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Supplemental Material

Exposure to road, railway, and aircraft noise and arterial stiffness in the SAPALDIA study: annual average noise levels and temporal noise characteristics

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Table S1. Spearman rank correlations among brachial-ankle pulse wave velocity (baPWV) and the different residential outdoor noise indicators and air pollutant variables, n=2775.

	baPWV	Lden, air	Lden, rail	Lden, road	Lday, air	Lday, rail	Lday, road	Lnight, air	Lnight, rail	Lnight, road	IR day, all	IR night, all	NE day	NE night, all	NO_2
baPWV	1.00**														
Lden[a], aircraft (dB)	0	1.00**													
Lden[a], rail (dB)	0.04*	0.13**	1.00**												
Lden[a], road (dB)	-0.01	-0.03	0.02	1.00**											
Lday[b], aircraft	0	0.92**	0.16**	-0.05**	1.00**										
Lday[b], rail	0.03*	0.09**	0.92**	0.01	0.11**	1.00**									
Lday[b], road	-0.01	-0.03	0.02	1.00**	-0.05**	0.01	1.00**								
Lnight[c], aircraft	-0.01	0.55**	-0.06**	0.06**	0.33**	-0.07**	0.06**	1.00**							
Lnight[c], rail	0.04**	0.15**	0.98**	0.01	0.18**	0.89**	0.01	-0.05**	1.00**						
Lnight[c], road	-0.01	-0.03	0.02	1.00**	-0.05**	0.02	1.00**	0.06**	0.02	1.00**					
IR[d] day	-0.01	0.07**	0.03	-0.06**	0.04**	0.05**	-0.06**	-0.14**	0.03	-0.07**	1.00**				
IR[d] night (%)	0	-0.01	0.11**	0.11**	-0.04**	0.14**	0.11**	-0.15**	0.11**	0.10**	0.88**	1.00**			
NE[e] day	0	-0.03	-0.05**	0.77**	-0.05**	-0.05**	0.77**	0.04**	-0.06**	0.77**	-0.06**	0.22**	1.00**		
NE[e] night (n)	-0.01	-0.03	-0.05**	0.67**	-0.03	-0.05**	0.67**	0.06**	-0.06**	0.66**	-0.52**	-0.28**	0.80**	1.00**	
NO_2[f] ($\mu g/m^3$)	0.02	-0.02	0.21**	0.42**	0.08**	0.17**	0.42**	0.03	0.23**	0.42**	-0.29**	-0.19**	0.30**	0.39**	1.00**
$PM_{2.5}$[g] ($\mu g/m^3$)	0.03*	0.24**	0.08**	0.23**	0.31**	0.03	0.23**	0.19**	0.10**	0.23**	-0.36**	-0.33**	0.13**	0.28**	0.58**

*p-value < 0.1, **p-value < 0.05; [a] Annual average noise levels for the 24h with + 5 dB and + 10dB penalties for the evening and night (dB); [b]Annual average noise levels for the day-time (7am-11pm) (dB); [c]Annual average noise levels for the night-time (11pm-7am) (dB); [d] Total noise intermittency ratio (%); [e] Total number of noise events (number); [f] 2-y average nitrogen dioxide levels ($\mu g/m^3$), [g] 2-y average particulate matter levels of 2.5 μm ($\mu g/m^3$).

Table S2. Study characteristics in the study sample (n=2775) compared to the baseline samples and additional study characteristics.

Variables	Excluded (n=293)	Included (n=2775)	baPWV sample ≥ 50 years (n=3086)	All SAP3 ≥ 50 years (n=4832)	All SAP3 (n=6088)
Continuous variables [p50 (IQR)[a]]					
baPWV (m/s)	13.7 (3.2)	13.4 (3.1)	13.5 (3.1)	-	-
Lden[b], road (dB)	53.4 (10.4)	54.2 (10.6)	54.0 (10.6)	54.3 (10.7)	54.1 (10.8)
Lden[b], railway (dB)	30.0 (8.0)	30.0 (8.1)	30.0 (8.1)	30.0 (8.0)	30.0 (7.8)
Lden[b], aircraft (dB)	31.5 (7.5)	32.8 (8.0)	32.5 (7.9)	33.9 (8.3)	33.9 (8.5)
IR[c] night (%)	74.0 (31.9)	73.1 (27.2)	73.2 (27.4)	73.2 (27.2)	73.0 (26.9)
NE[d] night (n)	118 (171)	123 (179)	123 (177)	125 (181)	125 (178)
Lnight[e], road (dB)	44.5 (10.5)	45.3 (10.5)	45.3 (10.6)	45.4 (10.7)	45.3 (10.8)
Lnight[e], rail (dB)	20.6 (10.9)	20.0 (10.9)	20.0 (10.9)	20.0 (10.9)	20.0 (10.7)
Lnight[e], aircraft (dB)	20.0 (3.8)	20.0 (4.0)	20.0 (3.9)	20.0 (4.3)	20.0 (4.5)
IR[c] day (%)	68.2 (47.0)	63.8 (40.3)	64.2 (40.6)	63.4 (40.5)	63.4 (40.3)
NE[d] day (n)	421(752)	433 (870)	432 (862)	447 (877)	440 (870)
Lday[f], road (dB)	51.8 (10.7)	52.5 (10.7)	52.4 (10.6)	52.6 (10.7)	52.5 (10.8)
Lday[f], rail (dB)	30.0 (3.3)	30.0 (3.4)	30.0 (3.3)	30.0 (3.3)	30.0 (3.1)
Lday[f], aircraft (dB)	30.0 (6.6)	30.0 (7.0)	30.0 (7.0)	30.0 (7.5)	30.0 (7.7)
Nitrogen dioxide (µg/m^3)	16.5 (9.2)	17.3 (10.5)	17.2 (10.3)	17.6 (10.8)	17.2 (10.1)
Age (years)	63.6 (14.6)	63.2 (12.3)	63.3 (12.6)	63.6 (13.9)	60.3 (17.8)
Pack-years smoked	0.0 (20.4)	1.0 (20.5)	1.0 (20.4)[g]	1.0 (21.0)[h]	0.5 (18.5)[h]
Body mass index (kg/m^2)	26.4 (5.6)	25.9 (5.6)	26.0 (5.6)	26.1 (5.8)[h]	25.8 (5.7)[h]
Mean blood pressure (mmHg)	96.8 (15.2)	97.5 (16.0)	97.5 (15.8)	97.3 (15.8)[h]	96.3 (15.7)[h]
Noise sensitivity score (n)	29.0 (16.0)	32.0 (16.0)[h]	31.0 (16.0)[h]	32.0 (16.0)[i]	32.0 (16.0)[i]
Daytime sleepiness score (n)	14.0 (5.0)	14.0 (5.0)	14.0 (5.0)[g]	14.0 (5.0)[h]	14.0 (5.0)[h]
Categorical variables [n (%)]					
Sex, Women	113 (38.6)	1417 (51.1)	1530 (49.9)	2576 (53.3)	3191 (52.4)
Education, Low	25 (8.6)	169 (6.1)	194 (6.3)	383 (7.9)	414 (6.8)
Middle	185 (63.4)	1817 (65.5)	2002 (65.3)	3198 (66.2)	3980 (65.4)
High	82 (28.1)	789 (28.4)	871 (28.4)	1249 (25.9)	1692 (27.8)
Smoking, Never	105 (35.8)	1175 (42.3)	1280 (41.7)	2003 (41.6)	2646 (43.6)
Former	142 (48.5)	1140 (41.1)	1282 (41.8)	1974 (41.0)	2306 (38.0)
Current	46 (15.7)	460 (16.6)	506 (16.5)	836 (17.4)	1113 (18.4)
Second-hand smoking, Yes	31 (10.7)	330 (11.9)	361 (11.8)	599 (12.6)[g]	808 (13.5)[g]
Alcohol consumption, Yes	131 (52.8)	1286 (46.3)	1417 (46.9)[g]	1793 (45.1)[h]	2130 (42.2)[h]
Moderate physical activity, ≥ 150min/week	131 (59.5)	1648 (59.4)	1779 (59.4)[g]	2259 (57.5)[h]	2798 (56.0)[h]
Raw vegetables, ≥ 5 days/week	160 (65.3)	2013 (72.5)	2173 (72.0)[g]	2825 (71.1)[h]	3550 (70.3)[h]
Cooked vegetables, ≥ 5 days/week	130 (52.8)	1586 (57.2)	1716 (56.8)[g]	2274 (57.2)[h]	2841 (56.3)[h]
Fish, ≥ 1 day/week	165 (67.6)	1889 (68.1)	2054 (68.0)[g]	2704 (68.0)[h]	3363 (66.6)[h]
Area, Basel	39 (13.3)	329 (11.9)	368 (12.0)	620 (12.8)	814 (13.4)
Wald	47 (16.0)	484 (17.4)	531 (17.3)	893 (18.5)	1117 (18.3)

Table S2. Continued.

Variables	Excluded (n=293)	Included (n=2775)	baPWV sample ≥ 50 years (n=3086)	All SAP3 ≥ 50 years (n=4832)	All SAP3 (n=6088)
Categorical variables [n (%)]					
Davos	32 (10.9)	289 (10.4)	321 (10.5)	448 (9.3)	511 (8.4)
Lugano	43 (14.7)	357 (12.9)	400 (13.0)	645 (13.3)	769 (12.6)
Montana	31 (10.6)	307 (11.1)	338 (11.0)	420 (8.7)	565 (9.3)
Payerne	32 (10.9)	350 (12.6)	382 (12.5)	674 (13.9)	878 (14.4)
Aarau	56 (19.1)	457 (16.5)	513 (16.7)	705 (14.6)	905 (14.9)
Geneva	13 (4.4)	202 (7.3)	215 (7.0)	427 (8.8)	529 (8.7)
Bedroom orientation, Backyard	152 (63.1)[h]	1607 (58.2)	1759 (58.6)[g]	2258 (57.1)[h]	2878 (57.4)[h]
Close window at night, Yes	51 (21.0)[h]	621 (22.5)	672 (22.4)[g]	891 (22.6)[h]	1111 (22.2)[h]
Noise annoyance, Yes	108 (47.2)	1588 (57.2)	1696 (56.5)[g]	2239 (56.6)[h]	2831 (56.3)[h]
CVD medication, Yes	93 (31.7)	835 (30.1)	928 (30.2)	1375 (28.5)	1442 (23.7)
CVD, Yes	123 (42.0)	1090 (39.3)	1213 (39.6)	1913 (41.2)[g]	2072 (35.4)[g]

[a]Median (interquartile range); [b]Annual average noise levels for the 24h with + 5 dB and + 10dB penalties for the evening and night, respectively; [c]Total noise intermittency ratio; [d]Total number of noise events; [e]Annual average noise levels for the night-time (11pm-7am); [f]Annual average noise levels for the day-time (7am-11pm); [g] < 4% missing observations [h] < 20% missing observations;
[i] < 31% missing observations. Cells without missing footnote have < 1% missing observations.

Table S3. Associations of annual average transportation noise levels (Lden) and total noise intermittency ratio (IR) with arterial stiffness, expressed per 10 dB or 10 % change in IR, respectively, instead of IQRs (n=2775).

Noise indicators	Single-exposure models	Multi-exposure model A	Multi-exposure model B	Multi-exposure model C
	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)
Lden, aircraft	-0.27 (-1.64, 1.11)	-0.42 (-1.80, 0.97)	-0.39 (-1.78, 1.00)	-0.32 (-1.71, 1.08)
Lden, railway	1.08 (0.39, 1.78)**	1.08 (0.38, 1.78)**	1.15 (0.44, 1.86)**	1.17 (0.47, 1.87)**
Lden, road	0.18 (-0.47, 0.83)	0.15 (-0.50, 0.80)	0.23 (-0.44, 0.89)	0.22 (-0.43, 0.88)
IR_{night}	-0.03 (-0.26, 0.21)	-	-0.12 (-0.36, 0.13)	-
IR_{day}	-0.14 (-0.33, 0.06)	-	-	-0.18 (-0.38, 0.01)*

Single-exposure models include one noise indicator at a time. Multi-exposure models include all noise indicators. All linear mixed models were adjusted for sex, age, sex×age, education, smoking status, pack-years smoked, secondary smoke, alcohol consumption, diet, body mass index (BMI), BMI^2, physical activity, mean arterial pressure (MAP), MAP×sex, nitrogen dioxide, noise truncation indicators, and a random intercept by study area. *p-value<0.1, **p-value<0.05.

Table S4. Association of annual average transportation noise levels (Lden), total day-time noise intermittency ratio (IR_{day}), and total number of day-time noise events (NE_{day}) with arterial stiffness (n=2775).

	Single-exposure models	Multi-exposure model A	Multi-exposure model B	Multi-exposure model C
Noise variables	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)
Lden, road	0.19 (-0.50, 0.88)	0.16 (-0.53, 0.85)	0.24 (-0.46, 0.93)	-0.04 (-1.04, 0.96)
Lden, railway	0.87 (0.31, 1.43)**	0.87 (0.31, 1.43)**	0.94 (0.37, 1.50)**	0.93 (0.36, 1.49)**
Lden, aircraft	-0.21 (-1.30, 0.88)	-0.33 (-1.43, 0.77)	-0.25 (-1.35, 0.85)	-0.32 (-1.42, 0.78)
IR_{day}	-0.52 (-1.31, 0.26)	-	-0.74 (-1.54, 0.05)*	-
NE_{day}, Q1 (0-209)	Ref.	-	-	Ref.
NE_{day}, Q2 (210-433)	0.70 (-0.49, 1.90)	-	-	0.90 (-0.31, 2.11)
NE_{day}, Q3 (434-1079)	0.95 (-0.25, 2.16)	-	-	1.14 (-0.20, 2.48)*
NE_{day}, Q4 (1080-5572)	0.56 (-0.73, 1.84)	-	-	0.77 (-1.04, 2.57)

Single-exposure models include one noise indicator at a time. Multi-exposure models include all noise indicators. Multi-exposure model A includes all source-specific Lden levels; model B = model A+IR; model C = model A + NE. All percent changes are per IQR of the respective noise indicator (road: 10.6 dB, railway: 8.1 dB, aircraft: 8 dB, IR day: 40.3%), or quartile for NE. All linear mixed models were adjusted for sex, age, sex×age, education, smoking status, pack-years smoked, secondary smoke, alcohol consumption, diet, body mass index (BMI), BMI^2, physical activity, mean arterial pressure (MAP), MAP×sex, nitrogen dioxide, noise truncation indicators, and a random intercept by study area. *p-value<0.1, **p-value<0.05.

Table S5. Sensitivity analyses for the association between annual average transportation noise levels (Lden) and arterial stiffness (baPWV) applying inverse probability weighting for participation selection bias, or excluding non-movers, or participants with hearing impairment, or with CVD.

Models	Lden, road % (95%CI)	Lden, railway % (95%CI)	Lden, aircraft % (95%CI)
All (n=2775)	0.16 (-0.53, 0.85)	0.87 (0.31, 1.43)**	-0.33 (-1.43, 0.77)
IPW (n=2754)	0.40 (-0.35, 1.14)	1.21 (0.32, 2.09)**	-0.09 (-0.02, 0.08)
Non-movers (n=1850)	0.31 (-0.58, 1.20)	0.86 (0.19, 1.53)**	0.19 (-1.19, 1.56)
No hearing impairment (n=1995)	-0.06 (-0.88, 0.77)	0.92 (0.26, 1.58)**	-0.11 (-1.45, 1.24)
No CVD (n=1684)	0 (-0.85, 0.84)	0.89 (0.17, 1.61)**	-0.62 (-1.99, 0.75)

All percent changes are per IQR of the respective noise indicator (road: 10.6 dB, railway: 8.1 dB, aircraft: 8 dB). Multi-exposure linear mixed models were adjusted for all transportation noise sources, their noise truncation indicators, sex, age, sex×age, education, smoking status, pack-years smoked, secondary smoke, alcohol consumption, diet, body mass index (BMI), BMI^2, physical activity, mean arterial pressure (MAP), MAP×sex, nitrogen dioxide, and a random intercept by study area. [a]Lday and Lnight are truncated at 30 dB (aircraft and railway) and 35 dB (road) for direct comparison with Lden. *p-value < 0.1, ** p-value < 0.05.

Table S6. Median source-specific noise levels and interquartile ranges in the entire sample, and percentage of noise exposed by groups of potential effect modifiers (n=2775).

	Lden, road		Lden, railway		Lden, aircraft	
Variable	% Exposed	Median (IQR)	% Exposed	Median (IQR)	% Exposed	Median (IQR)
Male	99.6	53.8 (10.6)	43.8	30.0 (7.7)	57.0	32.2 (7.8)
Female	99.7	54.6 (10.7)	45.3	30.0 (8.5)	58.2	33.4 (8.2)
Day sleepiness, < p50	99.7	54.3 (10.9)	44.5	30.0 (8.2)	56.0	31.9 (8.0)
≥ p50	99.7	54.0 (10.1)	44.7	30.0 (8.0)	59.2	34.1 (8.0)
Noise annoyance, < p75	99.6	52.3 (9.2)	43.4	30.0 (7.4)	58.6	32.5 (7.6)
≥ p75	99.9	58.8 (10.3)	47.1	30.0 (9.8)	55.6	33.4 (8.4)
Noise sensitivity, < p50	99.6	54.3 (10.4)	44.7	30.0 (8.4)	55.9	32.2 (8.1)
≥ p50	99.6	53.9 (10.7)	42.4	30.0 (7.5)	56.0	31.8 (7.1)
IR_{night}[a], ≤ 40	100	52.5 (9.8)	47.3	30.0 (6.9)	63.0	35.5 (8.1)
40.1-60	99.6	53.5 (11.2)	44.0	30.0 (8.3)	61.1	34.5 (7.2)
60.1-80	99.7	53.9 (11.5)	37.9	30.0 (5.8)	56.5	31.9 (7.8)
> 80	99.6	55.3 (9.9)	50.7	30.2 (13.0)	55.1	31.2 (10.7)
Rural area	99.3	53.2 (10.3)	36.3	30.0 (6.2)	37.8	30.0 (1.8)
Urban area	99.9	54.9 (10.8)	49.8	30.0 (8.8)	70.2	36.2 (14.6)
Bedroom orientation, Street	99.7	55.6 (10.3)	41.2	30.0 (7.9)	54.9	31.2 (6.8)
Backyard	99.6	53.1 (10.8)	47.0	30.0 (8.3)	59.4	34.4 (8.8)
Closing windows, No	99.6	53.5 (10.4)	45.6	30.0 (8.2)	59.5	33.6 (8.1)
Yes	99.8	56.8 (11.8)	40.6	30.0 (7.8)	51.9	30.9 (6.8)

[a] Total night-time noise intermittency ratio

Table S7. Source-specific noise levels for participants exposed to railway noise levels (n=1237, 44.6%) and by intermittency ratio category.

	Lden, road	Lden, railway	Lden, aircraft
	median (IQR)	median (IQR)	median (IQR)
Overall	54.4 (10.6)	39.6 (12.1)	35.5 (9.4)
IR_{night}[a] ≤ 40	54.4 (10.0)	37.2 (8.0)	35.7 (8.1)
40.1 - 60	53.5 (11.2)	39.2 (9.9)	35.5 (7.6)
60.1 - 80	55.0 (11.9)	38.1 (10.9)	35.7 (11.2)
> 80	54.2 (9.9)	42.7 (17.5)	34.6 (15.9)

[a] Total night-time noise intermittency ratio

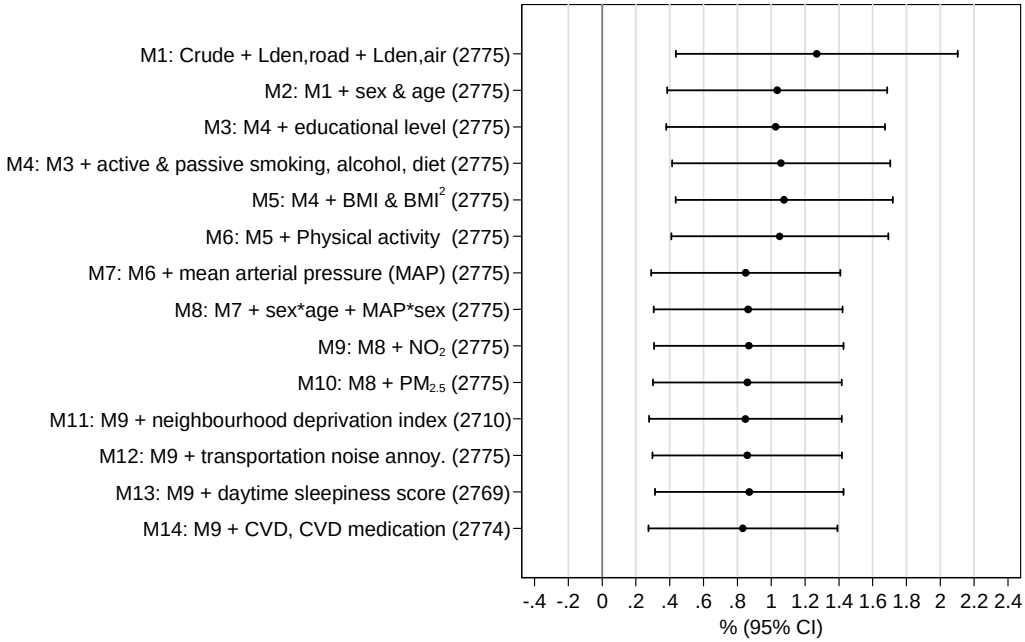

Figure S1. Association between annual average railway noise levels (Lden) and arterial stiffness (baPWV) across different model adjustments. All linear mixed models included a random intercept by study area and the noise truncation indicators. Dot: % change in baPWV per IQR change in Lden (8.1 dB); spikes: 95% confidence interval. M=model (sample size). BMI: Body Mass Index, NO_2: Nitrogen dioxide, $PM_{2.5}$: particulate matter levels of 2.5 μm; CVD: Cardiovascular Disease.

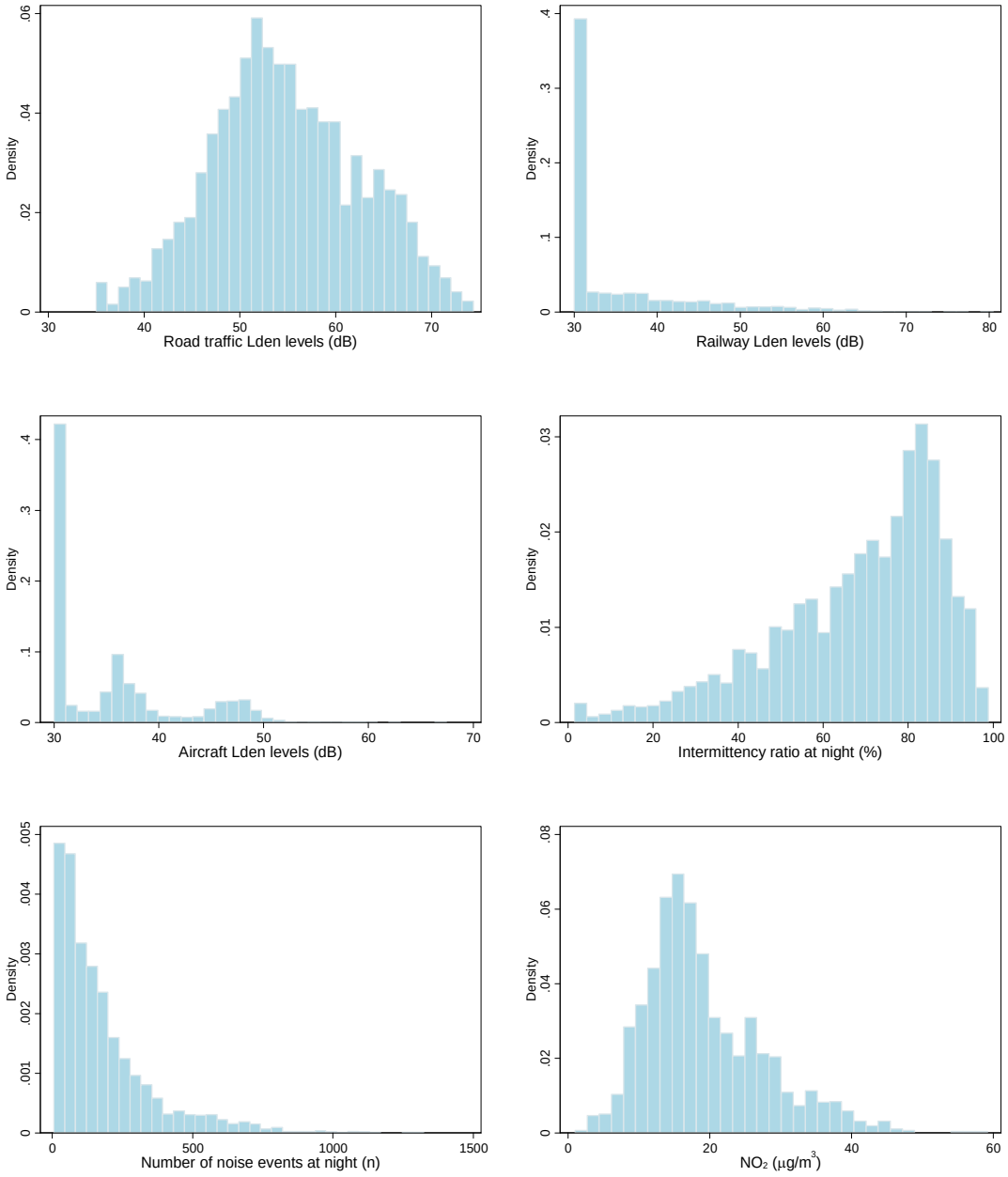

Figure S2: Distribution of the main noise and air pollution indicators in the study sample.

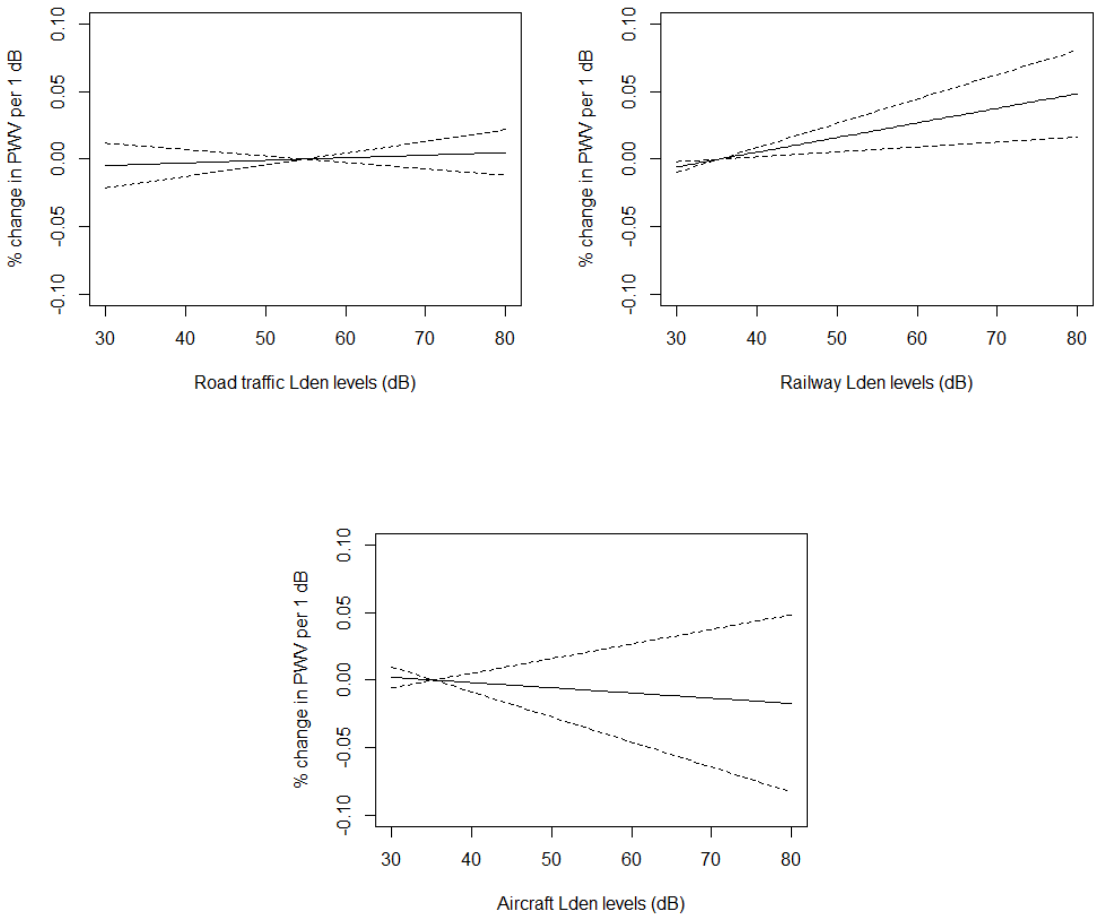

Figure S3. Thin plate penalized smoothing splines for the association between annual average transportation noise levels (Lden) and arterial stiffness (baPWV), per 1 dB. Generalized additive models were adjusted for the complementary Lden sources, their noise truncation indicators, and sex, age, sex×age, education, smoking status, pack-years smoked, secondary smoke, alcohol consumption, diet, body mass index (BMI), BMI^2, physical activity, mean arterial pressure (MAP), MAP×sex, nitrogen dioxide, and a random intercept by study area.