AIR INDICATOR WORK GROUP SUMMARY DOCUMENT
State Environmental Health Indicator Collaborative
Council for State and Territorial Epidemiologists

I. Introduction

Exposure to ambient air pollution causes significant public health impacts in the U.S. Exposure to criteria air pollutants (i.e. ozone, particulate matter (PM), sulfur oxides, nitrogen oxides, carbon monoxide, and lead) and toxic or hazardous air contaminants (e.g. benzene, perchlorethlyene, methylene chloride) have been related to acute and chronic health conditions as diverse as respiratory illness, reduced lung function, cancer, heart disease, and adverse reproductive outcomes. An analysis in 2002 found that a 10% reduction of PM and ozone in Santiago, Mexico City, Sao Paulo, and New York over next 20 years would avoid 64,000 premature deaths, 65,000 chronic bronchitis cases, and 37 million person days of work loss.[1] Recently, the U.S. EPA has also been mandated to regulate emissions of carbon dioxide (CO_2), which is a major greenhouse gas which causes global warming. Increases in heat due to CO_2 emissions and global warming also create conditions which favor raised ozone levels in urban areas, furthering public health impacts.

The goal of the State Environmental Health Indicator Collaborative (SEHIC) Air Indicator Workgroup was to develop a set of nationally consistent state-level indicators and measures of air quality, including how-to guides, for national surveillance of air quality trends which are germane to public health. These indicators, which are standardized and can be compared across states, can be used to detect trends over time, identify geographic areas in need of improvement, and be used as a basis for influencing environmental public health policy.

II. Selection of indicators and measures

Indicator #1: Long-term trends in overall burden of ozone and particulate matter.

First, an indicator was selected which would reflect long-term trends in the overall burden of criteria air pollutants. Ozone and particulate matter were the two pollutants selected due to their national significance of public health exposure of concern. Exposure to ozone is related to increased emergency room visits and hospital admissions due to chronic obstructive lung disease, asthma, pneumonia and other respiratory emergencies. According to the California Air Resources Board, premature deaths linked to particulate matter are now at levels comparable to deaths from traffic accidents and second-hand smoke.

Three measures were developed for this indicator:

1. Ambient air concentrations of particulate matter (< 10 microns diameter = PM_{10})

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[1] Cifuentes, et al: (Science 293: 1257, 2002)

2. Ambient air concentrations of particulate matter (<2.5 microns diameter = $PM_{2.5}$)
3. Ambient concentrations of ozone (O_3)

The particulate matter measures (#1 and 2) are the annual average of all 24-hour average values from each monitor by county in micrograms per cubic meter ($\mu g/m^3$). Certain geographic areas, such as those near construction sites, are likely to have higher values. Considerable within-county variation in concentrations will likely exist but will not be captured in these measures.

The ozone measure is the average of all daily eight hour maximums for each monitor by county for the six month ozone season in parts per million (ppm). The ozone season is defined as the six months with highest ozone values. Ozone tends to be a regional rather than a localized pollutant, so measurement at the county level is informative.

The data source for these measures is the EPA Air Quality System (AQS) Database, State Air Monitoring Data (http://www.epa.gov/oar/data/aqsdb.html). Air monitoring data provides information regarding concentrations at the specific location of each monitor. The measures may be affected by density and placement of monitors, and coverage will vary by state and county. They do not directly reflect exposure.

Figure 1 shows the average of the daily 8-hour maximums for the 2005 ozone season by county in Florida. County averages range from 0.03 to over 0.05 ppm.

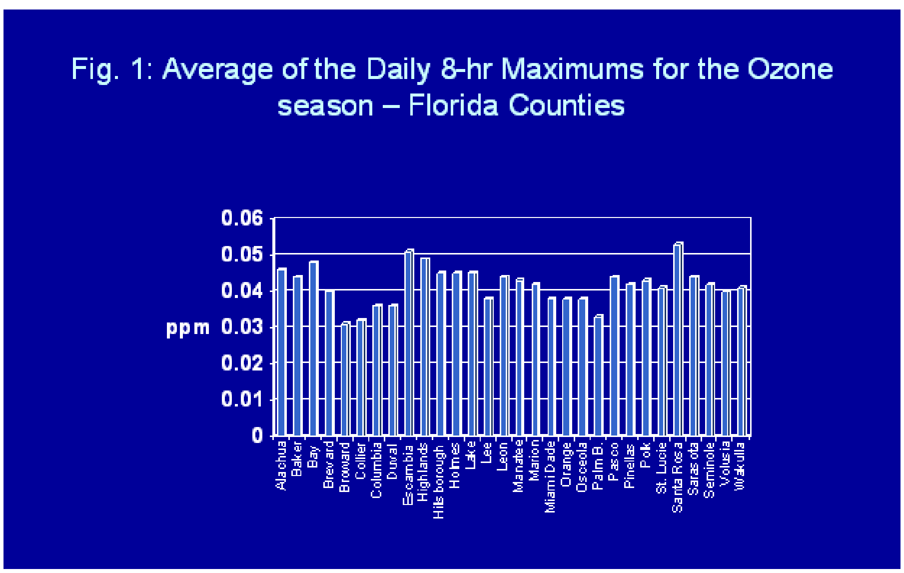

Figure 2 shows the annual average of all 24-hour $PM_{2.5}$ average values for all counties in Florida also for 2005. The graph shows significant variation by county, ranging from under 8 $\mu g/m^3$ to more than 13 $\mu g/m^3$.

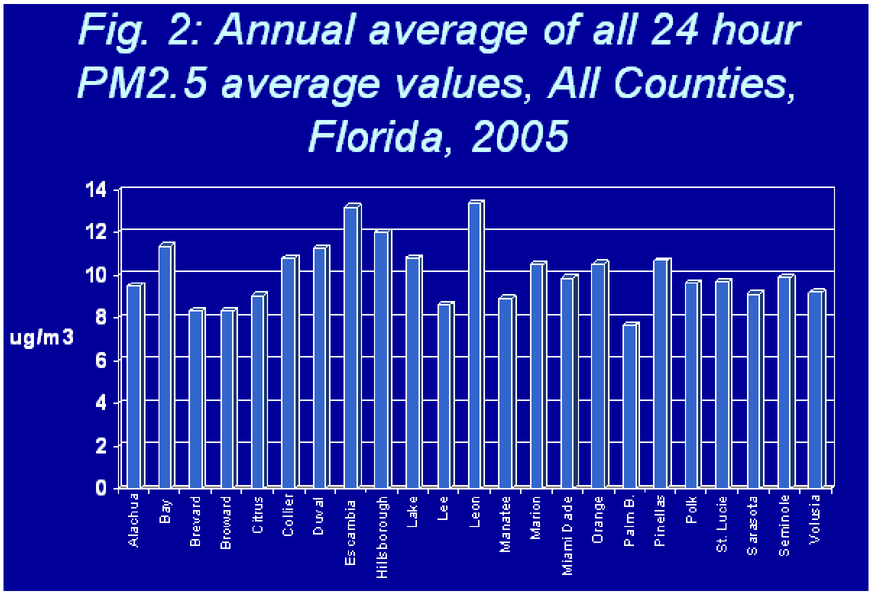

Fig. 2: Annual average of all 24 hour PM2.5 average values, All Counties, Florida, 2005

Indicator #2: Regional estimates of days and days weighted by population which air quality exceed National and State standards for particulate matter and ozone

The second indicator selected reflects the number of days in which air is unhealthy in a region (as measured by exceedances over national and state standards for particulate matter and ozone) and the number of people exposed to these unhealthy levels. More than half of the U.S. population, approximately 159 million Americans, live in counties with unhealthy levels of air pollution in the form of either ozone or particulate matter.[2] Prolonged exposures to particulate pollution are associated with an increase of all causes of mortality by as much as 26 percent. The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards (NAAQS) for wide-spread pollutants from numerous and diverse sources considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as individuals diagnosed with asthma, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against visibility impairment, damage to animals, crops, vegetation, and buildings. The Clean Air Act requires periodic review of the science upon which the standards are based and the standards themselves. Primary air quality standards tell us how much of a substance can be in the air without causing harm, based on proven scientific and medical research.

Two measures were developed for this indicator. It was determined that PM_{10} monitoring was too sparse to develop a measure for PM_{10}.

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[2] ALA (American Lung Association). 2004. State of the Air 2004. Available: http://lungaction.org/reports/sota04_full.html

1. Number of days & person-days for daily $PM_{2.5}$ 24-hour average concentrations over national and/or state standards
2. Number of days & person-days with maximum 8-hr average O_3 concentration over national and/or state standards

These measures should be computed for Counties or Metropolitan Statistical Areas (MSAs) with monitors on an annual basis. The data for this indicator only represent MSAs and counties that have air monitors and tend to reflect urban air quality (where most people live). Thus, although populations in counties and MSAs without monitors may also be exposed to particulate matter and ozone concentrations that exceed the standard, they are not counted.

This indicator is understood to function as a surrogate measure for actual population exposure. The relationship between ambient concentrations and personal exposure is largely unknown and highly variable, depending upon activity patterns, and microenvironments. Variation within counties and MSAs may exist but will not be captured in this indicator. The number of days that exceed the EPA national and/or state standards do not provide information regarding the severity (maximum concentrations) of potential exposures.

Analytically, there is a need to carefully sum data by counties and MSA to avoid "double counting." Within these areas, the monitor with the highest reading on any day is used in the measure. Results for larger MSAs and counties may be biased higher than results for smaller MSAs or counties because the indicator uses the highest value of any monitor in the area. Larger areas will have a broader range of pollution values and likely more monitors that may capture a high value on a given day. At the state level, this indicator may underestimate the number of person-days of potential exposure, since all people in the state are not included in the analysis.

It is important to understand that this indicator is not intended to be used to make compliance determinations regarding NAAQS or progress toward attaining compliance. This indicator is generated based on air quality monitoring data with recognized uncertainties. Air monitoring data is available only for every 1 in 3 or 1 in 6 days, with some exceptions. The effort to obtain all the data may indicate that a central system is needed to gather the data and calculate the measures.

Indicator #3: Proportion of population potentially exposed to traffic-related pollutants.

Finally, indicator #3 estimates the proportion of population potentially exposed to traffic-related pollutants. Motor vehicles are a major contributor to the load of greenhouse gases, toxic and criteria pollutants in urban air. Numerous health studies have found associations between traffic pollution exposure and adverse health outcomes.

The measure for this indicator is the percentage of population living within 300 meters of busy roads (defined as greater than 10,000 cars/day) summarized by county. This measure is calculated by overlaying U.S. Census (2000) block group polygons with a traffic segment layer that includes average annual daily traffic attributes in a geographic information system (GIS) environment (see how-to-guide in Appendix). Three hundred (300) meters is considered a reasonable distance in which a substantial proportion of traffic-related pollutants have not dispersed to background levels, according to statistical models. There is no standardized definition for “busy roads,” so 10,000 cars/day is an arbitrary cut-point, but it is considered an approximate amount of traffic found on busy highways. Figure 3 shows the percentage of population living within 300 meters of busy roads by county in California. The figure shows substantial variation, with urban counties such as San Francisco and Los Angeles having greater than 70% of the population living near busy roads, and many less populated rural counties having less than 20% of the population living near these roadways.

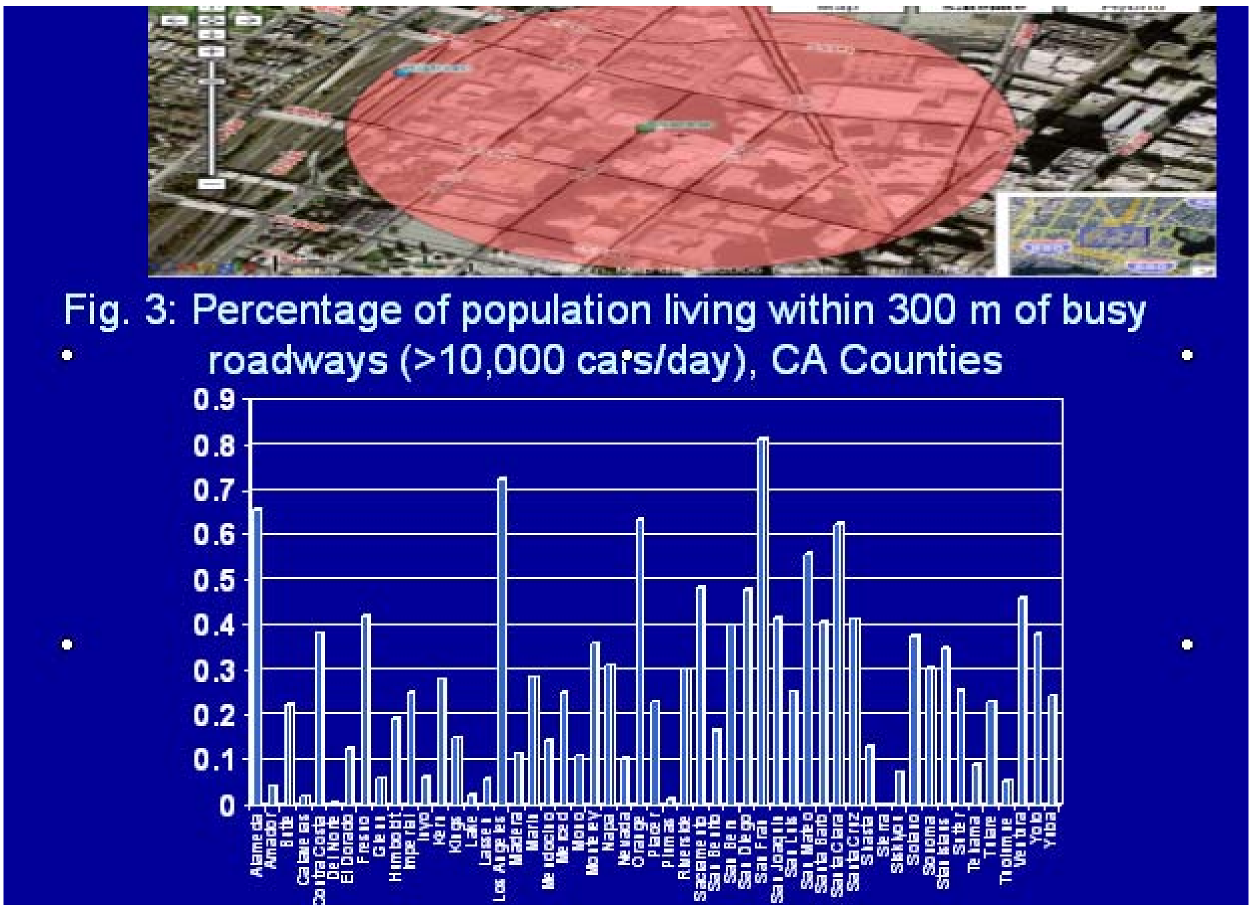

Fig. 3: Percentage of population living within 300 m of busy roadways (>10,000 cars/day), CA Counties

There are several limitations to this measure. First, it is unknown the degree to which this measure reflects actual exposure. Traffic mix (e.g. amount of diesel traffic), upwind and downwind direction of pollutants, and other meteorological conditions will affect exposure, and are beyond the scope this measure. The estimate of the percentage of population living near busy roads will be an approximation based on overlays of census block groups. However, until further refinements, this measure can serve as a rough estimate of potential exposure of populations to traffic pollutants.

III. Discussion

Lessons learned from indicator development/pilot testing to date

<u>What about this topic area makes indicator development easy/challenging?</u>

The templates and guidance documents generally follow the previously developed CSTE/CDC Occupational Indicators. However, in completing the templates and guidance documents ("how-to"), there were changes that occurred, in part because of numerous reviews and edits during the course of development and also due to different members working on portions of the indicators at different times. The resulting inconsistencies in the formats of the indicator documents required additional review and editing.

The scope of environmental data for this topic and the variability in which each state collects data was somewhat problematic. However, the federal agency's standards helped focus the group on generally available data. It is critical to the process to have a variety of states (both in terms of geographic size and population) as well as skilled technical advisors accustomed to ambient air monitoring techniques and data interpretation methods. Therefore, federal agency participation was extremely helpful.

Issues also arose regarding use of census data since that also introduced variability among states. The participation of health professionals with experience in application of population counts was also important. The work group reaffirmed the necessity and priority that indicators should be readily reproducible by any state. This guided the development process, and also led to some changes in templates and guidance.

Further remarks about the development of these indicators will be addressed by categories: ambient air monitoring (indicators 1 -3), and population-based calculations (indicators 4 – 6). The work group has put forth three additional indicators considered "developmental" since they are currently incomplete and to some degree they present unique challenges.

<u>Ambient air monitoring</u>

In general, the U.S. Environmental Protection Agency's standard air monitoring, reporting, collection, and dissemination process has provided the primary resource from which states draw data (EPA Air Quality System (AQS) Database). Some states are able to access state-generated data. Public health agencies closely associated with their sister agencies in environmental air monitoring, or with integrated environment and public health agencies, are likely to access data directly. Other agencies may have to retrieve the data from the EPA website. Some difficulties have been reported in downloading files from those sources. There were discussions about the use of daily averages, time period for ozone season (varies across the U.S.), and ozone values. Identification of problems or recommendations for change will be facilitated by the piloting and evaluation process.

Population-based calculations

There were a number of challenges associated with calculating environmental measures by population. There was discussion about an appropriate denominator; difficulties arose since some states do not collect air samples state-wide, therefore it was not always possible to calculate by county population. Also, determining which census data to use was problematic since the census is collected every 10 years, with estimates and projections disseminated between census collections. Some states adjust these measures, others may not. Changes in demographic measures, particularly regarding race/ethnicity, make any calculations related to those categories difficult. The three population bases considered were county, state, metropolitan statistical areas. The variability of tables available and the tables used by different agencies make consistency in comparisons important. This should be considered in the piloting and evaluation process.

Lessons Learned to Date:

1. Collaboration across programs and disciplines is essential.

It became evident early in the process that assumptions always need to be verified. There also need to be a variety of scientific disciplines involved, from the technical, social and policy level.

2. Clearly communicating during development and creating indicators is critical.

Speaking the same language or providing explanations as each discipline contributes to the process is essential. There are a staggering number of acronyms and technological resources that may be involved. This is both a strength and a challenge.

3. Considerations for formatting/presentation should be determined early in the process.

Consistency in format is important early on. If individuals or sub-groups take on crafting the templates and guidelines, there should be a process for either adhering to the format or recommending changes and incorporating changes systematically.

Assuring that the presentation of the data does not mislead the user of the templates or guidelines is critical. It was difficult, at times, to adhere to the fact that indicators are a surveillance tool and not a method of determining statistical association or cause-effect relationships. This is particularly true for the marketing of these tools.

4. Decisions in the group process require time.

At times “interesting” or innovative concepts were simply too demanding and difficult to achieve any kind of progress. The work group was challenged and often reminded each other that the purpose was a uniform usability across many states, including those without many resources or measures.

Comparing measures to a standard was controversial at times, especially where states may have more conservative standards than federal programs.

Addressing issues among the group, especially while operating primarily by teleconferencing and electronic mail, took time.

5. Pilot testing and tracking changes is a critical step in the process

Testing or "trying" the proposed measures or how-to guidelines happened throughout the process. Some of the testing wasn't particularly well-planned or orchestrated. There was a heavy reliance upon the "experts" to review and edit language and steps.

The quantity of "draft" documents shared among members, attribution of edits, consideration of whether to accept/change, and finalization of the indicators and associated documents was unwieldy. Because these were developed with little face-to-face meetings, timing and tracking versions became critical, though there was not a commitment to any particular process.

The work group had difficulty at time achieving an end-product because of the sheer volume of work.

IV. Conclusion

How can this work and lessons be used to inform others regarding the indicator development process within each content area to date?

The SEHIC Air team developed three core indicators of air quality: (1) long-term trends in overall burden of ozone and particulate matter; (2) number of days and person-days that air is unhealthy in a region; and (3) percent of population potentially exposed to traffic-related pollution. With the exception of indicator #3, these indicators are based on data collected from existing U.S. EPA monitoring locations which is made available subsequent to quality assurance and quality control review.

These indicators should be used to examine air quality trends over time in a region and to inform policy makers regarding the percentage of populations which live in urban areas with air monitors which exceed air quality standards. Since the measures for these indicators are averages or exceedances, they do not give information on the severity of a specific air pollution episode.

Further, these indicators are not surrogate measures of exposure and therefore any link to health effects measures has considerable limitations. However, long-term trends may inform us of long-term health effects.

View air quality indicators: < http://envirohealth.berkeley.edu/SEHIC2007/index.htm>

How can these indicators be improved?

To the degree that these indicators assemble data that is representative of the topic area, and propose measures that are derived from evidence-based science and are readily reproducible by state public health agencies, these indicators are useful to the environmental health practitioner. The limitations are expressed in the templates as well as described by this project summary document. There are considerations that should be made in evaluating the effectiveness of these indicators more specifically. For example:

1. Consideration should be given to evaluating more specifically how well county boundaries and MSAs represent regions of similar air quality (based on the monitors within these areas), how well these areas are comparable, and whether they capture the vast majority of elevated exposure within a state.

2. Consideration should be given to calculating the percent of the population in the state that lived in MSAs and counties with monitors (above and below the standard) (i.e., 100* (Population living in MSAs and counties with monitors exceeding standard) / (total population in all MSA and counties with monitors)).

What other indicators may expand on the understanding of air quality and public health for the environmental practitioner?

Two additional "developmental" indicators are recommended for future consideration:

1. Number of days and person-days a defined population was exposed to the top three levels of the federal Air Quality Index (e.g., Very Unhealthy, Unhealthy, and Unhealthy for Sensitive Groups)
2. Hazardous air pollutants and health benchmarks - this measure would provide an indication of the proportion of population living in counties with levels of hazardous air pollutants of potential health concern. This proposed indicator would compare ambient concentrations of hazardous air pollutants with three health benchmark concentrations. Two benchmarks reflect potential cancer risks, at levels of 1-in-100,000risk and 1-in-10,000 risk. The third benchmark concentration corresponds to the level at which exposure to the hazardous air pollutant is judged to be of minimal risk; exposures above this benchmark may be associated with adverse health effects other than cancer.
3. CO_2-equivalent Greenhouse Gas emissions per capita.

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