



Supplementary data

Reducing PM_{2.5} exposure and lower hypertension risk: evidence from two large cohort studies

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1. Supplementary note 1: construction of the area deprivation Index in the Taiwan MJ Cohort

We constructed an Area Deprivation Index (ADI) as an area-level socioeconomic indicator using principal component analysis of three variables: annual average household income, the proportion of individuals who were unemployed, and the proportion of individuals aged over 15 years without a diploma from senior high school or senior vocational high school ^[1]. These socioeconomic data were sourced from the National Statistics of Taiwan ^[2]. The eigenvalues for the three components were 1.39, 0.98, and 0.34. A higher ADI score indicated areas with lower levels of deprivation. For each year, the ADI was calculated at the city or county level and assigned to participants based on their self-reported residential areas.

2. Supplementary note 2: definition of diseases at baseline

(1) Diabetes

In the MJ Cohort, diabetes was defined as any type of diabetes that was either self-reported or diagnosed by a physician.

In the UKB, diabetes was defined as self-reported (codes: 1220, 1222, 1223 in field ID 20002) or physician-diagnosed (field ID: 2443), ICD-9 (codes: 250), ICD-10 (codes: E10, E11, E13, E14), first occurrence data (field IDs: 130706, 130708, 130710, 130712, 130714), or use of glucose-lowering medications (code 3 in field IDs 6153 and 6177).

(2) Dyslipidemia

In the MJ Cohort, dyslipidemia was defined as meeting any of the following criteria: TC $\geq$ 240 mg/dL, TG $\geq$ 200 mg/dL, LDL-C $\geq$ 160 mg/dL, or HDL-C $<$ 40 mg/dL. Participants were

also classified as having dyslipidemia if they self-reported a physician diagnosis or reported use of lipid-lowering medications.

In the UKB, dyslipidemia was defined as ICD-10 codes E780–E786, E788, or E789; first occurrence data (field ID: 130814); use of lipid-lowering medications (code 1 in field IDs 6153 and 6177); or meeting any of the following criteria: TC $\geq$ 240 mg/dL, TG $\geq$ 200 mg/dL, LDL-C $\geq$ 160 mg/dL, or HDL-C $<$ 40 mg/dL (field IDs: 30690, 30870, 30760, 30780).

(3) Cardiovascular diseases (CVD) and stroke

In the MJ Cohort, CVD and stroke were defined as either self-reported or physician-diagnosed. CVD included coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, or venous thromboembolism (deep vein thrombosis and pulmonary embolism).

In the UKB, CVD (ICD-10 codes: I20–I25) and stroke (ICD-10 codes: I60, I61, I63, I64, I69) were defined based on hospital diagnoses.

(4) Kidney disease

In the MJ Cohort, serum creatinine concentrations were measured using either the Hitachi 7150 (Tokyo) or Toshiba C8000 (Tokyo) automatic biochemical analyzers. Estimated glomerular filtration rate (eGFR) was calculated using age-adjusted equations, and chronic kidney disease was defined as eGFR $<$ 60 mL/min/1.73 m² or self-reported physician-diagnosed chronic kidney disease.

In the UKB, kidney disease was defined based on hospital diagnoses (ICD-10 codes: N03, N06, N08, N11–N16, N18–N21, E85.3, Q60.1, T82.4, T86.1, Y60.2, Y61.2, Y62.2, Y84.1, Z49.0, Z49.1, Z49.2, Z94.0, Z99.2).

(5) Cancer

In the MJ Cohort, cancer was defined as any type of cancer that was either self-reported or diagnosed by a physician.

In the UKB, cancer was defined as any physician-diagnosed cancer (field ID: 2453).



3. Supplementary tables

Table S1. Definition of harmonized covariates in the two cohorts.

Variable	Categories	Definition	
		Taiwan MJ cohort	UK Biobank
Age	NA	Age at visit	Age at recruitment
Sex	Female	Female participants	Female participants
	Male	Male participants	Male participants
Ethnicity	White	NA	Self-reported ethnicity category as White
	Non-White	NA	Self-reported ethnicity categories as Asian, Black, Mixed, and other ethnic group categories
Educational background	Low	Lower than high school, defined as less than 10 years of education	Certificate of Secondary Education or equivalent, Ordinary levels/General Certificate of Secondary Education or equivalent
	Medium	High school, defined as 10–13 years of education	Advanced levels/Advanced Subsidiary levels or equivalent, National Vocational Qualifications or Higher National Diploma or Higher National Certificate or equivalent
	High	College or university, or above, defined as more than 13 years of education	College or University degree, Other professional qualifications e.g.: nursing, teaching
Average yearly household income	Low	Less than 400 thousand NTD\$	Less than 18 thousand £
	Medium	410–1200 thousand NTD\$	18–52 thousand £
	High	More than 1210 thousand NTD\$	More than 52 thousand £
Area level socioeconomic condition	NA	Area Deprivation Index, with higher scores indicating lower levels of deprivation	Townsend Deprivation Index, with lower scores indicating lower levels of deprivation
Smoking status	Never	Never smoke	Never smoke
	Former	Former smoker	Former smoker
	Current	Current smoker	Current smoker
Alcohol use	Seldom	Less than once per week	Less than once per week
	Occasional	1–3 times per week	1–2 times per week
	Regular	More than 3 times per week	More than 2 times per week
Vegetable intake	Seldom	Less than 1 serving per day	Less than 1 tablespoons per day
	Moderate	1–2 servings per day	1–4 tablespoons per day
	Frequent	More than 2 servings per day	More than 4 tablespoons per day
Fruit intake	Seldom	Less than 1 serving per day	Less than 1 pieces per day
	Moderate	1–2 servings per day	1–3 pieces per day
	Frequent	More than 2 servings per day	More than 3 pieces per day
Exercise intensity	Inactive	1st quartiles of MET-minutes per week for physical activity	1st quartiles of MET-minutes per week for physical activity
	Light	2nd quartiles of MET-minutes per week for physical activity	2nd quartiles of MET-minutes per week for physical activity
	Moderate	3rd quartiles of MET-minutes per week for physical activity	3rd quartiles of MET-minutes per week for physical activity
	High	4th quartiles of MET-hours per week for physical activity	4th quartiles of MET-minutes per week for physical activity
BMI	NA	Weight (kilograms) divided by the square of height (meters)	Weight (kilograms) divided by the square of height (meters)
SBP	NA	Measured in the morning using a computerized automated mercury sphygmomanometer	Measured twice after a 5-minute rest using an electronic blood pressure monitor
DBP	NA	Measured in the morning using a computerized auto-mercury sphygmomanometer	Measured twice after a 5-minute rest using an electronic blood pressure monitor

Table S1. Cont.

Variable	Categories	Definition	
		Taiwan MJ cohort	UK Biobank
Diabetes	Yes	Fasting blood glucose ≥ 126 mg/dl or self-reported diagnosis of diabetes	Self-reported diagnosis of diabetes, hospital diagnosis of diabetes (ICD-10 codes: E10–E14), or taking medications for diabetes
	No	Negative of any criterion	Negative of any criterion
Dyslipidemia	Yes	TC ≥ 240 mg/dL, TG ≥ 200 mg/dL, LDL-C ≥ 160 mg/dL, or HDL-C < 40 mg/dL	TC ≥ 240 mg/dL, TG ≥ 200 mg/dL, LDL-C ≥ 160 mg/dL, or HDL-C < 40 mg/dL, or hospital diagnosis of dyslipidemia (ICD-10 codes: E78) or taking medications for dyslipidemia
	No	Negative of any criterion	Negative of any criterion
Baseline PM_{2.5} exposure	NA	Average annual PM _{2.5} concentration during the four years preceding the baseline visit plus the baseline year	Average annual PM _{2.5} concentration during the four years preceding the baseline visit plus the baseline year

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; MET, metabolic equivalent task; TC, total cholesterol; TG, triglycerides; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

Table S2. Data code used for extraction in the UK Biobank.

Variable	Field ID
Longitude	20074
Latitude	20075
Location history	22700–22704
Systolic blood pressure	93
Diastolic blood pressure	94
Self-reported diagnosis of hypertension	6150
Hospital diagnosis of hypertension	41270, 41280, 131286, 131288, 131290, 131292, 131294
Anti-hypertensive treatment	6153, 6177
Age	21022
Sex	31
Ethnicity	21000
Educational background	6138
Average yearly household income	738
Townsend Deprivation Index	189
Smoking status	1239, 20116
Alcohol use	1558, 20117
Vegetable intake	1289, 1299
Fruit intake	1309, 1319
Exercise intensity	22037, 22038, 22039
Body mass index	21001
Self-reported diagnosis of diabetes	2443
Hospital diagnosis of diabetes	41270, 41280, 130706, 130708, 130710, 130712, 130714
Medications for diabetes	6153, 6177
Total cholesterol	30690
Triglycerides	30870
Low-density lipoprotein cholesterol	30760
High-density lipoprotein cholesterol	30780
Hospital diagnosis of dyslipidemia	41270, 41280, 130814
Hospital diagnosis of cardiovascular diseases and stroke	41270, 41280, 131296, 131298, 131300, 131302, 131304, 131306, 131360, 131362, 131366, 131368, 131378
Hospital diagnosis of kidney diseases	41270, 41280, 132004, 132010, 132014, 132018, 132020, 132022, 132024, 132026, 132028, 132032, 132034, 132036, 132038
Self-reported diagnosis of cancer	2453

Table S3. Baseline characteristics of participants between the two groups in the Taiwan MJ Cohort and the UK Biobank.

	Taiwan MJ Cohort		UK Biobank	
	Consistently High PM _{2.5} Exposure Group (n = 32,221)	PM _{2.5} Reduction Group (n = 6176)	Consistently High PM _{2.5} Exposure Group (n = 54,712)	PM _{2.5} Reduction Group (n = 12,125)
Age (years), mean ± SD	38.7 ± 10.5	37.5 ± 10.4	52.6 ± 7.9	53.2 ± 7.9
Male, n (%)	15,185 (47.1%)	2887 (46.7%)	21,657 (39.6%)	4969 (41.0%)
Educational background, n (%)				
Low	3099 (9.6%)	507 (8.2%)	15450 (28.2%)	3690 (30.4%)
Medium	7017 (21.8%)	1132 (18.3%)	10622 (19.4%)	2546 (21.0%)
High	22,105 (68.6%)	4537 (73.5%)	28640 (52.3%)	5889 (48.6%)
Ethnicity, n (%)				
White	NA	NA	48,424 (88.5%)	11,022 (90.9%)
Non-White	NA	NA	6288 (11.5%)	1103 (9.1%)
Average yearly household income, n (%)				
Low	6122 (19.0%)	1039 (16.8%)	7420 (13.6%)	1712 (14.1%)
Medium	19,053 (59.1%)	3481 (56.4%)	27,649 (50.5%)	6247 (51.5%)
High	7046 (21.9%)	1,656 (26.8%)	19,643 (35.9%)	4166 (34.4%)
Area level socioeconomic condition, mean ± SD[†]	0.2 ± 1.0	1.5 ± 1.1	−1.0 ± 3.1	−1.8 ± 2.7
Smoking status, n (%)				
Never	24,979 (77.5%)	4780 (77.4%)	31,031 (56.7%)	7268 (59.9%)
Former	1589 (4.9%)	333 (5.4%)	17,596 (32.2%)	3656 (30.2%)
Current	5653 (17.5%)	1063 (17.2%)	6085 (11.1%)	1201 (9.9%)
Alcohol use, n (%)				
Seldom	27,699 (86.0%)	5386 (87.2%)	14,995 (27.4%)	3557 (29.3%)
Occasional	3155 (9.8%)	562 (9.1%)	14,281 (26.1%)	3222 (26.6%)
Regular	1367 (4.2%)	228 (3.7%)	25,436 (46.5%)	5346 (44.1%)
Vegetable intake, n (%)				
Seldom	3704 (11.5%)	742 (12.0%)	980 (1.8%)	221 (1.8%)
Moderate	18,865 (58.5%)	3662 (59.3%)	28,303 (51.7%)	6380 (52.6%)
Frequent	9652 (30.0%)	1772 (28.7%)	25,429 (46.5%)	5524 (45.6%)
Fruit intake, n (%)				
Seldom	9701 (30.1%)	2122 (34.4%)	3684 (6.7%)	859 (7.1%)
Moderate	17,948 (55.7%)	3346 (54.2%)	33,106 (60.5%)	7461 (61.5%)
Frequent	4572 (14.2%)	708 (11.5%)	17,922 (32.8%)	3805 (31.4%)
Exercise intensity, n (%)				
Inactive	12,478 (38.7%)	2199 (35.6%)	13,530 (24.7%)	3181 (26.2%)
Low	6861 (21.3%)	1352 (21.9%)	13,789 (25.2%)	2925 (24.1%)
Moderate	5371 (16.7%)	1216 (19.7%)	13,806 (25.2%)	2903 (23.9%)
High	7511 (23.3%)	1409 (22.8%)	13,587 (24.8%)	3116 (25.7%)
BMI (kg/m²), mean ± SD	22.7 ± 3.4	22.7 ± 3.4	25.7 ± 4.0	26.0 ± 4.0
SBP (mmHg), mean ± SD	112.3 ± 12.5	112.8 ± 12.3	123.3 ± 9.9	123.9 ± 9.8
DBP (mmHg), mean ± SD	68.4 ± 8.9	68.7 ± 9.0	76.1 ± 7.0	76.3 ± 7.0
Diabetes, n (%)				
Yes	685 (2.1%)	146 (2.4%)	1033 (1.9%)	220 (1.8%)
No	31,536 (97.9%)	6030 (97.6%)	53,679 (98.1%)	11,905 (98.2%)
Dyslipidemia, n (%)				
Yes	6707 (20.8%)	1252 (20.3%)	21,184 (38.7%)	4799 (39.6%)
No	25,514 (79.2%)	4924 (79.7%)	33,528 (61.3%)	7326 (60.4%)
Baseline PM_{2.5} exposure (µg/m³), median [IQR]	26.8 [22.7, 31.8]	22.0 [21.5, 22.5]	13.4 [13.1, 15.2]	13.0 [12.9, 13.1]

[†] Different indicators were used in the two cohorts (Area Deprivation Index for the MJ Cohort and the Townsend Deprivation Index for the UK Biobank).SD, standard deviation; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; IQR, interquartile range; NA, not available.

Table S4. Association between reduced exposure to ambient PM_{2.5} and the risk of incident hypertension using a three-year exposure time window.

	N of participants	N (%) of incident hypertension	Model 1		Model 2		Model 3	
			HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Taiwan MJ Cohort								
Consistently High PM _{2.5} Exposure Group	31,292	2209 (7.1%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	6352	364 (5.7%)	0.83 (0.74, 0.95)	0.005	0.84 (0.74, 0.96)	0.009	0.84 (0.74, 0.96)	0.010
Per 1 µg/m ³ decrease	37,644	2573 (6.8%)	0.94 (0.92, 0.96)	< 0.001	0.95 (0.93, 0.97)	< 0.001	0.94 (0.92, 0.96)	< 0.001
Per IQR decrease [†]	37,644	2573 (6.8%)	0.84 (0.80, 0.89)	< 0.001	0.87 (0.83, 0.92)	< 0.001	0.86 (0.81, 0.91)	< 0.001
UK Biobank								
Consistently High PM _{2.5} Exposure Group	59,500	1271 (2.1%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	10,404	143 (1.4%)	0.55 (0.45, 0.67)	< 0.001	0.54 (0.44, 0.65)	< 0.001	0.53 (0.44, 0.65)	< 0.001
Per 1 µg/m ³ decrease	69,904	1414 (2.0%)	0.81 (0.75, 0.88)	< 0.001	0.71 (0.64, 0.78)	< 0.001	0.69 (0.63, 0.76)	< 0.001
Per IQR decrease [†]	69,904	1414 (2.0%)	0.83 (0.77, 0.89)	< 0.001	0.74 (0.68, 0.80)	< 0.001	0.72 (0.66, 0.79)	< 0.001

† Analyses were conducted among participants in both PM_{2.5} exposure group. The interquartile ranges (IQR) for the change in PM_{2.5} concentration was 2.6 µg/m³ for the Taiwan MJ Cohort and 0.9 µg/m³ for the UK Biobank. HR, hazard ratio; CI, confidence interval.

Baseline PM_{2.5} exposure was defined as the average annual PM_{2.5} concentration over the two years preceding the baseline visit plus the baseline year. Model 1 included exposure groups and baseline PM_{2.5} exposure. Model 2 further adjusted for sex, age, ethnicity (only for the UK Biobank), educational background, average yearly household income, and area level socioeconomic conditions. Model 3 included all covariates from Model 2 and additionally adjusted for smoking status, alcohol use, vegetable and fruit intake, exercise intensity, diabetes, and dyslipidemia.

Table S5. Association between reduced exposure to ambient PM_{2.5} and the risk of incident hypertension by treating the baseline assessment period as unexposed.

	N of participants	N (%) of incident hypertension	Model 1		Model 2		Model 3	
			HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Taiwan MJ Cohort								
Consistently High PM _{2.5} Exposure Group	32,221	2278 (7.1%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	6176	334 (5.4%)	0.85 (0.74, 0.96)	0.010	0.84 (0.73, 0.96)	0.008	0.83 (0.73, 0.95)	0.006
Per 1 µg/m ³ decrease	38,397	2612 (6.8%)	0.96 (0.95, 0.98)	< 0.001	0.98 (0.96, 0.99)	0.015	0.97 (0.95, 0.99)	0.002
Per IQR decrease [†]	38,397	2612 (6.8%)	0.91 (0.87, 0.95)	< 0.001	0.94 (0.89, 0.99)	0.015	0.92 (0.88, 0.97)	0.002
UK Biobank								
Consistently High PM _{2.5} Exposure Group	54,712	1144 (2.1%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	12,125	233 (1.9%)	0.69 (0.60, 0.80)	< 0.001	0.68 (0.59, 0.79)	< 0.001	0.68 (0.59, 0.79)	< 0.001
Per 1 µg/m ³ decrease	66,837	1377 (2.1%)	0.87 (0.80, 0.93)	< 0.001	0.78 (0.72, 0.86)	< 0.001	0.76 (0.70, 0.83)	< 0.001
Per IQR decrease [†]	66,837	1377 (2.1%)	0.91 (0.86, 0.95)	< 0.001	0.85 (0.80, 0.91)	< 0.001	0.84 (0.79, 0.89)	< 0.001

† Analyses were conducted among participants in both PM_{2.5} exposure group. The interquartile ranges (IQR) for the change in PM_{2.5} concentration were 1.6 µg/m³ for the Taiwan MJ Cohort and 0.5 µg/m³ for the UK Biobank. HR, hazard ratio; CI, confidence interval.

Status at baseline assessment period as treated as unexposed (*i.e.*, assigning that period to the “Consistently High PM_{2.5} Exposure” group and including it in the person-time at risk). Model 1 included exposure groups and baseline PM_{2.5} exposure. Model 2 further adjusted for sex, age, ethnicity (only for the UK Biobank), educational background, average yearly household income, and area level socioeconomic conditions. Model 3 included all covariates from Model 2 and additionally adjusted for smoking status, alcohol use, vegetable and fruit intake, exercise intensity, diabetes, and dyslipidemia.

Table S6. Association between reduced exposure to ambient PM_{2.5} and the risk of incident hypertension among participants free of cardiovascular disease and stroke, kidney diseases, and cancer at baseline.

among participants free of cardiovascular disease and stroke, kidney diseases, and cancer at baseline.								
	N of participants	N (%) of incident hypertension	Model 1		Model 2		Model 3	
			HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Taiwan MJ Cohort								
Consistently High PM _{2.5} Exposure Group	30,335	2102 (6.9%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	5896	318 (5.4%)	0.87 (0.76, 0.99)	0.035	0.86 (0.75, 0.99)	0.030	0.86 (0.75, 0.99)	0.034
Per 1 µg/m ³ decrease	36,231	2420 (6.7%)	0.96 (0.95, 0.98)	< 0.001	0.98 (0.96, 0.99)	0.019	0.97 (0.95, 0.99)	0.002
Per IQR decrease †	36,231	2420 (6.7%)	0.91 (0.86, 0.95)	< 0.001	0.94 (0.89, 0.99)	0.019	0.92 (0.87, 0.97)	0.002
UK Biobank								
Consistently High PM _{2.5} Exposure Group	49,864	950 (1.9%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	11,011	189 (1.7%)	0.90 (0.74, 1.10)	0.305	0.88 (0.72, 1.07)	0.188	0.88 (0.72, 1.07)	0.188
Per 1 µg/m ³ decrease	60,875	1139 (1.9%)	0.99 (0.91, 1.10)	0.977	0.90 (0.80, 1.01)	0.079	0.88 (0.78, 0.99)	0.031
Per IQR decrease †	60,875	1139 (1.9%)	1.00 (0.94, 1.07)	0.977	0.93 (0.86, 1.01)	0.079	0.91 (0.84, 0.99)	0.031

† Analyses were conducted among participants in both PM_{2.5} exposure group. The interquartile ranges (IQR) for the change in PM_{2.5} concentration was 2.6 µg/m³ for the Taiwan MJ Cohort and 0.7 µg/m³ for the UK Biobank. HR, hazard ratio; CI, confidence interval.

Participants were restricted to those free of cardiovascular disease and stroke, kidney diseases, and cancer at baseline. Model 1 included exposure groups and baseline PM_{2.5} exposure. Model 2 further adjusted for sex, age, ethnicity (only for the UK Biobank), educational background, average yearly household income, and area level socioeconomic conditions. Model 3 included all covariates from Model 2 and additionally adjusted for smoking status, alcohol use, vegetable and fruit intake, exercise intensity, diabetes, and dyslipidemia.

Table S7. Association between reduced exposure to ambient PM_{2.5} and the risk of incident hypertension after exclusion of participants who developed hypertension within the first year of follow-up.

	N of participants	N (%) of incident hypertension	Model 1		Model 2		Model 3	
			HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Taiwan MJ Cohort								
Consistently High PM _{2.5} Exposure Group	31,180	2168 (7.0%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	5935	323 (5.4%)	0.86 (0.76, 0.99)	0.030	0.85 (0.74, 0.97)	0.017	0.84 (0.73, 0.96)	0.013
Per 1 µg/m ³ decrease	37,115	2491 (6.7%)	0.96 (0.95, 0.98)	< 0.001	0.98 (0.96, 0.99)	0.024	0.97 (0.95, 0.99)	0.003
Per IQR decrease [†]	37,115	2491 (6.7%)	0.91 (0.87, 0.95)	< 0.001	0.94 (0.90, 0.99)	0.027	0.93 (0.88, 0.97)	0.004
UK Biobank								
Consistently High PM _{2.5} Exposure Group	51,766	1043 (2.0%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	11,769	213 (1.8%)	0.86 (0.71, 1.03)	0.106	0.83 (0.69, 1.00)	0.053	0.83 (0.69, 1.00)	0.053
Per 1 µg/m ³ decrease	63,535	1256 (2.0%)	0.99 (0.91, 1.08)	0.844	0.89 (0.80, 0.99)	0.031	0.87 (0.78, 0.97)	0.009
Per IQR decrease [†]	63,535	1256 (2.0%)	0.99 (0.94, 1.06)	0.844	0.92 (0.86, 0.99)	0.031	0.91 (0.84, 0.98)	0.009

† Analyses were conducted among participants in both PM_{2.5} exposure group. The interquartile ranges (IQR) for the change in PM_{2.5} concentration were 2.6 µg/m³ for the Taiwan MJ Cohort and 0.7 µg/m³ for the UK Biobank. HR, hazard ratio; CI, confidence interval. Analysis excluded participants who developed hypertension within one year during the follow-up period. Model 1 included exposure groups and baseline PM_{2.5} exposure. Model 2 further adjusted for sex, age, ethnicity (only for the UK Biobank), educational background, average yearly household income, and area level socioeconomic conditions. Model 3 included all covariates from Model 2 and additionally adjusted for smoking status, alcohol use, vegetable and fruit intake, exercise intensity, diabetes, and dyslipidemia.

Table S8. Association between reduced exposure to ambient PM_{2.5} and the risk of incident hypertension in multivariate imputation data.

			Model 1		Model 2		Model 3	
	N of participants	N (%) of incident hypertension	HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
Taiwan MJ Cohort								
Consistently High PM _{2.5} Exposure Group	42,507	3327 (7.8%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	7717	443 (5.7%)	0.75 (0.67, 0.83)	< 0.001	0.76 (0.68, 0.85)	< 0.001	0.76 (0.68, 0.85)	< 0.001
Per 1 µg/m ³ decrease	50,224	3770 (7.5%)	0.94 (0.93, 0.96)	< 0.001	0.97 (0.95, 0.98)	< 0.001	0.96 (0.94, 0.97)	< 0.001
Per IQR decrease [†]	50,224	3770 (7.5%)	0.86 (0.82, 0.89)	< 0.001	0.92 (0.88, 0.96)	< 0.001	0.90 (0.86, 0.94)	< 0.001
UK Biobank								
Consistently High PM _{2.5} Exposure Group	87,140	2139 (2.5%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	17,782	360 (2.0%)	0.75 (0.66, 0.86)	< 0.001	0.75 (0.65, 0.85)	< 0.001	0.74 (0.65, 0.85)	< 0.001
Per 1 µg/m ³ decrease	104,922	2499 (2.4%)	0.84 (0.79, 0.90)	< 0.001	0.77 (0.71, 0.83)	< 0.001	0.74 (0.69, 0.81)	< 0.001
Per IQR decrease [†]	104,922	2499 (2.4%)	0.89 (0.85, 0.93)	< 0.001	0.83 (0.80, 0.88)	< 0.001	0.83 (0.80, 0.88)	< 0.001

[†] Analyses were conducted among participants in both PM_{2.5} exposure group. The interquartile ranges (IQR) for the change in PM_{2.5} concentration was 2.2 µg/m³ for the Taiwan MJ Cohort and 0.7 µg/m³ for the UK Biobank. HR, hazard ratio; CI, confidence interval.

Multiple imputation method was used to fill in missing information on covariates across five complete datasets. Model 1 included exposure groups and baseline PM_{2.5} exposure. Model 2 further adjusted for sex, age, ethnicity (only for the UK Biobank), educational background, average yearly household income, and area level socioeconomic conditions. Model 3 included all covariates from Model 2 and additionally adjusted for smoking status, alcohol use, vegetable and fruit intake, exercise intensity, diabetes, and dyslipidemia.

Table S9. Association between reduced exposure to ambient PM_{2.5} and the risk of incident hypertension after exclusion of participants with any residential address changes.

	N of participants	N (%) of incident hypertension	Model 1		Model 2		Model 3	
			HR (95% CI)	<i>P</i> value	HR (95% CI)	<i>P</i> value	HR (95% CI)	<i>P</i> value
Taiwan MJ Cohort								
Consistently High PM _{2.5} Exposure Group	28,716	2175 (7.6%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	5456	312 (5.7%)	0.84 (0.74, 0.96)	0.012	0.83 (0.73, 0.95)	0.008	0.83 (0.72, 0.95)	0.006
Per 1 µg/m ³ decrease	34,172	2487 (7.3%)	0.97 (0.95, 0.98)	< 0.001	0.98 (0.96, 0.99)	0.047	0.97 (0.95, 0.99)	0.006
Per IQR decrease [†]	34,172	2487 (7.3%)	0.91 (0.87, 0.96)	< 0.001	0.95 (0.90, 0.99)	0.047	0.93 (0.88, 0.98)	0.006
UK Biobank								
Consistently High PM _{2.5} Exposure Group	47,647	1048 (2.2%)	Reference	-	Reference	-	Reference	-
PM _{2.5} Reduction Group	10,439	212 (2.0%)	1.01 (0.83, 1.22)	0.943	0.98 (0.81, 1.19)	0.825	0.98 (0.81, 1.19)	0.841
Per 1 µg/m ³ decrease	58,086	1260 (2.2%)	1.03 (0.93, 1.14)	0.574	0.94 (0.83, 1.06)	0.314	0.91 (0.80, 1.03)	0.153
Per IQR decrease [†]	58,086	1260 (2.2%)	1.02 (0.95, 1.10)	0.574	0.96 (0.88, 1.04)	0.314	0.94 (0.86, 1.02)	0.153

[†] Analyses were conducted among participants in both PM_{2.5} exposure group. The interquartile ranges (IQR) for the change in PM_{2.5} concentration was 2.6 µg/m³ for the Taiwan MJ Cohort and 0.7 µg/m³ for the UK Biobank. HR, hazard ratio; CI, confidence interval.

Participants were restricted to those without any address changes during the follow-up period. Model 1 included exposure groups and baseline PM_{2.5} exposures. Model 2 further adjusted for sex, age, ethnicity (only for the UK Biobank), educational background, average yearly household income, and area level socioeconomic conditions. Model 3 included all covariates from Model 2 and additionally adjusted for smoking status, alcohol use, vegetable and fruit intake, exercise intensity, diabetes, and dyslipidemia.

4. Supplementary figures

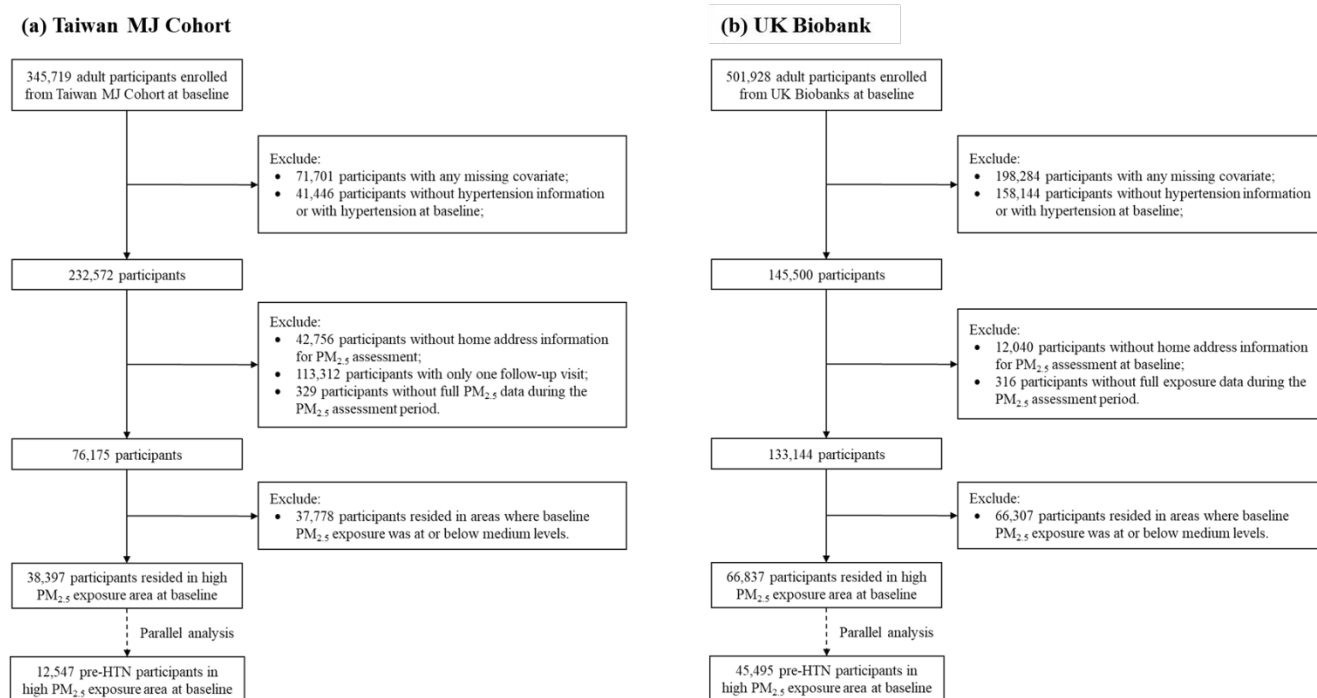


Figure S1. Selection procedure for the Taiwan MJ Cohort and the UK Biobank.

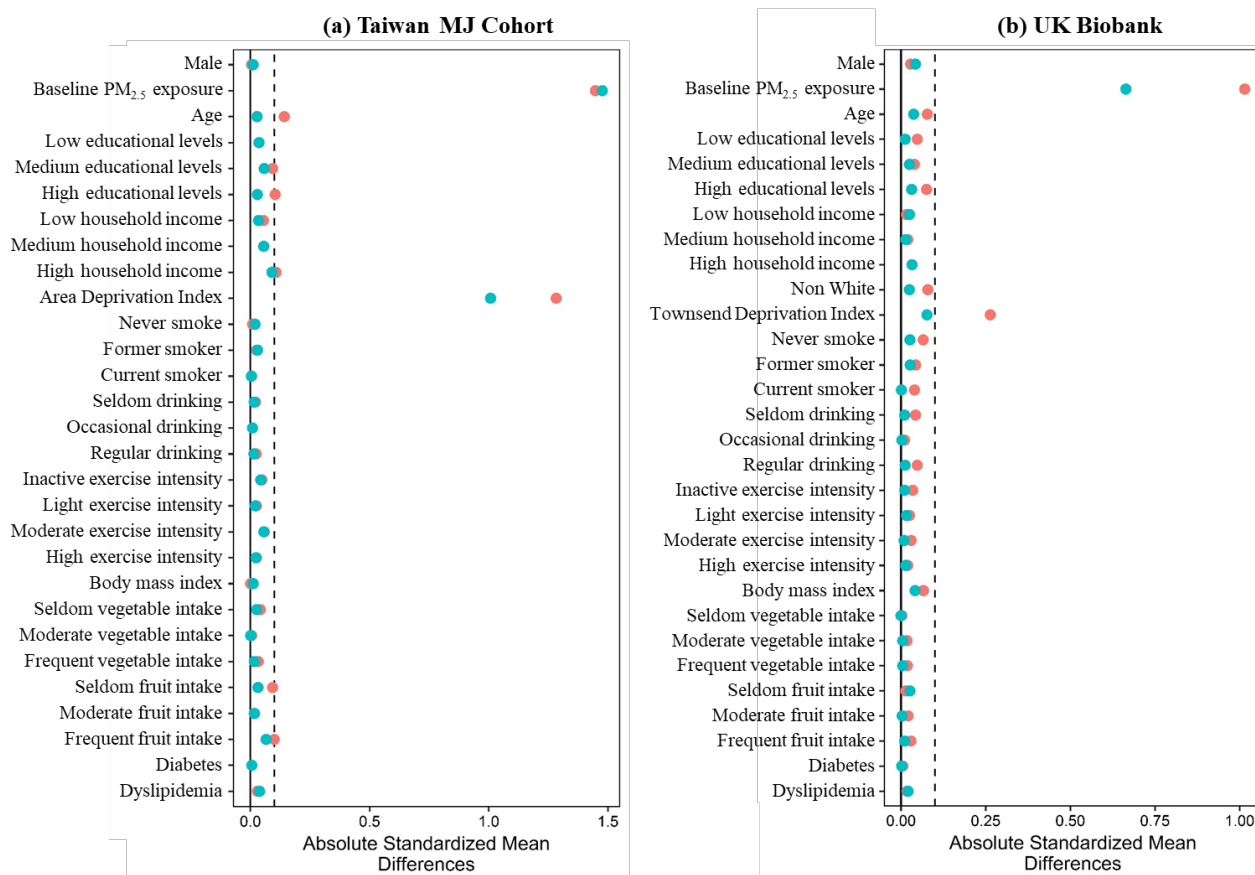


Figure S2. Covariate balance before and after weighting in each cohort.

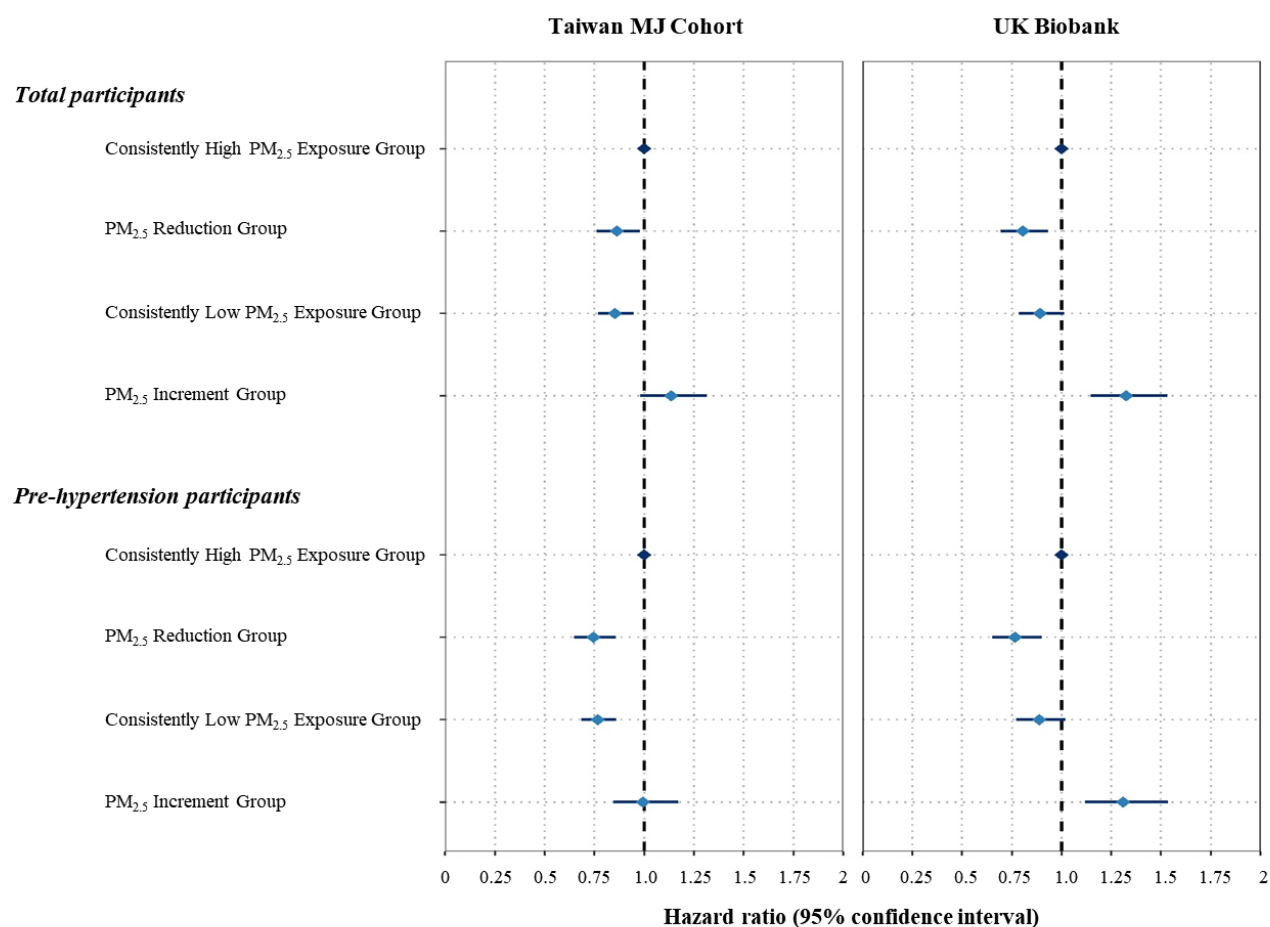


Figure S3. Associations between different exposure categories and the risk of hypertension by including participants whose baseline exposure was below the cohort-specific median.

References

- [1] Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. *Health Policy Plan*. 2006, 21(6):459–468. DOI: [10.1093/heapol/czl029](https://doi.org/10.1093/heapol/czl029)
- [2] National Statistics ROCT. DGBAS statistical database. 2025. Available: <https://www.stat.gov.tw/> (accessed on 25 March).