**Supplemental Materials**

**Ambient PM1 air pollution and cardiovascular disease prevalence: Insights from the 33 Communities Chinese Health Study**

Bo-Yi Yang, Yuming Guo, Lidia Morawska, Michael S. Bloom, Iana Markevych, Joachim Heinrich, Shyamali C. Dharmage, Luke D. Knibbs, Shao Lin, Steve Hung-Lam Yim, Gongbo Chen, Shanshan Li, Xiao-Wen Zeng, Kang-Kang Liu, Li-Wen Hu, Guang-Hui Dong

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**Supplemental methods:** Explanation for ground-monitored data on PM1 and PM2.5

Ground-monitored PM1 and PM2.5 were obtained from the China Atmosphere Watch Network (CAWNET) of the China Meteorological Administration (CMA). The network consisted of 96 stations across mainland China. Concentrations of PM1 and PM2.5 at all stations were measured with GRIMM 180 Environmental dust monitors (Model 1.108, Grimm Aerosol Technik GmbH, Ainring, Germany). Two quality-control procedures were applied to all PM measurements: a "limit check" and "climatological check". For the limit check, we evaluated each valid PM measurement to determine whether it fell within its possible limits, otherwise, they were removed. In the climatological check, the median and standard deviation (SD) of hourly PM measurements were calculated at each PM observational site. Any PM values lying outside of more than three SDs from the median PM have been removed.

**Supplemental methods:** Detailed information on Generalized Linear Mixed Models

At the participant level, we predicted the logit of rate of CVD as a function of k covariates (X1 ….Xk) as follows:

logit [Probability (Yij)] = αj + β1X1ij + ….+ βkX1ij + eij (1)

The variable (Y) in equation 1 is CVD, the subscript j is for communities (j=1,…, 33), the subscript i is for participants (i=1,..nj), αj are intercepts at the community level, β1 …βk are the regression coefficients of covariates, and eij are the random errors, assumed to have means of zero and constant variance. The αj are random coefficients because they are assumed to vary across communities.

At the community level, we regressed the community-specific intercepts αj on the community-specific pollutant level (Zj) to explain the variations of αj, as follows:

αj = α + γ1 Zj + uj (2)

Equation 2 predicts the CVD prevalence proportion in a community by Zj. If γ1 is positive then the communities with higher pollutant levels have a higher prevalence rate of CVD (adjusting for covariates). Conversely, if γ1 is negative, then the prevalence proportion is lower in communities with a higher pollutant level (adjusting for covariates). The u-terms uj are random errors at the community level, assumed to be independent and have mean of zero and constant variance. These random errors characterize the variation between communities and are assumed to be independent from eij at the participant level. Note that α, β1,…, βk, and γ1 do not vary across communities. Therefore, they have no subscript j to indicate to which community they belong; they are referred to as “fixed effects” given that they apply to all communities.

Substituting the equation 2 into equation 1 yields a single regression equation:

logit [P (Yij)] = (α+γ1Zj + β1X1ij + ...+ βkXkij) +(uj + eij) (3)

The terms in the first and second parentheses in equation 3 are often respectively called the fixed (or deterministic) and random (or stochastic) parts of the model.

**Table S1** Associations of one-, two-, and three-year average air pollutants (per10-μg/m3 increment) with CVD prevalence

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| --- | --- | --- |
| Air pollutants | Adjusted OR (95% CI)a | P value |
| PM1 |  |  |
| One-year average (2008) | 1.12 (1.05, 1.20) | .0007 |
| Two-year average (2007-08) | 1.13 (1.05, 1.21) | .0005 |
| Three-year average (2006-08) | 1.13 (1.06, 1.21) | .0004 |
| PM2.5 |  |  |
| One-year average (2008) | 1.06 (1.01, 1.11) | .0208 |
| Two-year average (2007-08) | 1.06 (1.01, 1.11) | .0150 |
| Three-year average (2006-08) | 1.06 (1.01, 1.12) | .0127 |
| PM1-2.5 |  |  |
| One-year average (2008) | 0.98 (0.85, 1.13) | .8052 |
| Two-year average (2007-08) | 0.99 (0.86, 1.15) | .9285 |
| Three-year average (2006-08) | 0.99 (0.86, 1.15) | .9025 |

Abbreviations: CI, confidence interval; CVD, cardiovascular disease; OR, odds ratio; PM1, particle with aerodynamic diameter ≤ 1.0 µm; PM1-2.5, particle with aerodynamic diameter ranges from 1 to 2.5 µm; PM2.5, particle with aerodynamic diameter ≤ 2.5 µm.

aAdjusted for age, sex, ethnicity, income, education, smoking status, regular exercise, and district-level of gross domestic product.

**Table S2** Previous studies of long-term exposure to PM2.5 and CVD prevalence or incidence in human populations

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Author (Year) | Samplesize | Study setting | Exposure | Outcome | Main findings |
| Kim et al. (2017) | 136,094 men and women | South Korea | PM2.5 | Acute myocardial infarction, congestive heart failure, and stroke incidences | A 1 µg/m3 increase in PM2.5 was associated with 1.36- (95% CI: 1.19-1.56), 1.44- (95% CI: 1.29-1.61), and 1.39-fold (95% CI: 1.27-1.52) increased risk of acute myocardial infarction, congestive heart failure, and stroke incidences, respectively. Age, sex, income, hypertension, diabetes mellitus, malignancy, obesity, smoking, and anemia were not modifiers. |
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| Cesaroni et al. (2014) | 100,166 (11 cohorts) men and women | Europe | PM2.5 | Acute coronary events (myocardial infarction and unstable angina) | A 5 µg/m3 increase in annual mean PM2.5 was associated with a 1.19-fold (95% CI: 0.88-1.62) increased risk of stroke. Age (but not sex, educational level, smoking status, BMI, hypertension, and residence in low or high urbanized settings) is modifier, with higher associations observed in the elderly. |
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| Stafoggia et al. (2014) | 99,446 (11 cohorts) men and women | Europe | PM2.5 | Stroke | A 5 µg/m3 increase in annual mean PM2.5 was associated with a 1.13-fold (95% CI: 0.98-1.30) increased risk of coronary events. Stronger associations were found in the elderly, current smokers, and participants with low PM2.5 levels. sex, education level, BMI, diabetes, hypertension, and living area did not modify the association. |
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| Puett et al. (2009) | 66,250 women | America | PM2.5 | First coronary heart disease, fata coronary heart disease, nonfatal myocardial infarction | A 10 µg/m3 increase in PM2.5 was associated with 1.10- (95% CI: 0.76-1.60), 2.13- (95% 1.07-4.26), and 0.71-fold (95% CI: 0.44-1.13) increased risk of first coronary heart disease, fata coronary heart disease, and nonfatal myocardial infarction, respectively. Although all interaction terms (except family history of myocardial infarction) were not statistically significant, women with family history of myocardial infarction, hypercholesterolemia, hypertension, never smokers, low physical activity, lowest house value, low family income, and higher body mass index were at higher risk. |
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| Johnson et al. (2010) | 7336 men and women | Canada | PM2.5 | Stroke incidence (first admission for stroke) | No significant association was observed between PM2.5 and stroke. |
|  |  |  |  |  |  |
| Lipsett et al. (2011) | 73489 female teachers | America | PM2.5 | Myocardial infarction and stroke incidence | No significant association was observed between PM2.5 and myocardial infarction and stroke incidence. |
|  |  |  |  |  |  |
| Miller et al. (2007) | 65,893 women | America | PM2.5 | Coronary heart disease, cerebrovascular disease, myocardial infarction, coronary revascularization, and stroke | A 10 µg/m3 increase in PM2.5 was associated with 1.21- (95% CI: 1.04-1.42), 1.35- (95% CI: 1.08-1.68), 1.06- (95% CI: 0.85-1.34), 1.20- (95% CI: 1.00-1.43), and 1.28-fold (95% CI: 1.02-1.61) increased risk of Coronary heart disease, cerebrovascular disease, myocardial infarction, coronary revascularization, and stroke, respectively. body mass index, waist-to-hip ratio and time lived in the current state modified the association, but not household income, education, age, smoking status, living with smoker, waist circumference, hormone-replacement therapy, diabetes, hypertension, hypercholesterolemia, family history of CVD, health insurance coverage, and time spent outdoors. |
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| To et al. (2015) | 29,549 women | Canada | PM2.5 | Acute myocardial infarction, angina, congestive heart failure, ischemic heart disease, stroke | A 10 µg/m3 increase in PM2.5 was associated with 1.04- (95% CI: 0.78-1.40), 1.10- (95% CI: 0.97-1.24), 1.30- (95% CI: 1.11-1.52), 1.18- (95% CI: 1.08-1.29), and 1.26-fold (95% CI: 1.11-1.43) increased risk of acute myocardial infarction, angina, congestive heart failure, ischemic heart disease, and stroke, respectively. The associations were stronger among smokers and obese participants.  |
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| Kloog et al. (2012) | 345,977 men and women | America | PM2.5 | Hospital admissions for CVD and stroke | A 10 µg/m3 increase in PM2.5 was associated with 3.12% and 3.49% increase in hospital admissions for CVD and stroke, respectively. |
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Abbreviations: CI, confidence interval; CVD, cardiovascular disease; PM2.5, particle with aerodynamic diameter ≤ 2.5 µm.

**Table S3** Prior studies using similar study strategy with ours

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| --- | --- | --- | --- | --- | --- | --- |
| Authors | Country | Study design | Sample size | Outcome | Exposures | Range of exposure (min-max) |
| Hassanvand et al. 2018  | Iran | Cross-sectional | 2916 | Diabetes prevalence | PM10 from 23 air monitoring stations | 70.41-130.112 μg/m3 |
| Lepeule et al. 2012 | U.S. | Cohort | 8096 | Mortality | PM2.5 from 6 cities (i.e., 6 air monitoring stations) | 11.4-23.6 μg/m3 |
| Johnson et al. 2010 | Canada | Case-crossover | 7336 | Stroke | PM2.5, NO2, O3, CO, SO2 from 5-9 air monitoring stations | NO2: 10.1-20.3 ppbO3: 16.4-22.6 ppbCO: 0.26-0.40 ppmSO2: 1.06-1.47 ppbPM2.5: 4.40-5.09 μg/m3 |
| Hwang et al. 2010 | China | Cross-sectional | 5052 | Bronchitic prevalence | PM2.5, SO2, NO2, and O3 from 14 air monitoring stations | PM2.5: 19.83-51.34 μg/m3SO2: 2.16-10.09 ppbNO2: 10.06-26.83 ppbO3: 30.34-59.12 ppb |
| Zhao et al. 2008 | China | Cross-sectional | 1993 | Asthmatic symptoms | SO2, NO2, and O3 from 10 schools | SO2: 476.0-1015.0 μg/m3NO2: 37.9-65.2 μg/m3O3: 7.1-17.5 μg/m3 |
| Peters et al. 1999 | U.S. | Cross-sectional | 3676 | Respiratory morbidity | PM10, NO2, and O3 from 12 communities | PM10: 28.0-84.9 μg/m3NO2: 1.6-44.8 μg/m3O3: 18.4-54.2 ppb |
| Braun-Fahrländer et al. 1997 | Switzerland | Cross-sectional | 4470 | Respiratory and allergic symptoms | PM10, SO2, NO2, and O3 from 10 communities | PM10: 10-33 μg/m3NO2: 9-56 μg/m3SO2: 2-23 μg/m3O3: 17-75 μg/m3 |
| Dockery et al. 1993 | U.S. | Cohort | 8111 | Mortality | PM2.5 from 6 cities (i.e., 6air-monitoring stations) | PM2.5: 11.0-29.6 μg/m3SO2: 1.6-24.0 ppbNO2: 6.1-21.9 ppbO3: 19.7-28.0 ppb |

Abbreviations: U.S., United States; CVD, cardiovascular disease; PM2.5, particle with aerodynamic diameter ≤2.5 µm; PM2.5-10, particle with aerodynamic diameter ranges from 2.5 to 10 µm; PM10, particle with aerodynamic diameter ≤10 µm; SO2, sulfur dioxide; NO2, nitrogen dioxide; CO, carbon monoxide; NOx, nitrogen oxide; O3, ozone.

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**Fig. S1.** Directed acyclic graph for the association between air pollution and CVD, created with the help of dagitty.net