# Household air pollution from solid fuel use as a dose-dependent risk factor for cognitive impairment in northern China

Supplementary information

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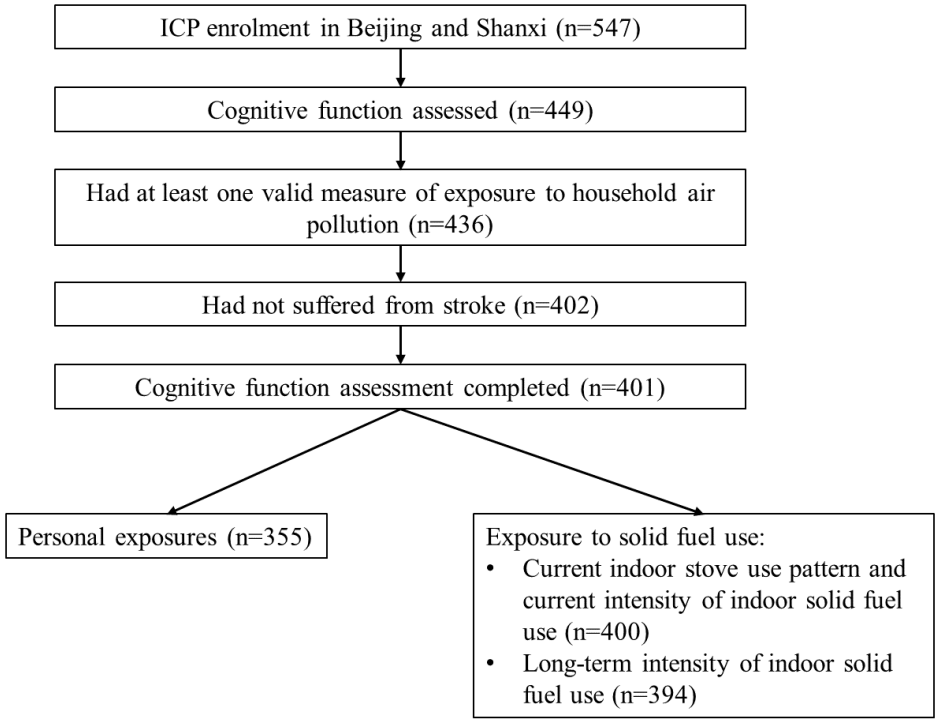



**Supplementary Fig. 1.** Inclusion flowchart of study participants. Refer to **Supplementary Table 10** for a comparison on baseline socio-demographic and health characteristics for ICP participants who would have been eligible for this study and the analytic sample.

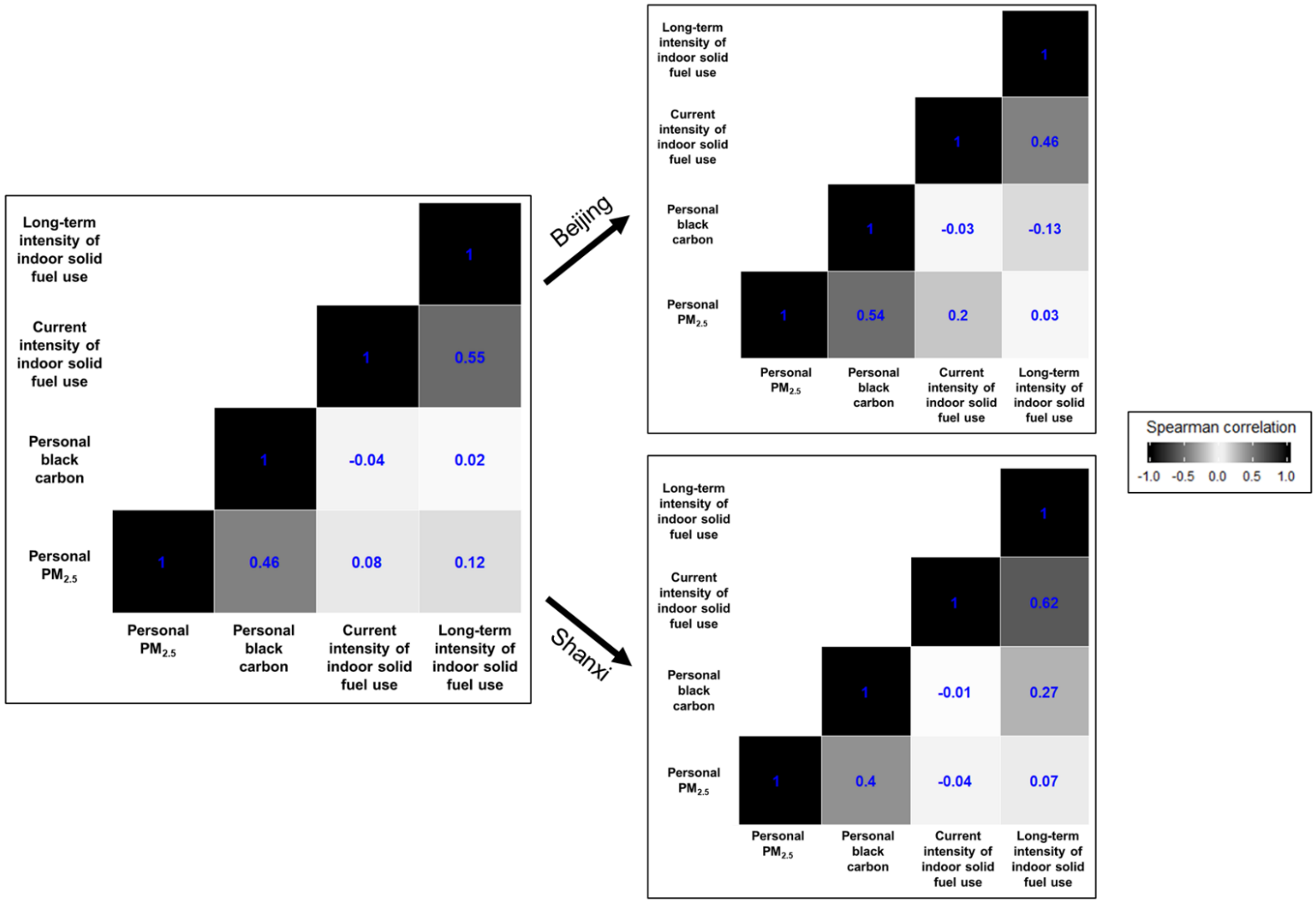
**Supplementary Table 1.** Measures of exposure to household air pollution and health conditions among study participants by current cooking fuel use.

| Characteristic | Exclusive use of clean fuel cookstoves (n=220) | Use of solid fuel cookstoves (n=180) | All participants (n=401)[a] |
|---|---|---|---|
| Personal exposure to $PM_{2.5}$ ($\mu g/m^3$) | | | |
| Mean (SD) | 97.3 (51.6) | 106.9 (51.2) | 101.8 (51.6) |
| Median (IQR) | 87.4 (52.1) | 97.0 (60.0) | 93.4 (53.2) |
| Geometric mean (95% CI) | 86.9 (81.2, 93.0) | 96.5 (90.0, 103.6) | 91.3 (86.9, 95.9) |
| Missing; n (%) | 28 (13) | 18 (10) | 46 (12) |
| Personal exposure to black carbon ($\mu g/m^3$) | | | |
| Mean (SD) | 1.6 (0.9) | 1.6 (0.8) | 1.6 (0.9) |
| Median (IQR) | 1.4 (0.9) | 1.4 (0.9) | 1.4 (0.9) |
| Geometric mean (95% CI) | 1.4 (1.3, 1.5) | 1.4 (1.3, 1.5) | 1.4 (1.3, 1.5) |
| Missing; n (%) | 28 (13) | 18 (10) | 46 (12) |
| Current heat stove use; n (%) | | | |
| Exclusive use of clean fuel | 88 (40) | 65 (36) | 153 (38) |
| Use of solid fuel stoves | 132 (60) | 115 (64) | 247 (62) |
| Missing | 0 (0) | 0 (0) | 1 (0) |
| Current stove use type for both cooking and heating; n (%) | | | |
| Exclusive use of clean fuel | 88 (40) | 0 (0) | 88 (22) |
| Use of solid fuel stoves | 132 (60) | 180 (100) | 312 (78) |
| Missing | 0 (0) | 0 (0) | 1 (0) |
| Current intensity of indoor solid fuel use (ie, stove-use days in the past year) | | | |
| Mean (SD) | 83.0 (78.8) | 433.3 (159.8) | 240.6 (212.8) |
| Median (IQR) | 121.0 (121.0) | 486.0 (121.0) | 121.0 (365.0) |
| Missing; n (%) | 0 (0) | 0 (0) | 1 (0) |
| Long-term intensity of indoor solid fuel use (ie, stove-use years in the past 20 years) | | | |
| Mean (SD) | 13.9 (6.6) | 20.8 (7.4) | 17.0 (7.8) |
| Median (IQR) | 14.1 (10.0) | 21.6 (5.8) | 17.5 (12.5) |
| Missing; n (%) | 5 (2) | 1 (1) | 7 (2) |
| Self-reported physician-diagnosed health conditions; n (%) | | | |
| Diabetes | 33 (15) | 22 (12) | 55 (14) |
| Heart disease | 16 (7) | 13 (7) | 30 (7) |
| Hypertension | 120 (55) | 94 (52) | 214 (53) |
| Body mass index ($kg/m^2$); mean (SD) | 26.4 (3.4) | 25.8 (3.8) | 26.1 (3.6) |

| | | | |
|---|---|---|---|
| Missing; n (%) | 12 (6) | 4 (2) | 16 (4) |

[a] Includes 1 participant with measured personal exposure to air pollution but missing fuel use data.

Abbreviations: $PM_{2.5}$, particulate matter ≤2.5 μm in aerodynamic diameter; SD, standard deviation; IQR, interquartile range; CI, confidence interval.




**Supplementary Fig. 2.** Spearman correlations between continuous exposure variables: personal exposures to $PM_{2.5}$ and black carbon ($\mu g/m^3$), current intensity of indoor solid fuel use (stove-use days in the past year), and long-term intensity of indoor solid fuel use (stove-use years in the past 20 years) for the entire study sample (n=401) and by province (n=202 in Beijing and 199 in Shanxi). Abbreviation: $PM_{2.5}$, particulate matter ≤2.5 μm in aerodynamic diameter.

**Supplementary Table 2.** Associations and 95% confidence intervals between measures of cognitive function and personal exposures to air pollution, current indoor fuel use patterns, or intensity of indoor solid fuel use: results from univariate and multivariable models.

| | | Univariable | | Univariable plus age and gender | | Univariable plus age, gender, and education | | Multivariable | | Multivariable plus ambient $PM_{2.5}$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Exposure** | **Cognitive domain** | **Difference in score[a]** | **95% CI** | **Difference in score[a]** | **95% CI** | **Difference in score[a]** | **95% CI** | **Difference in score[a]** | **95% CI** | **Difference in score[a]** | **95% CI** |
| Personal $PM_{2.5}$ | Visuospatial/ Executive | 0.01 | (-0.18, 0.21) | -0.10 | (-0.28, 0.08) | -0.12 | (-0.29, 0.05) | -0.16 | (-0.34, 0.02) | -0.20 | (-0.38, -0.01) |
| | Naming | 0.03 | (-0.15, 0.22) | -0.05 | (-0.23, 0.13) | -0.07 | (-0.25, 0.12) | -0.11 | (-0.30, 0.08) | -0.14 | (-0.34, 0.06) |
| | Attention | -0.06 | (-0.25, 0.12) | -0.15 | (-0.33, 0.03) | -0.19 | (-0.36, -0.03) | -0.22 | (-0.39, -0.04) | -0.23 | (-0.41, -0.05) |
| | Language | -0.12 | (-0.28, 0.05) | -0.15 | (-0.31, 0.02) | -0.18 | (-0.34, -0.02) | -0.16 | (-0.32, 0.01) | -0.17 | (-0.34, 0.01) |
| | Abstraction | -0.02 | (-0.22, 0.18) | -0.09 | (-0.29, 0.10) | -0.12 | (-0.31, 0.07) | -0.09 | (-0.30, 0.11) | -0.16 | (-0.37, 0.05) |
| | Delayed recall | -0.03 | (-0.23, 0.17) | 0.00 | (-0.20, 0.19) | -0.04 | (-0.23, 0.15) | -0.12 | (-0.31, 0.08) | -0.16 | (-0.37, 0.04) |
| | Orientation | -0.01 | (-0.18, 0.16) | -0.01 | (-0.19, 0.16) | -0.04 | (-0.21, 0.12) | -0.06 | (-0.23, 0.11) | -0.11 | (-0.29, 0.07) |
| | Overall | -0.03 | (-0.21, 0.15) | -0.10 | (-0.27, 0.07) | -0.15 | (-0.31, 0.00) | -0.20 | (-0.36, -0.04) | -0.24 | (-0.41, -0.08) |
| | Overall (raw score) | -0.18 | (-1.24, 0.88) | -0.58 | (-1.57, 0.41) | -0.89 | (-1.79, 0.00) | -1.19 | (-2.12, -0.25) | -1.41 | (-2.37, -0.45) |
| Personal black carbon | Visuospatial/ Executive | -0.08 | (-0.20, 0.04) | -0.07 | (-0.18, 0.03) | -0.08 | (-0.18, 0.03) | -0.08 | (-0.18, 0.02) | -0.10 | (-0.21, 0.00) |
| | Naming | 0.00 | (-0.11, 0.12) | -0.01 | (-0.12, 0.09) | -0.01 | (-0.12, 0.09) | -0.01 | (-0.12, 0.10) | -0.03 | (-0.14, 0.09) |
| | Attention | -0.13 | (-0.24, -0.02) | -0.14 | (-0.24, -0.03) | -0.13 | (-0.23, -0.04) | -0.12 | (-0.22, -0.02) | -0.13 | (-0.24, -0.03) |
| | Language | -0.09 | (-0.19, 0.01) | -0.09 | (-0.20, 0.01) | -0.09 | (-0.19, 0.00) | -0.05 | (-0.14, 0.04) | -0.06 | (-0.16, 0.04) |
| | Abstraction | 0.01 | (-0.12, 0.13) | -0.01 | (-0.12, 0.11) | -0.01 | (-0.12, 0.10) | 0.02 | (-0.09, 0.14) | -0.02 | (-0.14, 0.10) |
| | Delayed recall | -0.06 | (-0.18, 0.07) | -0.04 | (-0.16, 0.07) | -0.05 | (-0.16, 0.07) | -0.01 | (-0.12, 0.11) | -0.04 | (-0.16, 0.08) |
| | Orientation | -0.08 | (-0.18, 0.03) | -0.07 | (-0.18, 0.03) | -0.07 | (-0.17, 0.03) | -0.04 | (-0.14, 0.06) | -0.08 | (-0.18, 0.02) |
| | Overall | -0.10 | (-0.21, 0.01) | -0.11 | (-0.21, -0.01) | -0.11 | (-0.20, -0.02) | -0.08 | (-0.17, 0.01) | -0.11 | (-0.21, -0.01) |
| | Overall (raw score) | -0.60 | (-1.25, 0.04) | -0.65 | (-1.24, -0.06) | -0.66 | (-1.19, -0.13) | -0.48 | (-1.02, 0.06) | -0.64 | (-1.20, -0.08) |
| Exclusive use of clean fuel for cooking (ref: use of solid fuel) | Visuospatial/ Executive | 0.07 | (-0.13, 0.28) | 0.04 | (-0.14, 0.22) | -0.03 | (-0.20, 0.14) | -0.05 | (-0.22, 0.13) | – | – |
| | Naming | -0.03 | (-0.23, 0.17) | -0.04 | (-0.23, 0.15) | -0.05 | (-0.24, 0.14) | 0.00 | (-0.19, 0.19) | – | – |
| | Attention | 0.21 | (0.01, 0.41) | 0.20 | (0.02, 0.38) | 0.16 | (0.00, 0.33) | 0.19 | (0.02, 0.37) | – | – |
| | Language | 0.07 | (-0.12, 0.26) | 0.04 | (-0.14, 0.23) | 0.03 | (-0.16, 0.21) | 0.02 | (-0.13, 0.18) | – | – |
| | Abstraction | 0.18 | (-0.04, 0.40) | 0.18 | (-0.03, 0.39) | 0.17 | (-0.03, 0.37) | 0.18 | (-0.03, 0.39) | – | – |
| | Delayed recall | 0.05 | (-0.17, 0.27) | 0.00 | (-0.20, 0.21) | -0.04 | (-0.24, 0.16) | 0.01 | (-0.20, 0.22) | – | – |
| | Orientation | -0.09 | (-0.28, 0.10) | -0.11 | (-0.30, 0.08) | -0.13 | (-0.31, 0.05) | -0.07 | (-0.25, 0.10) | – | – |
| | Overall | 0.07 | (-0.13, 0.27) | 0.04 | (-0.15, 0.22) | -0.01 | (-0.17, 0.16) | 0.06 | (-0.11, 0.22) | – | – |
| | Overall (raw score) | 0.40 | (-0.76, 1.57) | 0.21 | (-0.85, 1.28) | -0.04 | (-0.99, 0.91) | 0.33 | (-0.63, 1.29) | – | – |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Exclusive use of clean fuel for heating (ref: use of solid fuel) | Visuospatial/ Executive | 0.19 | (-0.01, 0.39) | 0.14 | (-0.04, 0.33) | 0.09 | (-0.08, 0.27) | 0.12 | (-0.06, 0.30) | — | — |
| | Naming | 0.14 | (-0.05, 0.32) | 0.13 | (-0.04, 0.31) | 0.12 | (-0.06, 0.30) | 0.09 | (-0.09, 0.27) | — | — |
| | Attention | 0.13 | (-0.06, 0.32) | 0.12 | (-0.06, 0.29) | 0.07 | (-0.10, 0.23) | 0.04 | (-0.13, 0.20) | — | — |
| | Language | 0.06 | (-0.11, 0.24) | 0.05 | (-0.12, 0.22) | 0.02 | (-0.14, 0.18) | 0.00 | (-0.16, 0.16) | — | — |
| | Abstraction | 0.07 | (-0.14, 0.27) | 0.05 | (-0.14, 0.25) | 0.02 | (-0.17, 0.22) | 0.06 | (-0.14, 0.25) | — | — |
| | Delayed recall | 0.10 | (-0.10, 0.31) | 0.10 | (-0.10, 0.29) | 0.05 | (-0.14, 0.24) | 0.06 | (-0.13, 0.25) | — | — |
| | Orientation | 0.18 | (0.01, 0.35) | 0.17 | (0.01, 0.34) | 0.15 | (-0.01, 0.31) | 0.15 | (-0.01, 0.31) | — | — |
| | Overall | 0.19 | (0.01, 0.38) | 0.18 | (0.01, 0.35) | 0.12 | (-0.03, 0.27) | 0.13 | (-0.02, 0.28) | — | — |
| | Overall (raw score) | 1.13 | (0.08, 2.19) | 1.04 | (0.06, 2.01) | 0.73 | (-0.15, 1.60) | 0.75 | (-0.13, 1.63) | — | — |
| Current intensity of indoor solid fuel use | Visuospatial/ Executive | -0.05 | (-0.10, 0.00) | -0.03 | (-0.07, 0.01) | -0.01 | (-0.05, 0.03) | -0.01 | (-0.05, 0.04) | — | — |
| | Naming | -0.01 | (-0.06, 0.04) | 0.00 | (-0.05, 0.04) | 0.00 | (-0.04, 0.05) | -0.01 | (-0.05, 0.04) | — | — |
| | Attention | -0.07 | (-0.12, -0.03) | -0.06 | (-0.10, -0.02) | -0.05 | (-0.09, -0.01) | -0.05 | (-0.09, -0.01) | — | — |
| | Language | -0.03 | (-0.07, 0.02) | -0.02 | (-0.06, 0.03) | -0.01 | (-0.05, 0.03) | -0.01 | (-0.04, 0.03) | — | — |
| | Abstraction | -0.05 | (-0.11, 0.00) | -0.05 | (-0.10, 0.00) | -0.04 | (-0.09, 0.01) | -0.05 | (-0.10, 0.00) | — | — |
| | Delayed recall | -0.03 | (-0.08, 0.02) | -0.01 | (-0.06, 0.03) | 0.00 | (-0.05, 0.05) | -0.01 | (-0.06, 0.04) | — | — |
| | Orientation | -0.01 | (-0.05, 0.04) | 0.00 | (-0.05, 0.04) | 0.01 | (-0.04, 0.05) | -0.01 | (-0.05, 0.03) | — | — |
| | Overall | -0.05 | (-0.10, -0.01) | -0.04 | (-0.08, 0.01) | -0.02 | (-0.06, 0.02) | -0.03 | (-0.07, 0.01) | — | — |
| | Overall (raw score) | -0.31 | (-0.58, -0.03) | -0.21 | (-0.46, 0.04) | -0.12 | (-0.34, 0.11) | -0.19 | (-0.41, 0.04) | — | — |
| Long-term intensity of indoor solid fuel use | Visuospatial/ Executive | -0.08 | (-0.14, -0.02) | -0.05 | (-0.11, 0.00) | -0.03 | (-0.09, 0.02) | -0.02 | (-0.08, 0.04) | — | — |
| | Naming | -0.04 | (-0.10, 0.02) | -0.02 | (-0.08, 0.04) | -0.02 | (-0.08, 0.04) | -0.04 | (-0.10, 0.02) | — | — |
| | Attention | -0.09 | (-0.15, -0.03) | -0.06 | (-0.12, 0.00) | -0.06 | (-0.11, -0.01) | -0.07 | (-0.12, -0.01) | — | — |
| | Language | -0.06 | (-0.12, -0.01) | -0.04 | (-0.10, 0.01) | -0.04 | (-0.09, 0.01) | -0.04 | (-0.09, 0.01) | — | — |
| | Abstraction | -0.05 | (-0.12, 0.01) | -0.03 | (-0.10, 0.03) | -0.03 | (-0.09, 0.04) | -0.04 | (-0.11, 0.02) | — | — |
| | Delayed recall | -0.04 | (-0.10, 0.03) | 0.00 | (-0.07, 0.06) | 0.01 | (-0.05, 0.07) | 0.00 | (-0.06, 0.07) | — | — |
| | Orientation | -0.03 | (-0.09, 0.03) | -0.02 | (-0.07, 0.04) | -0.01 | (-0.07, 0.04) | -0.02 | (-0.08, 0.03) | — | — |
| | Overall | -0.09 | (-0.14, -0.03) | -0.05 | (-0.10, 0.01) | -0.04 | (-0.09, 0.01) | -0.05 | (-0.10, 0.00) | — | — |
| | Overall (raw score) | -0.50 | (-0.84, -0.15) | -0.29 | (-0.61, 0.03) | -0.22 | (-0.51, 0.07) | -0.29 | (-0.58, 0.01) | — | — |

[a] Difference in score in each cognitive measure associated with a 100-μg/m$^3$ increase in exposure to $PM_{2.5}$ (n=355), 1-μg/m$^3$ increase in exposure to black carbon (n=355), use of clean fuel exclusively for cooking or heating versus use of solid fuel as reference (n=400), per 100-day increase in solid fuel stove-use days in the past year (current use; n=400), or per 5-year increase in solid fuel stove-use years over the past 20 years (long-term use; n=394).
Abbreviations: $PM_{2.5}$, particulate matter ≤2.5 μm in aerodynamic diameter; CI, confidence interval.

**Supplementary Table 3.** Assessment of potential effect modification by province and gender on the associations between measures of cognitive function and personal exposures to air pollution, current indoor fuel use patterns, or intensity of indoor solid fuel use: results from multivariable models.

| Effect modifier evaluated | By province | | | By gender | | |
|---|---|---|---|---|---|---|
| | Beijing | Shanxi | Interaction p-value[a] | Male | Female | Interaction p-value[a] |
| Difference in score and 95% CI per 100-μg/m$^3$ increase in $PM_{2.5}$ (n = 355) | | | | | | |
| Visuospatial/Executive | -0.27 (-0.54, 0.00) | -0.14 (-0.39, 0.11) | 0.48 | -0.14 (-0.37, 0.08) | -0.31 (-0.64, 0.01) | 0.38 |
| Naming | -0.11 (-0.40, 0.17) | -0.16 (-0.42, 0.10) | 0.83 | -0.08 (-0.32, 0.15) | -0.26 (-0.60, 0.08) | 0.38 |
| Attention | -0.47 (-0.73, -0.20) | -0.05 (-0.28, 0.19) | 0.02 | -0.13 (-0.35, 0.09) | -0.46 (-0.77, -0.15) | 0.08 |
| Language | -0.31 (-0.56, -0.05) | -0.06 (-0.28, 0.17) | 0.13 | -0.15 (-0.36, 0.06) | -0.20 (-0.50, 0.10) | 0.81 |
| Abstraction | -0.24 (-0.55, 0.07) | -0.09 (-0.37, 0.18) | 0.47 | -0.31 (-0.56, -0.06) | 0.20 (-0.16, 0.56) | 0.02 |
| Delayed recall | -0.28 (-0.58, 0.02) | -0.07 (-0.33, 0.20) | 0.28 | -0.18 (-0.42, 0.07) | -0.13 (-0.48, 0.22) | 0.83 |
| Orientation | -0.25 (-0.51, 0.01) | 0.00 (-0.24, 0.23) | 0.15 | -0.16 (-0.37, 0.06) | -0.01 (-0.32, 0.29) | 0.44 |
| Overall | -0.42 (-0.66, -0.18) | -0.10 (-0.31, 0.12) | 0.04 | -0.22 (-0.42, -0.03) | -0.28 (-0.56, 0.00) | 0.74 |
| Overall (raw score) | -2.45 (-3.85, -1.06) | -0.58 (-1.83, 0.67) | 0.04 | -1.31 (-2.45, -0.16) | -1.64 (-3.29, 0.01) | 0.74 |
| Difference in score and 95% CI per 1-μg/m$^3$ increase in black carbon (n = 355) | | | | | | |
| Visuospatial/Executive | -0.08 (-0.21, 0.04) | -0.17 (-0.37, 0.03) | 0.47 | -0.08 (-0.22, 0.06) | -0.14 (-0.30, 0.03) | 0.62 |
| Naming | -0.02 (-0.16, 0.11) | -0.03 (-0.25, 0.19) | 0.95 | 0.02 (-0.13, 0.17) | -0.09 (-0.26, 0.09) | 0.36 |
| Attention | -0.18 (-0.30, -0.05) | -0.02 (-0.22, 0.18) | 0.17 | -0.09 (-0.23, 0.05) | -0.20 (-0.36, -0.04) | 0.30 |
| Language | -0.09 (-0.21, 0.03) | 0.01 (-0.17, 0.18) | 0.37 | -0.06 (-0.19, 0.07) | -0.05 (-0.20, 0.10) | 0.92 |
| Abstraction | 0.00 (-0.14, 0.14) | -0.08 (-0.30, 0.14) | 0.56 | -0.09 (-0.25, 0.07) | 0.08 (-0.10, 0.26) | 0.16 |
| Delayed recall | -0.08 (-0.22, 0.05) | 0.09 (-0.13, 0.32) | 0.18 | -0.08 (-0.23, 0.07) | 0.02 (-0.16, 0.20) | 0.38 |
| Orientation | -0.11 (-0.23, 0.01) | -0.01 (-0.19, 0.18) | 0.36 | -0.13 (-0.26, 0.00) | -0.01 (-0.16, 0.15) | 0.22 |
| Overall | -0.14 (-0.25, -0.02) | -0.04 (-0.22, 0.14) | 0.36 | -0.11 (-0.23, 0.02) | -0.11 (-0.26, 0.03) | 0.96 |
| Overall (raw score) | -0.79 (-1.44, -0.14) | -0.23 (-1.28, 0.82) | 0.36 | -0.63 (-1.35, 0.09) | -0.66 (-1.50, 0.19) | 0.96 |
| Difference in score and 95% CI for exclusive use of clean fuel (ref. use of solid fuel indoors) for cooking (n = 400) | | | | | | |
| Visuospatial/Executive | -0.05 (-0.31, 0.21) | -0.04 (-0.28, 0.20) | 0.98 | -0.08 (-0.34, 0.18) | -0.03 (-0.26, 0.21) | 0.77 |
| Naming | -0.16 (-0.41, 0.10) | 0.19 (-0.09, 0.47) | 0.07 | 0.00 (-0.28, 0.27) | 0.00 (-0.24, 0.25) | 0.96 |
| Attention | 0.14 (-0.09, 0.38) | 0.24 (-0.01, 0.50) | 0.57 | 0.14 (-0.11, 0.40) | 0.23 (0.00, 0.45) | 0.61 |
| Language | 0.01 (-0.22, 0.25) | 0.03 (-0.17, 0.24) | 0.90 | -0.13 (-0.36, 0.10) | 0.15 (-0.06, 0.36) | 0.08 |
| Abstraction | 0.03 (-0.25, 0.30) | 0.41 (0.11, 0.70) | 0.07 | 0.34 (0.04, 0.64) | 0.04 (-0.22, 0.31) | 0.12 |
| Delayed recall | -0.14 (-0.41, 0.13) | 0.21 (-0.09, 0.51) | 0.09 | 0.05 (-0.25, 0.34) | -0.02 (-0.28, 0.24) | 0.73 |
| Orientation | -0.13 (-0.36, 0.11) | 0.01 (-0.25, 0.26) | 0.44 | 0.09 (-0.16, 0.34) | -0.21 (-0.43, 0.02) | 0.07 |
| Overall | -0.07 (-0.28, 0.15) | 0.22 (-0.03, 0.46) | 0.09 | 0.07 (-0.17, 0.30) | 0.05 (-0.16, 0.26) | 0.90 |
| Overall (raw score) | -0.39 (-1.65, 0.87) | 1.26 (-0.15, 2.67) | 0.09 | 0.39 (-0.98, 1.75) | 0.28 (-0.94, 1.50) | 0.90 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Difference in score and 95% CI for exclusive use of clean fuel (ref. use of solid fuel indoors) for heating (n = 400) | | | | | | |
| Visuospatial/Executive | 0.11 (-0.15, 0.37) | 0.13 (-0.11, 0.37) | 0.91 | 0.11 (-0.16, 0.38) | 0.13 (-0.10, 0.36) | 0.91 |
| Naming | -0.03 (-0.29, 0.23) | 0.21 (-0.04, 0.45) | 0.19 | -0.05 (-0.32, 0.23) | 0.19 (-0.04, 0.42) | 0.19 |
| Attention | -0.05 (-0.29, 0.19) | 0.12 (-0.11, 0.35) | 0.31 | 0.00 (-0.25, 0.25) | 0.06 (-0.15, 0.28) | 0.70 |
| Language | -0.01 (-0.24, 0.23) | 0.00 (-0.21, 0.22) | 0.96 | -0.11 (-0.35, 0.13) | 0.08 (-0.12, 0.29) | 0.22 |
| Abstraction | -0.01 (-0.29, 0.27) | 0.12 (-0.15, 0.39) | 0.52 | -0.29 (-0.59, 0.00) | 0.30 (0.05, 0.55) | 0.00 |
| Delayed recall | -0.05 (-0.33, 0.23) | 0.16 (-0.10, 0.43) | 0.27 | 0.09 (-0.20, 0.38) | 0.04 (-0.21, 0.29) | 0.81 |
| Orientation | 0.24 (0.00, 0.47) | 0.07 (-0.15, 0.29) | 0.32 | 0.17 (-0.08, 0.42) | 0.13 (-0.08, 0.35) | 0.84 |
| Overall | 0.06 (-0.16, 0.28) | 0.19 (-0.02, 0.40) | 0.38 | 0.06 (-0.17, 0.29) | 0.18 (-0.02, 0.38) | 0.42 |
| Overall (raw score) | 0.33 (-0.94, 1.61) | 1.13 (-0.09, 2.36) | 0.38 | 0.33 (-1.01, 1.67) | 1.05 (-0.09, 2.19) | 0.42 |
| Difference in score and 95% CI per 100-day increase in solid fuel stove-use days in the past year (n = 400) | | | | | | |
| Visuospatial/Executive | -0.01 (-0.08, 0.05) | 0.00 (-0.05, 0.05) | 0.72 | 0.00 (-0.06, 0.06) | -0.01 (-0.07, 0.05) | 0.84 |
| Naming | 0.02 (-0.04, 0.09) | -0.04 (-0.10, 0.03) | 0.17 | -0.01 (-0.08, 0.05) | 0.00 (-0.06, 0.05) | 0.84 |
| Attention | -0.05 (-0.11, 0.01) | -0.05 (-0.11, 0.01) | 0.99 | -0.03 (-0.09, 0.03) | -0.07 (-0.12, -0.01) | 0.32 |
| Language | 0.00 (-0.06, 0.06) | -0.01 (-0.05, 0.04) | 0.90 | 0.03 (-0.03, 0.08) | -0.03 (-0.08, 0.02) | 0.13 |
| Abstraction | -0.01 (-0.08, 0.06) | -0.09 (-0.16, -0.03) | 0.09 | -0.07 (-0.15, 0.00) | -0.04 (-0.10, 0.02) | 0.43 |
| Delayed recall | 0.03 (-0.04, 0.10) | -0.05 (-0.12, 0.01) | 0.09 | -0.04 (-0.11, 0.03) | 0.01 (-0.05, 0.07) | 0.28 |
| Orientation | 0.00 (-0.06, 0.06) | -0.01 (-0.06, 0.05) | 0.87 | -0.05 (-0.11, 0.01) | 0.03 (-0.02, 0.08) | 0.04 |
| Overall | -0.01 (-0.06, 0.05) | -0.06 (-0.11, 0.00) | 0.20 | -0.04 (-0.10, 0.02) | -0.03 (-0.07, 0.02) | 0.70 |
| Overall (raw score) | -0.04 (-0.36, 0.28) | -0.32 (-0.63, -0.01) | 0.20 | -0.23 (-0.56, 0.10) | -0.15 (-0.43, 0.12) | 0.70 |
| Difference in score and 95% CI per 5-year increase in solid fuel stove-use years over the past 20 years (n = 394) | | | | | | |
| Visuospatial/Executive | -0.05 (-0.12, 0.02) | 0.03 (-0.06, 0.12) | 0.18 | -0.02 (-0.11, 0.06) | -0.02 (-0.10, 0.05) | 0.96 |
| Naming | -0.05 (-0.12, 0.02) | -0.02 (-0.13, 0.08) | 0.66 | -0.07 (-0.16, 0.02) | -0.02 (-0.10, 0.05) | 0.47 |
| Attention | -0.09 (-0.15, -0.02) | -0.02 (-0.12, 0.08) | 0.28 | -0.05 (-0.14, 0.03) | -0.08 (-0.15, -0.01) | 0.65 |
| Language | -0.06 (-0.12, 0.00) | -0.01 (-0.09, 0.07) | 0.32 | -0.03 (-0.11, 0.05) | -0.05 (-0.12, 0.02) | 0.65 |
| Abstraction | -0.03 (-0.11, 0.05) | -0.07 (-0.19, 0.05) | 0.56 | -0.08 (-0.18, 0.02) | -0.02 (-0.10, 0.06) | 0.39 |
| Delayed recall | 0.00 (-0.07, 0.08) | 0.00 (-0.11, 0.12) | 0.99 | -0.05 (-0.14, 0.05) | 0.03 (-0.05, 0.11) | 0.19 |
| Orientation | -0.03 (-0.09, 0.04) | -0.02 (-0.12, 0.07) | 0.97 | -0.05 (-0.13, 0.03) | -0.01 (-0.08, 0.06) | 0.40 |
| Overall | -0.06 (-0.12, 0.00) | -0.03 (-0.12, 0.06) | 0.67 | -0.08 (-0.15, 0.00) | -0.03 (-0.10, 0.03) | 0.36 |
| Overall (raw score) | -0.33 (-0.68, 0.02) | -0.19 (-0.72, 0.34) | 0.67 | -0.44 (-0.89, 0.01) | -0.19 (-0.56, 0.18) | 0.36 |

[a] Interaction p-values were derived by including each potential modifier as an interaction term with exposure variables in our models.
Abbreviations: CI, confidence interval.

**Supplementary Table 4.** Assessment of potential effect modification by education level on the associations between measures of cognitive function and personal exposures to air pollution, current indoor fuel use patterns, or intensity of indoor solid fuel use: results from multivariable models.

| | Difference in score and 95% CI | | | Interaction p-value[a] | | |
|---|---|---|---|---|---|---|
| | No school | Primary school | Secondary school/ college | Exposure:Primary school (ref. no school) | Exposure:Secondary school/college (ref. no school) | Exposure:Secondary school/college (ref. primary school) |
| $PM_{2.5}$ (per 100-μg/$m^3$; n=355) | | | | | | |
| Visuospatial/Executive | -0.28 (-0.92, 0.36) | -0.09 (-0.37, 0.20) | -0.27 (-0.51, -0.02) | 1.00 | 1.00 | 0.97 |
| Naming | -0.47 (-1.15, 0.21) | -0.11 (-0.41, 0.19) | -0.12 (-0.38, 0.14) | 1.00 | 0.98 | 1.00 |
| Attention | -0.87 (-1.49, -0.25) | -0.24 (-0.51, 0.04) | -0.16 (-0.40, 0.08) | 0.19 | 0.10 | 1.00 |
| Language | 0.14 (-0.46, 0.73) | -0.38 (-0.65, -0.12) | -0.04 (-0.27, 0.18) | 0.33 | 1.00 | 0.14 |
| Abstraction | -0.44 (-1.16, 0.29) | -0.11 (-0.43, 0.21) | -0.16 (-0.44, 0.11) | 1.00 | 1.00 | 1.00 |
| Delayed recall | 0.20 (-0.50, 0.90) | -0.36 (-0.66, -0.05) | -0.06 (-0.33, 0.20) | 0.44 | 1.00 | 0.41 |
| Orientation | -0.24 (-0.85, 0.37) | -0.02 (-0.30, 0.25) | -0.16 (-0.39, 0.07) | 1.00 | 1.00 | 1.00 |
| Overall | -0.34 (-0.91, 0.23) | -0.28 (-0.53, -0.03) | -0.20 (-0.42, 0.01) | 1.00 | 1.00 | 1.00 |
| Overall (raw score) | -1.99 (-5.29, 1.31) | -1.63 (-3.09, -0.17) | -1.18 (-2.44, 0.08) | 1.00 | 1.00 | 1.00 |
| Black carbon (per 1-μg/$m^3$; n=355) | | | | | | |
| Visuospatial/Executive | -0.12 (-0.40, 0.17) | -0.09 (-0.26, 0.09) | -0.11 (-0.26, 0.03) | 0.98 | 1.00 | 0.97 |
| Naming | -0.15 (-0.45, 0.16) | 0.03 (-0.15, 0.22) | -0.04 (-0.19, 0.12) | 0.56 | 0.79 | 0.83 |
| Attention | -0.42 (-0.70, -0.15) | -0.11 (-0.28, 0.06) | -0.08 (-0.22, 0.05) | 0.13 | 0.07 | 0.96 |
| Language | -0.13 (-0.39, 0.14) | -0.10 (-0.26, 0.07) | -0.02 (-0.16, 0.11) | 0.98 | 0.76 | 0.77 |
| Abstraction | -0.17 (-0.49, 0.15) | 0.14 (-0.05, 0.34) | -0.10 (-0.26, 0.06) | 0.21 | 0.92 | 0.13 |
| Delayed recall | -0.12 (-0.43, 0.19) | 0.00 (-0.19, 0.19) | -0.04 (-0.20, 0.11) | 0.79 | 0.90 | 0.94 |
| Orientation | -0.20 (-0.46, 0.07) | -0.14 (-0.30, 0.03) | -0.02 (-0.16, 0.12) | 0.92 | 0.47 | 0.52 |
| Overall | -0.30 (-0.55, -0.05) | -0.08 (-0.24, 0.07) | -0.09 (-0.21, 0.04) | 0.30 | 0.29 | 1.00 |
| Overall (raw score) | -1.74 (-3.20, -0.27) | -0.47 (-1.37, 0.44) | -0.51 (-1.25, 0.23) | 0.30 | 0.29 | 1.00 |
| Exclusive use of clean fuel (ref. use of solid fuel indoors) for cooking (n=400) | | | | | | |
| Visuospatial/Executive | 0.02 (-0.41, 0.44) | 0.02 (-0.24, 0.29) | -0.17 (-0.44, 0.10) | 1.00 | 1.00 | 0.96 |
| Naming | 0.14 (-0.29, 0.57) | 0.02 (-0.26, 0.30) | -0.07 (-0.34, 0.21) | 1.00 | 1.00 | 1.00 |
| Attention | 0.14 (-0.26, 0.54) | 0.29 (0.03, 0.55) | 0.12 (-0.14, 0.38) | 1.00 | 1.00 | 1.00 |
| Language | -0.10 (-0.48, 0.29) | 0.18 (-0.06, 0.41) | -0.09 (-0.33, 0.15) | 0.69 | 1.00 | 0.37 |
| Abstraction | 0.08 (-0.39, 0.54) | 0.31 (0.00, 0.62) | 0.09 (-0.21, 0.40) | 1.00 | 1.00 | 0.89 |
| Delayed recall | 0.14 (-0.32, 0.59) | 0.07 (-0.23, 0.38) | -0.09 (-0.39, 0.21) | 1.00 | 1.00 | 1.00 |
| Orientation | -0.55 (-0.94, -0.16) | 0.13 (-0.13, 0.38) | -0.07 (-0.33, 0.18) | 0.01 | 0.13 | 0.77 |
| Overall | -0.03 (-0.40, 0.33) | 0.18 (-0.06, 0.42) | -0.02 (-0.26, 0.22) | 0.95 | 1.00 | 0.69 |
| Overall (raw score) | -0.20 (-2.33, 1.92) | 1.05 (-0.36, 2.46) | -0.11 (-1.49, 1.27) | 0.95 | 1.00 | 0.69 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Exclusive use of clean fuel (ref. use of solid fuel indoors) for heating (n=400) | | | | | | |
| Visuospatial/Executive | 0.16 (-0.32, 0.63) | 0.16 (-0.11, 0.44) | 0.07 (-0.20, 0.33) | 1.00 | 1.00 | 1.00 |
| Naming | 0.12 (-0.36, 0.59) | 0.05 (-0.22, 0.33) | 0.12 (-0.14, 0.39) | 1.00 | 1.00 | 1.00 |
| Attention | -0.05 (-0.49, 0.39) | 0.06 (-0.20, 0.32) | 0.05 (-0.20, 0.29) | 1.00 | 1.00 | 1.00 |
| Language | 0.03 (-0.40, 0.46) | 0.01 (-0.23, 0.26) | -0.03 (-0.26, 0.21) | 1.00 | 1.00 | 1.00 |
| Abstraction | -0.27 (-0.78, 0.24) | 0.12 (-0.18, 0.42) | 0.11 (-0.18, 0.40) | 0.59 | 0.61 | 1.00 |
| Delayed recall | -0.13 (-0.63, 0.37) | 0.11 (-0.18, 0.41) | 0.07 (-0.21, 0.35) | 1.00 | 1.00 | 1.00 |
| Orientation | 0.39 (-0.04, 0.82) | 0.22 (-0.03, 0.47) | 0.01 (-0.23, 0.24) | 1.00 | 0.37 | 0.64 |
| Overall | 0.03 (-0.36, 0.43) | 0.19 (-0.05, 0.42) | 0.11 (-0.11, 0.33) | 1.00 | 1.00 | 1.00 |
| Overall (raw score) | 0.19 (-2.12, 2.49) | 1.08 (-0.28, 2.44) | 0.63 (-0.66, 1.93) | 1.00 | 1.00 | 1.00 |
| Current intensity of indoor solid fuel use (per 100-day increase in solid fuel stove-use days in the past year; n=400) | | | | | | |
| Visuospatial/Executive | -0.04 (-0.15, 0.07) | -0.02 (-0.08, 0.04) | 0.03 (-0.04, 0.10) | 1.00 | 0.95 | 0.90 |
| Naming | -0.03 (-0.14, 0.09) | -0.01 (-0.07, 0.05) | 0.00 (-0.06, 0.07) | 1.00 | 1.00 | 1.00 |
| Attention | -0.07 (-0.18, 0.03) | -0.06 (-0.12, 0.00) | -0.03 (-0.09, 0.04) | 1.00 | 1.00 | 1.00 |
| Language | 0.04 (-0.06, 0.14) | -0.03 (-0.08, 0.03) | 0.00 (-0.05, 0.06) | 0.71 | 1.00 | 1.00 |
| Abstraction | -0.01 (-0.13, 0.12) | -0.07 (-0.13, 0.00) | -0.05 (-0.13, 0.02) | 1.00 | 1.00 | 1.00 |
| Delayed recall | -0.02 (-0.14, 0.10) | -0.02 (-0.08, 0.05) | 0.00 (-0.08, 0.07) | 1.00 | 1.00 | 1.00 |
| Orientation | 0.09 (-0.02, 0.19) | -0.04 (-0.10, 0.01) | 0.01 (-0.05, 0.08) | 0.07 | 0.67 | 0.54 |
| Overall | -0.01 (-0.11, 0.09) | -0.05 (-0.10, 0.01) | -0.02 (-0.08, 0.04) | 1.00 | 1.00 | 1.00 |
| Overall (raw score) | -0.06 (-0.61, 0.50) | -0.27 (-0.57, 0.03) | -0.12 (-0.47, 0.23) | 1.00 | 1.00 | 1.00 |
| Long-term intensity of indoor solid fuel use (per 5-year increase in solid fuel stove-use years over the past 20 years; n=394) | | | | | | |
| Visuospatial/Executive | -0.11 (-0.24, 0.03) | -0.01 (-0.10, 0.08) | 0.02 (-0.07, 0.10) | 0.80 | 0.40 | 1.00 |
| Naming | -0.09 (-0.23, 0.05) | -0.03 (-0.12, 0.07) | -0.04 (-0.13, 0.05) | 1.00 | 1.00 | 1.00 |
| Attention | -0.20 (-0.33, -0.08) | -0.04 (-0.13, 0.05) | -0.03 (-0.12, 0.05) | 0.09 | 0.08 | 1.00 |
| Language | -0.06 (-0.18, 0.06) | -0.02 (-0.10, 0.06) | -0.05 (-0.13, 0.03) | 1.00 | 1.00 | 1.00 |
| Abstraction | -0.06 (-0.21, 0.08) | 0.03 (-0.07, 0.13) | -0.10 (-0.20, 0.00) | 0.89 | 1.00 | 0.22 |
| Delayed recall | -0.10 (-0.24, 0.05) | 0.03 (-0.07, 0.13) | 0.02 (-0.07, 0.12) | 0.46 | 0.52 | 1.00 |
| Orientation | -0.05 (-0.18, 0.08) | -0.04 (-0.12, 0.05) | 0.00 (-0.09, 0.08) | 1.00 | 1.00 | 1.00 |
| Overall | -0.14 (-0.26, -0.03) | -0.01 (-0.09, 0.07) | -0.04 (-0.12, 0.03) | 0.18 | 0.45 | 1.00 |
| Overall (raw score) | -0.83 (-1.50, -0.17) | -0.07 (-0.53, 0.39) | -0.25 (-0.69, 0.19) | 0.18 | 0.45 | 1.00 |

[a] Interaction p-values were derived by including education as an interaction term with exposure variables in our models. The p-values were adjusted using the Bonferroni method to correct for multiple comparisons.

Abbreviations: CI, confidence interval.

**Supplementary Table 5.** Sensitivity analyses for the associations between measures of cognitive function and personal exposures to air pollution: results from multivariable models.

| Sensitivity analysis | n | Difference in score[a] and 95% CI | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Visuospatial/ Executive | Naming | Attention | Language | Abstraction | Delayed recall | Orientation | Overall | Overall (raw score) |
| Personal $PM_{2.5}$ | | | | | | | | | | |
| Adjusted for whether had diabetes | 355 | -0.20 (-0.39, -0.01) | -0.12 (-0.32, 0.08) | -0.23 (-0.41, -0.04) | -0.17 (-0.35, 0.00) | -0.16 (-0.37, 0.05) | -0.16 (-0.36, 0.05) | -0.10 (-0.28, 0.08) | -0.24 (-0.40, -0.07) | -1.38 (-2.35, -0.41) |
| Adjusted for whether had heart disease | 355 | -0.20 (-0.38, -0.01) | -0.14 (-0.34, 0.06) | -0.23 (-0.41, -0.05) | -0.16 (-0.34, 0.01) | -0.16 (-0.37, 0.06) | -0.16 (-0.36, 0.04) | -0.11 (-0.29, 0.07) | -0.24 (-0.40, -0.08) | -1.40 (-2.36, -0.44) |
| Adjusted for whether had high blood pressure | 355 | -0.20 (-0.39, -0.01) | -0.14 (-0.34, 0.06) | -0.23 (-0.42, -0.05) | -0.17 (-0.34, 0.01) | -0.16 (-0.38, 0.05) | -0.17 (-0.37, 0.04) | -0.11 (-0.29, 0.07) | -0.25 (-0.41, -0.08) | -1.44 (-2.40, -0.47) |
| Adjusted for annual household income in more resolved categories[b] | 355 | -0.22 (-0.41, -0.03) | -0.14 (-0.34, 0.06) | -0.24 (-0.42, -0.06) | -0.16 (-0.34, 0.02) | -0.14 (-0.35, 0.08) | -0.15 (-0.36, 0.05) | -0.14 (-0.32, 0.04) | -0.25 (-0.41, -0.08) | -1.43 (-2.40, -0.46) |
| Adjusted for body mass index | 355 | -0.20 (-0.39, -0.01) | -0.13 (-0.33, 0.06) | -0.23 (-0.41, -0.05) | -0.16 (-0.34, 0.01) | -0.16 (-0.37, 0.05) | -0.16 (-0.36, 0.04) | -0.11 (-0.29, 0.07) | -0.24 (-0.40, -0.07) | -1.38 (-2.33, -0.43) |
| Personal black carbon | | | | | | | | | | |
| Adjusted for whether had diabetes | 355 | -0.11 (-0.22, 0.00) | -0.02 (-0.14, 0.10) | -0.13 (-0.24, -0.03) | -0.06 (-0.16, 0.04) | -0.02 (-0.14, 0.10) | -0.04 (-0.16, 0.08) | -0.07 (-0.18, 0.03) | -0.11 (-0.20, -0.01) | -0.63 (-1.19, -0.06) |
| Adjusted for whether had heart disease | 355 | -0.11 (-0.22, 0.00) | -0.03 (-0.14, 0.09) | -0.14 (-0.24, -0.03) | -0.06 (-0.16, 0.04) | -0.02 (-0.14, 0.10) | -0.04 (-0.16, 0.08) | -0.08 (-0.18, 0.02) | -0.11 (-0.21, -0.02) | -0.65 (-1.21, -0.09) |
| Adjusted for whether had high blood pressure | 355 | -0.10 (-0.21, 0.01) | -0.02 (-0.14, 0.09) | -0.14 (-0.24, -0.03) | -0.06 (-0.16, 0.04) | -0.02 (-0.14, 0.10) | -0.04 (-0.16, 0.08) | -0.08 (-0.18, 0.02) | -0.11 (-0.20, -0.01) | -0.63 (-1.19, -0.06) |
| Adjusted for annual household income in more resolved categories[b] | 355 | -0.12 (-0.23, -0.01) | -0.04 (-0.15, 0.08) | -0.14 (-0.24, -0.03) | -0.07 (-0.17, 0.03) | -0.02 (-0.14, 0.10) | -0.03 (-0.15, 0.09) | -0.09 (-0.19, 0.02) | -0.11 (-0.21, -0.02) | -0.66 (-1.23, -0.09) |
| Adjusted for body mass index | 355 | -0.10 (-0.21, 0.01) | -0.01 (-0.13, 0.10) | -0.13 (-0.24, -0.02) | -0.05 (-0.15, 0.05) | -0.02 (-0.14, 0.10) | -0.03 (-0.15, 0.09) | -0.07 (-0.18, 0.03) | -0.10 (-0.19, 0.00) | -0.58 (-1.13, -0.02) |

[a] Difference in score in each cognitive measure associated with a 100-$\mu g/m^3$ increase in exposure to $PM_{2.5}$ or 1-$\mu g/m^3$ increase in exposure to black carbon.
[b] The original questionnaire collected participants' annual household income in the following categories: less than 2,500 yuan, 2500-4999 yuan, 5000-9999 yuan, 10000-19999 yuan, 20000-34999 yuan, above 35,000 yuan. We assigned participants who did not disclose the income (n=44) as a separate category.
Abbreviations: CI, confidence interval; $PM_{2.5}$, particulate matter ≤2.5 μm in aerodynamic diameter.

**Supplementary Table 6.** Sensitivity analyses for the associations between measures of cognitive function and intensity of indoor solid fuel use: results from multivariable models.

| Sensitivity analysis | n | Difference in score[a] and 95% CI | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Visuospatial/ Executive | Naming | Attention | Language | Abstraction | Delayed recall | Orientation | Overall | Overall (raw score) |
| Current intensity of indoor solid fuel use | | | | | | | | | | |
| Adjusted for annual household income in more resolved categories[b] | 400 | -0.01 (-0.05, 0.03) | 0.00 (-0.05, 0.04) | -0.05 (-0.09, -0.01) | 0.00 (-0.04, 0.03) | -0.05 (-0.10, 0.00) | -0.01 (-0.06, 0.04) | -0.01 (-0.05, 0.03) | -0.03 (-0.07, 0.01) | -0.17 (-0.40, 0.05) |
| Adjusted for whether had diabetes | 400 | -0.01 (-0.05, 0.03) | 0.00 (-0.05, 0.04) | -0.05 (-0.09, -0.01) | -0.01 (-0.04, 0.03) | -0.05 (-0.10, -0.01) | -0.01 (-0.06, 0.04) | 0.00 (-0.04, 0.04) | -0.03 (-0.07, 0.01) | -0.19 (-0.41, 0.04) |
| Adjusted for whether had heart disease | 400 | -0.01 (-0.05, 0.03) | -0.01 (-0.05, 0.04) | -0.05 (-0.09, -0.01) | -0.01 (-0.04, 0.03) | -0.05 (-0.10, 0.00) | -0.01 (-0.06, 0.04) | -0.01 (-0.05, 0.03) | -0.03 (-0.07, 0.01) | -0.19 (-0.41, 0.03) |
| Adjusted for whether had high blood pressure | 400 | -0.01 (-0.05, 0.04) | -0.01 (-0.05, 0.04) | -0.05 (-0.09, -0.01) | -0.01 (-0.04, 0.03) | -0.05 (-0.10, 0.00) | -0.01 (-0.06, 0.04) | -0.01 (-0.05, 0.03) | -0.03 (-0.07, 0.01) | -0.18 (-0.41, 0.04) |
| Adjusted for body mass index[c] | 400 | -0.01 (-0.05, 0.04) | 0.00 (-0.04, 0.04) | -0.05 (-0.09, -0.01) | 0.00 (-0.04, 0.03) | -0.05 (-0.10, 0.00) | -0.01 (-0.06, 0.04) | 0.00 (-0.05, 0.04) | -0.03 (-0.07, 0.01) | -0.17 (-0.39, 0.05) |
| Long-term intensity of indoor solid fuel use | | | | | | | | | | |
| Adjusted for annual household income in more resolved categories[b] | 394 | -0.03 (-0.09, 0.03) | -0.04 (-0.10, 0.02) | -0.07 (-0.12, -0.01) | -0.05 (-0.10, 0.01) | -0.05 (-0.12, 0.02) | 0.01 (-0.06, 0.07) | -0.02 (-0.08, 0.03) | -0.05 (-0.10, 0.00) | -0.29 (-0.59, 0.01) |
| Adjusted for whether had diabetes | 394 | -0.02 (-0.08, 0.04) | -0.04 (-0.10, 0.02) | -0.07 (-0.12, -0.01) | -0.04 (-0.09, 0.01) | -0.04 (-0.11, 0.02) | 0.00 (-0.06, 0.07) | -0.03 (-0.08, 0.03) | -0.05 (-0.10, 0.00) | -0.29 (-0.59, 0.01) |
| Adjusted for whether had heart disease | 394 | -0.02 (-0.08, 0.04) | -0.04 (-0.10, 0.02) | -0.07 (-0.12, -0.01) | -0.04 (-0.09, 0.01) | -0.04 (-0.11, 0.02) | 0.00 (-0.06, 0.06) | -0.03 (-0.08, 0.03) | -0.05 (-0.10, 0.00) | -0.30 (-0.59, 0.00) |
| Adjusted for whether had high blood pressure | 394 | -0.02 (-0.08, 0.04) | -0.04 (-0.10, 0.02) | -0.07 (-0.12, -0.01) | -0.04 (-0.09, 0.01) | -0.04 (-0.11, 0.02) | 0.00 (-0.06, 0.07) | -0.02 (-0.08, 0.03) | -0.05 (-0.10, 0.00) | -0.28 (-0.58, 0.01) |
| Adjusted for body mass index[c] | 394 | -0.02 (-0.08, 0.04) | -0.04 (-0.10, 0.02) | -0.06 (-0.12, -0.01) | -0.04 (-0.09, 0.01) | -0.04 (-0.11, 0.02) | 0.00 (-0.06, 0.07) | -0.02 (-0.08, 0.03) | -0.05 (-0.10, 0.00) | -0.27 (-0.57, 0.02) |
| Excluding 61 participants who reported no history of solid fuel use in the past 20 years | 333 | -0.03 (-0.09, 0.03) | -0.04 (-0.11, 0.03) | -0.07 (-0.14, -0.01) | -0.05 (-0.11, 0.01) | -0.04 (-0.11, 0.03) | 0.00 (-0.07, 0.07) | -0.02 (-0.09, 0.04) | -0.05 (-0.11, 0.01) | -0.29 (-0.61, 0.03) |

[a] Difference in score in each cognitive measure associated with a 100-day increase in solid fuel stove-use days in the past year or 5-year increase in solid fuel stove-use years over the past 20 years.

[b] The original questionnaire collected participants' annual household income in the following categories: less than 2,500 yuan, 2500-4999 yuan, 5000-9999 yuan, 10000-19999 yuan, 20000-34999 yuan, above 35,000 yuan. We assigned participants who did not disclose the income (n=49) as a separate category.
[c] We imputed values for participants who did not have body mass index measured (n=16 when investigating current intensity of indoor solid fuel use and n=11 when investigating long-term intensity of indoor solid fuel use).
Abbreviations: CI, confidence interval.

**Supplementary Table 7.** Sensitivity analyses for the associations between measures of cognitive function and exclusive use of clean fuel (ref. use of solid fuel stoves indoors) currently for cooking or heating: results from multivariable models.

| Sensitivity analysis | n | Difference in score[a] and 95% CI | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Visuospatial/ Executive | Naming | Attention | Language | Abstraction | Delayed recall | Orientation | Overall | Overall (raw score) |
| Cooking | | | | | | | | | | |
| Adjusted for heating fuel type | 400 | -0.06 (-0.24, 0.12) | -0.01 (-0.20, 0.18) | 0.19 (0.01, 0.37) | 0.02 (-0.13, 0.18) | 0.17 (-0.04, 0.39) | 0.01 (-0.20, 0.22) | -0.08 (-0.25, 0.09) | 0.05 (-0.11, 0.21) | 0.29 (-0.67, 1.25) |
| Adjusted for annual household income in more resolved categories[b] | 400 | -0.02 (-0.21, 0.16) | -0.02 (-0.21, 0.17) | 0.19 (0.01, 0.36) | 0.02 (-0.14, 0.19) | 0.17 (-0.04, 0.38) | -0.01 (-0.22, 0.19) | -0.08 (-0.25, 0.10) | 0.05 (-0.12, 0.21) | 0.29 (-0.68, 1.25) |
| Adjusted for whether had diabetes | 400 | -0.04 (-0.22, 0.14) | -0.01 (-0.20, 0.18) | 0.19 (0.01, 0.37) | 0.03 (-0.12, 0.19) | 0.18 (-0.03, 0.39) | 0.01 (-0.20, 0.22) | -0.08 (-0.26, 0.10) | 0.06 (-0.11, 0.22) | 0.33 (-0.64, 1.29) |
| Adjusted for whether had heart disease | 400 | -0.04 (-0.22, 0.14) | 0.00 (-0.19, 0.19) | 0.20 (0.02, 0.37) | 0.02 (-0.13, 0.18) | 0.17 (-0.04, 0.38) | 0.01 (-0.19, 0.22) | -0.07 (-0.24, 0.11) | 0.06 (-0.10, 0.23) | 0.36 (-0.60, 1.31) |
| Adjusted for whether had high blood pressure | 400 | -0.05 (-0.22, 0.13) | 0.00 (-0.19, 0.19) | 0.19 (0.02, 0.37) | 0.02 (-0.13, 0.18) | 0.18 (-0.03, 0.39) | 0.01 (-0.20, 0.22) | -0.07 (-0.25, 0.10) | 0.06 (-0.11, 0.22) | 0.33 (-0.63, 1.29) |
| Adjusted for body mass index[c] | 400 | -0.05 (-0.23, 0.13) | -0.01 (-0.20, 0.17) | 0.19 (0.01, 0.36) | 0.02 (-0.14, 0.17) | 0.17 (-0.04, 0.38) | 0.00 (-0.20, 0.21) | -0.08 (-0.25, 0.10) | 0.05 (-0.11, 0.21) | 0.29 (-0.66, 1.24) |
| Heating | | | | | | | | | | |
| Adjusted for cooking fuel type | 400 | 0.12 (-0.05, 0.30) | 0.09 (-0.09, 0.27) | 0.03 (-0.14, 0.19) | 0.00 (-0.16, 0.15) | 0.06 (-0.14, 0.25) | 0.06 (-0.13, 0.25) | 0.15 (-0.01, 0.32) | 0.13 (-0.02, 0.28) | 0.74 (-0.15, 1.62) |
| Adjusted for annual household income in more resolved categories[b] | 400 | 0.12 (-0.07, 0.30) | 0.06 (-0.12, 0.25) | 0.03 (-0.14, 0.21) | 0.00 (-0.16, 0.17) | 0.05 (-0.15, 0.24) | 0.04 (-0.16, 0.23) | 0.16 (-0.01, 0.32) | 0.12 (-0.04, 0.27) | 0.68 (-0.22, 1.57) |
| Adjusted for whether had diabetes | 400 | 0.13 (-0.05, 0.30) | 0.08 (-0.09, 0.26) | 0.04 (-0.13, 0.20) | 0.01 (-0.15, 0.16) | 0.06 (-0.14, 0.26) | 0.06 (-0.13, 0.25) | 0.14 (-0.02, 0.31) | 0.13 (-0.02, 0.28) | 0.75 (-0.13, 1.64) |
| Adjusted for whether had heart disease | 400 | 0.13 (-0.05, 0.30) | 0.10 (-0.08, 0.28) | 0.05 (-0.11, 0.22) | 0.01 (-0.15, 0.17) | 0.05 (-0.14, 0.25) | 0.07 (-0.12, 0.26) | 0.15 (-0.01, 0.32) | 0.14 (-0.01, 0.29) | 0.82 (-0.06, 1.70) |
| Adjusted for whether had high blood pressure | 400 | 0.12 (-0.06, 0.30) | 0.09 (-0.09, 0.27) | 0.04 (-0.13, 0.21) | 0.00 (-0.16, 0.16) | 0.06 (-0.14, 0.25) | 0.06 (-0.13, 0.25) | 0.15 (-0.02, 0.31) | 0.13 (-0.02, 0.28) | 0.74 (-0.14, 1.63) |
| Adjusted for body mass index[c] | 400 | 0.12 (-0.06, 0.30) | 0.09 (-0.09, 0.26) | 0.04 (-0.13, 0.20) | 0.00 (-0.16, 0.15) | 0.06 (-0.14, 0.25) | 0.06 (-0.13, 0.25) | 0.15 (-0.01, 0.31) | 0.13 (-0.02, 0.28) | 0.74 (-0.13, 1.62) |
| Both cooking and heating | 400 | 0.04 (-0.17, 0.25) | 0.04 (-0.18, 0.25) | 0.12 (-0.08, 0.32) | 0.04 (-0.15, 0.22) | 0.19 (-0.05, 0.43) | 0.01 (-0.22, 0.25) | 0.13 (-0.06, 0.32) | 0.14 (-0.05, 0.32) | 0.80 (-0.27, 1.87) |

[a] Difference in score in each cognitive measure associated with using clean fuel exclusively for cooking, heating or both with use of solid fuel indoors as reference.

[b] The original questionnaire collected participants' annual household income in the following categories: less than 2,500 yuan, 2500-4999 yuan, 5000-9999 yuan, 10000-19999 yuan, 20000-34999 yuan, above 35,000 yuan. We assigned participants who did not disclose the income (n=49) as a separate category.
[c] We imputed values for participants who did not have body mass index measured (n=16).
Abbreviations: CI, confidence interval.

**Supplementary Table 8.** Cognitive equivalence of additional years of age associated with measures of exposure to household air pollution calculated using coefficient estimates from final multivariable models with overall raw MoCA score.

| **Exposure** | Estimated cognitive equivalences in years of age[a] |
|---|---|
| Personal $PM_{2.5}$; n=355 | |
| per 100-μg/$m^3$ increase | 8.29 |
| per IQR (53.2 μg/$m^3$) increase | 4.41 |
| from WHO interim annual target-1 (35 μg/$m^3$) to participants' mean exposure (101.8 μg/$m^3$) | 5.54 |
| from WHO annual guideline (10 μg/$m^3$) to participants' mean exposure (101.8 μg/$m^3$) | 7.61 |
| Personal black carbon; n=355 | |
| per 1-μg/$m^3$ increase | 3.65 |
| per IQR (0.9 μg/$m^3$) increase | 3.32 |
| Use of solid fuel for cooking (ref. exclusive use of clean fuel); n=400 | 2.03 |
| Use of solid fuel for heating (ref. exclusive use of clean fuel); n=400 | 4.52 |
| Current intensity of indoor solid fuel use; n=400 | |
| per 100-day increase in solid fuel stove-use days in the past year | 1.18 |
| Long-term intensity of indoor solid fuel use; n=394 | |
| per 5-year increase in solid fuel stove-use years over the past 20 years | 1.91 |

[a] Estimated cognitive equivalences in years of age were calculated by dividing coefficients for household air pollution exposures by the coefficients for age (range: -0.15 to -0.18) from the final multivariable models predicting overall (raw) cognitive score.

Abbreviations: $PM_{2.5}$, particulate matter ≤2.5 μm in aerodynamic diameter; IQR, interquartile range; CI, confidence interval.

**Supplementary Table 9.** Baseline health conditions of study participants.

| Characteristic | Beijing (n=202) | Shanxi (n=199) | All participants (n=401) |
|---|---|---|---|
| Self-reported physician-diagnosed health conditions; n (%) | | | |
| Diabetes | 21 (10) | 34 (17) | 55 (14) |
| Heart disease | 15 (7) | 15 (8) | 30 (7) |
| Hypertension | 109 (54) | 105 (53) | 214 (53) |
| Body mass index ($kg/m^2$); mean (SD) | 26.3 (3.6) | 26.0 (3.6) | 26.1 (3.6) |
| Missing; n (%) | 9 (5) | 7 (4) | 16 (4) |

Abbreviations: SD, standard deviation.

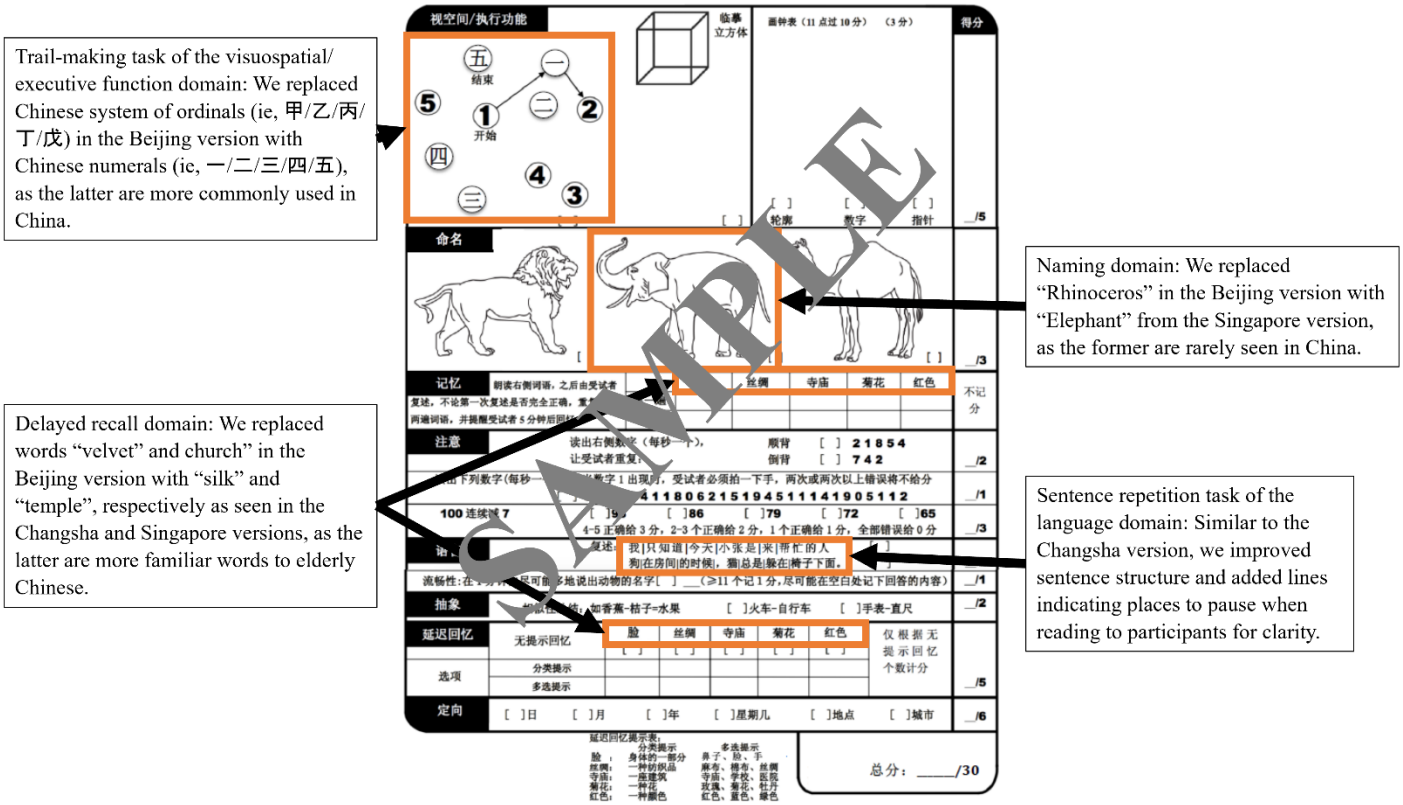
**Supplementary Table 10.** Characteristics of participants who reported not having had stroke at enrollment in Beijing and Shanxi sites of the ICP Study by whether they were included in the final analytic sample.

| Characteristic | Included in the analytic sample (n=401) | Not included (n=99) | All eligible participants (n=500) |
|---|---|---|---|
| Age (years); mean (SD) | 62.5 (8.0) | 62.0 (9.3) | 62.4 (8.3) |
| Female; n (%) | 232 (58) | 55 (56) | 287 (57) |
| Ethnicity; n (%) | | | |
| Han | 399 (100) | 99 (100) | 498 (100) |
| Other | 2 (0) | 0 (0) | 2 (0) |
| Education level; n (%) | | | |
| No school | 66 (16) | 14 (14) | 80 (16) |
| Primary school | 162 (40) | 33 (33) | 195 (39) |
| Secondary school/college | 173 (43) | 52 (53) | 225 (45) |
| Occupation; n (%) | | | |
| Agriculture | 308 (77) | 70 (71) | 378 (76) |
| Other jobs outside of the household | 27 (7) | 9 (9) | 36 (7) |
| Not working outside of the household | 66 (16) | 20 (20) | 86 (17) |
| Annual household income (RMB); n (%) | | | |
| <2,500 | 40 (10) | 18 (18) | 58 (12) |
| 2,500-4,999 | 33 (8) | 6 (6) | 39 (8) |
| 5,000-9,999 | 53 (13) | 12 (12) | 65 (13) |
| 10,000-19,999 | 77 (19) | 11 (11) | 88 (18) |
| 20,000-34,999 | 74 (18) | 21 (21) | 95 (19) |
| ≥35,000 | 75 (19) | 14 (14) | 89 (18) |
| Missing | 49 (12) | 17 (17) | 66 (13) |
| Marital status; n (%) | | | |
| Married | 362 (90) | 86 (87) | 448 (90) |
| Single, widowed, or divorced | 39 (10) | 13 (13) | 52 (10) |
| Number of household occupants; mean (SD) | 3.2 (1.7) | 3.1 (1.7) | 3.2 (1.7) |
| Self-reported health status; n (%) | | | |
| Excellent | 47 (12) | 11 (11) | 58 (12) |
| Good | 135 (34) | 31 (31) | 166 (33) |
| Fair | 165 (41) | 47 (47) | 212 (42) |
| Poor | 54 (13) | 10 (10) | 64 (13) |
| Smoking status; n (%) | | | |
| Current smoker | 95 (24) | 32 (32) | 127 (25) |
| Former smoker | 65 (16) | 11 (11) | 76 (15) |
| Never smoker | 241 (60) | 56 (57) | 297 (59) |
| Ever lived with a smoker for 6 months[a]; n (%) | | | |
| Never | 63 (16) | 13 (13) | 76 (15) |
| Yes, but not now | 66 (16) | 11 (11) | 77 (15) |
| Yes, at present | 112 (28) | 32 (32) | 144 (29) |
| Frequency of exercising; n (%) | | | |
| None | 168 (42) | 45 (45) | 213 (43) |
| Sometimes | 100 (25) | 26 (26) | 126 (25) |
| Daily | 133 (33) | 28 (28) | 161 (32) |

| | | | |
|---|---|---|---|
| Frequency of drinking alcohol; n (%) | | | |
| Never or stopped drinking in past year | 258 (64) | 61 (62) | 319 (64) |
| Sometimes | 100 (25) | 21 (21) | 121 (24) |
| Daily | 43 (11) | 17 (17) | 60 (12) |
| Total cholesterol (mmol/L); mean (SD) | 4.7 (1.0) | 5.1 (0.8) | 4.7 (1.0) |
| Missing; n (%) | 23 (6) | 74 (75) | 97 (19) |
| Had experienced past food shortage; n (%) | 299 (75) | 74 (75) | 373 (75) |

[a] Only never smokers would report whether they lived with a smoker.

Abbreviations: MoCA, Montreal Cognitive Assessment; SD, standard deviation; RMB, Renminbi.



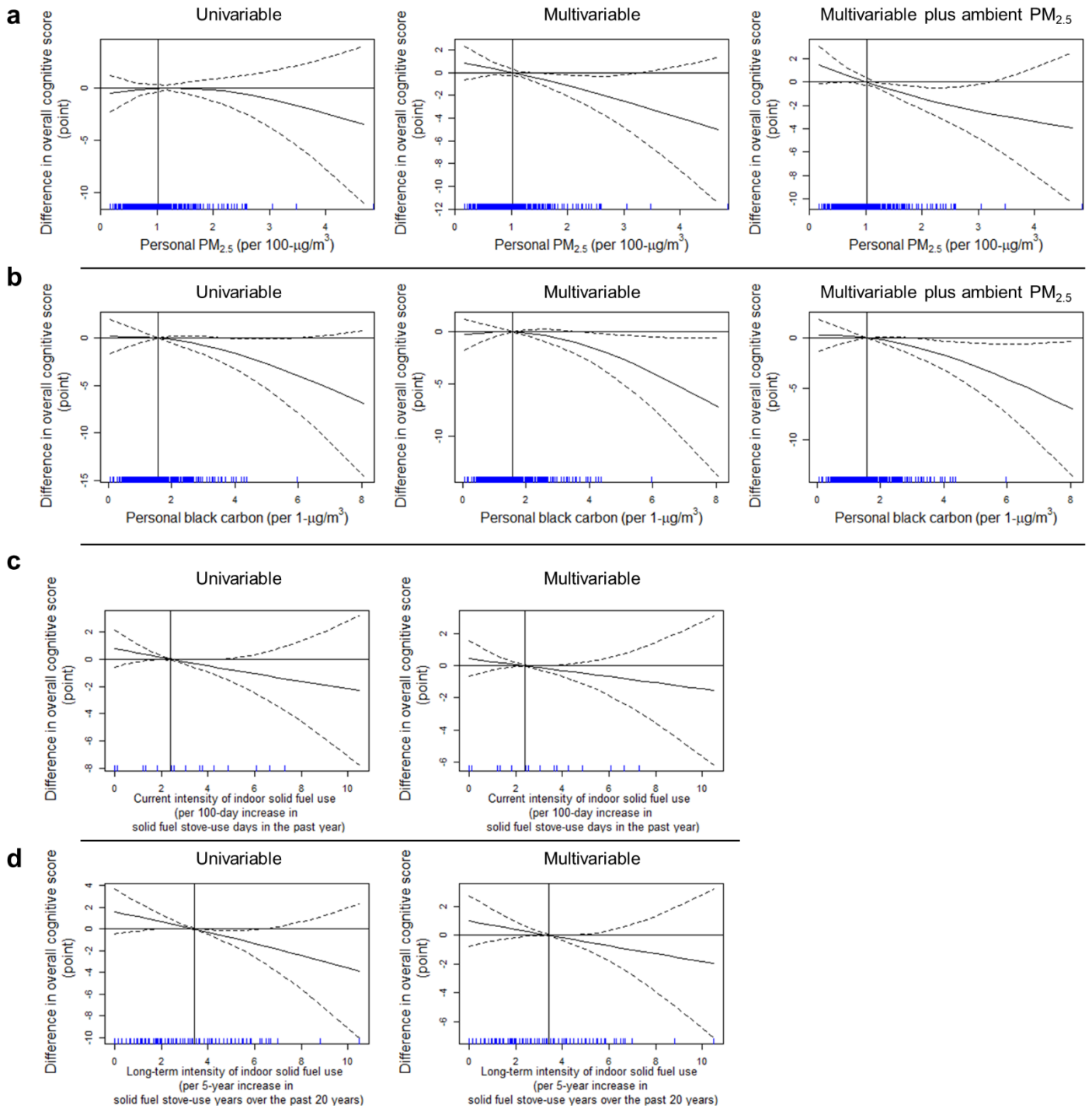



**Supplementary Fig. 3.** Montreal Cognitive Assessment in Mandarin-Chinese used in the ICP Study. Here we illustrate the minor changes made to the Beijing version (https://www.mocatest.org/) of Montreal Cognitive Assessment (MoCA) to increase the cultural appropriateness of the survey for our peri-urban study population.

**Supplementary Equation 1.** General regression equation for the models used to estimate the cognitive associations with exposures to household air pollution.

$$\gamma_{ij} = \mu + \beta_{ij} + nx_{ij} + \psi_j + \omega_j + \varepsilon_{ij},$$

where $\gamma_{ij}$ denotes the domain-specific or overall cognitive score for individual i in village j, $\mu$ represents a constant; $\beta_{ij}$ is personal exposure to household air pollution, measured by stove use, $PM_{2.5,}$ or black carbon for participant i in village j, $x_{ij}$ represents the set of n covariates, $\psi_j$ is a random intercept at the village level, $\omega_j$ represents the random effect, and $\varepsilon_{ij}$ is the error term."




**Supplementary Fig. 4.** Natural cubic splines with 2 degrees of freedom (solid line) and associated 95% confidence intervals (dashed lines) illustrating the associations between raw score for overall cognition and personal exposures to **(*a*)** $PM_{2.5}$ (n = 355; per 100 μg/m$^3$) or **(*b*)** black carbon (n = 355; per 1 μg/m$^3$), **(*c*)** current intensity of indoor solid fuel use (n = 400; per 100-day increase in solid fuel stove-use days in the past year) or **(*d*)** long-term intensity of indoor solid fuel use (n = 394; per 5-year increase in solid fuel stove-use years over the past 20 years) in

older Chinese adults. Mean difference is relative to the mean exposure (vertical black line). Results presented as univariate (left); multivariable models adjusted for province, age, gender, education level, marital status, exposure to tobacco smoking, frequency of farming, frequency of exercising and occupation, annual household income, self-reported health, total cholesterol, past food shortage experience, number of household occupants and frequency of drinking alcohol (middle); and multivariable additionally adjusted for outdoor $PM_{2.5}$ level during exposure assessment (right). The vertical cyan lines along the x-axes show the distribution of the exposures. All models included a random effect at the village level.
Abbreviations: $PM_{2.5}$, particulate matter ≤2.5 μm in aerodynamic diameter.