Air pollution exposure

BRHS 20 year follow-up (Q20)

1998 – 2000

1. Air pollution exposure

Description

Air pollution exposure data were based on BRHS participants' postcodes at the 20-year follow-up in 1998-2000 (Q20) and the 30-year follow-up in 2010-12 (Q30). Data included particulate matter 10 (PM_{10}) and nitrogen dioxide (NO_2) based on national estimates.

For the 1998-2000 (Q20) data, these were obtained for PM_{10} and NO_2 exposure and estimated for 1999 based on 2001 models adjusted to 1999 concentrations using standard back extrapolation techniques (references below). The PM_{10} model was on a 100m grid and NO_2 on 200m grids.
For the 2010-12 (Q30) data, these were obtained for PM_{10} and NO_2 exposures in 2009, extrapolated to 2011.

The air pollution exposure estimation for the BRHS participants was carried out by John Gulliver & Daniela Fecht at the MRC-PHE Centre for Environment & Health (http://www.environment-health.ac.uk/) in the Department of Epidemiology and Biostatistics, Imperial College in November 2014.

Data is available for all **5668** surviving BHRS men at the time of the 20-year follow-up examination in 1998-2000 (Q20). It includes participants who did not attend the physical examination. (*N=5668).*

Variable description	units	BRHS Variable name	Data access
Air pollution exposure data			
Geocode: address location(X/Y) X		Q20_airpol_x	No
Geocode: address location(X/Y) Y		Q20_airpol_y	No
Nitrogen dioxide (NO_2)	µg/m^3	Q20_NO2_99	Yes
Particulate Matter (PM_{10})	µg/m^3	Q20_PM10_99	Yes

References:
1) Gulliver J, de Hoogh K, Hansell A, Vienneau D. Development and back-extrapolation of NO_2 land use regression models for historic exposure assessment in Great Britain. Environ. Sci. Technol. 2013; 47(14): 7804-11
2)Vienneau D, de Hoogh K, Beelen R, Fischer P, Hoek G, Briggs D. Comparison of land-use regression models between Great Britain and the Netherlands. Atmos. Environ. 2010; 44: 688-696
3) Air pollution exposure estimation report by John Gulliver & Daniela Fecht

2. Air pollution exposure estimation report by John Gulliver & Daniela Fecht:

Air pollution exposure estimation for the British Regional Heart Study (BRHS)

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Imperial College
November 2014

Summary

Address locations of BRHS participants were attributed with modelled concentrations (μg/m^3) of NO_2 and PM_{10} corresponding to the mid years of relevant examinations, i.e. 1999 and 2011, respectively. Baseline exposure estimates (i.e. concentrations) were made using models developed for the year 2001 (Vienneau et al., 2010) by intersecting address locations with NO_2 and PM_{10} concentration surfaces in a geographical information system (GIS). Following analysis of changes in air pollution measurements over time, using routine monitoring data from the Automatic Urban and Rural Network (AURN), we did not make adjustments to the 2001 modelled concentrations to estimate 1999 exposures, but made adjustments using a method known as 'differencing' (Gulliver et al., 2013) to extrapolate 2001 modelled concentrations to estimate 2011 exposures.

Geocoding

We used QAS software to geocode the supplied 1999 and 2011 address lists. For both years, 96.5% of addresses were matched with 'high confidence' and retained for exposure assessment: 5668 records for 1999 and 3408 records for 2011.

Air pollution models

We used modelled surfaces of annual average air pollution concentrations (Vienneau, 2010) with coverage over the whole of Great Britain (GB) for NO_2 and PM_{10}, which were developed and validated against measured concentrations from the AURN (www.airquality.co.uk). There is an alternative (2009) model developed at Imperial only for NO_2 (Gulliver et al., 2013), but we used the 2001 models as this was available for both NO_2 and PM_{10} from the same year. Vienneau et al. (2010) used leave-one-out-cross-validation (LOOCV) to evaluate 2001 models. For NO_2 and PM_{10} values of R^2 are 0.61 ($p < .001$) and 0.37 ($p < .001$), respectively, and values of Root Mean Square Error (RMSE) are 9.26 (μg/m^3) and 4.10 (μg/m^3), respectively. A moderate R^2 for PM_{10} is typical in national scale models (Stedman, 2005) as PM_{10} is largely a background air pollutant and exhibits low spatial variability compared, for example, to NO_2. Values of RMSE for NO_2 and PM_{10} are similar relative to the variance of measured concentrations. The models were applied to produce GB concentration surfaces with a spatial resolution of 100m x 100m (i.e. grid pixel).

Extrapolation of modelled air pollution concentrations from 2001 to 1999 and 2001 to 2011

We adopted a method, described in Gulliver et al. (2013), for forward (to 2011) and backward extrapolation (to 1999) of 2001 air pollution exposure estimates. The method compares the difference in rural background concentrations at concomitant sites from the source year (i.e. the year of the model, in this case 2001) and the target year(s) (i.e. 1999 and 2011 for exposure estimation). These absolute differences are then applied to extrapolate (i.e. increase/reduce) modelled concentrations from source year to target years.

We obtained data from the AURN on rural background concentrations of NO_2 and PM_{10} for 1999, 2001 and 2011. In GB, there are five and four concomitant sites for NO_2 and PM_{10}, respectively, for all years, and with sufficient data for extrapolation purposes (i.e. at least 50% of days operating within each year). We used one site in Northern Ireland (Lough Navar) to represent background concentrations of PM_{10} in northern GB as there were no rural PM_{10} sites available in Scotland or the north of England. Table 1 shows average concentrations of NO_2 and PM_{10} at rural background stations in each year and the difference in average concentrations between each pair of years. As concentrations from some measurement sites were rounded to the nearest whole number, and differences in average background concentrations were negligible between 2001 and 1999, we did not apply extrapolation (i.e. differencing) in exposure estimation for 1999. We applied a difference of -3 $\mu g/m^3$ to all NO_2 and PM_{10} exposure estimates from the 2001 models to forward extrapolate them for the 2011 situation.

Table 1. Average rural background concentrations ($\mu g/m^3$) of NO_2 and PM_{10} for 1999, 2001 and 2011 and absolute differences in concentrations between 2001 and target years.

Pollutant	N (sites)	Measured rural background concentrations			Extrapolation (differencing)	
		1999	2001	2011	2001 to 1999	2001 to 2011
NO_2	5	13.4	13.6	10.3	0.2	-3.3
PM_{10}	4	17.0	16.6	13.4	-0.4	-3.2

Relationship of air pollution concentrations over time

Previous studies have shown that spatial contrasts in NO_2 concentrations, especially, are remarkably consistent over time (Eeftens et al., 2011; Cesaroni et al., 2012; Gulliver et al., 2013). We compared data obtained from the AURN on concentrations of NO_2 and PM_{10} from concomitant air pollution sites for 1999, 2001, and 2011. There are 36 and 22 concomitant roadside and background sites with measurement data for NO_2 and PM_{10}, respectively. Table 2 shows the relationship of measured air pollution concentrations between 1999 and 2001 and 2001 and 2011, for NO_2 and PM_{10}, including correlation (R^2), RMSE and regression line fits. As Table 2 shows, correlation over time is very high except in the comparison of measured concentrations of PM_{10} between 2001 and 2011 where it is medium-to-high. Regression slopes are close to unity in all cases except, again, the comparison of 2001 and 2011 PM_{10} concentrations.

Table 2 also shows changes in values of RMSE ($RMSE_E$) and the regression constant (C_E) following forward extrapolation of 2001 measured concentrations to predict 2011 measured concentrations of NO_2 and PM_{10}. Figure 1 shows scatterplots comparing 2001 and 2011 measured concentrations before and after extrapolation. For both NO_2 and PM_{10}, there are lower values of RMSE and closer fits to unity (i.e. 1:1 lines shown in Figure 1) following extrapolation of concentrations using the differencing method.

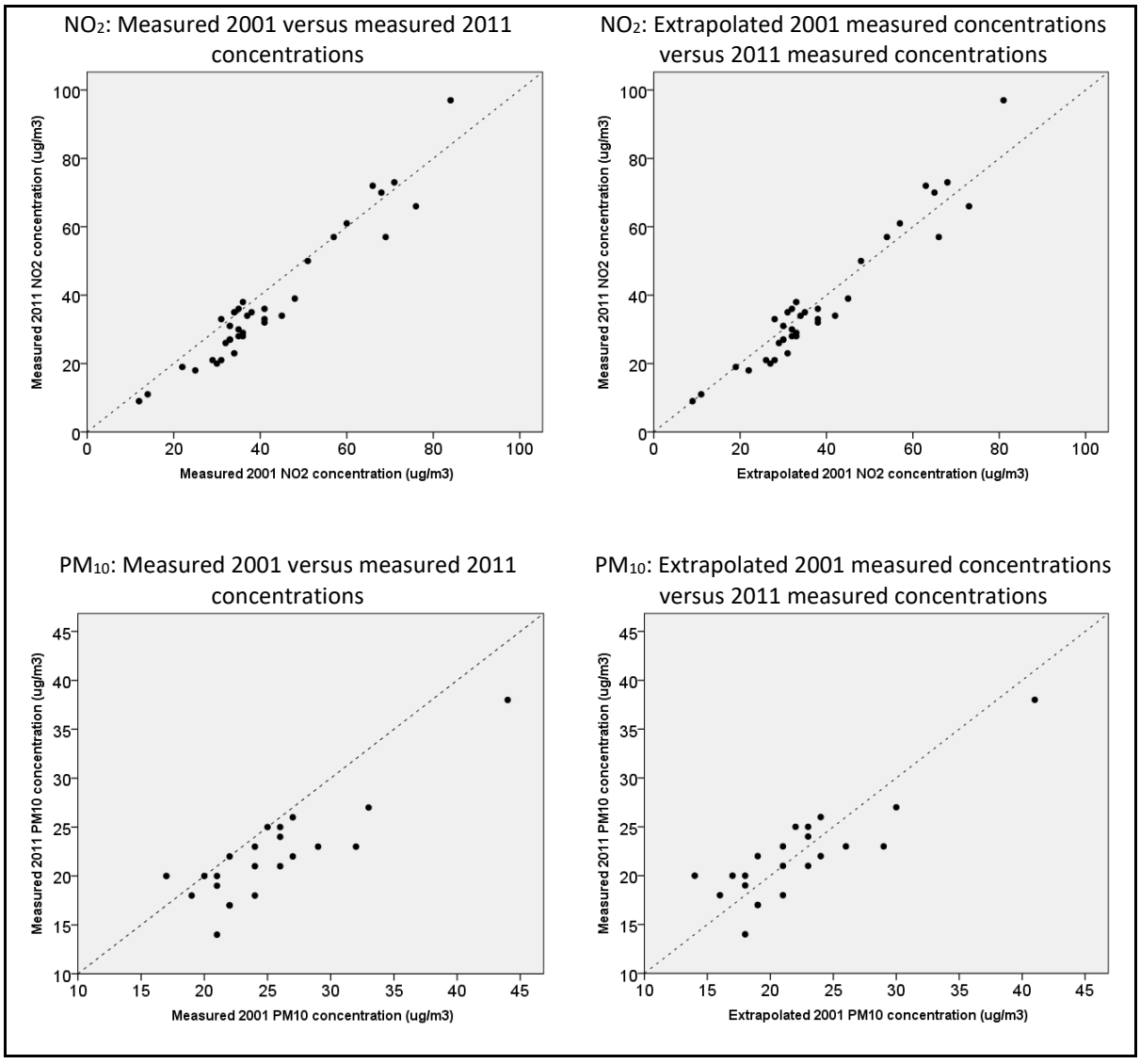
Table 2. Relationship of NO_2 and PM_{10} concentrations ($\mu g/m^3$) over time at concomitant AURN sites.

Pollutant	N	Predictor	Dependent variable	R^2	$RMSE_M$	$RMSE_E$	Regression fit line			p
							β	C_M	C_E	
NO2	36	2001	1999	0.94	5.40	-	1.10	-2.01	-	.000
	36	2001	2011	0.93	6.71	5.49	1.11	-8.67	-5.33	.000
PM10	22	2001	1999	0.95	1.38	-	0.99	0.80	-	.000
	22	2001	2011	0.73	4.29	2.93	0.72	4.02	6.16	.000

$_M$2001 measured concentrations to predict 2011 measured concentrations.

$_E$extrapolated 2001 measured concentrations to predict 2011 measured concentrations.

Figure 1. Extrapolation of NO_2 and PM_{10} concentrations from 2001 to 2011 using 'differencing'



Model Validation

There were not enough concomitant air pollution sites over time that were used in the Vienneau et al. (2010) model validation to make a comparative evaluation of the performance of extrapolated modelled values of NO_2 and PM_{10} in this study. For the 36 and 22 concomitant sites we compared modelled concentrations for the year 2001 with measured concentrations from 1999, and compared extrapolated modelled concentrations for the year 2001 with measured concentrations for 2011. For NO_2, values of R^2 and RMSE were 0.47 (p = .000) and 11.62 $\mu g/m^3$ for 1999 and 0.65 (p = .000) and 14.21 $\mu g/m^3$ for 2011, respectively. For PM_{10}, values of R^2 and RMSE were 0.33 (p = .005) and 4.70 $\mu g/m^3$ for 1999 and 0.30 (p = .008) and 4.19 $\mu g/m^3$ for 2011, respectively. The magnitude of change in R^2 (i.e. up to 0.14 for NO_2 and up to 0.07 for PM_{10}) from the Vienneau et al (2010) model evaluation are to be expected given the relationship of measured concentrations of air pollutants over time (Table 2), but this is not a direct comparison.

Exposure estimation

We intersected the 2001 (n=5668) and 2011 (n=3408) address locations (X/Y) with each air pollution surface in a GIS to obtain NO_2 and PM_{10} concentrations. We did not make adjustments to 2001 modelled air pollution concentrations for the 1999 dataset. For 2011 we subtracted 3 $\mu g/m^3$ from modelled concentrations of both NO_2 and PM_{10}.

References

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