FINAL REPORT ON THE SEPTEMBER 12, 2012 ADVISORY COUNCIL MEETING ON ULTRAFINE PARTICLES: EXPOSURE REDUCTION

SUMMARY

The following presentations were made at the September 12, 2012 Advisory Council meeting on Ultrafine Particles: Exposure Reduction:

1. Exposure to Ultrafine Particles on and Near Roadways by Yifang Zhu, Ph.D. Professor Zhu is currently an Associate Professor at the University of California, Los Angeles in the Environmental Health Sciences Department in the Fielding School of Public Health. Prior to that, she worked as an Assistant Professor in the Environmental Engineering Department at Texas A&M-Kingsville. Her research focuses primarily in the field of environmental exposure assessment and aerosol science and technology. Specifically, she is interested in determining the data necessary to fill the knowledge gap in quantitative exposure/risk assessments on vehicular emitted ultrafine particles that have shown higher toxicity than larger particles on a unit mass basis. Her current research focuses on identifying key factors that affect human exposure to ultrafine particles on and near roadways by measuring and modeling their emissions, transport, and transformation in the atmosphere as well as into the in-cabin and indoor environments. These research efforts are supported by two prestigious national awards, the National Science Foundation Faculty Early Career Development (CAREER) Award and the Walter Rosenblith New Investigator Award from the Health Effects Institute.

2. Policy Strategies to Reduce Health Effects from Particulates by Rajiv Bhatia, MD, MPH. Dr. Bhatia is the Director of Occupational and Environmental Health for the San Francisco Department of Public Health and an Assistant Clinical Professor of Medicine at the University of California San Francisco. He has been responsible for environmental health law and policy in San Francisco since 1998 and has broadened the scope of local environmental health to include issues of labor rights, working conditions, housing, land use, transportation, injury prevention, and food security. He has pioneered the practice of health impact assessment (HIA) in the US, institutionalizing a HIA unit in San Francisco government, teaching the first US graduate course on HIA at the University of California at Berkeley, and co-founding Human Impact Partners, a non-profit organization working nationally to build the field. He is a founding member of the Health and Social Justice Team for the National Association of County and City Health Officials and the co-editor of *Tackling Health Inequities through Public Health Practice: Theory to Action*. Dr. Bhatia earned a MD from Stanford University in 1989.

KEY POINTS

Yifang Zhu, Ph.D. - "Exposure to Ultrafine Particles on and Near Roadways"

Dr. Zhu reiterated the following points that have been previously presented to the Advisory Council:

1. Most ultrafine particle (UFP) deposition occurs in the deep-lung alveolar (gas-blood interface) region. Deposited UFP can result in alveolar inflammation and, because of their small size and ability to cross membranes, UFP can migrate from the lung and nasal passages to the heart, brain, and other areas of the body.

2. Recent studies have examined the air pollution health effects of ultrafine particles (UFP) related to exposures near heavily trafficked roadways, and these health effects have included cardiac and pulmonary health risks, adverse effects on children's lung development, decreased lung function in adult asthmatics, and autism incidence.

3. Compared to PM10 and PM2.5, the UFP fraction has relatively higher particle numbers, but lower mass.

4. Vehicle emissions usually constitute the most significant source of primary UFPs in an urban environment.

Dr. Zhu also reported:

1. UFP numbers measured at two monitoring locations in the Los Angeles (LA) area were highest during commute periods, consistent with vehicle emissions as a major contributor. Also consistent with vehicle emissions as a major UFP contributor, particle numbers in the air over an LA freeway were measured at nearly seven times higher than background, while particle mass increased only about 10 percent.

2. UFP numbers decayed exponentially with distance downwind of two LA freeways, dropping by nearly an order of magnitude within 100 meters of the roadway; this is a faster reduction than what occurs with gaseous emissions. Elevated UFP numbers downwind of one freeway in LA persisted during the night at a distance of up to a mile, a greater distance than during the day. It is important to note that shifts in wind speed and direction can affect and even reverse UFP concentrations on either side of a roadway.

3. Higher UFP numbers were measured on a freeway (I-710) more heavily travelled by heavy-duty diesel trucks than on another freeway (I-405) with less such traffic, indicating diesel trucks as a significant contributor to UFP. However, UFP was measured at significant levels along both freeways, not just those with diesels. Thus gasoline engines also contribute to UFP emissions.

4. Significant numbers of UFP can penetrate indoors into residences near roadways. This can be a significant contributor to UFP exposure for residents, given that people spend more than

80% (and often more than 90%) of their time indoors. Of note, UFPs –50 to 100 nanometers (nm) in size penetrate indoors more easily than those that are less than 50 nm.

5. In-vehicle cab recirculation using a filter reduced UFP exposure measured in three different makes/models of vehicles to between 5% and 40% of UFP levels in outside air. The degree of UFP reduction depends on age and model/make of vehicle and such factors as cabin tightness and type of filter, which can influence outdoor air penetration, deposition efficiency, and degree of filtration. However, with reduced air penetration while air is recirculating, carbon dioxide (CO_2) levels can build up inside the car significantly, creating a secondary concern.

6. Using a mathematical model, in-cabin ventilation measures, including recirculating cabin air (RC) and a fan, were calculated to affect in-cabin UFP exposure while in a new and tight vehicle as follows:

   a) Fan off and RC off: ~40% of outdoor on-roadway levels.
   b) Fan on and RC off: ~20% of outdoor on-roadway levels.
   c) Fan on and RC on: <10% of outdoor on-roadway levels (i.e., this combination affords the greatest protection).

7. Future advances in in-cabin filtration technology have significant potential to reduce commuters' exposure to ultrafine particles while at the same time solving the CO_2 build-up problem. HEPA filters provide the greatest protection, though stand-alone air purifiers can also significantly reduce $PM_{2.5}$ and UFP levels inside vehicles, as has been done in school buses.

8. 2011 data show that UFP concentrations on and near the freeways tested have decreased with low sulfur fuel, exhaust catalytic converters, diesel particulate filters, removal of clunkers (high emitters), and other modern technological changes.

9. Factors that can reduce UFP exposure near roadways include:
   a) Meteorological: Staying on the upwind side of major roadways or 100+ m downwind
   b) Spatial: Staying away from major roadways
   c) Temporal: Avoiding roadways during heavy traffic hours.

10. Factors that can reduce UFP exposure inside vehicles include:
    a) Route-related: Avoiding driving on heavy-duty vehicle routes
    b) Driving-related: Avoiding idling (this includes turning off bus engines at transfer points)
    c) In-cabin ventilation usage: Closing windows and turning on recirculation and fan
    d) In-cabin filtration usage: Using HEPA filters/air purifiers.

<u>Rajiv Bhatia, MD, MPH – "Policy Strategies to Reduce Health Impacts from Urban Particulate Pollution"</u>

1. Regional monitors are not adequate for assessing localized exposure levels in close proximity to significant local sources, such as freeways, and do not provide adequate data for policies directed at such exposures. Europe has been doing localized monitoring for some time. There is a priority need for neighborhood scale air pollution monitors and models.

2. For a variety of reasons, infill growth has been concentrated near eastern San Francisco (SF) freeways. SF is a leader in air pollution exposure assessment and mitigation. To guide policy, the city has developed maps showing model-estimated traffic-related PM 2.5 concentrations along roadways. These maps are useful in determining where PM2.5 exposure reduction measures are required for new development projects and have been extremely helpful in building public support for policies to mitigate emissions and exposures.

3. Compared to many areas around the state, San Francisco has good overall air quality. All areas of San Francisco meet both federal and state annual PM2.5 standards, and few areas of SF have PM2.5 levels higher than 10 ug/m3 (the state annual standard is 12 ug/m3 and the federal annual standard is 15 ug/m3). Background levels in SF are approximately 8 ug/m3. SFDPH has estimated there are 103 annual premature deaths due to exposures in areas with annual PM2.5 levels at or above 8 ug/m3. This illustrates the value of continued PM2.5 exposure reductions, even when clean air standards are met.

4. Local strategies to reduce PM exposure could include:
   a) Emission reductions (e.g., reducing growth of traffic density through measures such as land use zoning, congestion pricing, parking control, impact fees, improved transit, improved bicycle and pedestrian environments)
   b) Exposure management (e.g., enhanced ventilation systems for new residences in areas with high particulate levels or cancer risks; improving ventilation in existing residential dwellings).

5. To reduce indoor exposures to urban air pollution in infill areas, SF developed <u>Health Code Article 38</u> for new residential development in areas in proximity to freeways and major roadways. Under the requirements of this article, dwelling units proposed to be located within a potential roadway exposure zone at a location having PM2.5 greater than 0.2 ug/m3 attributable to local roadway traffic sources have to install a ventilation system capable of removing at least 80 percent of ambient PM2.5 from habitable areas. It is important to note, however, that this regulation applies to new construction, and does not protect existing residential or other uses in such areas.

6. A number of thoughts for regional air pollution policy were listed, including:
   a) Regulation of traffic corridors as emissions sources (e.g., limits on highway capacity expansion, urban freeway speed and flow control).
   b) Identification and prevention of local air pollution use conflicts (e.g., commercial exhausts)
   c) Regionalization of local best practices (e.g., instituting ventilation upgrades to accompany weatherization work, prioritizing near-roadway areas).

7. Because more mid to upper income residents are choosing to move into infill areas with higher levels of PM, air pollution exposure disparity by income levels is decreasing.

8. Both noise and pollution emission levels increase with traffic. Noise control ordinances and other building code laws can be used as an administrative example for addressing indoor air quality via an air pollution exposure reduction ordinance (i.e., by requiring mitigation via building design when pollution exceeds a certain level).

9. Air quality solutions can be integrated into existing programs and regulations to produce desired co-benefits (i.e., some technologies that protect interior noise levels may also work to reduce interior air pollutants; programs that target energy efficiency/home weatherization can be expanded to include concepts of ventilation and air filtration).

EMERGING ISSUES

The Advisory Council has identified the following emerging issues:

1. Proximity to traffic and vehicle emissions are keys to UFP exposure. There is a need to better understand the relative effectiveness of, and interaction between, various strategies to reduce UFP and other sources of air pollution. In doing so, there is a need to recognize the following hierarchy of exposure reduction mechanisms, with the higher-tier ones, though often harder to implement, more effective and able to protect a larger proportion of the population:
   a) Reduce sources (such as reducing the number of vehicle miles traveled, as well as high emitting vehicles; incentivize more user-friendly bicycle and pedestrian environments)
   b) Replace or substitute (such as increasing the number of electric or alternative fuel vehicles)
   c) Engineering controls (such as utilizing lower-emitting vehicles; developing more effective in-cabin filters; improving building ventilation near roadways)
   d) Administrative (such as reducing/enforcing speed limits; utilizing congestion pricing; instituting parking controls; changing land use zoning; improving incentives for biking, walking and public transportation; locating residential development further from busy roadways; mitigating traffic emissions)
   e) Personal behavior (such as utilizing more effective in-cabin ventilation practices, lowering driving speeds, altering travel routes and trip timing; expanding use of public transit).

2. There is a need to better understand the range of measures available to reduce UFP and PM2.5 and their co-benefits (e.g., reducing traffic speed to 50 MPH may have a significant and immediate impact on reducing greenhouse gases, UFP, and other air pollutants, with reductions in noise, injuries and fatalities as co-benefits). Technologies that result in air pollution exposure reduction that also have positive co-benefits also should be pursued.

3. It will be important to craft effective public education messages that help the public understand how to reduce UFP exposure, especially for neighborhoods, sports fields and playgrounds closest to freeways, while commuting, and for age or occupation groups expected to have higher UFP exposures (e.g., cyclists, pedestrians and those in near-roadway occupations).

4. There is a need to consider source and receptor siting criteria that better take into account local conditions to most effectively reduce UFP exposure. Neighborhood scale exposure models coupled with monitoring could assist local governments in identifying locations where resources should be expended to reduce emissions and/or exposures most effectively (e.g., in determining areas to site new sources or receptors, as well as areas of existing sources and receptors that need attention).

5. There is a need to develop measures to reduce UFP exposures while driving. This is expected to include enhanced vehicle cabin recirculation and filtration. There is a wide

range of filter efficiencies for in-cabin filters, and none approach HEPA level efficiencies.

6. There is a need for state/regional agencies to further develop model policies for UFP exposure and disseminate them to local governments. San Francisco leads in modeling at the neighborhood level and in establishing building code standards to minimize air pollution exposures (e.g., enhanced ventilation systems for new residences with higher fine particulate levels or cancer risks). There are approximately100 cities and 9 counties within the BAAQMD jurisdiction that do not have any such mechanisms in place.

7. Regional monitors are not adequate to assess localized exposure levels in close proximity to significant local sources, such as freeways and do not provide adequate data for policies directed at such exposures. Europe has been doing localized monitoring for some time. There is a priority need for neighborhood scale air pollution models.

8. Energy efficiency programs to weatherize existing housing stock could be expanded to help ensure that ventilation systems are also improved as air penetration is tightened.

9. Noise control codes for new construction can be a model for crafting code-related strategies to reduce indoor air quality exposures.

RECOMMENDATIONS

The Advisory Council recommends that the Air District:

1. Continue planning to integrate UFP into its efforts to reduce PM exposure.

2. Continue to follow the development of, and incorporate into the District's existing multi-pollutant approach to air quality planning, emerging methods for analyzing UFP exposures, health risks, and mitigation.

3. Continue to consider the hierarchy of exposure reduction mechanisms in developing measures to reduce exposure to PM and other air pollutants.

4. Continue efforts to develop suitable tools to model UFP air quality impacts at a neighborhood and regional level and the development and refinement of a UFP emission inventory. UFP modeling should be validated with monitoring data.

5. Integrate UFP monitoring with required NO2 roadside monitoring. Consider supplementing the District's regional monitoring network with localized monitoring to gain a better understanding of UFP exposures in varying traffic and neighborhood environments.

6. Work with other agencies to encourage development of standards and incorporation of measures to reduce UFP and other air pollutant exposures in vehicles (e.g., in-cabin vehicle filtration and recirculation systems). Educate the public regarding the use of such measures.

7. Provide guidance to regional and local agencies, particularly those with land use authority, on systematic approaches for evaluating and reducing exposures to UFP and other air pollutants in both outdoor air and indoor spaces, and develop model policies and regulations to address PM2.5, UFP and other air pollutant exposures (e.g., criteria/guidelines for siting sensitive land uses and/or technological solutions for improving indoor air quality in both new and existing buildings; education programs that provide information on reducing personal exposure to UFP and to support existing strategies to reduce PM2.5 and other pollutants).

8. Present material to the Advisory Council on the state of the science of cumulative impacts analyses.

9. Consider developing, or offer a prize for developing, a District smart-phone and/or iPad app that can improve public understanding of the dangers of air pollution and provide information about current air quality, Spare-the-Air alerts, personal actions that could be taken, news and events, alternative fueling station locations, calculation of carbon footprints, smoking vehicle complaints, and other useful information.

10. Work jointly with the Advisory Council to identify and implement means for the Council to support the efforts of the District's Health and Science Officer.

GLOSSARY

CO_2 – Carbon Dioxide

HEPA – High Efficiency Particulate Air

NO_2 – Nitrogen Dioxide

nm – Nanometer (one billionth of a meter)

PM – Particulate Matter

RC – Recirculate

UFP – Ultrafine Particulates

SFDPH – San Francisco Department of Public Health