A comparison of self reported air pollution problems and GIS-modelled levels of air pollution in people with and without chronic diseases

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Abstract

Objective

To explore the association between self reported air pollution problems and GIS-modelled air pollution in area of living, and to investigate whether those with respiratory or other chronic diseases tend to over-report air pollution problems, compared to healthy people.

Methods

Cross-sectional data from the Oslo Health Study (2000-2001) were linked with GIS-modelled air pollution data from the Norwegian Institute of Air Research. Multivariate logistic regression analyses were performed. 14 294 persons (30, 40/45, 60 and 75 years old) with complete information on modelled and self reported air pollution were included.

Results

People who reported air pollution problems were exposed to significantly higher GIS-modelled air pollution levels than those who did not report such problems. People with chronic disease, reported significantly more air pollution problems, even if they had a non-respiratory disease. This difference was robust after adjustment for modelled levels of nitrogen dioxides, socio-demographic variables, smoking, depression, dwelling conditions and an area deprivation index.

Conclusions

Self reported air pollution problems in area of living are strongly associated with increased levels of GIS-modelled air pollution. Over and above this, those who report to have a chronic disease tend to over-report air pollution problems in area of living. Studies on the association

between self reported air pollution and health should be aware of the possibility that disease itself may influence the reporting of air pollution.

Background

Self reported air pollution is sometimes used as a pollution indicator in lack of objective measures. In a recent study by Heinrich et al. [1] on self reported traffic intensity compared to modelled exposure of air pollution from traffic, the subjective assessments of exposure tended to overestimate the modelled estimates of air pollution exposure, indicating only a weak association between self reported and modelled air pollution. The results by Heinrich et al. [1] have important implications for the research on health effects of air pollution, as several studies use subjective assessment of traffic exposure in their effort to document such effects [2][3][4]. Additionally, within the literature on area effects on health, composite indexes that include self reported measures of air quality, air pollution or traffic are frequently used [5][6].

A methodological problem arises in studies that have no objectively measured equivalents to their self reported measures of air pollution. Typically, subjects who reported on air pollution at their home address also answered health questionnaires. In cross-sectional studies, results could be severely biased if both the exposure and the potential health impacts are assessed subjectively. Because some studies more or less explicitly assume that self reported air pollution is a sufficient measure of air pollution exposure and that air pollution is predictive to health, they face the dilemma of whether their results in fact express a systematic over-reporting of air pollution among those with the same disease for which they try to establish effects upon from air pollution.

The aim of this article is to explore the association between self rated air pollution problems and GIS-modelled air pollution in area of living, and to investigate whether those with respiratory diseases (asthma, chronic obstructive pulmonary disease), other chronic diseases (coronary heart disease, osteoporosis, fibromyalgia) or poor self rated health tend to over-report air pollution problems, compared to healthy people. We describe the association between self reported air pollution problems in area of living and local variability in ambient air pollution at home addresses based on dispersion modelling; and explore to what extent self reported and modelled air pollution are associated.

Methods

Data were obtained from the Oslo Health Study (HUBRO), a joint collaboration between the Oslo City Council, the University of Oslo, and the Norwegian Institute of Public Health from May 2000 to September 2001. 40 888 persons in five age cohorts were invited. Participation rate was 46%. Study population and non-respondents are explained and evaluated in detail elsewhere [7]. In terms of relative effect estimates of disability, the non-participants did not differ from the study participants [7]. The data collection included a main questionnaire, various supplementary questionnaires and a simple clinical examination. Among the 18 770 participants, we have included those who answered the question on self reported air pollution problems, and for whom we had GIS-modelled exposure data at their home address (n=14 294).

Ethics and approvals

All the participants of the Oslo Health Study gave their written consent. The participants' names and personal ID numbers were omitted when data were used. The Norwegian Data Inspectorate approved the study and the Regional Committee for Medical Research Ethics evaluated it.

Dependent variable: self reported air pollution problems (APP)

Self reported air pollution problems (APP) was derived from the question "Are you (in your local environment) troubled by air pollution from traffic?", with the response categories 'very troubled' and 'somewhat trouble' collapsed into yes, and 'not troubled' indicating no.

Modelled exposure assessment

Indicator of ambient air pollution exposure at the participants' home addresses was nitrogen dioxide (NO_2). Air pollution data was estimated using the GIS-based Air Quality Information System (AirQUIS) developed at the Norwegian Institute of Air Research (NILU) [8][9]. This model combines data on meteorology, emissions, background air pollution concentrations and topography. The model calculates the ambient exposure levels according to home addresses on a km^2 grid and a large number of receptor points close to busy roads.

On the day the study participants were examined they were given a supplementary questionnaire in which they should answer the APP-question. Most participants returned the questionnaire after 2-4 weeks. Based on this, we calculated the average NO_2 exposure at the participants' home addresses in the four weeks after examination. This modelled exposure would reflect the time period in which the participants answered the APP-question. NO_2 values were quintilized for the analyses. Initial analyses with yearly average values of NO_2 and analyses where NO_2 was measured continuously were performed with results quite similar to the 4-weeks variable (figures not shown). We therefore chose to proceed with the 4-weeks variable for two reasons. Firstly, to minimize the possibility of migration bias and secondly to better handle the possibility that the participants' reporting of APP could be affected by the air pollution levels at the time of answering the questionnaire, rather than being a reflection of what it is like in the area of living during the year as a whole.

We adjusted for season of examination by categorizing the months of examination into seasons; December, January and February (winter); March, April and May (spring); June, July and August (summer); September, October and November (autumn) [10].

Independent variables

Age (30, 40/45, 60 and 75) and *sex* had no missing values. Missing values for the other variables are described in table 1. *Employment status* was either fulltime, part-time or not working. *Education* was high (academic college or university education) and low (lower educational forms). *Smoking* was either current smoker, former smoker or never smoker. *Type of dwelling* was either houses (including farms), apartment blocks (including flats in a terraced block of flats and semi-detached houses) or other dwelling types.

We adjusted for two indicators of housing quality that may affect the susceptibility to feel troubled by outdoor air pollution, namely moisture/draught/cold and other forms of bad indoor climate. *Dwelling moisture* was derived from the question "Are you (in your home) troubled by moisture, draught or cold?", with the response categories 'very troubled' and 'somewhat trouble' collapsed into yes, and 'not troubled' indicating no. Similarly, *bad indoor climate* was derived from the question "Are you (in your home) troubled by other forms of bad indoor climate?" with the same responses collapsed. *Self reported pollution from factories* was derived from the question "Are you (in your local environment) troubled by air pollution from factories/firewood/oil furnace etc?" with the response categories 'very troubled' and 'somewhat trouble' collapsed into yes, and 'not troubled' indicating no.

Area deprivation was a composite measure of five items, a method that has been shown to have stronger independent effects on health than any one variable on its own [11]. The items were area percentages of population affected by social aid, being unemployed, receiving disability pension, having no academic college or university education, and average taxable income in the areas. A rank score for Oslo's 25 administrative areas was calculated and quintilized for the analyses. Each participant was assigned a value for area of living in year 2000. The Oslo City Council provided these data.

In addition, we adjusted for *depression* because there is a possibility that it may be present in some of the chronic diseases and therefore related to the reporting of air pollution. *Depression* was derived from the question "Have you during the last two weeks felt depressed?" with the response category 'no' indicating no, 'a little' indicating some, and the categories 'quite much' and 'very much' indicating yes.

Asthma, diabetes, fibromyalgia and *osteoporosis* were derived from the question "Do you have any of these illnesses, or have you suffered from any of them in the past?" *Self rated health* was derived from the question "How would you describe your present state of health?" dichotomised into good (good or very good) and poor (not very good or poor). *Coronary heart disease (CHD)* was measured by The Rose Questionnaire of angina pectoris [12], and *chronic obstructive pulmonary disease (COPD)* by a modified version of the Medical Research Council's questionnaire with three items [13].

Analyses

The statistical analyses were conducted using the SPSS 11.0 software program. The chi-square test and independent samples t-test were used in comparing the excluded (i.e. those with missing values) and the included respondents. Logistic regression was used in the main analyses. For each disease we first conducted an initial model measuring the association between the health variables one by one after adjustment for age, sex, employment status, education, smoking, area deprivation, season of examination and GIS-modelled NO_2. The models were then supplemented with dwelling conditions, depression and self reported pollution from factories. The same analyses were then performed by removing each of the latter three variables one by one.

Results

Among the study participants with missing values that were removed from the logistic analyses, 23.4% reported APP, whereas 21.3% of those that were included reported APP. The groups did not differ in mean NO_2 during the four weeks after study conduct (not shown in tables). Mean NO_2 (95% CI) was 28.6 (28.2 – 29.0) in the missing group and 28.2 (28.0 – 28.5) in the included group. Neither did the groups differ by season of examination. Thus, the missing respondents did not differ by any of the key variables in this study. Remaining results reported here are based on the 12350 persons that were included in the analyses.

APP increased significantly by levels of NO_2. 7.9% in the quintile with lowest levels of NO_2 reported APP, 12.3% in the second quintile, 22.6% in the third quintile, 27.5% in the fourth quintile and 33.1% in the fifth quintile (not shown in tables).

The correlation between APP and NO_2 measured as a categorical variable was moderate ($r=.229$, $p<0.001$), which was also the case when measured continuously ($r=.236$, $p<0.001$), and did not vary by season (correlations not shown in tables). We divided the participants in two groups, those who reported APP and those who did not (table 1). APP did not vary much by independent variables, except age (lower among the oldest and higher among the youngest), area deprivation (an uneven distribution but markedly highest among those in the most deprived areas), self reported air pollution from factories and in all three variables representing dwelling conditions. These results corresponded quite well with mean NO_2-levels, except self reported pollution from factories where there in fact were no significant differences in mean NO_2 between those who reported that they were troubled by such pollution and those who were not.

INSERT TABLE 1

There were small variations in APP by season and a larger share of APP in spring than in winter, even though modelled NO_2-levels were significantly higher in winter. For depression and all health outcomes (except diabetes) there was a much higher reporting of APP among those with a disease than those without, even though there were no statistically significant differences in NO_2-levels between the groups. For all variables except diabetes, those who reported APP were exposed to significantly higher levels of NO_2.

We stratified the participants by season of examination (figures not shown). In all seasons there was an increase in APP with increased levels of NO_2, even though mean levels of NO_2 were significantly higher in winter for all quintiles and statistically lower in summer for all quintiles. This indicated that stratification by season was not important as APP did not vary and was verified by stratified regression models showing no differences in associations between independent variables and APP by season (figures not shown).

Table 2 shows results from multivariate logistic regression analysis with associations between APP and asthma, adjusted for several variables. In the initial model, NO_2 was strongly associated with APP, with more than five times as big probability for APP among those living in the quintiles with the highest NO_2 levels compared to those with the least. All quintiles but the two with highest exposures were significantly different from one another. There were also independent associations between APP and other variables (age, employment status and season of examination). In area deprivation we found that living in the most deprived areas gave an approximately 2.5 times higher probability for APP than would living in the least deprived areas. Estimates based on season showed that spring and summer were significantly stronger associated with APP than winter. Those who reported asthma had a 51% higher probability for reporting APP.

INSERT TABLE 2

In the full model, where self reported pollution from factories, dwelling conditions and depression were included, there were some reductions in the previous significant estimates (employment status was no longer significant), but the associations for quintiles of NO_2 were still strong, although slightly reduced. The new variables were all significantly associated with APP, indicating that dwelling factors (type of dwelling, moisture/draught/cold and other forms of bad indoor climate) and depression were important for APP. The association between asthma and APP was reduced (odds ratio decreasing from approximately 1.5 to 1.3) but remained significant (p=0.010).

Table 3 shows odds ratios for all health variables when added one by one to the multivariate regression model in table 2 as we did with asthma. Including these health variables did not have any influence on the estimates of the other independent variables in table 2 (and they are not reported in table 3). All health outcomes (except diabetes) were significantly associated with APP in the initial model (column a). In the full model (column b), the inclusion of self reported pollution from factories, dwelling conditions and depression, led to reductions in all associations and CHD (p=0.082) and osteoporosis (p=0.080) were no longer significant at the 0.05-level. Still, asthma, COPD, fibromyalgia and self reported poor health were all significantly associated with APP. Then, when we removed one variable at the time (self reported air pollution from factories in column c, dwelling conditions in column d and depression in column e), CHD was significantly associated with APP in all three cases, and osteoporosis in the models where self reported pollution from factories and dwelling conditions were removed.

INSERT TABLE 3

Discussion

We found a strong independent association between self reported air pollution problems and GIS-modelled air pollution, i.e. the higher the levels of air pollution in area of living, the higher the susceptibility to report being plagued by air pollution problems. Independent associations were also found between air pollution problems and asthma, chronic obstructive pulmonary disease, fibromyalgia and self reported poor health, whereas independent associations between APP and coronary heart disease and osteoporosis were conditional on the presence of either self reported pollution from factories, dwelling conditions or depression.

One variable from the final model needs some explanation. In the absence of self reported pollution from factories, all variables (except diabetes) were significantly associated with APP. This self reported variable may suffer from the same bias that this article is essentially about, and constitutes our research question; do people with a disease tend to over-report air pollution problems? The reporting of pollution from factories may be as dependent on health as APP is. We therefore believe that the most appropriate model to make up our conclusions from is the one that does not include this variable. In this model (column c in Table 3), all variables except diabetes were associated with APP, indicating that not only respiratory disease, but chronic disease in general, makes people more susceptible to report air pollution problems. These associations were independent of age, sex, education, employment status, smoking, season of examination, area deprivation, dwelling conditions and depression; hopefully excluding the possibility of over-reporting of air pollution problems among people with a disease because of socio-demographic background or a more pessimistic view upon the environments due to residence in a deprived area, and/or poor dwelling conditions and/or depression. We believe our results demonstrate that people with chronic disease tend to over-report air pollution problems, even when the disease is non-respiratory.

Study limitations

A strength in our study is the good correspondence between the phenomenon for which we have self reported and modelled data. But, because our health measures were self-reported we cannot say whether our results indicate that those with a disease over-report air pollution problems or whether those susceptible to report disease in a questionnaire are also over-reporting air pollution problems.

We were unable to account for two conditions that may be important. First, *daily mobility,* in order to capture some of the potential for exposure misclassification in those that reside in the city but work elsewhere as those who work close to their homes would be most likely to have an accurate exposure assessment [14]. Second, objective measures of *dwelling conditions,* as our data on these aspects were self reported and may be biased by disease. Previous studies have found that those who rent (compared to those who own) their dwellings are significantly more affected by noise, hazards, vibration, cold and dampness [15]. Indoor exposures may be as important as outdoor exposures [16], although there is evidence that indoor pollution can be directly related to outdoor pollution [17]. Other dwelling factors that righteously may shape reporting of air pollution problems (floor level, whether windows are against road or backyard, etc.) were not available.

Contributors to the construct of self reported air pollution problems

Different environmental impacts may result from at least two important pathways: differential exposures or differential susceptibilities [18]. The incorporation of social stratification as a health effect modifier is well established in air pollution epidemiology [14][19][20][21]. Evidence have been provided that lower socio-economic status areas [22] and households [16] experience the worst air quality, described as examples of the 'inverse air law' [16], analogous to the inverse care law, i.e. that people with the worst lung function tend to live in areas with the worst air quality. This may trigger 'the triple jeopardy', which begins with increased exposure among lower status groups, is augmented by the pre-existing burden of poor health that accompanies low status, and is confounded by an interaction between the two conditions [23].

Over and above modelled air quality many aspects of the environment have been identified in shaping people's perception of the air quality [24][25][26], indicating that perceptions are socially and culturally constructed [27]. Individuals' perceptions of whether or not they have the ability to bring about change through their behaviour may also influence the perception of local air quality or degree of air pollution problems [24]. For example, when the analyses of Heinrich et al. [1] were restricted to participants with asthma or hay fever, the subjective assessments of air pollution from traffic were increasingly overestimated compared to the modelled levels. Over-reporting of pollution exposure among people with respiratory disease (or any family members) has been found in previous studies [28][29], and it has been argued that this over-reporting could be caused by the publicity/media coverage given to air pollution and respiratory health [28]. Therefore, it does not seem unreasonable to claim that the associations between self reported air pollution/traffic and disease may be severely biased by the concern and awareness of having a disease that the lay public link to air pollution. For example, Petrie et al. [30] identified how certain modern health worries were associated with having a disease that most people would be likely to associate with it (e.g. tainted food concerns and gastrointestinal problems, or toxic intervention concerns and pseudoneurology complaints).

It has been claimed that more educated people have longer time horizons than the poorly educated [31], which could explain why well-educated people behave differently as they are more concerned about (and possibly more aware of) the long-term consequences of day-to-day activities [32]. It could be that those with diseases commonly related to air pollution have a greater susceptibility to report air pollution problems due to a greater concern of the long term-consequences of such exposure. This assumption was tested in our analyses by including both respiratory and non-respiratory diseases, and our conclusion is that the over-reporting of air pollution problems seen for all diseases indicates an over-reporting from chronic disease in general, and not only from those diseases commonly related to air pollution.

The association between air pollution and respiratory health seem well established [33][34], although there is unclear evidence of impacts of outdoor air pollution and asthma incidence [34][35][36]. Thus, claiming that self reported air pollution/traffic intensity is predictive to health seems plausible. But such a presumption is normally not tested against diseases for which the etiological evidence in reference to air pollution is scarce or missing. This is especially problematic in those studies that do not have any objectively measured equivalents to the self-reported problems, as they are then unable to differentiate the part of the association into that of true exposure and that of a socially or culturally constructed bias. Three such biases were tested in our analyses; that of disease, that of living in deprived areas, and that of depression. After the partitioning of NO_2 and disease/area deprivation/depression was done in our analyses, our results indicated, despite the cross-sectional design, that health status affects the reporting of air pollution problems, making the latter an unreliable variable in studies on air pollution effects on health.

Conclusions

Modelled air pollution and self reported air pollution problems are strongly associated. However, several other factors than air pollution itself contribute to people's reporting of air pollution problems. Independent associations between air pollution problems and both respiratory and non-respiratory diseases were found after adjustment for socio-demographic variables, smoking, area deprivation, dwelling conditions, depression and GIS-modelled air pollution. We therefore believe that people with a disease are in general more susceptible to report air pollution problems, regardless of the pollution they are in fact exposed to. This is a methodological problem, which should be carefully considered in studies that either tries to find associations between air pollution and health using self reported pollution or traffic intensity, or studies that try to establish a predictive effect of perceptions of neighbourhood problems on health.

Competing interests

None declared.

Authors' contributions

FNP planned the study design, performed the analyses and wrote the manuscript. CM and PN contributed to the acquisition of data and preparing the data files, planning the study design, contributed with academic discussions and drafted and revisited the manuscript. ØN and BC participated in planning the study design, contributed with academic discussions and drafted and revisited the manuscript. All authors read and approved the final manuscript.

Acknowledgements

The National Health Screening Service of Norway (now the Norwegian Institute of Public Health) conducted the practical part of the data collection. Air pollution data was available from the Norwegian Institute of Air Research (NILU). The Oslo City Council provided additional data. This study has been financed by our departments and the Norwegian Research Council.

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Tables

Table 1: Distributions of independent variables, percentages reporting air pollution problems (APP) and mean NO_2-levels. N=14,294.

					Mean NO_2-levels (95% CI) during four weeks after examination	
Variables (% Missing)		**N**	**%**	**%APP**	**APP: No**	**APP: Yes**
Age	*30*	3063	21.4	25.9	29.9 (29.4 – 30.4)	36.3 (35.6 – 37.0)
	40/45	5002	35.0	21.6	25.6 (25.2 – 26.0)	33.8 (33.1 – 34.5)
	60	3569	25.0	20.3	25.4 (25.0 – 25.9)	33.0 (32.1 – 33.8)
	75	2660	18.6	16.9	26.6 (26.1 – 27.1)	32.4 (31.3 – 33.6)
Sex	*Men*	6355	44.5	20.5	26.9 (26.5 – 27.2)	34.3 (33.6 – 34.9)
	Women	7939	55.5	22.0	26.4 (26.1 – 26.7)	33.9 (33.4 – 34.5)
Employment status (0,7%)	*Fulltime*	8426	58.9	21.4	27.0 (26.7 – 27.3)	34.7 (34.2 – 35.3)
	Part-time	1506	10.5	22.1	25.1 (24.3 – 25.8)	33.6 (32.3 – 34.9)
	Not working	4266	29.8	20.7	26.3 (25.9 – 26.8)	32.9 (32.1 – 33.7)
Education (1,0%)	*Low*	6987	48.9	22.0	27.4 (27.1 – 27.7)	35.0 (34.5 – 35.5)
	High	7160	50.1	20.6	25.9 (25.5 – 26.2)	33.1 (32.5 – 33.7)
Smoking (0,7%)	*Never*	6198	43.4	20.6	26.4 (26.1 – 26.8)	34.1 (33.5 – 34.8)
	Yes, former	4407	30.8	20.7	26.2 (25.8 – 26.6)	33.5 (32.8 – 34.3)
	Yes, current	3582	25.1	22.9	27.5 (27.0 – 28.0)	34.6 (33.8 – 35.3)
Area deprivation (0,9%)	*1st quintile*	3052	21.4	11.2	23.5 (23.1 – 23.9)	30.2 (28.9 – 31.4)
	2nd quintile	2891	20.2	26.7	32.2 (31.7 – 32.6)	35.8 (35.1 – 36.4)
	3rd quintile	2468	17.3	18.2	23.2 (22.6 – 23.7)	29.1 (27.9 – 30.3)
	4th quintile	3249	22.7	17.9	23.5 (23.0 – 24.0)	31.8 (30.7 – 32.9)
	5th quintile	2499	17.5	35.3	34.5 (34.0 – 35.0)	38.0 (37.4 – 38.6)
Season of examination	*Winter*	4016	28.1	21.1	30.6 (30.1 – 31.0)	38.3 (37.5 – 39.1)
	Spring	3005	21.0	24.1	26.0 (25.5 – 26.6)	33.6 (32.7 – 34.5)
	Summer	2286	16.0	21.7	21.4 (20.9 – 21.9)	28.6 (27.7 – 29.5)
	Autumn	4987	34.9	19.7	26.2 (25.8 – 26.5)	33.5 (32.8 – 34.1)
Pollution from factories (0.7%)	*No*	13477	94.3	18.1	26.6 (26.4 – 26.8)	33.9 (33.4 – 34.4)
	Yes	712	5.0	72.9	27.6 (25.8 – 29.3)	34.9 (33.9 – 35.8)
Type of dwelling (0.3%)	*House/villa*	2960	20.7	13.4	23.9 (23.4 – 24.3)	30.5 (29.3 – 31.6)
	Blocks	10541	73.7	22.7	27.1 (26.8 – 27.3)	34.3 (33.9 – 34.8)
	Other types	755	5.3	32.8	32.6 (31.5 – 33.7)	37.2 (36.0 – 38.3)
Dwelling moisture (0.6%)	*No*	12750	89.2	19.3	26.5 (26.3 – 26.8)	34.0 (33.6 – 34.5)
	Yes	1464	10.2	35.3	27.7 (26.9 – 28.4)	34.2 (33.2 – 35.2)
Bad indoor climate (1.2%)	*No*	13258	92.8	18.9	26.6 (26.3 – 26.8)	34.1 (33.6 – 34.5)
	Yes	871	6.1	49.4	27.8 (26.6 – 29.0)	34.5 (33.3 – 35.7)
Depression (2.6%)	*No*	9122	63.8	18.4	26.4 (26.2 – 26.7)	34.2 (33.6 – 34.7)
	Some	3710	26.0	26.4	26.7 (26.2 – 27.2)	34.0 (33.3 – 34.8)
	Yes	1087	7.6	28.8	27.7 (26.8 – 25.5)	34.0 (32.7 – 35.3)
Asthma (1,8%)	*No*	12732	89.1	20.4	26.7 (26.4 – 26.9)	34.1 (33.6 – 34.5)
	Yes	1298	9.1	28.4	25.6 (24.7 – 26.4)	33.7 (32.5 – 34.9)
COPD (2,5%)	*No*	13260	92.8	20.6	26.5 (26.3 – 26.8)	34.1 (33.7 – 34.6)
	Yes	678	4.7	34.7	27.6 (26.5 – 28.8)	33.4 (31.9 – 34.9)
CHD (0,8%)	*No*	12969	90.7	20.8	26.7 (26.4 – 26.9)	34.2 (33.8 – 34.6)
	Yes	1208	8.5	26.7	26.0 (25.1 – 26.8)	32.5 (31.1 – 33.9)
Diabetes (2,1%)	*No*	13620	95.3	21.2	26.6 (26.4 – 26.9)	34.2 (33.8 – 34.6)
	Yes	376	2.6	20.2	26.7 (25.3 – 28.1)	29.6 (26.8 – 32.5)
Fibromyalgia (3,3%)	*No*	12993	90.9	20.6	26.7 (26.5 – 27.0)	34.2 (33.7 – 34.6)
	Yes	824	5.8	28.0	24.6 (23.7 – 25.6)	32.6 (30.9 – 34.3)
Osteoporosis (2,8%)	*No*	13331	93.3	21.0	26.7 (26.4 – 26.9)	34.1 (33.7 – 34.5)
	Yes	560	3.9	24.3	25.8 (24.6 – 26.9)	32.3 (30.2 – 34.3)

Poor SRH (1,1%)	*No*	10911	76.3	20.1	26.8 (26.5 – 27.0)	34.5 (34.0 – 35.0)
	Yes	3222	22.5	25.7	26.2 (25.7 – 26.7)	32.8 (32.0 – 33.6)

Table 2: Multivariate logistic regression analyses. Odds ratios (95% CI) for self reported air pollution problems (APP).

Variables		**OR (95% CI)**	**OR (95% CI)**
Age	*30*	1.00	1.00
	40/45	1.00 (0.88 – 1.13)	1.01 (0.89 – 1.15)
	60	0.91 (0.79 – 1.05)	1.03 (0.88 – 1.19)
	75	0.54 (0.43 – 0.66)***	0.71 (0.57 – 0.89)**
Sex	*Men*	1.00	1.00
	Women	1.09 (0.99 – 1.19)	1.10 (0.99 – 1.21)
Employment status	*Fulltime*	1.00	1.00
	Part-time	1.08 (0.92 – 1.26)	1.01 (0.85 – 1.19)
	Not working	1.40 (1.21 – 1.62)***	1.14 (0.97 – 1.33)
Education	*Low*	1.00	1.00
	High	0.98 (0.88 – 1.08)	0.94 (0.84 – 1.05)
Smoking	*Never*	1.00	1.00
	Yes, former	1.09 (0.98 – 1.22)	1.08 (0.96 – 1.21)
	Yes, current	1.00 (0.89 – 1.12)	1.02 (0.90 – 1.16)
Area deprivation	*1st quintile*	1.00	1.00
	2nd quintile	2.01 (1.72 – 2.35)***	1.89 (1.60 – 2.23)***
	3rd quintile	1.80 (1.52 – 2.14)***	1.69 (1.41 – 2.02)***
	4th quintile	1.63 (1.38 – 1.92)***	1.49 (1.25 – 1.77)***
	5th quintile	2.56 (2.18 – 3.02)***	2.13 (1.79 – 2.53)***
Season of examination	*Winter*	1.00	1.00
	Spring	1.40 (1.23 – 1.59)***	1.43 (1.24 – 1.64)***
	Summer	1.45 (1.25 – 1.69)***	1.50 (1.28 – 1.76)***
	Autumn	1.08 (0.96 – 1.22)	1.10 (0.97 – 1.24)
NO_2	*1st quintile*	1.00	1.00
	2nd quintile	1.69 (1.39 – 2.05)***	1.67 (1.37 – 2.04)***
	3rd quintile	3.07 (2.56 – 3.68)***	2.98 (2.47 – 3.60)***
	4th quintile	3.97 (3.31 – 4.77)***	3.79 (3.13 – 4.59)***
	5th quintile	5.17 (4.31 – 6.20)***	4.90 (4.04 – 5.93)***
Pollution from factories	*No*		1.00
	Yes		9.96 (8.18 – 12.30)***
Type of dwelling	*House/villa*		1.00
	Blocks		1.41 (1.23 – 1.63)***
	Other types		1.58 (1.26 – 1.99)***
Dwelling moisture	*No*		1.00
	Yes		1.35 (1.16 – 1.57)***
Bad indoor climate	*No*		1.00
	Yes		2.49 (2.07 – 2.98)***
Depression	*No*		1.00
	Some		1.37 (1.23 – 1.53)***
	Yes		1.22 (1.02 – 1.47)*
Asthma	*No*	1.00	1.00
	Yes	1.51 (1.30 – 1.76)***	1.31 (1.12 – 1.55)**

* p<0.05, ** p<0.01, *** p<0.001

Table 3: Associations between health variables and self reported air pollution problems (APP)[1].

Variables	OR (95% CI) and p-values				
	a) Initial model	b) Full model	c) Full model (Pollution from factories excl.)	d) Full model (Dwelling conditions excl.)	e) Full model (Depression excl.)
Asthma	1.51 (1.30 – 1.76) p=0.000	1.31 (1.12 – 1.55) p=0.001	1.38 (1.18 – 1.61) p=0.000	1.39 (1.18 – 1.63) p=0.000	1.33 (1.13 – 1.57) p=0.000
COPD	1.80 (1.48 – 2.21) p=0.000	1.50 (1.21 – 1.85) p=0.000	1.59 (1.29 – 1.95) p=0.000	1.59 (1.29 – 1.97) p=0.000	1.54 (1.24 – 1.91) p=0.000
CHD	1.43 (1.20 – 1.70) p=0.000	1.17 (0.98 – 1.41) p=0.082	1.20 (1.01 – 1.44) p=0.037	1.29 (1.07 – 1.54) p=0.006	1.21 (1.01 – 1.46) p=0.036
Diabetes	1.01 (0.73 – 1.38) p=0.940	1.03 (0.74 – 1.43) p=0.831	0.97 (0.70 – 1.34) p=0.876	1.04 (0.75 – 1.44) p=0.788	1.05 (0.75 – 1.45) p=0.762
Fibromyalgia	1.45 (1.19 – 1.77) p=0.000	1.24 (1.01 – 1.53) p=0.038	1.26 (1.03 – 1.54) p=0.025	1.32 (1.08 – 1.62) p=0.007	1.30 (1.06 – 1.60) p=0.012
Osteoporosis	1.40 (1.08 – 1.82) p=0.010	1.27 (0.97 – 1.68) p=0.080	1.31 (1.00 – 1.71) p=0.042	1.31 (1.00 – 1.73) p=0.047	1.31 (0.99 – 1.72) p=0.053
Poor SRH	1.42 (1.26 – 1.59) p=0.000	1.19 (1.04 – 1.35) p=0.008	1.20 (1.06 – 1.35) p=0.004	1.27 (1.12 – 1.44) p=0.00	1.25 (1.11 – 1.42) p=0.000

[1] Adjusted for all variables in Table 2. Each health variable entered separately in the model. The associations reported in the model are not adjusted for the other health variables.