COMPARISON OF EXPOSURE ESTIMATION METHODS FOR AIR POLLUTANTS: AMBIENT MONITORING DATA AND REGIONAL AIR QUALITY SIMULATION

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Background and Aims: Ambient monitors are often used to estimate air pollution exposure for epidemiological studies. This approach is efficient and economical but has limitations, including restricted coverage and resolution. Three-dimensional air quality modeling has potential to address some limitations of monitoring networks. We evaluated application of a regional air quality model to estimate air pollution exposure for epidemiological studies.
Methods: Individual and spatially-aggregated (county-level) exposure estimates for $PM_{2.5}$ and O_3 were calculated for the eastern U.S. in 2002 using simulation results from the Community Multi-scale Air Quality (CMAQ) modeling system and a traditional approach based on ambient monitoring data. Differences in populations included in monitor- versus model-derived exposure estimates were evaluated, and advantages and limitations of exposure estimation approaches were assessed.
Results: Exposure estimates generated from CMAQ provided greater spatial coverage and higher spatial and temporal resolutions compared to estimates from monitor data. The monitoring approach produced estimates for 370 counties for $PM_{2.5}$ and 454 for O_3. Modeled estimates included 1861 counties, covering 50% more population. Populations with and without monitor coverage differed: counties with monitors tended to be more urban, with a higher percentage of black residents, college graduates, young children, and higher median income and modeled pollutant levels. CMAQ slightly overestimated O_3 (annual normalized mean bias [NMB]=4.30%); annual modeled $PM_{2.5}$ estimates were similar to observations (NMB=-2.09%), though bias varied seasonally (e.g., -27.1% in July to 32.0% in November).
Conclusions: Epidemiology may benefit from use of regional air quality models, with improved spatial and temporal resolutions and ability to study populations far from monitors that may differ from those near monitors. However, model performance varied by pollutant, measure of performance, and exposure metric. Appropriateness of using modeled pollutant exposures in health studies depends on the pollutant, acceptable level of uncertainty, population of interest, study design, and other factors.