Development and Evaluation of a Model for Estimating Long-term Average Population Ozone Exposures of Children

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Introduction

Ozone is an oxidant gas that has been shown to exert a variety of adverse effects on the human respiratory system. Accurate estimates of personal ozone exposure are important for human health risk assessments. Because personal ozone measurements are ideal but expensive to collect, modeled estimates of population ozone exposure can be used to assess its importance. A hierarchical regression model was used to estimate long-term (over one year) population ozone exposure. It was found that a simple model with easily accessible data can reasonably predict long-term population personal ozone exposure and help assess related health effects.

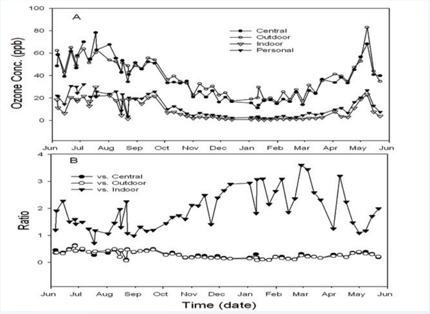

Figure 1. Temporal profile of ozone concentrations and ratios of personal to central, outdoor and indoor ozone concentrations

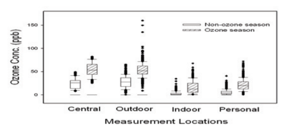

Figure 2. Ozone concentration variations in different measurements and by season.

Method

1) Data obtained from the Harvard California Chronic Ozone Exposure Study
   a) about 200 children ages 6-12 years followed for 1 year (6/95 – 5/96)
   b) detailed information on time activity and housing characteristics collected for each study subject; measurements of personal, indoor, and outdoor ozone concentrations collected for each subject
   c) personal ozone samplers worn for 6 consecutive days each month.
   d) indoor and outdoor ozone concentrations at participants' home monitored using passive ozone samplers
2) Central ozone concentrations derived from AIRS matched by GIS
3) Randomly-assigned two portions of data for Upland and Mountain areas, respectively: one for fitting models, other for model evaluation
4) Hierarchal-fitting regression models developed with time activity data, central outdoor ozone, outdoor ozone near children's homes, children's indoor ozone, etc.
5) Used fitted parameters and models independently to predict personal ozone exposure for the two geographic areas.
6) Used R^2s and coefficients to check fits for the different models

Table 1. Summary statistics of ozone concentration (ppb) by locations and sites

Ozone	site	mean	std	p50	p5	p95
Outdoor Ozone Conc. at Central site	Mountain Area	45.9	19.1	43.9	22.6	79.0
Outdoor Ozone Conc. at Central site	upland	29.0	15.2	28.2	8.5	54.3
Inddoor Ozone Conc. near Kid Home	Mountain Area	10.8	13.9	3.5	0.6	40.3
Inddoor Ozone Conc. near Kid Home	upland	6.7	7.7	3.5	0.6	24.6
Outdoor Ozone Conc. near Kid Home	Mountain Area	46.2	18.3	43.8	22.5	75.1
Outdoor Ozone Conc. near Kid Home	upland	32.5	17.5	30.3	8.3	63.3
Personal Ozone Conc. near Kid Home	Mountain Area	13.8	13.6	8.6	0.6	39.6
Personal Ozone Conc. near Kid Home	upland	11.6	10.0	8.5	0.6	30.8

Fit R2: predicted personal ozone using parameters from one portion of data and observed personal ozone from the model evaluation data, its coefficient is Fit Coeff.

Table 2. Results of hierarchal-fitting regression models

	Upland Area			Mountain Area		
Independent Variables	Model R2	Fit R2	Fit Coeff.	Model R2	Fit R2	Fit Coeff.
percent time indoor	0.239	0.186	0.52	0.514	0.510	1.21
Central outdoor ozone	0.715	0.785	0.98	0.792	0.782	1.11
Time-wegihted central outdoor ozone	0.705	0.574	0.87	0.772	0.758	1.18
Near-home outdoor ozone	0.784	0.848	0.98	0.727	0.682	1.07
Time-wegihted Near-home outdoor ozone	0.751	0.550	0.79	0.753	0.707	1.13
Indoor ozone	0.713	0.888	1.02	0.889	0.918	1.06
Time-wegihted indoor ozone	0.683	0.895	1.03	0.873	0.911	1.06
Outdoor and indoor ozone	0.833	0.909	0.95	0.917	0.932	1.07
Time-weight indoor and outdoor ozone	0.853	0.816	0.89	0.945	0.933	1.06
Central outdoor and indoor ozone	0.799	0.890	0.95	0.919	0.937	1.08
Time-wieghted central outdoor and indoor ozone	0.828	0.840	0.93	0.939	0.939	1.08

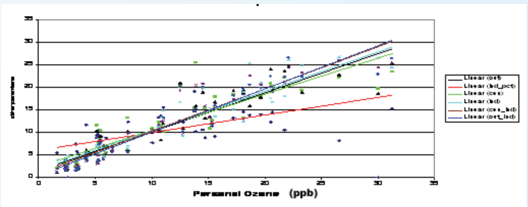

Figure 3. Linear regression of personal ozone with other ozone parameters in Upland

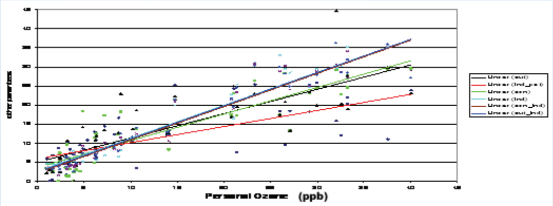

Figure 4. Linear regression of personal ozone with other ozone parameters in Lake area

Results

- Outdoor and central outdoor ozone >> personal ozone exposure and average outdoor and central ozone concentrations were very similar
- Variability of ratios of personal ozone to outdoor or central ozone is small, while that with indoor ozone is much greater across whole year (see figure 1)
- Concentrations were much higher in May-Sept. than other months (see figure 2)
- Best models fit when indoor ozone used with outdoor or central ozone, R^2s range from 0.8 to 0.9 with almost 100% accuracy
- Worst model resulted when using only activity time data (in term of R^2 and accuracy); time-weighted ozone concentrations do not help model prediction and accuracy
- Results are consistent between Upland and Mountain areas (see table 2, figures 3 and 4)
- Modeling with central outdoor ozone concentrations which are easily and cost-effectively obtainable can predict personal ozone exposure with reasonable prediction (R^2 range from 0.7 to 0.9 and accuracy is about 90% for average personal ozone, about 10% over-prediction)

Conclusions

- A model with only central ozone concentrations can predict long-term ozone personal exposures with reasonable accuracy.
- This model could help decision makers for controlling ozone concentrations at population level and reducing health risks from ozone exposure.

References:

Schwartz, J. Lung function and chronic exposure to air Pollution: A cross-section analysis of NHANES II; Environ. Res. 1989, 50, 309-321

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