Online supplement

Chronic airflow obstruction and ambient particulate air pollution

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BOLD study details

The BOLD study has been described in detail elsewhere[1]. Briefly, representative samples of the general population over the age of 40 were drawn from a sample of sites taken from around the world. These were drawn so as to represent most of the regions defined by the Global Burden of Disease (the exceptions were Latin America which had a separate study, the high-income countries of Asia, and Oceania) with a bias towards larger regions such as South Asia. All sites received approval from their local ethics committee, and participants provided informed consent. Spirometry was conducted before and after a bronchodilator (200 μg Salbutamol inhaled via a spacer) using a forced manoeuvre and an EasyOne spirometer (ndd Medizintechnik AG, Zurich, Switzerland). All spirometry data were reviewed for quality control during the study in either Salt Lake City or London. CAO was defined as a post-bronchodilator ratio of the forced expiratory volume in the first second (FEV_1) to the forced vital capacity (FVC), less than the lower limit of normal, which was determined using the equations for white Americans in the NHANES III study[2]. Information from participants on several risk factors, including whether they had ever smoked, was collected using a standardised questionnaire.

$PM_{2.5}$ concentrations

The concentrations of annual mean $PM_{2.5}$ were downloaded from a freely available resource on the Atmospheric Composition Analysis Group website.[3] Briefly, global ground-level $PM_{2.5}$ concentrations were estimated by combining aerosol optical depth data from satellites with simulation-based data from a chemical transport model. These were then calibrated to ground-based observations of $PM_{2.5}$ using a geographically weighted regression, which allows the estimation of local levels.[4] We used data at a spatial resolution of 0.01° latitude by 0.01° longitude.

Statistical analysis

The unit of our ecological analysis was the site, and the analysis was performed separately for males and females. The counts of the male and female cases of CAO in each site were regressed separately in negative binomial models, with the local sample size as an offset. The analyses included the prevalence of male, or female, smoking in the site as measured from the BOLD sample, the GNI and the level of $PM_{2.5}$ (all composition) for the site. Both GNI and $PM_{2.5}$ were log transformed as there is evidence in each case of a non-linear relationship with chronic lung disease[5,6]. We conducted a series of sensitivity analyses in which we re-run the main analysis: 1) using $PM_{2.5}$ (all composition) estimates for a 10-km radius buffer; and 2) using dust and sea-salt removed $PM_{2.5}$ instead of all composition $PM_{2.5}$.

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Table S1. Sample size and prevalence of chronic airflow obstruction (CAO) in the population and in never smokers by site and sex.

	Males			Females		
Site	N	CAO %	CAO % in never smokers	N	CAO %	CAO % in never smokers
Albania (Tirana)	467	12.8	2.3	472	4.2	3.8
Algeria (Annaba)	442	9.3	3.8	448	4.5	4.5
Australia (Sydney)	265	7.9	4.8	276	13.8	9.0
Austria (Salzburg)	685	12.8	7.8	573	19.4	12.9
Benin (Sèmè-Kpodji)	302	6.6	6.6	396	8.1	8.1
Cameroon (Limbe)	206	6.3	4.5	138	4.3	4.5
Canada (Vancouver)	344	12.8	6.8	483	12.0	7.1
China (Guangzhou)	236	9.9	2.3	237	6.3	4.5
England (London)	323	16.1	6.6	354	15.8	7.9
Estonia (Tartu)	309	8.7	1.8	305	5.2	5.3
Germany (Hannover)	349	10.0	3.2	334	7.8	5.4
Iceland (Reykjavik)	403	8.9	5.1	354	13.3	8.8
India (Kashmir)	416	17.3	4.1	344	15.4	13.5
India (Mumbai)	275	6.2	2.6	165	7.9	7.9
India (Mysore)	258	11.2	9.0	348	5.5	5.2
India (Pune)	502	5.8	5.0	343	6.7	6.7
Jamaica	243	10.3	3.4	335	7.5	6.6
Kyrgyzstan (Chui)	280	13.9	9.7	611	7.9	7.1
Kyrgyzstan (Naryn)	328	11.0	8.5	531	4.7	4.4
Malawi (Blantyre)	160	6.9	4.5	242	9.1	9.3
Malawi (Chikwawa)	222	18.0	12.3	212	9.4	8.0
Malaysia (Penang)	340	4.4	2.3	323	3.4	3.4
Morocco (Fes)	354	11.9	8.3	414	7.5	7.6
Netherlands (Maastricht)	300	19.0	3.8	290	17.2	10.4
Nigeria (Ile-Ife)	346	7.5	7.2	538	6.7	6.4
Norway (Bergen)	324	14.8	9.6	334	10.2	5.0
Pakistan (Karachi)	268	14.6	10.0	339	6.5	6.7
Philippines (Manila)	378	13.0	6.6	515	5.2	4.5
Philippines (Nampicuan-Talugtug)	356	16.3	8.5	366	12.3	9.4
Poland (Krakow)	266	15.0	3.6	260	12.3	13.7
Portugal (Lisbon)	331	13.9	9.4	380	9.5	8.1
Saudi Arabia (Riyadh)	375	3.5	2.6	325	2.8	2.8
South Africa (Uitsig-Ravensmead)	315	23.8	2.0	532	16.2	6.7
Sri Lanka	460	11.7	8.1	568	3.9	3.9
Sudan (Gezeira)	301	5.6	5. 1	283	6.0	6.1
Sudan (Khartoum)	307	10.4	9.5	210	10.0	10.3
Sweden (Uppsala)	283	10.2	5.6	264	8.3	6.4
Trinidad & Tobago	437	6.6	4.2	660	6.7	6.4
Tunisia (Sousse)	309	8.4	8.1	352	2.0	1.6
Turkey (Adana)	389	19.8	6.8	417	9.1	8.3
USA (Lexington, KY)	206	13.6	2.3	302	16.2	5.8

N, sample size.

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Table S2. Sensitivity analysis – as for table 3, with estimates of $PM_{2.5}$ for a 10-km radius buffer.

	Males			Females		
Variable	Rate ratio	95%CI	*P*	Rate ratio	95%CI	*P*
Smoking	4.17	2.39-7.29	< 0.001	11.1	5.66-21.8	< 0.001
Log(GNI)	0.90	0.81-0.99	0.048	0.83	0.73-0.94	0.003
Log($PM_{2.5}$)	0.93	0.79-1.09	0.37	1.05	0.89-1.25	0.55

GNI, gross national income per capita; $PM_{2.5}$, particulate matter <2.5μm aerodynamic diameter.

Table S3. Sensitivity analysis – as for table 3, with estimates of $PM_{2.5}$ with dust and sea-salt removed.

	Males			Females		
Variable	Rate ratio	95%CI	*P*	Rate ratio	95%CI	*P*
Smoking	4.38	2.51-7.62	< 0.001	10.4	5.52-19.6	< 0.001
Log(GNI)	0.92	0.83-1.02	0.1	0.83	0.73-0.94	0.003
Log($PM_{2.5}$)	1.04	0.92-1.18	0.48	1.03	0.92-1.16	0.59

GNI, gross national income per capita; $PM_{2.5}$, particulate matter <2.5μm aerodynamic diameter.

Table S4. Sensitivity analysis – as for table 3, with estimates of $PM_{2.5}$ with dust and sea-salt removed for a 10-km radius buffer.

	Males			Females		
Variable	Rate ratio	95%CI	*P*	Rate ratio	95%CI	*P*
Smoking	4.41	2.53-7.68	< 0.001	10.3	5.47-19.4	< 0.001
Log(GNI)	0.92	0.84-1.02	0.11	0.83	0.73-0.94	0.004
Log($PM_{2.5}$)	1.06	0.93-1.19	0.39	1.03	0.92-1.16	0.60

GNI, gross national income per capita; $PM_{2.5}$, particulate matter <2.5μm aerodynamic diameter.