Appendix A

Spatial Assessment of the attributable burden of disease due to transportation noise in England

Calvin Jephcote[1*], Sierra N. Clark[2*], Anna L. Hansell[1,3], Nigel Jones[4], Yingxin Chen[1], Claire Blackmore[1], Katie Eminson[1], Megan Evans[1], Xiangpu Gong[3], Kathryn Adams[1], Georgia Rodgers[2], Benjamin Fenech[2,3**], John Gulliver[1,3**]

[1] Centre for Environmental Health and Sustainability, University of Leicester, Leicester, UK
[2] Noise and Public Health, Radiation Chemical and Environmental Hazards, Science Group, UK Health Security Agency, UK
[3] NIHR Health Protection Research Unit in Environmental Exposures and Health at the University of Leicester
[4] Extrium, UK

*Joint first authors
** Joint senior/corresponding authors

**Table A1. ICD-10 codes used to classify underlying cause of death for mortality fractions**

Health outcome	ICD codes	ICD codes: Recorded underlying causes of death in England (2009-13)
Ischemic heart disease	I20-25	I209, I249, I251, I255, I258
Diabetes mellitus	E08-13	E107, E109, E110, E111, E112, E113, E114, E115, E116, E117, E119
Stroke	I60-69	I609, I630, I631, I632, I633, I634, I635, I636, I638, I639, I672, I678, I692, I693, I698

LAD-level distribution of population exposure to noise ≥ 50 dB (L$_{night}$ and L$_{den}$)
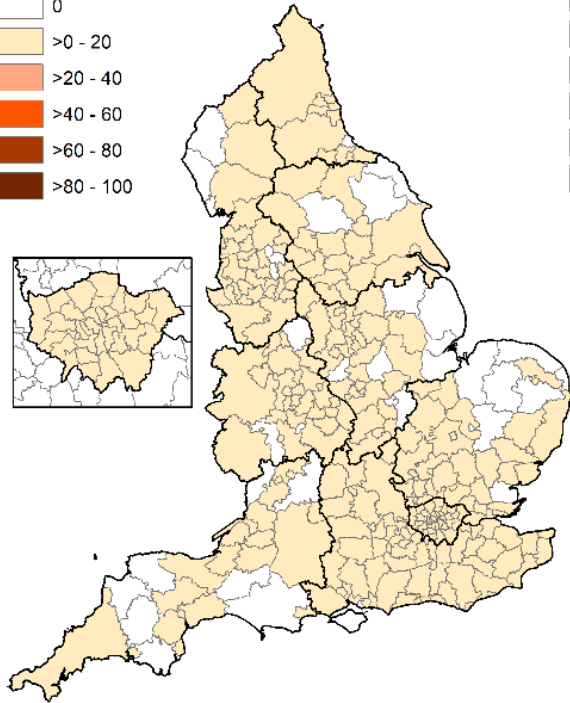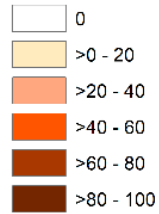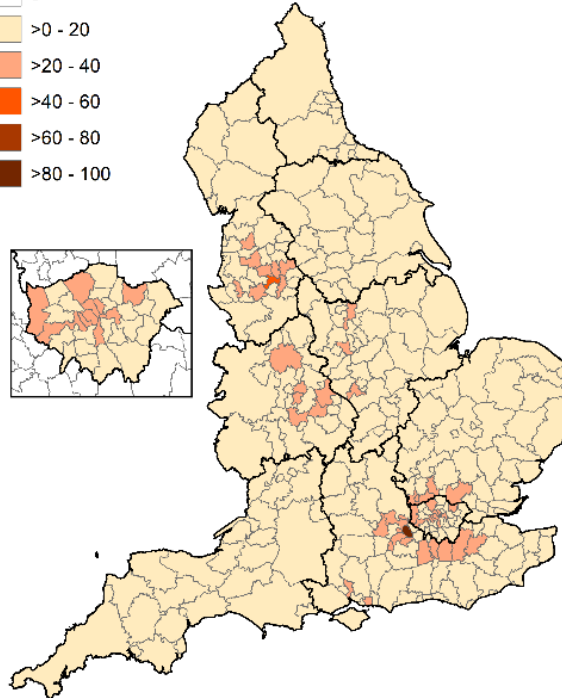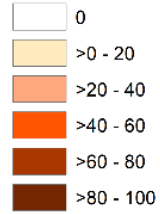
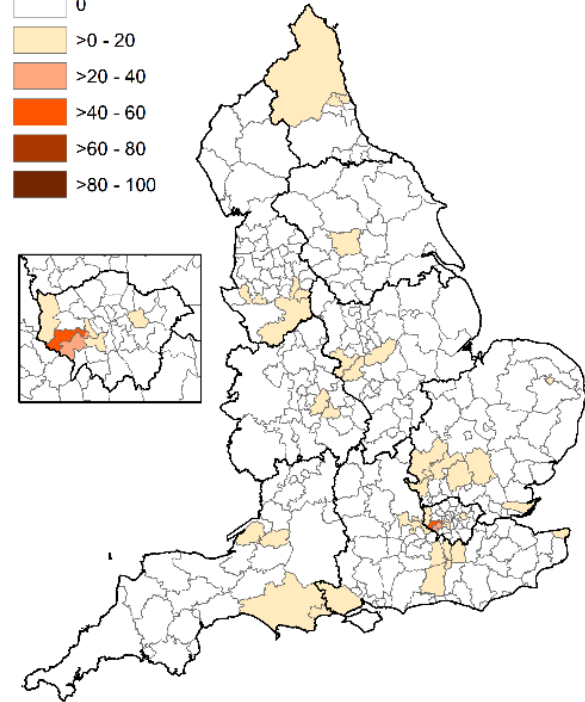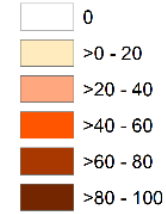**Figure A1. Spatial variation in the percentage (%) of the population exposed to road, railway, and aircraft night-time noise from major sources above 50 dB (L$_{night}$) across local authorities (LADs) in England, based on strategic noise mapping.**
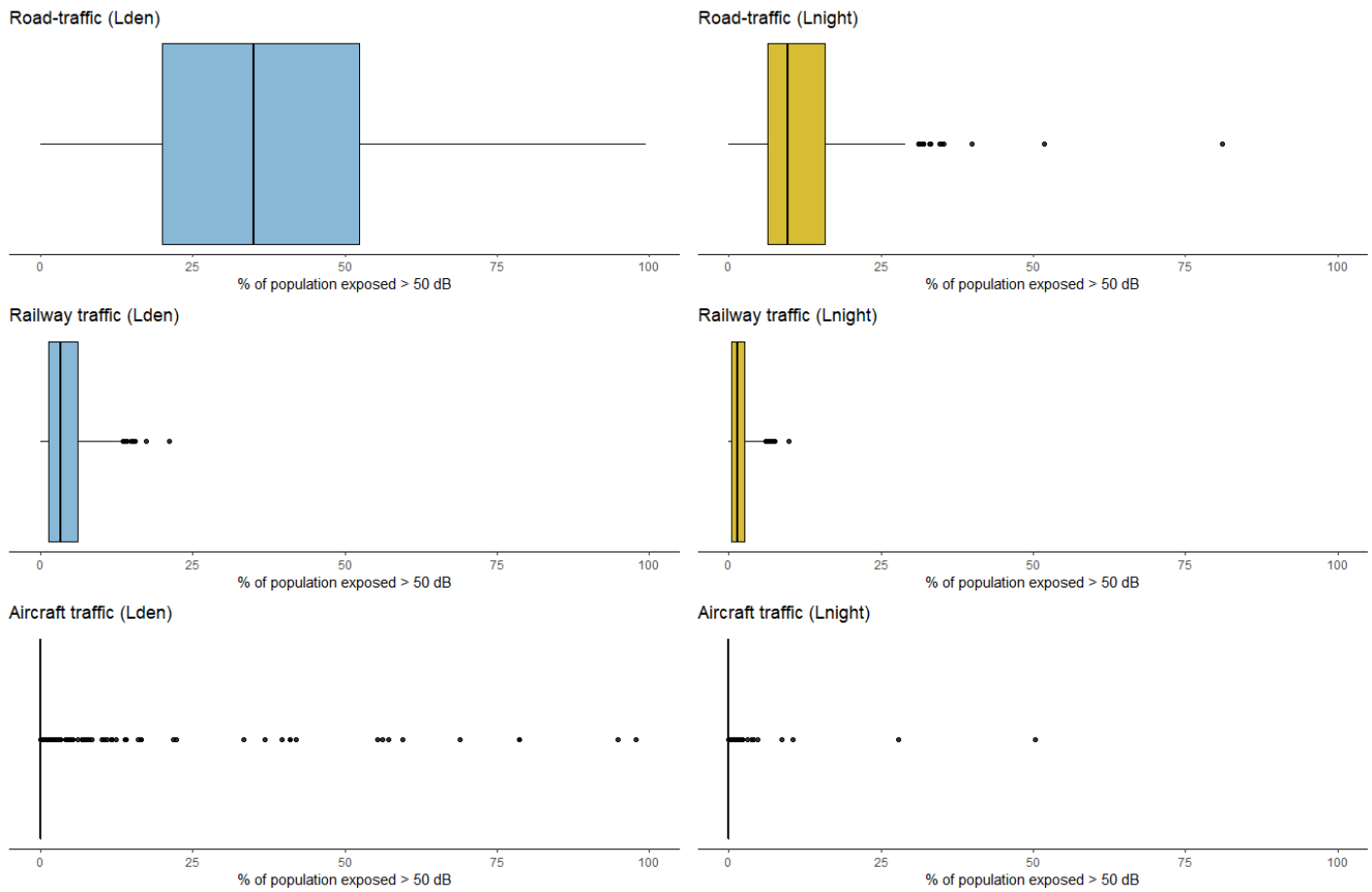
Figure A2. Distribution of the percentage of the population exposed to L$_{den}$ and L$_{night}$ transportation noise at or above 50 dB across Local Authority Districts (LADs) in England. The vertical line represents the median, the bounding box around the line the interquartile range (IQR) and the dotted points are outlier LADs in the distribution.

Sensitivity analysis with alternative disability weights
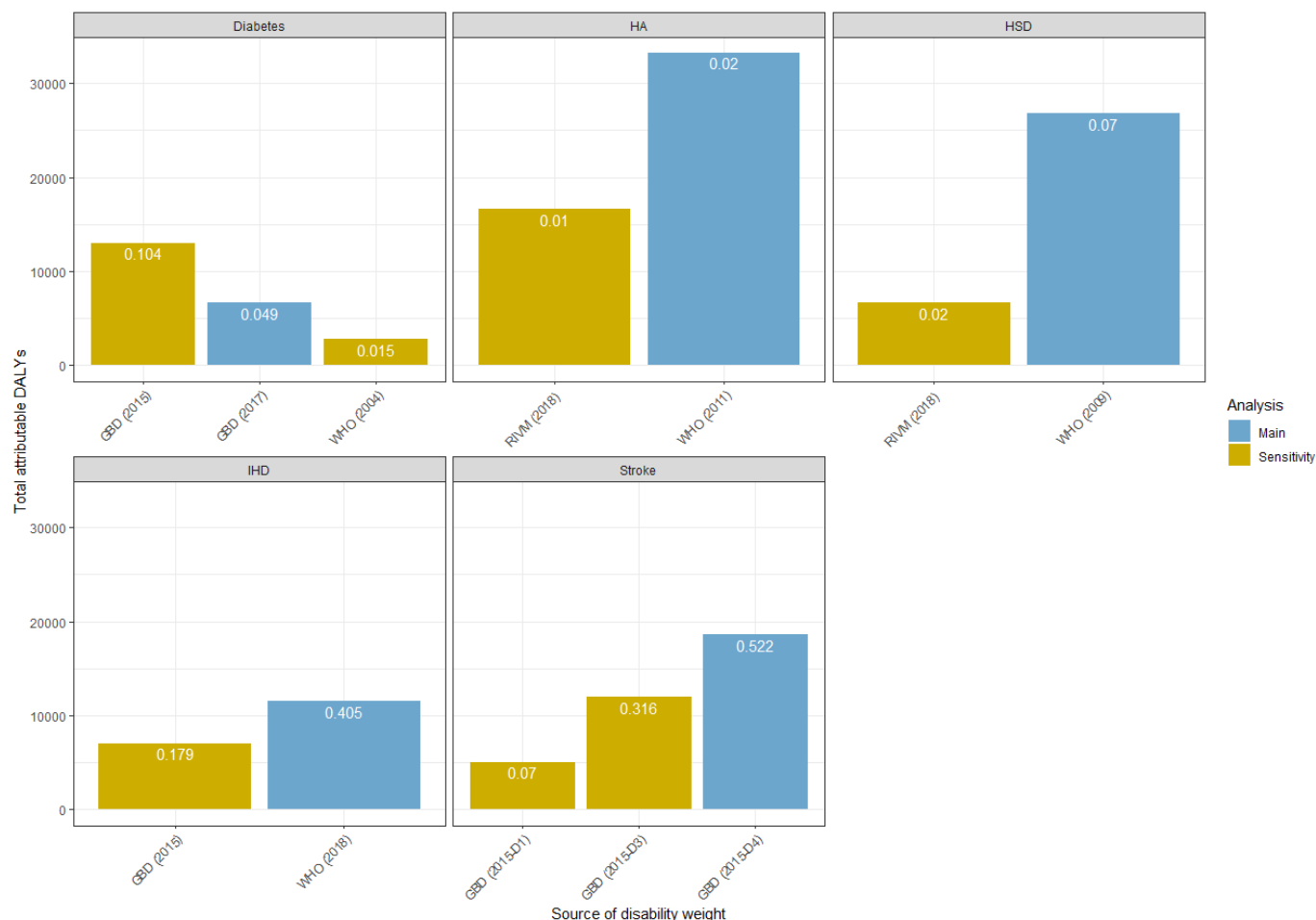
Figure A3. Sensitivity analyses comparing the total attributable DALYs due to road-traffic noise exposure above 50 dB in England using alternative disability weights. Estimates are for the adult population (20+) in 2018. Numbers on the bar plots indicate the disability weight. Main: DW used in main analysis; Sensitivity: Alternative DW; IHD: Ischemic heart disease; HA: Highly annoyed; HSD: Highly sleep disturbed.

Table A2. Description of disability weights and sources of information. Bolded entries indicate disability weights used in the main analysis.

| Health outcome	Source	Description	Disability Weight (central estimate)	Citation
Highly annoyed	**WHO 2011**	**Highly annoyed**	**0.02**	(WHO Regional Office for Europe 2011)
	RIVM 2018	Highly annoyed	0.01	(National Institute for Public Health and the Environment (RIVM) 2018)
Highly sleep disturbed	**WHO 2009**	**Highly sleep disturbed**	**0.07**	(WHO 2009)
	RIVM 2018	Highly sleep disturbed	0.02	(National Institute for Public Health and the Environment (RIVM) 2018)
Ischemic heart disease	**WHO 2018**	**Ischaemic Heart Disease**	**0.405**	(WHO 2018)
	GBD 2015	Severe heart failure	0.179	(Salomon et al. 2015)
Stroke	**GBD 2015-D4**	**Long-term consequences severe**	**0.552**	(Salomon et al. 2015)
	GBD 2015-D3	Long-term consequences, moderate, plus cognition problems	0.316	(Salomon et al. 2015)
	GBD 2015-D1	Long-term consequences, moderate	0.07	(Salomon et al. 2015)
Diabetes mellitus	**GBD 2017**	**Uncomplicated Diabetes Mellitus**	**0.049**	(Global Burden of Disease Collaborators 2017)
	GBD 2015	Chronic kidney disease (stage 4)	0.104	(Salomon et al. 2015)
	WHO 2004	Diabetes Mellitus	0.015	(WHO 2004)

GBD: Global burden of disease study coordinated by the Institute of Health Metrics and Evaluation (University of Washington); WHO: World Health Organization: RIVM: National Institute for Public Health and the Environment.

Sensitivity analyses comparing alternative exposure response relationships (ERR)

Table A3. Attributable burden of disease due to road-traffic noise exposure using alternative exposure response relationships (ERR) for ischemic heart disease.

	Ischemic heart disease					
ERR	Main ERR (van Kempen et al. 2018)			Sensitivity ERR (Vienneau et al. 2019)		
ERR range	53 – 80 dB			40 – 80 dB		
Metrics	RR per 10 dB [95% CI]	PAF (%)	Total DALYs/yr [95% CI]	RR per 10 dB [95% CI]	PAF (%)	Total DALYs/yr [95% CI]
Estimate [95% CI]	1.08 [1.01-1.15]	1.5%	11,556 [1,427-21,942]	1.02 [1.0-1.04]	1.3%	10,582 [0 - 21,453]

%: percentage; PAF: Population attributable fraction: DALY: Disability adjusted life year; RR: Relative risk; ERR: Exposure Response Relationship; CI: Confidence interval

Table A4. Attributable burden of disease due to road-traffic noise exposure using alternative exposure response relationships (ERR) for stroke.

	Stroke					
ERR	Main ERR (van Kempen et al. 2018)			Sensitivity ERR (Roswall et al. 2021)		
ERR range	50 – 70 dB			40 – 70 dB		
Metrics	RR per 10 dB [95% CI]	PAF (%)	Total DALYs/yr [95% CI]	RR per 10 dB [95% CI]	PAF (%)	Total DALYs [95% CI]
Estimate [95% CI]	1.14 [1.03 – 1.25]	3.8%	18,592 [2,926 - 41,093]	1.06 [1.03 - 1.08]	3.9%	19,070 [6,901- 32,006]

%: percentage; PAF: Population attributable fraction: DALY: Disability adjusted life year; RR: Relative risk; ERR: Exposure Response Relationship; CI: Confidence interval

Table A5. Attributable burden of disease due to road-traffic noise exposure using alternative exposure response relationships (ERR) for annoyance (HA).

Source of exposure response relationship	% of the population highly annoyed	Number of people highly annoyed	Total DALYs/yr
Main ERR (Guski et al. 2017) *WHO Excl. Asian and Alpine* *	3.9%	1,662,157	33,243
Sensitivity ERR (Guski et al. 2017) *WHO full dataset* **	5.4%	2,311,990	46,240
Sensitivity ERR (Fenech et al. 2022) *2022 update* ***	5.1%	2,195,850	43,917

%: percentage; DALY: Disability adjusted life year. Noise range was 40 – 80 dBA for all ERRs.

*ERR developed by excluding Asian and Alpine studies from WHO database of studies (*WHO Excl. Asian and Alpine*):
%HA = $116.4304 - 4.7342 \times L_{den} + 0.0497 \times L_{den}^2$

** ERR developed including all studies in WHO database of studies ('*WHO full dataset*'):
%HA = $78.9270 - 3.1162 \times L_{den} + 0.0342 \times L_{den}^2$

*** ERR developed by updating the WHO ERR curve with new studies published between 2014-2022 (*2022 update*):
%HA = $57.256 - 2.5731 \times L_{den} + 0.0312 \times L_{den}^2$

Table A6. Attributable burden of disease due to conventional railway-traffic noise exposure using alternative exposure response relationships (ERR) for annoyance (HA).

Source of exposure response relationship	% of the population highly annoyed	Number of people highly annoyed	Total DALYs/yr
Main ERR (Guski et al. 2017) *WHO full dataset* *	0.7%	295,766	5,916
Sensitivity ERR (Fenech et al. 2022) *2022 update* **	0.8%	341,849	6,837

%: percentage; DALY: Disability adjusted life year. Noise range was 40 – 85 dBA for all ERRs.

* ERR in WHO commissioned systematic review (Guski et al. 2017)

$\%HA = 38.1596 - 2.05538 \times L_{den} + 0.0285 \times L_{den}^2$

** ERR developed by updating the WHO ERR curve with new studies published between 2014-2022:

$\%HA = 39.216 - -2.1835 \times L_{den} + 0.0311 \times L_{den}^2$

Road-traffic noise DALYs (per 100,000 people) lost – Regions

Table A7. Road-traffic noise DALY rates (per 100,000 people) by English regions (2018).

Regions	Highly annoyed	Highly sleep disturbed	Ischemic heart disease (IHD)	Stroke	Diabetes
North East	55	36	25	41	12
North West	99	79	43	63	21
Yorkshire and The Humber	69	55	29	45	15
East Midlands	55	41	20	34	12
West Midlands	78	64	29	48	19
East of England	54	37	18	30	11
London	116	101	28	39	21
South East	80	66	26	46	15
South West	53	41	20	37	11

Table shows the central DALY estimates.

Regional prevalence and mortality estimates

Table A8. Disease prevalence per 100,000 people by English regions.

Region	Measurement	Prevalence per 100,000 people		
		Diabetes Mellitus	**IHD**	**Stroke**
East Midlands	Estimate	6,823	3,502	1,849
	Lower 95% CI	6,726	3,438	1,803
	Upper 95% CI	6,921	3,567	1,897
East of England	Estimate	6,128	3,174	1,715
	Lower 95% CI	6,039	3,116	1,672
	Upper 95% CI	6,218	3,233	1,759
London	Estimate	6,229	2,066	1,063
	Lower 95% CI	6,132	2,015	1,027
	Upper 95% CI	6,328	2,118	1,101
North East	Estimate	6,782	4,339	2,202
	Lower 95% CI	6,679	4,264	2,148
	Upper 95% CI	6,887	4,416	2,257
North West	Estimate	6,739	3,800	1,938
	Lower 95% CI	6,630	3,726	1,885
	Upper 95% CI	6,850	3,876	1,993
South East	Estimate	5,760	2,956	1,709
	Lower 95% CI	5,665	2,895	1,662
	Upper 95% CI	5,856	3,019	1,757
South West	Estimate	6,107	3,529	2,107
	Lower 95% CI	6,042	3,485	2,072
	Upper 95% CI	6,172	3,574	2,142
West Midlands	Estimate	7,276	3,353	1,834
	Lower 95% CI	7,175	3,290	1,787
	Upper 95% CI	7,378	3,418	1,883
Yorkshire and The Humber	Estimate	6,606	3,804	1,951
	Lower 95% CI	6,506	3,735	1,902
	Upper 95% CI	6,708	3,874	2,002

Source of prevalence data described in Section 2.7 in Methods (main paper)

Table A9. All-cause mortality and Age-Standardised Mortality Rates (ASMR) per 100,000 people by sex and English regions in 2018.

Region	LAD Count	Total Population	Mortalities per 100,000			ASMR per 100,000 *		
			Total	Male	Female	Total	Male	Female
East Midlands	40	4,804,000	964	960	968	951	942	961
East of England	45	6,202,300	956	954	958	882	877	887
London	33	8,908,300	561	567	556	815	829	802
North East	12	2,658,700	1,084	1,076	1,093	1,046	1,037	1,056
North West	39	7,291,300	1,002	998	1,005	1,024	1,018	1,030
South East	64	9,134,600	914	901	927	851	845	858
South West	30	5,599,100	1,047	1,034	1,059	878	871	884
West Midlands	30	5,901,800	963	966	961	969	977	962
Yorkshire and The Humber	21	5,480,100	970	968	972	984	987	982

Source of mortality data described in Section 2.7 in Methods (main paper)
* Mortality rates standardised to national population profiles for England using 5-year age bands of mortality and population counts by sex in 2018, published by the Office for National Statistics (ONS).

References

Fenech, B.,Clark, S.N.,Rodgers, G. An update to the WHO 2018 Environmental Noise Guidelines exposure response relationships for annoyance from road and railway noise. Inter-noise; 2022

Global Burden of Disease Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017;390:1211-1259

Guski, R.,Schreckenberg, D.,Schuemer, R. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance. International Journal of Environmental Research and Public Health 2017;14

National Institute for Public Health and the Environment (RIVM). Study on methodology to perform environmental noise and health assessment. Netherlands: RIVM; 2018

Roswall, N.,Pyko, A.,Ogren, M.,Oudin, A.,Rosengren, A.,Lager, A.,Poulsen, A.H.,Eriksson, C.,Segersson, D.,Rizzuto, D.,Andersson, E.M.,Aasvang, G.M.,Engstrom, G.,Jorgensen, J.T.,Selander, J.,Christensen, J.H.,Thacher, J.,Leander, K.,Overvad, K.,Eneroth, K.,Mattisson, K.,Barregard, L.,Stockfelt, L.,Albin, M.,Ketzel, M.,Simonsen, M.K.,Spanne, M.,Raaschou-Nielsen, O.,Magnusson, P.K.E.,Tiittanen, P.,Molnar, P.,Ljungman, P.,Lanki, T.,Lim, Y.H.,Andersen, Z.J.,Pershagen, G.,Sorensen, M. Long-Term Exposure to Transportation Noise and Risk of Incident Stroke: A Pooled Study of Nine Scandinavian Cohorts. Environmental Health Perspectives 2021;129

Salomon, J.,Haagsma, J.A.,Davis, A.,de Noordhout, C.M.,Polinder, S.,Havelaar, A.H.,Cassini, A.,Devleesschauwer, B.,Kretzschmar, M.,Speybroeck, N.,Murray, C.J.L.,Vos, T. Disability weights for the Global Burden of Disease 2013 study. Lancet Glob Health 2015;3:E712-E723

van Kempen, E.,Casas, M.,Pershagen, G.,Foraster, M. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary. International Journal of Environmental Research and Public Health 2018;15

Vienneau, D.,Eze, I.C.,Probst-Hensch, N.,Roosli, M. Association between transportation noise and cardio-metabolic diseases: an update of the WHO meta-analysis. ICA. Aachen, Germany; 2019

WHO. The global burden of disease: 2004 update. Geneva: World Health Organization; 2004

WHO. Night Noise Guidelines for Europe. 2009

WHO. Environmental Noise Guidelines for the European Region. 2018

WHO Regional Office for Europe. Burden of disease from environmental noise: Quantification of healthy life years lost in Europe. World Health Organization; 2011