawa filters. Radon was evaluated through the deployment of 90 day passively collecting detectors. Approximately 50% of subjects were visited again in a second season to allow seasonal adjustment of findings. Predictive linear mixed effect models were constructed for each pollutant, in which villages and individual subjects were assigned as random effects.(Downward 2015; Downward et al. 2016; Hu et al. 2014; Seow et al. 2016) Model construction was performed under a supervised step-wise procedure wherein variables were individually considered for model inclusion on the basis of goodness of fit and Akaike information criteria (AIC). A variety of potential predictors (including fuel type, fuel source, amount of fuel used, stove design, room size, number of windows/doors, the presence/absence of stairways, meteorological conditions, and season of measurement) were considered for inclusion as fixed effects. For all exposure variables (except for NO_2) the fuel type and/or source was identified as an important exposure predictor. The type of stove in use was also identified as a major predictor for exposure variables.

Quartz analyses of collected air samples resulted in a high proportion (89%) of non-detects with detected levels at or slightly above the limit of detection (LOD = 0.2 μg/m^3). In addition, review of fibre characteristics by scanning electronic microscopy did not reveal asbestiform fibers.(Downward et al. 2017) Radon was only detected in 50% of households with an average radon concentration of 3.4 pCi/L and there was no evidence of a difference in radon detection between homes using smoky vs. smokeless coal. Trace elements (Silicon, Aluminium, Arsenic, Bromine, Cadmium, Calcium, Chromium, Copper, Manganese, Nickel, Magnesium, Phosphorus, Lead, Sulphur, Selenium, Chlorine, Iron, Potassium, Titanium, Zinc, Vanadium, Yttrium, Molybdenum) were measured on filters using Energy Dispersive X-ray Fluorescence (EDXRF) and showed no evidence of difference between fuel or stove types.(Downward 2015)

The predictive models derived from the exposure survey were applied to the self-reported histories of stove and fuel use within the case-control dataset to assign annual geometric mean predicted exposure levels. For case-control subjects who reported using more than one fuel/stove in a given year, predictions from each permutation was combined based on the proportion of time spent using each permutation (e.g. a person using smoky coal and wood in equal amounts would have their final assignment calculated from a 50% smoky coal and 50% wood prediction).

References:

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Table S3. Sensitivity analysis – model comparison against different levels of regularization

			Effective model size for Horseshoe analysis			Limited regularization model*
Cluster	Exposure	Population SD	25 (main model)	4	0.04	-
WB7	RET	741	0.81 (0.24, 1.61)	0.82 (0.24, 1.53)	0.68 (0.25, 1.44)	0.48 (0.01, 19.18)
WB7	BC	185	0.82 (0.41, 1.25)	0.9 (0.49, 1.29)	0.95 (0.53, 1.26)	0.59 (0.25, 1.38)
WB7	FLT	731	0.83 (0.14, 2.46)	0.84 (0.17, 2.17)	0.82 (0.18, 1.94)	1.91 (0.01, 417.29)
WB7	ANT	193	0.83 (0.28, 1.47)	0.83 (0.29, 1.43)	0.87 (0.32, 1.35)	0.13 (0.01, 1.46)
WB7	PYR	906	0.86 (0.17, 2.37)	0.84 (0.16, 2.08)	0.88 (0.2, 1.96)	2.71 (0.01, 809.28)
WB7	CdP	694	0.91 (0.24, 2.28)	0.9 (0.25, 2.41)	0.93 (0.32, 1.87)	1.32 (0, 337.62)
WB7	PM2.5	4263	1.05 (0.68, 1.85)	1.02 (0.65, 1.62)	1.01 (0.68, 1.6)	1.23 (0.54, 2.85)
SO2	SO2	12584	0.86 (0.58, 1.12)	0.87 (0.59, 1.13)	0.88 (0.6, 1.11)	0.83 (0.49, 1.43)
PAH2	NkF	28	0.54 (0.27, 1.02)	0.58 (0.29, 1.02)	0.68 (0.31, 1.06)	0.54 (0.19, 1.57)
PAH2	DlP	41	1.16 (0.95, 1.53)	1.17 (0.95, 1.53)	1.12 (0.96, 1.5)	1.67 (1.07, 2.64)
PAH7	NaP	165	0.73 (0.24, 1.19)	0.77 (0.27, 1.2)	0.83 (0.31, 1.16)	0.13 (0.02, 0.83)
PAH7	BbP	52	0.99 (0.59, 1.64)	1 (0.63, 1.59)	0.99 (0.66, 1.5)	0.95 (0.18, 5.14)
PAH7	6MC	285	1.01 (0.56, 2.01)	1 (0.57, 1.88)	1.01 (0.6, 1.66)	2.15 (0.18, 27.49)
PAH7	DMBA	95	1.04 (0.43, 3.05)	1.01 (0.42, 2.78)	1.02 (0.51, 2.27)	1.11 (0.03, 38.66)
PAH7	DiP	131	1.15 (0.7, 2.44)	1.11 (0.68, 2.21)	1.08 (0.73, 2.14)	3.75 (0.5, 31.38)
PAH7	DhP	194	1.19 (0.82, 2.27)	1.21 (0.83, 2.23)	1.15 (0.85, 2.12)	1.32 (0.37, 4.76)
PAH7	BjA	133	1.23 (0.68, 4.08)	1.21 (0.69, 3.74)	1.08 (0.66, 3.29)	4.14 (0.38, 51.35)
PAH25	BaC	304	0.35 (0, 1.56)	0.42 (0.01, 1.57)	0.53 (0.01, 1.53)	0.05 (0, 7.86)
PAH25	BbF	414	0.54 (0.05, 1.63)	0.5 (0.04, 1.5)	0.53 (0.05, 1.35)	0.6 (0.01, 37.07)
PAH25	NbF	305	0.56 (0.02, 1.9)	0.62 (0.03, 1.87)	0.69 (0.04, 1.64)	0.22 (0, 27.73)
PAH25	DeP	390	0.64 (0.04, 2.06)	0.65 (0.04, 1.92)	0.64 (0.05, 1.76)	0.23 (0, 27.91)
PAH25	BaF	750	0.65 (0.06, 2.03)	0.62 (0.06, 1.75)	0.71 (0.07, 1.56)	0.34 (0, 22.96)
PAH25	DBA	423	0.69 (0.04, 2.15)	0.73 (0.06, 2.06)	0.8 (0.1, 1.76)	0.19 (0, 24.3)
PAH25	BjF	511	0.8 (0.11, 2.29)	0.8 (0.11, 2.11)	0.84 (0.14, 1.89)	2.1 (0.02, 387.04)
PAH25	IPY	633	0.83 (0.12, 2.18)	0.82 (0.13, 1.99)	0.84 (0.14, 1.79)	0.13 (0, 9.43)

PAH25	DBT	3	0.85 (0.33, 1.49)	0.85 (0.34, 1.45)	0.65 (0.23, 1.38)	2.02 (0.3, 13.01)
PAH25	BbT	1570	0.86 (0.14, 2.35)	0.84 (0.14, 2.09)	0.87 (0.16, 1.92)	0.14 (0, 10.73)
PAH25	NjF	191	0.91 (0.21, 2.82)	0.94 (0.26, 2.81)	0.93 (0.27, 2.12)	1.5 (0.02, 128.2)
PAH25	BkF	422	0.92 (0.18, 2.89)	0.89 (0.17, 2.61)	0.85 (0.18, 2.13)	1.25 (0.01, 163.41)
PAH25	DBF	425	0.97 (0.2, 3.88)	0.98 (0.25, 3.51)	0.91 (0.29, 2.76)	1.15 (0.01, 136.81)
PAH25	BaP	917	0.99 (0.23, 4)	0.97 (0.23, 3.81)	0.99 (0.29, 2.95)	3.99 (0.02, 1727.02)
PAH25	BeP	1577	1.04 (0.27, 4.99)	1.02 (0.26, 4.24)	1.02 (0.35, 3.1)	0.56 (0, 77.6)
PAH25	BcF	239	1.06 (0.32, 4.9)	1.03 (0.3, 4.09)	1.01 (0.37, 3.2)	1.33 (0.02, 116.62)
PAH25	DelP	2321	1.09 (0.34, 5.88)	1.07 (0.36, 4.76)	1.08 (0.44, 3.64)	2.92 (0.03, 455.85)
PAH25	NeP	197	1.12 (0.28, 8.24)	1.08 (0.27, 6.72)	1.06 (0.37, 4.65)	1.24 (0.01, 225.49)
PAH25	CHR	1495	1.25 (0.37, 11.99)	1.25 (0.4, 13.08)	1.18 (0.46, 9.36)	1.09 (0.01, 98.49)
PAH25	1MP	331	1.34 (0.51, 11.34)	1.32 (0.54, 10.6)	1.81 (0.59, 11.54)	0.52 (0.01, 25.06)
PAH25	TPY	962	1.36 (0.49, 16.28)	1.36 (0.52, 14.62)	1.24 (0.56, 13.23)	2.73 (0.04, 292.08)
PAH25	COR	514	1.58 (0.58, 29.53)	1.42 (0.55, 18.29)	1.34 (0.64, 12.58)	13.37 (0.12, 4739.15)
PAH25	BgP	1277	1.84 (0.52, 74.45)	1.66 (0.54, 44.93)	1.87 (0.59, 33.52)	2.69 (0.02, 555.79)
PAH25	BaA	1373	3.15 (0.65, 134.58)	4 (0.68, 218.69)	3.21 (0.75, 186.93)	2.5 (0.03, 272.31)
PAH25	5MC	142	5.42 (0.94, 37.49)	5.12 (0.91, 33.35)	3.27 (0.86, 32.63)	15.39 (1.15, 242)
NO2	NO2	1638	2.06 (1.19, 3.49)	1.9 (1.1, 3.24)	1.81 (1.1, 3.1)	2.52 (1.35, 4.68)

* : Student t prior with 7 degrees of freedom and a scale of 2.5

All models were adjusted for age, self-reported exposure to second-hand smoke, and self-reported food-sufficiency before marriage

Table S4. Distribution of eligible population among communes in Xuanwei and Fuyuan

County	Commune	N (percentage in county)
Xuanwei		442,975
	Rongcheng	48,356 (11%)
	Laibin	29,661 (7%)
	Geyi	17,497 (4%)
	Tianba	23,940 (5%)
	Yangchang	20,445 (5%)
	Banqiao	27,835 (6%)
	Tangtang	22,472 (5%)
	Jingwuai	5,696 (1%)
	Longchang	17,014 (4%)
	Baoshan	19,619 (4%)
	Puli	11,932 (3%)
	Dongshan	17,735 (4%)
	Haidai	19,322 (4%)
	Luoshui	13,330 (3%)
	Reshui	25,247 (6%)
	Xize	13,903 (3%)
	Wude	15,155 (3%)
	Longtan	19,165 (4%)
	Delu	11,779 (3%)
Fuyuan		207,302
	Zhongan	39,613 (19%)
	Yingshang	20,009 (10%)
	Huangnihe	16,381 (8%)
	Housuo	18,482 (9%)
	Dahe	23,326 (11%)
	Mohong	18,339 (9%)
	Zhuyuan	13,313 (6%)
	Fucun	24,015 (12%)
	Gugansuizu	4,322 (2%)
	Yuwang	17,755 (9%)
	Laochang	11,747 (6%)
	Yangliu	12,200 (3%)
	Shuanghe	8,514 (2%)
	Lefeng	14,615 (3%)
	Wenxing	16,130 (4%)
	Adu	11,413 (3%)

Information derived from Fifth National Population Census of China

Table S5. Spearman correlations between cluster variables in the full study population.

	WB7	SO2	PAH2	PAH7	PAH25	NO2
WB7	-	0.15	0.35	0.26	0.55	0.63
SO2		-	0.17	0.38	0.57	0.58
PAH2			-	-0.51	0.22	0.29
PAH7				-	0.58	0.47
PAH25					-	0.64
NO2						-

Clusters were derived from the exposure data of controls.

Table S6. Spearman correlations between individual exposures and cluster variables in the full study population.

	WB7	SO2	PAH2	PAH7	PAH25	NO2
RET	0.76	-0.05	0.52	-0.24	0.17	0.28
Black Carbon	0.75	0.09	-0.08	0.53	0.28	0.65
FLT	0.90	0.23	0.15	0.45	0.71	0.59
ANT	0.85	0.02	0.60	0.04	0.47	0.51
PYR	0.94	0.18	0.32	0.28	0.67	0.55
CdP	0.96	0.04	0.45	0.11	0.48	0.49
PM2.5	0.89	0.30	0.31	0.28	0.44	0.79
SO2	0.15	1.00	0.17	0.38	0.57	0.58
NkF	0.47	0.09	0.95	-0.47	0.29	0.29
DlP	0.21	0.20	0.93	-0.49	0.11	0.27
NaP	0.25	0.18	-0.64	0.92	0.31	0.35
BbP	0.31	0.31	-0.57	0.91	0.37	0.46
6MC	0.22	0.55	-0.28	0.83	0.74	0.49
DMBA	0.34	0.57	-0.15	0.85	0.88	0.57
DiP	0.09	0.30	-0.51	0.94	0.46	0.38
DhP	0.14	0.43	-0.40	0.92	0.56	0.39
BjA	0.36	0.20	-0.60	0.93	0.44	0.41
BaC	0.44	0.64	0.12	0.65	0.98	0.62
BbF	0.61	0.47	0.26	0.46	0.95	0.59
NbF	0.46	0.63	0.24	0.56	0.99	0.62
DeP	0.36	0.64	0.10	0.64	0.96	0.59
BaF	0.52	0.51	0.20	0.50	0.96	0.56
DBA	0.42	0.62	0.01	0.73	0.96	0.60
BjF	0.76	0.41	0.42	0.41	0.91	0.66
IPY	0.75	0.42	0.37	0.46	0.90	0.67
DBT	0.65	0.55	0.15	0.60	0.90	0.71
BbT	0.52	0.59	0.21	0.60	0.99	0.63
NjF	0.62	0.54	0.34	0.51	0.97	0.67
BkF	0.74	0.43	0.34	0.49	0.92	0.68
DBF	0.45	0.61	0.16	0.62	0.99	0.59
BaP	0.72	0.47	0.29	0.54	0.95	0.69
BeP	0.42	0.61	0.09	0.67	0.98	0.60
BcF	0.64	0.46	0.21	0.52	0.95	0.61
DelP	0.37	0.61	0.19	0.56	0.97	0.55
NeP	0.40	0.62	0.10	0.65	0.97	0.59
CHR	0.58	0.55	0.29	0.50	0.99	0.62
1MP	0.64	0.49	0.11	0.64	0.96	0.64
TPY	0.40	0.60	0.19	0.54	0.97	0.55
COR	0.49	0.58	0.26	0.55	0.98	0.59
BgP	0.50	0.59	0.17	0.65	0.98	0.63
BaA	0.64	0.51	0.31	0.51	0.98	0.64
5MC	0.43	0.47	0.37	0.35	0.91	0.53
NO2	0.63	0.58	0.29	0.47	0.64	1.00

Correlations with an absolute value over 0.75 are highlighted.
Clusters were derived from the exposure data of controls.

Table S7. Spearman correlations between cluster variables in subjects using smoky coal almost exclusively

	retene	WB2	PAH5+	PAH2	PAH29+
retene	-	0.69	-0.24	0.67	0.54
WB2		-	0.16	0.69	0.79
PAH5			-	-0.44	0.42
PAH2				-	0.38
PAH29					-

Clusters were derived from the exposure data of controls.

Table S8. Spearman correlations between individual exposures and cluster variables in subjects using smoky coal almost exclusively.

	retene	WB2	PAH5+	PAH2	PAH29+
RET	1.00	0.69	-0.24	0.67	0.54
CdP	0.69	0.97	0.24	0.61	0.86
ANT	0.64	0.97	0.06	0.76	0.67
NaP	-0.39	0.05	0.96	-0.53	0.33
BbP	-0.19	0.04	0.96	-0.49	0.39
DiP	-0.30	0.14	0.98	-0.43	0.34
DhP	-0.21	0.23	0.91	-0.33	0.46
Black Carbon	0.09	0.38	0.83	-0.10	0.46
BjA	-0.24	0.09	0.95	-0.51	0.43
DlP	0.42	0.52	-0.39	0.90	0.23
NkF	0.75	0.70	-0.45	0.97	0.40
BaC	0.49	0.70	0.45	0.30	0.99
FLT	0.40	0.69	0.53	0.21	0.96
BbT	0.53	0.79	0.39	0.40	0.99
NbF	0.60	0.79	0.33	0.43	0.99
DMBA	0.21	0.57	0.75	0.01	0.87
DBA	0.41	0.64	0.56	0.19	0.97
PYR	0.55	0.79	0.35	0.40	0.97
IPY	0.56	0.88	0.35	0.48	0.94
BbF	0.61	0.72	0.26	0.41	0.96
BkF	0.54	0.88	0.38	0.46	0.95
BaF	0.60	0.68	0.27	0.37	0.95
DeP	0.52	0.69	0.43	0.30	0.98
SO2	0.37	0.54	0.43	0.26	0.81
BjF	0.62	0.90	0.28	0.54	0.95
DBF	0.52	0.76	0.40	0.36	0.99
BaP	0.53	0.86	0.41	0.42	0.98
NjF	0.62	0.87	0.32	0.50	0.96
CHR	0.62	0.79	0.28	0.46	0.98
6MC	0.14	0.27	0.70	-0.17	0.69
PM2.5	0.42	0.68	0.52	0.34	0.81
DBT	0.36	0.72	0.52	0.24	0.95
BeP	0.48	0.72	0.48	0.28	0.99
TPY	0.59	0.72	0.28	0.40	0.97
BcF	0.55	0.71	0.34	0.35	0.96
1MP	0.43	0.70	0.50	0.25	0.97
NeP	0.53	0.73	0.44	0.32	0.99
BaA	0.60	0.84	0.31	0.47	0.98
NO2	0.41	0.67	0.52	0.36	0.76
DelP	0.57	0.76	0.31	0.41	0.98
COR	0.56	0.84	0.31	0.46	0.97
BgP	0.51	0.81	0.46	0.36	0.98
5MC	0.81	0.81	0.05	0.61	0.87

Correlations with an absolute value over 0.75 are highlighted.

Clusters were derived from the exposure data of controls.

Table S9. Odds ratios (95% CI) for individual clusters in the whole population

Cluster	**OR (95% CI)**
WB7	0.24 (0.19, 0.31)
PAH2	1.14 (0.94, 1.5)
NO2	2.27 (1.48, 3.55)
PAH7	1.25 (0.95, 1.88)
PAH25	2.21 (1.67, 2.87)
SO2	0.55 (0.43, 0.7)

Models were adjusted for age, self-reported exposure to second-hand smoke, and self-reported food-sufficiency before marriage

Table S10. Odds ratios (95% CI) for individual clusters in the smoky coal subpopulation

Cluster	**OR (95% CI)**
retene	0.97 (0.8, 1.06)
WB2	1.04 (0.92, 1.33)
PAH5+	1.04 (0.93, 1.43)
PAH2	1.11 (0.98, 1.51)
PAH29+	1.13 (0.97, 1.54)

Models were adjusted for age, self-reported exposure to second-hand smoke, and self-reported food-sufficiency before marriage

Table S11. Odds ratios (95%CI) for individual constituents within identified clusters of the smoky coal subpopulation

Cluster	**Exposure**	**OR (95% CI)**
retene	RET	0 (0.00, 0.01)
WB2	CdP	0.42 (0, 33.76)
WB2	ANT	0.94 (0.14, 5.48)
PAH5+	NaP	0.18 (0.02, 1.05)
PAH5+	BbP	0.95 (0.29, 2.73)
PAH5+	DiP	1.72 (0.54, 12.32)
PAH5+	DhP	1.81 (0.8, 6.04)
PAH5+	Black Carbon	2.46 (0.82, 11.21)
PAH5+	BjA	2.83 (0.69, 36.28)
PAH2	DlP	0.99 (0.66, 1.52)
PAH2	NkF	1.09 (0.53, 2.75)
PAH29+	BaC	0.18 (0, 2.7)
PAH29+	SO2	0.25 (0.02, 1.45)
PAH29+	FLT	0.25 (0, 5.08)
PAH29+	PYR	0.33 (0, 7.46)
PAH29+	DMBA	0.46 (0.02, 2.96)
PAH29+	BbT	0.48 (0.01, 4.15)
PAH29+	NbF	0.48 (0, 6.26)
PAH29+	DBA	0.49 (0.01, 4.67)
PAH29+	IPY	0.51 (0.01, 3.96)
PAH29+	BbF	0.55 (0.02, 4.05)
PAH29+	BkF	0.58 (0.01, 5.93)
PAH29+	BaF	0.67 (0.03, 5.17)
PAH29+	DeP	0.68 (0.01, 8.56)
PAH29+	BjF	0.7 (0.02, 8.39)
PAH29+	DBF	0.78 (0.03, 12.01)
PAH29+	BaP	0.87 (0.03, 14.72)
PAH29+	NjF	0.9 (0.06, 9.77)
PAH29+	CHR	0.91 (0.05, 11.66)
PAH29+	6MC	1.15 (0.3, 6.01)
PAH29+	DBT	1.2 (0.27, 8.73)
PAH29+	PM2.5	1.35 (0.3, 7.96)
PAH29+	BeP	1.54 (0.11, 84.29)
PAH29+	TPY	1.58 (0.16, 48.81)
PAH29+	BcF	1.61 (0.2, 60.23)
PAH29+	1MP	1.62 (0.21, 47.26)
PAH29+	NeP	1.81 (0.13, 190.3)
PAH29+	BaA	1.91 (0.18, 108.67)
PAH29+	NO2	2.21 (0.96, 5.71)
PAH29+	DelP	2.4 (0.27, 197.88)
PAH29+	COR	4.64 (0.39, 814.39)
PAH29+	BgP	9.74 (0.34, 48789.29)
PAH29+	5MC	28.46 (1.02, 772.39)

Models were adjusted for age, self-reported exposure to second-hand smoke, and self-reported food-sufficiency before marriage

Table S12. Comparing deposit specific odds ratios (95% CI) for models with and without household air pollution (HAP) components

Coal Deposit Layer	Coal deposit only$	Coal deposit + HAP$
Never smoky coal users	0.11 (0.05, 0.27)	0.84 (0.38, 1.30)
9	2.80 (1.17, 7.83)	2.77 (1.12, 6.85)
24	1.55 (0.81, 5.00)	1.25 (0.72, 4.12)
1,2,4,7,8	1.00 (0.60, 2.00)	1.03 (0.70, 1.61)
10	0.80 (0.41, 1.46)	0.89 (0.45, 1.32)
12,13,14,38	1.32 (0.76, 3.52)	0.87 (0.36, 1.41)
16,17,19	1.29 (0.82, 2.73)	0.91 (0.53, 1.30)
20,27	0.75 (0.24, 1.66)	1.18 (0.68, 3.41)
Wood/Feces Users	0.20 (0.10, 0.43)	1.38 (0.87, 3.21)

$ Effect estimates for a categorical covariate in a Bayesian horseshoe model do not require reference coding, so these odds ratios are relative to an exposure-only model.
Deposit groupings were derived by combining coals of the same type and number of women using coal from each deposit. Deposits with sufficient users to allow separate analysis (9, 10, 24) were kept as such
Models were adjusted for age, self-reported exposure to second-hand smoke, and self-reported food-sufficiency before marriage

Table S13. Comparing deposit specific odds ratios (95% CI) for models with and without household air pollution (HAP) components among the smoky coal subpopulation

Coal Deposit Layer	Coal deposit only$	Coal deposit + HAP$
9	2.55 (1.00, 7.45)	1.58 (0.91, 4.11)
24	1.15 (0.47, 4.24)	1.17 (0.72, 3.05)
1,2,4,7,8	1.06 (0.56, 2.16)	0.74 (0.41, 1.12)
10	0.80 (0.28, 1.52)	0.79 (0.37, 1.21)
12,13,14,38	1.16 (0.50, 3.90)	1.23 (0.76, 3.26)
16,17,19	0.93 (0.40, 1.73)	1.07 (0.69, 1.82)

$ Effect estimates for a categorical covariate in a Bayesian horseshoe model do not require reference coding, so these odds ratios are relative to an exposure-only model.
Deposit groupings were derived by combining coals of the same type and number of women using coal from each deposit. Deposits with sufficient users to allow separate analysis (9, 24) were kept as such
Models were adjusted for age, self-reported exposure to second-hand smoke, and self-reported food-sufficiency before marriage