**eAppendix**

**The impact of measurement error in modelled ambient particles exposures on health effect estimates in multi-level analysis: a simulation study.**

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**Table S1.** Baseline disease rates (C3) and concentration response function for short-term ($β\_{1}$) and long-term $(β\_{2})$ used in our simulations.

**Table S2.** Coverage probabilities and power for the simulations on PM10.

**Table S3.** Coverage probabilities and power for the simulations of the association between PM2.5 and all-cause mortality or cardiovascular admissions.

[eAppendix references are listed at the end of this document]

**Table S1.** Baseline disease rates (C3) and concentration response function for short-term ($β\_{1}$) and long-term $(β\_{2})$ used in our simulations.

|  |  |  |  |
| --- | --- | --- | --- |
| Outcome | Baseline rate per LSOA per day$$exp(c\_{3})$$ | Pollutant | Concentration response function per 1 µg/m3 |
| Short-term exposure$$(β\_{1})$$ | Long-term exposure$$(β\_{2})$$ |
| All-cause Mortality | 0.0264§ | PM10 | 0.00032[1] | 0.00344[2] |
| PM2.5 | 0.00100[3] | 0.00686[4] |
| Cardiovascular hospital admissions | 0.0835¶ | PM10 | 0.00040[1] | 0.04055[5] |
| PM2.5 | 0.00091[6] | 0.00307[7] |

§Average death rate per LSOA per day in London in 2011 estimated using data from the Office for National Statistics.[8-9] ¶ Number of hospital admission per LSOA per day for the financial year 2011-2012 estimated using data from the Office for National Statistics,[8] and NHS Digital.[10]

**Table S2** Simulations’ results for the association between cardiovascular admissions and PM10. The true effects considered were 0.0040 for short –term exposure and 0.4055 for long-term per 10 μg/m3 increase in PM10.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Effect estimate for 10 μg/m3 increase in short-term exposure | Effect estimate for 10 μg/m3 increase in long-term exposure |
| $$\hat{β\_{1}}×10$$$$(se(\hat{β\_{1}}) ×10)$$ | Bias(%) | Coverage probability(%) | Power(%) | $$\hat{β\_{2}}×10$$$$(se(\hat{β\_{2}}) ×10)$$ | Bias(%) | Coverage Probability(%) | Power(%) |
| **Urban / Suburban** | Land Use Regression | 0.00466 (0.00233) | **16.6**b | 95.1 | 51.5 | 0.04584 (0.08062) | -88.7 | 2.7 | 16.4 |
| Dispersion | 0.00388 (0.00144) | -2.7b | 95.3 | 77.7 | 0.19909 (0.09505) | -50.9 | 43.8 | 52.8 |
| Hybrid 1 | 0.00415 (0.00154) | **4.0**b | 95 | 78.1 | 0.08338 (0.08245) | -79.4 | 5.9 | 23.7 |
| Hybrid 2 | 0.00428 (0.00159) | **7.3**b | 95.1 | 76.4 | 0.20930 (0.09941) | -48.4 | 48.8 | 54.3 |
| **Roadside / Kerbside** | Land Use Regression | 0.00403 (0.00173) | **1.0**b | 95.5 | 63.3 | 0.04116 (0.04997) | -89.8 | 0.0 | 15.5 |
| Dispersion | 0.00372 (0.00122) | -6.9b | 94.7 | 86.3 | 0.27562 (0.06056) | -32.0 | 43.3 | 98.4 |
| Hybrid 1 | 0.00370 (0.00124) | -7.3b | 94.3 | 84.7 | 0.10886 (0.05168) | -73.2 | 0.1 | 57.4 |
| Hybrid 2 | 0.00403 (0.00135) | **1.0**b | 95.7 | 83.8 | 0.30194 (0.06531) | -25.5c | 62.2 | 98.9 |

a Percent bias is highlighted in bold when positive (i.e. away from the null) rather than negative (i.e. towards the null); b Bias not statistically significant at the 5% level based on a one sample t-test.

**Table S3.**Simulations’ results for the association between cardiovascular admissions and PM2.5. The true effects considered were 0.0091 for short –term exposure and 0.0307 for long-term per 10 μg/m3 increase in PM2.5.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Model | Effect estimate for 10 μg/m3 increase in short-term exposure | Effect estimate for 10 μg/m3 increase in long-term exposure |
| $$\hat{β\_{1}}×10$$$$(se(\hat{β\_{1}}) ×10)$$ | Bias(%) | Coverage probability(%) | Power(%) | $$\hat{β\_{2}}×10$$$$(se(\hat{β\_{2}}) ×10)$$ | Bias(%) | Coverage Probability(%) | Power(%) |
| **Urban / Suburban** | Land Use Regression | 0.01054 (0.00371) | **16.3**b | 92.4 | 81.0 | 0.00141 (0.12787) | -95.4b | 86.0 | 12.7 |
| Dispersion | 0.00722 (0.00206) | -20.3b | 84.9 | 93.7 | 0.00579 (0.13573) | -81.1b | 84.5 | 14.1 |
| Machine learning methods | 0.00815 (0.00234) | -10.0b | 93.5 | 93.8 | 0.00855 (0.16441) | -72.2b | 75.8 | 24.1 |
| Hybrid 1 | 0.00929 (0.00266) | **2.5**b | 94.5 | 94.6 | 0.01411 (0.12849) | -54.1b | 86.4 | 13.5 |
| Hybrid 2 | 0.00900 (0.00258) | -0.7b | 95.1 | 94.1 | -0.00281 (0.15937) | -109.1b | 79.4 | 20.4 |
| Hybrid 3 | 0.00880 (0.00249) | -2.9b | 94.2 | 93.8 | 0.02418 (0.16757) | -21.3b | 84.3 | 16.8 |
| **Roadside Kerbside** | Land Use Regression | 0.00956 (0.00268) | **5.5**b | 94.9 | 95.5 | 0.02895 (0.04308) | -5.8b | 46.6 | 54.6 |
| Dispersion | 0.00762 (0.00177) | -15.9b | 88.2 | 99.4 | 0.03886 (0.03989) | **26.5**b | 57.5 | 46.5 |
| Machine learning methods | 0.00884 (0.00200) | -2.4b | 95.2 | 99.5 | 0.05307 (0.04415) | **72.7**b | 43.0 | 61.8 |
| Hybrid 1 | 0.00876 (0.00203) | -3.3b | 94.8 | 99.4 | 0.03658 (0.04031) | **19.0**b | 51.4 | 49.7 |
| Hybrid 2 | 0.00947 (0.00220) | **4.5**b | 94.8 | 99.2 | 0.04896 (0.04084) | **59.3**b | 50.7 | 53.1 |
| Hybrid 3 | 0.00944 (0.00212) | **4.2**b | 95.3 | 99.7 | 0.03886 (0.04580) | **26.5**b | 63.9 | 40.5 |

a Percent bias is highlighted in bold when positive (i.e. away from the null) rather than negative (i.e. towards the null); b Bias not statistically significant at the 5% level based on a one sample t-test.

**References**

[1] Katsouyanni K, Samet JM. Air pollution and Health: A European and North American Approach (APHENA). Health Effect Institute Report, Number 142, October 2009, p28 and 43, Tables 11 and 32. [Lag 1, partial autocorrelation function, natural spline model]*.*

[2] Hoek G, Krishnan RM, Beelen R, Peters A, Ostro B, Brunekreef B, Kaufman JD. Long-term air pollution exposure and cardio- respiratory mortality: a review. Environ Health 2013;12(1):43.

[3] Anderson HR, Atkinson RW, Bremner SA, Carrington J, Peacock J. Quantitative systematic review of short term associations between ambient air pollution (particulate matter, ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide), and mortality and morbidity. Report to Department of Health revised following first review, June 2007, p69, Table 4.2a. URL: <https://www.gov.uk/government/publications/quantitative-systematic-review-of-short-term-associations-between-ambient-air-pollution-particulate-matter-ozone-nitrogen-dioxide-sulphur-dioxide-and-carbon-monoxide-and-mortality-and-morbidity>

[4] Faustini A, Rapp R, Forastiere F. Nitrogen dioxide and mortality: review and meta-analysis of long-term studies. Eur Respir J 2014;44(3):744-53.

[5] Katsoulis M, Dimakopoulou K, Pedeli X, Trichopoulos, Gysparis A, Trichopoulou A, Katsouyanni K. Long-term exposure to traffic-related air pollution and cardiovascular health in a Greek cohort study. Sci Total Environ 2014;490;934-940. (Table 2)

[6] WHO. Health risk of air pollution in Europe - HRAPIE project. Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide. WHO Regional Office for Europe Report, 2013, page 6.

[7] Kloog I, Coull BA, Zanobetti A, Koutrakis P, Schwartz JD. Acute and chronic effects of particles on hospital admissions in New-England. PLoS One 2012;7(4):e34664. (Table 3)

[8] Office for National Statistics. 2011 Census: Usual residents by resident type, and population density, number of households with at least one usual resident and average household size, Output Areas (OAs) in London. https://www.ons.gov.uk /peoplepopulationandcommunity/ populationandmigration/ populationestimates/datasets/ 2011censuspopulationandhouseholdestimatesforwardsandoutputareasinenglandandwales. Accessed 22 Aug 2017. The data are © Crown Copyright 2012, licensed under the Open Government Licence v3.0. <http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>.

[9] Office for National Statistics‚ National Records of Scotland‚ Northern Ireland Statistics and Research Agency. Mortality Statistics: Deaths registered by area of usual residence, 2011 registrations. [https://www.ons.gov.uk/peoplepopulationandcommunity/ birthsdeathsandmarriages/deaths/datasets/deathsregisteredbyareaofusualresidenceenglandandwales](https://www.ons.gov.uk/peoplepopulationandcommunity/%20birthsdeathsandmarriages/deaths/datasets/deathsregisteredbyareaofusualresidenceenglandandwales). Accessed 21 Aug 2017. The data are © Crown Copyright 2013, licenced under the Open Government Licence (OGL) v3.0. <http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>.

[10] NHS Digital. Hospital Episode Statistics Admitted Patient Care - England, 2011-12: Provider-level analysis. Table A: “Headline figures for England, SHA and individual provider (2011-2012)” and Table E: “Finished admission episodes by primary diagnosis chapter for England, SHA and individual provider”. <https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/hospital-episode-statistics-admitted-patient-care-england-2011-12>. Source: Hospital Episode Statistics, HES. The Health and Social Care Information Centre. Information from NHS Digital, licenced under the current version of the Open Government Licence. Accessed 28th August 2018.