October 19, 2016

Airport Advisory Commission:
Karen Sherman, Glenn Ray, Jeffrey Anderson, Wayne Chaney, Elizabeth Cruz, Hal Gosling, Gerald Mineghino, Jeff Rowe, Roland Scott

Dear Commissioners:

The Jacobs Feasibility Study has just been released. That's all it is, a feasibility study. A study that suggests a "probable" finding based on information that is not comprised of 100% undisputable facts. It can also be regarded as a "judgement call". Let's just put it in simple layman's terms, it's a calculated guess with emphasis on "guess". Historically, we can look at countless calculated guesses that have turned into horrific and fatal catastrophes.

What's on the table here is a number of issues (health, economic and environmental etc.) that have actually occurred in many other cities once an airport goes "International" and/or steps up the air traffic volume. These local cities which are still victims of LAX, John Wayne International and Ontario International are: **Playa del Vista, Playa del Rey, Westchester**, El Toro, Santa Ana, Newport Beach, Laguna, Inglewood, Torrance, Downey, Westminster, Seal Beach, Los Alamitos and Avalon. There are countless more when you look countrywide. In the cases of Playa del Vista, Playa del Rey and especially the City of Westchester, feasibility studies were conducted and the end result was catastrophic to many residents.

This "calculated guess", which you may rely on to make a decision, will also affect other contiguous communities i.e.; Huntington Beach, Huntington Harbor, Sunset Beach, Surfside, Torrance, Palos Verdes, Rancho Palos Verdes, and many others within a 10 to 20 mile radius (studies show even further distances). There is more than just "cities" that are on "the table". Please consider and include our beaches, our ocean environment and its inhabitants, our open spaces with its inhabitants and our mountains with its inhabitants…trees, birds, animals, fishes, and all living things.

Long Beach is already a major contributor of pollution. It, combined with LA, is Ranked #1 (worst) for High Ozone out of 228 Metropolitan Areas in 2016. The American Lung Association says that LB fails for Ozone Contaminants, it fails for Particle Pollution over a 24 hour period and for the Particle Pollution measured annually…it fails. Other Studies show that LB is one of the largest emitters of Poisonous Lead Emitters. I have submitted six (6) "pdf's" for you to review, two of which are from the Jacobs Study. The other four, contradict the obvious bias of the Jacobs study regarding the health issues as a result of an International Airport nearby. As well, there are many other reports that are available that contradict the Jacobs Study.

As the LB Airport Advisory Commission, shouldn't you consider the International Airports that are already within the close proximity? Why subject a "seaside" community and its citizens to adversity and assault when other "International" Airports are so close by? Why try to put a square peg in a round hole? El Toro gave it up because there were other International Airports already too close by. The Airport Advisory Commission can do just fine leaving LB as a "neighborhood" friendly municipal airport….which most say emphatically: " That's why LB Airport is so attractive".

I could go on and on discussing the true economic impacts to LB residents, the noise invasion, the environmental impacts, the impacts of contaminant species from S. America (by Jet Blue), the further heath impacts beyond anyone's imagination and the political pay offs by corporate corruption (Jet Blue).

It's unwise to think that the existing "Noise" Ordinance will curb what is going to happen if you approve the International Airport. What will curb this devastating time bomb are your "honest" recommendations and the recommendation that says no "International". The Residents of Long Beach deserve a recommendation or vote that is not tainted by corrupt corporate influence and deserve a vote that is beneficial to all and the environment. Do no harm is a good practice. Jet Blue is already extremely violating our "Noise" Ordinance; International Flights will just increase their violations.

Please seriously think what you are about to decide and do. Think about that child playing in the park with their pet, or the youngster on the school playground, that elderly person that wants to go outside for fresh air, that wearied worker trying to go home amidst congested and gridlocked traffic, that person that has invested in their home for retirement, that small business entrepreneur that's counting on real neighborhood economics, that beach that will be noxiously fumed out, that Catalina Island retreat that will be smothered with airplane waste dump.

The argument that more jobs will be created may be somewhat so. But those jobs come at a cost and most likely, it will not be LB residents that get the new jobs.

I just can't forget my last experience when I flew home from D.C. (on business) to LAX. My wife and I were gasping from the noxious fumes from all the planes while taxing into our American Airlines Gate (imagine the same for the LB Airport Gates)….we collected our bags from the carousel and then went out to the shuttle pick up area. It was terrible!!! Fumes from the high volume of airplanes, fumes from the high volume of shuttles, fumes from the taxis, loud beeping horns....and then we went to our extended parking lot and I was continuously looking over my shoulder to protect my wife and me. I really don't think the Airport Advisory Commission will want this in our City.

If you approve the Int'l Airport in LB, there will be numerous and severe circumstances that will happen because of the increase air traffic volume (air traffic will increase once the International status is granted, it's foolhardy if you believe it won't be). Major transitions will happen! People will have pulmonary health issues, property values will evaporate, neighborhoods will be overrun by vehicle congestion, law suits for health problems and reverse condemnation will be rampant, crime will go up, and our environment, beach, mountains and air will be violated.

It's in your hands. Once the International process begins, it cannot be reversed. We look forward to those addressed above to keep Long Beach a wonderful city. All of us look to you for our healthy environment and peace.

Thank you for your considerations and diligence.

Cordially,

James Stok and Holly Kuwayama
Long Beach Resident

Attachments: Forbes Airport Noise
Health Hazards of Living Near Airports
Second Opinion
USC News – Airport Pollution
Jacobs Chapter 4
Jacobs Chapter 5

Cc: ci

Forbes Oct. 8, 2013

People Who Live Near Airports At Increased Risk For Cardiovascular Disease

Larry Husten ,
CONTRIBUTOR

I'm a medical journalist covering cardiology news.

Most previous research on the health effects of noise has focused on road noise. Now two new observational studies published in *BMJ*extend the research to noise from airports and provide fresh evidence that people who live near airports are at increased risk for cardiovascular disease.

(Photo credit: Wikipedia)

In the first paper, Anna Hansell and colleagues in the UK analyzed data from 3.6 million people living near Heathrow airport in London. People who lived in the noisiest areas had an elevated risk for stroke, coronary heart disease, and cardiovascular disease. The findings were diminished, but remained significant, after adjustments for ethnicity, social deprivation, smoking (estimated through lung cancer mortality), road traffic noise exposure, and air pollution. The researchers reported finding a dose-response relationship, in which the increased risk was greatest in the 2% of the population who experienced the highest levels of noise.

The authors acknowledged that they were unable to completely control for confounding or ecological bias and called for "further work to understand better the possible health effects of aircraft noise."

In the second paper, Andrew Correia and colleagues analyzed data from more than 6 million people on Medicare who lived in zip codes around 89 North American airports. They found that people who lived in zip codes with the top 10% of noise exposure had a significant increase in the risk of hospital admission for cardiovascular disease (after adjusting for age, sex, race, zip code level socioeconomic status and demographics, zip code level air pollution, and roadway density.) They calculated that for older people living near airports 2.3% of hospitalizations for cardiovascular disease could be attributed to aircraft noise.

In an accompanying editorial Steven Stansfeld placed the new studies in the context of previous research looking at the effects of environmental noise on cardiovascular disease. Despite the inevitable limitations of observational studies, he writes that the studies "provide preliminary evidence that aircraft noise exposure is not just a cause of annoyance, sleep disturbance, and reduced quality of life but may also increase morbidity and mortality from cardiovascular disease."

Health Hazards Of Living Near Airports

ByJaylaxmi Trivedi

Posted on October 23, 2015

A study has found that the increase in number of cases related to Asthma and also diseases like heart ailments among people who live near or within six miles of an airport is quite stark. It was found that **hospitalization** in relation to respiratory distress and asthma was almost 17 percent higher in the said radius. While hospitalization related to heart ailments was higher by 9 percent.

Scientists from University of California and Columbia University after inspecting 12 airports in the state of California concluded that the pollutant Carbon Monoxide (CO) was the main culprit in this case and the emission of CO was maximum when the planes were either idling or taxi-ing on the runway.

Another pollutant i.e. Nitrogen Dioxide (NO2) which is also a major pollutant that is released from airplanes was not considered as a reason for the hospitalizations as it is produced when planes are moving at a higher speed in the air.

Meanwhile, the study also found that even a small change in the quality of ambient air was a cause of increase in cases of respiratory problems and heart issues.

THE STUDY

The data was collected from 164 residential areas in and around 12 biggest **airports** of California and observed the number of hospitalizations overnight. What is important to note is that these areas are among the most posh localities and wealthiest of people live here.

The research also took into account the direction of wind blowing and found that on days with highest of pollution, the **maximum illnesses** were reported from areas that saw wind blowing towards it.

In fact the LA airport was found to be contributor of highest pollution.

Professor Wolfram Schlenker, co-author of the study said: ‘We looked to identify the ways in which daily variation in air pollution affects population health, as well as trying to estimate the effect of multiple pollutants simultaneously, as it has been traditionally difficult to decipher which pollutant is responsible for which adverse health condition.’

SECOND OPINION

UCare generously supports MinnPost's Second Opinion coverage; learn why.

Airport pollution may have been 'seriously underestimated,'

By Susan Perry | 06/02/14

Creative Commons/James Willamor

Ultrafine sulfur dioxide, nitrogen oxide and other toxic particles can embed themselves deep inside the lungs and then enter the bloodstream.

Heavy airplane traffic can pollute the air for a significantly wider area than previously reported — and in amounts that are equivalent to that produced by many hundreds of miles of freeway traffic, according to a study published late last week in the journalEnvironmental Science & Technology, which is published by the American Chemical Society.

The findings suggest, say the study's authors, that "the air quality impact areas of major airports may have been seriously underestimated."

The authors also warn that "a significant fraction of urban dwellers living near airports likely receive most of their outdoor [particle matter] exposure from airports rather than roadway traffic."

Airplane air pollution — the ultrafine sulfur dioxide, nitrogen oxide and other toxic particles that are created from the condensation of the jet's hot exhaust vapors — is a health concern. The particles can embed themselves deep inside the lungs and then enter the bloodstream. The inflammation they cause is suspected of worsening many lung conditions, such as asthma and chronic obstructive pulmonary disease (COPD), and of contributing to the development of heart disease.

A new Massachusetts study, also released last week, has found, for example, that children living near Logan International Airport in Boston were up to four times more likely to exhibit signs of undiagnosed asthma than children living in communities further away, even after taking into account socioeconomic and other factors. In addition, adults living in neighborhoods bordering the airport were almost twice as likely to have COPD than their farther-away peers. Unlike other studies, however, the Massachusetts study did not find a higher risk of heart disease among people whose homes were close to the airport. (All of these studies are observational, which means they are able to show only an association between airport pollution and an increased risk of disease; they do not prove a causative link. Other factors, not controlled for in the studies, may also explain the results.)

Up to 10 miles away

Previous studies that have investigated the amount of airplane-related particle-matter pollution that exists in communities near airports have sampled air only within a couple of miles of the airports. For the current study, researchers at the University of Southern California (USC) and the University of Washington in Seattle spent 29 days measuring levels of air pollutants while driving through neighborhoods up to 10 miles from Los Angeles International Airport (LAX). Most of the measurements were collected between 11 a.m. and 4 p.m., some of the airport's busiest hours, when 40 to 60 jets arrive per hour. But samples were also collected early in the morning and late at night, when air traffic was much lower.

LAX is the sixth busiest airport in the world in terms of "movement" (flights), and the third busiest in North America, behind the Hartfield-Jackson Atlanta International Airport and the O'Hare International Airport in Chicago, according to the Airports Council International. (The Minneapolis-St. Paul Airport is ranked 11th in North America and 16th in the world.)

The scientists found that over a 23-square-mile area — an area that starts at the ends of LAX's four runways and then fans out east for more than 10 miles downwind of the airport — particle-matter concentrations were double what they were in nearby areas outside the area of LAX impact.

They also found that the concentrations were five times higher over a 9-square-mile section of the impact area, and within an almost 2-mile area just east of the airport, the particle-matter pollutants reached concentrations that were 10 times higher than in the non-impact areas.

"The consistent and distinctive spatial pattern of elevated concentrations was aligned to prevailing westerly winds and landing jet trajectories, and roughly followed the shape of the contours of noise from landing jets," the study's authors note, "indicating that landing jets probably are an important contributor to the large downwind spatial extent of elevation [particle matter] concentrations."

The authors also calculated that the amount of pollutants produced by LAX is equivalent to the particle-matter pollution of 174 to 491 miles of freeway. To put that number in context, the total number of freeway miles in Los Angeles County, where LAX is located, is about 930.

"Therefore," the scientists conclude, "LAX should be considered one of the most important sources of [particle matter] pollution in Los Angeles."

The study was funded by the National Institute of Environmental Health Sciences. You'll find the study's abstract on the Environmental Science & Technology website.

USC News - MAY 30, 2014

New concerns raised about air pollution at LAX

Effects from planes that are landing appear to play a key role in the large area of impact

BY **Leslie Ridgeway**

Most previous research focused on measuring air quality near where jet takeoffs occur.

Research conducted by scientists at the Keck School of Medicine of USC shows that airliner activity at Los Angeles International Airport worsens air quality over a far larger area than previously assumed.

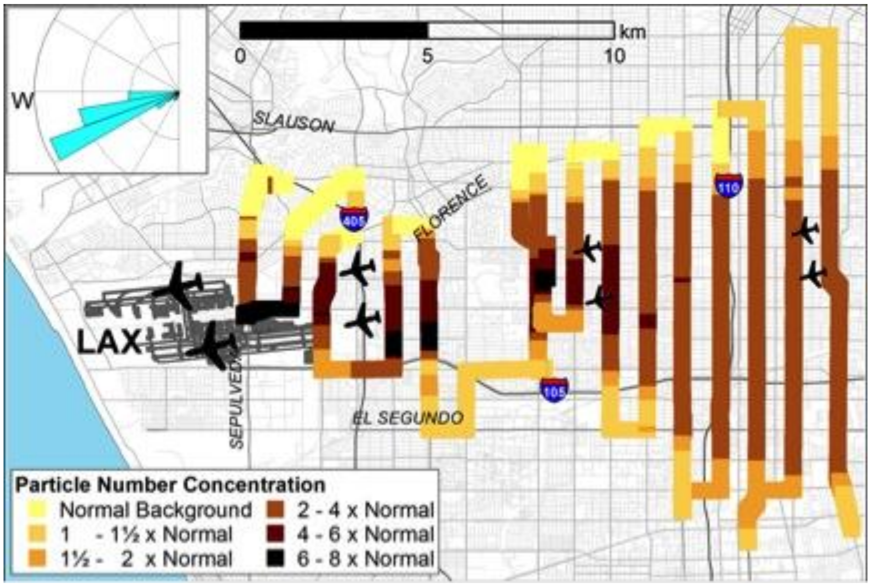
The study, published on May 29 in the journal *Environmental Science and Technology* and conducted with University of Washington researchers, found a doubling of ultrafine particle number concentrations extended east more than 10 miles downwind from the airport boundary over a 20-square-mile area, encompassing Lennox, Westmont, parts of South Los Angeles, Hawthorne and Inglewood, and, in certain wind conditions, areas south of LAX.

“Our research shows that airport impacts extend more than five times further than previously assumed,” said Scott Fruin, lead researcher and assistant professor of preventive medicine at the Keck School of Medicine. “Effects from planes that are landing appear to play a major role in this large area of impact.”

To put this large area of impact into perspective, the researchers calculated that one-quarter to one-half of the entire Los Angeles County freeway system produces an equivalent increase in ultrafine particle numbers on a concentration-weighted basis.

“LAX may be as important to LA’s air quality as the freeway system,” Fruin said. “The impact area is large, and the airport is busy most hours of the day. That makes it uniquely hard for people to avoid the effects of air pollution in affected areas.”

A previous assumption was incorrect



Graphic depicting ultrafine particle increase downwind of LAX relative to urban background air quality (Graphic/Neelakshi Hudda)

Most previous research on the air quality impacts of airports focused on measuring air quality near where jet takeoffs occur. Takeoffs produce immense plumes of exhaust but only intermittently, and pollution concentrations downwind have been observed to fall off rapidly with distance. The assumption has been that total airport impacts also fall off rapidly with distance. The new research finds that this assumption is wrong.

The study found that concentrations of ultrafine particles were more than double over 20 square miles compared to background concentrations in nearby areas outside the area of LAX impact. Also, ultrafine particle number concentrations four times higher than background extended a distance of six miles.

“Given the existing concern about the possible health effects of urban ultrafine particle levels, living in an area with two to four times the average LA levels of ultrafine particles is of high public health concern,” said first author Neelakshi Hudda, research associate in preventive medicine at the Keck School.

Ultrafine particles are currently unregulated, but are of concern because they appear to be more toxic than larger particles on an equal mass basis in animal and cellular studies, and because they appear able to enter the bloodstream, unlike large particles that lodge in the lungs.

The research team used vehicles equipped with special measurement devices to capture data not available using traditional fixed monitors. The team was able to take moving measurements for more than five hours under consistent wind conditions to fully capture the extent of the impact boundaries.

“Other airports generally have less steady wind directions, which would make these measurements more difficult,” Hudda said. “Similar impacts are probably happening, but their location likely shifts more rapidly than in Los Angeles.”

“The on-shore westerly winds cause this impact regularly in communities east of LAX because the impact’s location corresponds to the wind direction,” Hudda added. “In the winter months, when the winds were different, impacts were measured south of the airport during northerly winds.

The research was funded by the National Institute of Environmental Health Sciences.

University of Washington researchers included Tim Larson and Tim Gould in the Department of Civil Engineering and Kris Hartin in the Department of Environmental and Occupational Health Sciences.

CHAPTER 5

Current Understanding of Airport Air Quality Health Impacts

This chapter provides the current state of research related to potential health impacts from airport pollutant emissions. It has been organized to respond to the following basic, key questions:

- What pollutants are of most concern at an airport?
- What are the airport contributions to local air quality and health impacts?

The answers to these questions were obtained through a preponderance of the existing research studies conducted in this area. The latter question is a combination of airport contributions to ambient pollutant concentration levels as well as potential health impacts (risks). Because these issues typically accompany each other, they were integrated into one overall question. With on-going research in all of these areas, it should be noted that the answers are representative of a snapshot in time, and they may change with future research. Although there are some overlaps in the answers, they are kept to a minimum but are necessary to properly answer each question.

To promote the understanding of airport health impacts, this section tackles two basic questions dealing with the pollutants of most concern (highest risk) and the airport contributions to local air quality and potential health impacts.

The purpose of answering these questions is to better understand the current health implications of air pollutants generated by airports as a whole. The overall results and conclusions are not intended for scrutinizing individual airports because each airport presents unique characteristics.

5.1 What Pollutants Are of Most Concern at an Airport?

5.1.1 Evaluations

At first glance, the answer to the question of which pollutants are of most concern may simply be based on what pollutants are emitted by the airport and their toxicities. But in order to answer this question, one must consider the risks associated with each pollutant. As previously explained, risk involves taking into account emissions and exposure in addition to toxicity. Just considering toxicity may cause undue attention to be paid to a pollutant that may be emitted in small quantities at an airport such that it may pose minimal risks to the public. In contrast, just focusing on pollutants with high emission rates overall (for the whole airport) may cause undue attention to pollutants with relatively low toxicity that may have little or no impact on the public. In addition, the exposure pathway needs to be considered. If an airport is located in a region where the geography and meteorological patterns are such that most of the emitted pollutants tend to move away from populated areas, the risks associated with that airport may be less than with an airport with lower levels of emissions but with dispersion and atmospheric chemistry conditions that are conducive to exposing larger portions of the public.

As a result, it can be very difficult to determine risks in a general sense across all airports (or even a group of airports) since each has distinctly different characteristics (e.g., mixes of sources, airport layout, operations, etc.). Therefore, each airport needs to be assessed separately for each pollutant, and all of the aforementioned factors need to be taken into account.

That said, researchers still attempt to define risks in a general sense to provide helpful information that may be used as a screening-type starting point to help the aviation community make better decisions regarding airport planning efforts and emissions mitigation measures. That is, the research results could help identify which pollutants to target for such efforts so airports could make efficient use of resources, and also serve as a basis for future research work.

In developing *ACRP Report 7—Aircraft and Airport-Related Hazardous Air Pollutants: Research Needs and Analysis* (Wood et al. 2008), researchers focused on prioritizing HAP compounds. The prioritization was conducted based on combining emissions rates and toxicity, but without consideration of possible variability in the emissions-to-exposure relationship. Although both exposure pathway and the characteristics of the exposed groups were described as a necessary component in risk assessments, they were not included because they were outside the scope of the project. As such, the resulting prioritized list and research was intended to serve as an initial assessment to help identify information gaps.

The study involved reviewing emissions inventories from several major airports (e.g., BOS, PHL, ORD) for emissions contributions from each of the airport sources (aircraft, GSE, GAV, etc.), and the development of risk-based concentrations (RBCs) to serve as measures of toxicity for each pollutant. The resulting prioritized list is provided in Table 5-1.

Table 5-1 compares the prioritized list of pollutants developed from *ACRP Report 7* to those from an FAA 2003 analysis (URS 2003) and the ORD 2005 airport modernization environmental impact statement (EIS) (FAA 2005). The FAA-developed list was based just on emission rates while the ORD study used both emission rates and toxicity. The different results between the ACRP and ORD studies are largely attributed to different toxicity weighting schemes. These lists show similarities such as formaldehyde being included within the top three in all lists, but significant differences such as the fifth-place location of acrolein on the FAA list while it is first on the other two lists.

A study conducted under the FAA's Partnership for AiR Transportation Noise & Emissions Reduction (PARTNER) Program also involved the development of a prioritized list of pollutants

Table 5-1. Prioritized list of pollutants from *ACRP Report 7*.

This ACRP Review	FAA 2003	ORD 2005
Acrolein	Formaldehyde	Acrolein
Formaldehyde	Acetaldehyde	1,3-Butadiene
1,3-Butadiene	Benzene	Formaldehyde
Naphthalene	Toluene	Benzene
Benzene	Acrolein	Acetaldehyde
Acetaldehyde	1,3-Butadiene	Naphthalene
Ethylbenzene	Xylene	Toluene
	Lead	
	Naphthalene	
	Propanal (Propionaldehyde)	

Source: Wood et al. 2008

emitted from airport sources (Levy 2008). The study included assessments of emissions of criteria pollutants and HAPs but focused on fine particles ($PM_{2.5}$), ozone, and a selected group of HAPs (formaldehyde, acetaldehyde, benzene, toluene, acrolein, etc.). This reduced pollutant focus was based on a screening analysis that determined that the excluded compounds pose significantly less risk. Also, for pollutants such as NO_2, the literature was considered inadequate to develop the required concentration-response functions for the required risk assessments, and preliminary evidence indicated a greater criteria pollutant health impact from $PM_{2.5}$ and ozone (EPA 2004 and 2005).

The study included emissions from three airports: Chicago O'Hare International Airport (ORD), Hartsfield-Atlanta International Airport (ATL), and T.F. Green Airport (PVD). These airports were selected based on size, likely magnitude of impact, and location. Emissions inventories for each airport were prepared with the FAA's EDMS/AEDT, and dispersion modeling was performed using AERMOD and CMAQ, the latter of which was used with different grid cell sizes.

For the main comparison work, an intake fraction was defined as a "unitless measure characterizing the total population exposure to a compound per unit emissions of that compound or its precursor." This metric was used to represent population-based exposures, which correspond directly with health risks for pollutants with linear concentration-response functions, and it allowed for rapid comparisons among pollutants and airports. The intake fraction also allowed for rapid estimation of health risks, as it was beyond the scope of this screening-level analysis to conduct more detailed health risk modeling.

Tables 5-2 and 5-3 provide comparisons of the risks by pollutant for each airport studied. The risk values (deaths/year) indicate that fine particles ($PM_{2.5}$) clearly dominate the overall risk and their impacts are magnitudes higher than the other pollutants. For example, the risks for ORD are as follows:

- Total fine particles: 15 deaths/year,
- Total HAPs (air toxics): 0.09 deaths/year, and
- Highest ranking HAP (Formaldehyde): 0.043 deaths/year.

These results are consistent with general EPA risk statistics that also show significantly higher risks posed by fine particles (see http://www.epa.gov/ttn/atw/nata1999/tables.html). Furthermore, the study was simplified (for comparison purposes) such that the HAPs risks are actually cancer risks with only a fraction of that corresponding to death. As such, the relative contribution of fine particles would be even higher in comparison. Non-cancer effects such as those from acrolein and various other pollutants were not considered as part of the prioritizations, because the data available were not amenable to quantification, although the researchers noted that ambient acrolein in the grid cells surrounding the three airports exceeded its RfC, implying potential health effects. This would imply that other HAPs with respiratory effects also could contribute health effects following the non-cancer risk assessment approach used by EPA and others; this would potentially include acetaldehyde, formaldehyde, naphthalene, styrene, and toluene. The negative values for ozone risk in Table 5-3 are indicative of the nuances of ozone chemistry where increasing NO_x emissions can reduce ozone concentrations over an area.

As part of the study, the prioritized list of HAPs by risk was compared to rankings based on just emissions and emissions with toxicity (potency). As indicated in Table 5-4, formaldehyde is at the top of each list, but there are significant differences. For example, without taking into account toxicity or exposure, the emissions-based list shows acetaldehyde as second while the others have the pollutant in sixth place. This comparison helps to exemplify the need to include all aspects of risk so that the relative impacts of such pollutants are properly understood.

Table 5-2. Population risk (deaths/year) for three airports using AERMOD (50-km radius).

Pollutant	ORD	% of air toxics risk	ATL	% of air toxics risk	PVD	% of air toxics risk
Formaldehyde	4.3E-02	48%	3.4E-02	48%	2.7E-03	48%
Acetaldehyde	3.7E-03	4%	2.9E-03	4%	2.3E-04	4%
Benzene	6.4E-03	7%	4.9E-03	7%	4.0E-04	7%
1,3-butadiene	1.9E-02	22%	1.5E-02	21%	1.2E-03	22%
Naphthalene	6.9E-03	8%	5.4E-03	8%	4.4E-04	8%
Styrene	9.7E-03	11%	7.5E-03	11%	6.1E-04	11%
Phenanthrene	1.7E-06	0%	1.3E-06	0%	9.4E-08	0%
Fluoranthene	4.8E-05	0%	3.9E-05	0%	2.1E-06	0%
Pyrene	1.3E-06	0%	1.0E-06	0%	6.0E-08	0%
Anthracene	2.5E-07	0%	2.3E-07	0%	1.3E-08	0%
Benzo[b]fluoranthene	1.1E-04	0%	9.1E-05	0%	4.9E-06	0%
Benzo[k]fluoranthene	1.1E-04	0%	9.1E-05	0%	4.9E-06	0%
Benz[a]anthracene	1.6E-05	0%	1.6E-05	0%	8.8E-07	0%
Benzo[a]pyrene	1.5E-04	0%	1.6E-04	0%	8.7E-06	0%
Chrysene	2.0E-06	0%	2.0E-06	0%	8.8E-08	0%
Indeno[1,2,3-c,d]pyrene	1.1E-04	0%	9.1E-05	0%	4.9E-06	0%
Total air toxics	9.0E-02		7.0E-02		5.7E-03	
Total fine particulate matter	15.0		7.2		0.65	

Source: Levy et al. 2008

Table 5-3. Population risk (deaths/year) for three airports using CMAQ (12- and 36-km grids).

	ORD		ATL		PVD	
Pollutant	12 km	36 km	12 km	36 km	12 km	36 km
Formaldehyde	5.9E-02	4.2E-02	4.3E-02	3.5E-02	2.8E-03	2.2E-03
Acetaldehyde	4.0E-03	2.8E-03	3.0E-03	2.3E-03	1.9E-04	1.5E-04
Benzene	4.5E-03	3.5E-03	3.7E-03	2.9E-03	2.4E-04	1.9E-04
1,3-butadiene	1.4E-02	9.2E-03	9.9E-03	7.2E-03	6.4E-04	4.9E-04
Naphthalene	4.9E-03	3.4E-03	3.7E-03	2.9E-03	2.3E-04	1.9E-04
Total air toxics	8.6E-02	6.0E-02	6.3E-02	5.0E-02	4.1E-03	3.2E-03
Total fine particulate matter	12	7.9	4.5	4.2	0.57	0.48
% Sulfate	49%	52%	59%	64%	41%	37%
% Nitrate	-2%	-5%	-12%	-8%	13%	21%
% EC	15%	16%	19%	16%	13%	12%
% OC	21%	20%	18%	12%	18%	15%
% Ammonium	17%	17%	15%	16%	15%	16%
% Other	1%	0%	0%	0%	0%	-1%
Ozone	-1.9	-2.3	-2.1	-1.9	-0.2	-0.1

Source: Levy et al. 2008

Table 5-4. HAPs rankings based on different prioritization schemes.

Pollutant	Ranking, emissions only	Ranking, emissions*potency	Ranking, risk
Formaldehyde	1	1	1
Acetaldehyde	2	6	6
Benzene	3	5	5
1,3-butadiene	4	2	2
Naphthalene	6	4	4
Styrene	5	3	3
Phenanthrene	7	14	14
Fluoranthene	9	11	11
Pyrene	8	15	15
Anthracene	13	16	16
Benzo[b]fluoranthene	10	8	9
Benzo[k]fluoranthene	10	8	9
Benz[a]anthracene	15	12	12
Benzo[a]pyrene	16	7	7
Chrysene	14	13	13
Indeno[1,2,3-c,d]pyrene	12	10	8

Source: Levy et al. 2008

The pollutants selected for this project represent those that have the greatest risks based on airport emission levels and toxicity.

Another study conducted under the PARTNER Program (Project 15) used a combination of CMAQ and the Environmental Benefits Mapping and Analysis Program (BenMAP) to study airport air quality impacts from 325 U.S. airports, focusing on the nonattainment areas (Ratliff et al. 2009). BenMAP uses health impact functions for criteria air pollutants to relate changes in air concentrations to a change in the incidence of a health endpoint. Only the impacts from PM and ozone were included in the study. Similar to the previous studies, the modeled results indicated that almost all of the health impacts were due to fine particles with about 160 cases of PM-related premature mortality per year. Health impacts such as chronic bronchitis, non-fatal heart attacks, respiratory and cardiovascular illness, also were associated with aircraft emissions.

Although health concerns are associated with each of the criteria pollutants, the greatest risks (i.e., cancer and morbidity) seem to be posed by PM and HAPs. Specifically, fine PM ($PM_{2.5}$) appears to pose the greatest risk to human health—magnitudes higher than HAP species. Formaldehyde was ranked as the HAP species having the greatest risk. Although ultrafines are inherently included as part of $PM_{2.5}$, further research is necessary to better understand potential health impacts from ultrafines.

5.1.2 Summaries and Conclusions

Studies such as these illustrate the need to conduct further research on more pollutants and other airports, but they indicate that, with regard to the potential for health impacts (risk), fine particulate matter appears to pose the greatest risk. As such, much of the current research in airport air quality has focused on fine particles. Among criteria air pollutants, ozone also can contribute significantly to public health impacts, although it would have a lesser impact in the near field and has been excluded from some previous analyses given methodological limitations. For HAPs, formaldehyde was ranked as having the highest risk followed by others such as 1,3-butadiene, styrene, naphthalene, benzene, acetaldehyde, etc. Although fine particles may pose much greater risk, it does not negate the need to further investigate other pollutants. In addition, although many previous analyses have focused on fine particulate matter mortality given its large contribution to monetized health impacts, additional health outcomes from $PM_{2.5}$ and other pollutants merit inclusion.

5.2 What Are the Airport Contributions to Local Air Quality and Health Impacts?

5.2.1 Evaluations

The health effects of each pollutant are summarized in Chapter 4. Although there are uncertainties associated with the toxicities, exposures, etc., the effects are well documented. Organizations such as the EPA and the World Health Organization (WHO) provide extensive information on pollutant health effects.

- EPA Risk: http://www.epa.gov/oia/air/pollution.htm
- WHO Risk: http://www.who.int/mediacentre/factsheets/fs313/en/

Although the overall airport emissions characteristics (mix of pollutants, chemical characteristics, sizes ranges for PM, etc.) may not be the same as other sources, the health effects of each pollutant are the same. That is, all other things being equal, a mass of a pollutant emitted from an airport will produce the same health effects as the same amount from other sources (or another airport)—if the pollutants are identical (no differences in characteristics).

This section presents summaries of selected studies to illustrate the air pollutant concentration levels (and their variability) that can be found at different airports and implications for their contributions to local air quality.

As such, most studies that have addressed the question of airport impacts on local air quality and health impacts have used data from measurements or modeling results to provide indications of exposure (either with emissions or ambient pollutant concentrations) and have linked these data with literature-based concentration-response functions within human health risk assessments. These encompass correlating aircraft activities (e.g., aircraft operations) with emissions, modeling how those emissions influence concentrations, and comparing airport concentration contributions to background levels. Since no two airports are the same, it is difficult to make general statements regarding airport contributions to local air quality because this depends on many factors including emissions strength (emission factors), airport layout, local meteorology, etc. Although further studies are needed, the available findings from the literature can be used to provide some general understandings of airport contributions. As such, each of the studies cited in the references was reviewed, and the following abridged summaries of selected references provide an indication of the wide range of different types of studies and results available for consideration for further details:

- *ACRP Report 71: Guidance for Quantifying the Contribution of Airport Emissions to Local Air Quality* (Kim et al. 2012). The goal of the project was to better understand the use of modeling and measurement capabilities to determine airport contributions to air quality. This included measurements of ambient concentrations for both criteria pollutants and HAPs.
- *The Impact of NOx, CO and VOC Emissions on the Air Quality of Zurich Airport* (Schurmann 2007). Ambient measurements of criteria pollutants were performed to assess the impact of airport emissions on local air quality.
- *T.F. Green Airport Air Monitoring Study* (RIDEM 2008). A monitoring study was conducted by the Rhode Island Department of Environmental Management (RIDEM) to assess air quality levels and health risks to surrounding neighborhoods. Measurement sites were located around the airport with some near runways. The goal of the study was to characterize HAP concentrations in communities near the airport, assess contributions from different sources (e.g., aircraft, GSE, motor vehicles), verify modeling outputs, and develop a baseline that can be used to assess impacts of future airport changes.
- *Preliminary Study and Analysis of Toxic Air Pollutants from O'Hare International Airport and the Resulting Health Risks Created by These Toxic Emissions in Surrounding Residential Communities* (ENVIRON 2000). The study used emissions data collected in 1999 to conduct a health risk assessment for the airport.
- *General Aviation Airport Air Monitoring Study* (SCAQMD 2010). The goal of the study was to characterize the ambient levels of several important air toxics and ultrafines in communities adjacent to Van Nuys Airport (VNY) and Santa Monica Municipal Airport (SMO).
- *Teterboro Airport Detailed Air Quality Evaluation* (ENVIRON 2008). The study involved measurements of various pollutants including volatile organic compounds (VOCs) and PM to investigate health risks associated with airport operations.
- *ACRP Report 7: Aircraft and Airport-Related Hazardous Air Pollutants* (Wood 2008). San Leandro Measurements: After JETS-APEX2, the Aerodyne Mobile Laboratory spent 2 days at the San Leandro Marina, which is about 2 km downwind of the OAK runway.
- *Aircraft Emissions' Contributions to Organic Aerosols in a Regional Air Quality Model Using the Volatility Basis Set* (Woody 2012). The focus of this work was to estimate contributions of aircraft emissions from ATL to $PM_{2.5}$, focusing on organic aerosols, using a research version of CMAQ v4.7.
- *Relationships between Emissions-Related Aviation Regulations and Human Health* (Sequeira 2008). The study was conducted under the Energy Policy Act of 2005 to assess aircraft impacts on air quality in the United States.
- *Risk Factors of Jet Fuel Combustion Products* (Tesseraux 2004). Using available monitoring data, the possibilities and limitations for a risk assessment approach were determined for the population living around large airports. Measurement data from German airports at Frankfurt and Hamburg, as well as from ORD, were presented (Spicer 1994, Eickhoff 1998, and EPA 2002).
- *Detecting and Quantifying Aircraft and Other On-Airport Contributions to Ambient Nitrogen Oxides in the Vicinity of a Large International Airport* (Carslaw 2006). Based on concerns over the building of a third runway at London-Heathrow International Airport (LHR), data from NO_x monitoring sites near the airport were used to assess contributions by the airport.
- *LAX Air Quality and Source Apportionment Study* (Tetra Tech 2013). The Los Angeles International Airport (LAX) Air Quality Source Apportionment Study (AQSAS) was conducted to measure criteria pollutant HAP concentrations in the vicinity of LAX and to assess the potential impacts of airport-related emissions on ambient air quality of communities adjacent to the airport.

- *Current and Future Particulate-Matter-Related Mortality Risks in the United States from Aviation Emissions during Landing and Takeoff* (Levy 2012). A study was conducted to systematically quantify aviation contributions to air quality concentrations and corresponding public health effects using 99 airports.
- *Development and Evaluation of an Air Quality Modeling Approach to Assess Near-Field Impacts of Lead Emissions from Piston-Engine Aircraft Operating on Leaded Aviation Gasoline* (Carr 2011). A new methodology is presented on modeling the dispersion of lead emissions from general aviation aircraft.

These example studies illustrate the fact that recent and current research tends to follow the pollutant prioritization scheme previously discussed (i.e., significant focus on PM). Although more research is necessary, the information gathered from existing studies allows for a snapshot-in-time summary of airport impacts. This is a temporary summary since further research is expected, including both measurement and modeling efforts. In particular, measurements will be necessary to help assess actual conditions at an airport, as well as to validate modeling efforts. Based on the research work conducted thus far, it is expected that as the research work continues, some of the details may become clarified and corrected, but many of the more general understandings will likely remain intact.

Along those lines, one of the first general issues is whether airports have a discernible influence on local air quality. Some studies have indicated that pollutant concentration levels near an airport are similar to urban levels (e.g., Tesseraux 2004, McGulley 1995, and KM Chng 1999), which can result in a misunderstanding that airports overall contribute little or no pollutants to local air quality. Contrary to this, there have been several measurement studies that indicate that concentrations around airports are elevated (e.g., Wood 2008, RIDEM 2008, Zhu 2011). Depending on the pollutant, the contributions may range from a small or negligible contribution (e.g., some criteria pollutants and HAPs species) to significant contributions (e.g., ultrafine particles). Also, background concentrations may affect pollutants through chemical conversions. In addition, various modeling studies have quantified the concentration contributions and associated health risks (e.g., Levy 2008, Sequeira 2008, and Barrett 2012, etc.)

Although there have been differing conclusions from past studies, the preponderance of the evidence appears to indicate the concentrations of pollutants (depending on the pollutant) are generally elevated in the vicinity of airports.

Modeled estimates and measured findings for the specific contributions to local air quality and health impacts are varied and depend on pollutants. The focus of each study—which pollutants and heath assessments were included and which were left out—also is important. The following summaries provide examples of quantified airport contributions to ambient concentrations as well as health-related statistics.

- On a national level, the modeling study conducted under PARTNER Project 15 (Ratliff 2009 and Sequeira 2008) found aircraft emissions contributing to the following criteria pollutant concentrations:
  - Annual $PM_{2.5}$: 0.01 μg/m^3 (0.08 percent) and
  - 8-hour ozone: 0.10 ppb (0.12 percent).

  These contributions represent averages across the U.S. airports selected for this study. As such, individual airports may experience significantly different outcomes.

The airport concentrations (largely monitored data) presented herein were obtained from publicly available documents for illustration purposes to summarize and help expand the understanding of airport contributions to local air quality. Since most of the cited studies were research efforts, the concentrations should not be taken out of context and used for regulatory purposes. For further details and to understand the context of each dataset, it is recommended that the cited sources be reviewed accordingly.

- Measurements were conducted at Dulles International Airport (IAD) on the airside adjacent to an apron area (Kim et al. 2012). The measured 1-hour concentrations for criteria pollutants were all much lower than the NAAQS, and in most cases, *much* lower:
  - NO_2: Typically below 30 ppb,
  - CO: Typically below 1 ppm,
  - SO_2: Typically below 3 ppb,
  - O_3: Typically below 20 ppb in the winter and below 50 in the summer, and
  - $PM_{2.5}$: Typically below 25 μg/m³ (24-hour samples).

  These measured levels seem to suggest that the airport's contributions to local air quality tend to be small.
- The measurements and modeling conducted under the LAX Source Apportionment Study provided a lot of detailed information. A summary follows (Tetra Tech 2013):
  - CO, NO_2, SO_2, and Pb ambient concentrations within the communities next to LAX were below threshold levels for state and national standards.
  - $PM_{2.5}$ concentrations were near air quality standard levels and had compositions of
    - 50–75 percent ammonium nitrate, ammonium sulfate, and unapportioned organic matter;
    - 20–30 percent sea salt aerosol, soil-derived fugitive dust, and wood smoke;
    - 1–2 percent jet exhaust; and
    - 8–17 percent diesel plus gasoline vehicle exhaust.
  - Airport $PM_{2.5}$ concentration contributions were estimated to be 5–20 percent.
  - CMAQ modeling showed most of the nitrates, sulfates, and most of the residual organic matter were formed outside of the study area.
  - Winter: airport accounted for 15–22 percent of CO and NO_x concentrations.
  - Summer: airport accounted for 40–50 percent CO and 50–74 percent NO_x concentrations at some measurement sites.
  - Airport SO_2 contributions ranged from 10–80 percent depending on season.
  - HAP concentrations were consistently lower than the levels found elsewhere in the basin area.
  - The generally low concentration levels can be attributed to the coastal location of LAX.
  - Ultrafine composition was found to be largely composed of sulfuric acid aerosols from jet exhaust and their number concentrations east of LAX were found to be higher than typical values in the region.
- Using measured data near LHR, Carslaw et al. (2006) found that aircraft NO_x concentrations could be detected at least 2.6 km from the airport. At the airport boundary, approximately 27 percent of the annual mean NO_x and NO_2 concentrations were found to be due to aircraft. At distances of 2 to 3 km downwind of the airport, an upper limit of 15 percent contribution from the airport was estimated.
- Ellerman et al. (2010) used measurement data from Copenhagen Airport to show that the number of ultrafine particles (43,000 particles/cm³) in an apron area was approximately

Particles/cm³ is a measure of the number of particles over a unit volume (particle concentration) and should not be confused with PM mass concentrations such as µg/m³.

Particles/cm³ cannot be converted to mass concentrations without the use of (or assumptions involving) the density of the particles.

It also should be noted that particle counting equipment does not typically differentiate between primary and secondarily formed particles (i.e., particles formed in the atmosphere). As such, studies that do not explicitly account for the effects of secondary particles may overestimate the number of particles.

4.4 times greater than the levels found at a background site (near a major roadway). In contrast, a site located on the east side of the airport (closer to the airport boundary) experienced 12,000 particles/cm³ or 22 percent higher than the same background concentration. The study also found that 90 percent of the particles were in the lower end of the ultrafine size range of 6–40 nm.

- From measurements downwind of Santa Monica Municipal Airport (SMO), Hu et al. (2009) found elevated concentrations of ultrafine particles beyond 660 m downwind of SMO. At distances of 100 and 660 m downwind, respectively, ultrafine concentrations were found to be 10 and 2.5 times greater than background levels.
- Using measured data near runways at LAX, Hsu et al. (2013) observed median ultrafine particle concentrations of 150,000 particles/cm³. In some cases, concentrations exceeded 1,000,000 particles/cm³, which is far in excess of levels seen near roadway sources. However, the concentrations were observed to drop rapidly with distance—by an order of magnitude before reaching the airport boundaries.
- Based on data collected at the LAX blast fence (downwind sites up to 600 m from a runway and upwind of a major runway), Zhu et al. (2011) found high spikes in ultrafine particle concentrations. Time-averaged concentrations of $PM_{2.5}$, two carbonyl compounds, formaldehyde, and acrolein, were found to be elevated compared to background levels. As ultrafine particle and black carbon levels have previously shown to return to background levels at 300 m downwind for roadway sources, the persistence of airport ultrafine concentrations up to 600 m seem to indicate that airport emissions may have a broader spatial impact than roadway sources.
- Using data from a monitoring study in the vicinity of LAX, Westerdahl et al. (2008) found the following:
  - Upwind site:
    - Ultrafine particles ranged from 58 to 3,800 particles/cm³ at below 90 nm size,
    - NO_x ranged from 4–22 ppb,
    - BC ranged from 0.2–0.6 µg/m³, and
    - PM-PAH ranged from 18–36 ng/m³.
  - Downwind site:
    - Ultrafine particles—50,000 particles/cm³, 500 m downwind at 10–15 nm size and
    - Black carbon, PM-PAH, and NO_x levels were "elevated to a lesser extent."
- A monitoring study near PVD showed the following results (Rhode Island 2007):
  - None of the HAP species measured exceeded the acute health and non-cancer benchmarks.
  - Concentrations of benzene, 1,3-butadiene, formaldehyde, acetaldehyde, acetone, chloroform, carbon tetrachloride, and perchloroethylene exceeded the cancer benchmark levels.
  - Formaldehyde concentrations at all sites were greater than 10 times the cancer risk benchmark.

  - Acetaldehyde and acetone were 2.5–3 times higher than the cancer risk benchmark.
  - Black carbon concentrations in communities were higher in areas near roadways.
  - Although a non-reference method (with a bias towards higher readings) was used to measure $PM_{2.5}$, the levels were still below the NAAQS in the communities near the airport. Airport contributions could be identified based on the fidelity of the monitors.
- Based on data collected during a monitoring study around VNY and SMO, the following were found (SCAQMD 2010):
  - The daily average TSP lead concentrations at airport sites were 2–9 times higher than corresponding South Coast Basin levels and mostly below the NAAQS. But 24-hour concentrations at SMO near the tarmac were found to be above the NAAQS on more than one occasion.
  - The highest VOC concentrations at the airport sites were comparable to levels found at urban monitoring sites.
  - $PM_{2.5}$ concentration levels, as well as those of organic carbon (OC) and elemental carbon (EC), were found to be similar or below the corresponding South Coast Basin averages.
  - Ultrafine particle numbers measured near a runway were found to be up to 600 times that of background air.
  - Diurnal profiles suggest that CO concentrations may be mostly due to motor vehicles from surrounding roadways rather than the airport.
- From ambient measurements taken at the San Leandro Marina (Wood 2008), the average HCHO concentration in a time series is 1.3 ppb while the interpolated background value is approximately 0.8 (similar to the background value observed on the OAK airport grounds).
- On a national level, a system-level health risk assessment study (Levy 2012) using CMAQ and appropriate concentration response functions (CRF) to model baseline and future scenarios determined that national population health impacts would increase by a factor of 6.1 from 2005 to 2025. This was based on a notional "what if" aviation growth scenario and corresponding emissions assumptions. The factor of 6.1 increase was decomposed into the following contributing factors:
  - Emissions: 2.1;
  - Population factors (growth and aging): 1.3; and
  - Changing non-aviation concentrations, enhancing $PM_{2.5}$ formation: 2.3.
- A study analyzing HAP emissions from ORD and related health risks (ENVIRON 2000) showed that HAPs concentrations measured at the airport fence area may result in about 5 times higher cancer risks than those associated with background air. The most significant contributing HAPs such as aldehydes, benzene, and naphthalene are included in aircraft emissions.
- Based on a health impact study of U.K. airport expansions, especially LHR (i.e., third runway), the following results were estimated (Barrett et al. 2012 and Yim 2013):
  - Approximately 110 people in the United Kingdom die early each year due to airport emissions today. Of these deaths, approximately 50 are due to emissions from London Heathrow.
  - By 2030, without airport capacity expansion, the number of early deaths per year caused by U.K. airport emissions is projected to increase to 250.
- For an airport occupational exposure study (Tunnicliffe et al. 1999) conducted at Birmingham International Airport, U.K., it was found that the results appear to support an association between high occupational exposures to aviation fuel or jet stream exhaust and excess upper and lower respiratory tract symptoms for airport male workers. However, it is acknowledged that there could have been some bias effects such as residual confounding due to smoking.

These example findings illustrate the types of quantitative and investigative studies that have been conducted on airport air quality health impacts. They also illustrate that airport concentration contributions and health impact statistics are closely related. Although the types and scope of these studies vary, they help to form a picture of the current understanding of airport health impacts.

5.2.2 Summaries and Conclusions

In summary, it should be noted that all pollutants emitted from airports have some level of toxicity with the potential to cause health effects. Again, each airport is different and can have significantly different emissions, weather patterns, geography, etc., from each other, resulting in different air quality contributions. With that in mind, the existing body of research appears to suggest the following for each pollutant (or category of pollutants):

- Most criteria gases (CO, NO_2, and SO_2)—In most situations, airport contributions of these pollutants appear to be such that resulting ambient community or urban concentrations are generally below the NAAQS. Depending on the pollutant and distances to the affected communities, airport contributions of these pollutants may be relatively small. However, as studies have pointed out, the contributions can still be apportioned at relatively far distances (a few miles).

  While much of the health impact focus has been placed on PM and HAPs, it is worth remembering that gaseous criteria pollutants can cause damage to the respiratory system. But the evidence supporting quantitative health risk assessment is more limited for CO, NO_2, and SO_2, relative to ozone and fine particulate matter.

Although variability exists among airports, past studies seem to indicate that airport contributions of criteria gases generally tend to be small (or at least in most cases, not contributing to the point where the vicinity of an airport exceeds the NAAQS).

- In general, most studies suggest that ozone levels in the vicinity of airports will tend to be lower than background levels due to the chemistry with NO_x. Because airports emit large quantities of NO_x emissions, health assessments indicate the risks associated with airport indirect ozone contributions to *local* air quality are relatively small. However, the airport contributions to *regional* ozone can be greater and can contribute significantly to the overall health impacts of airport emissions.
- Lead has been an emerging source of concern due to its toxicity and use at GA airports. Modeling and measurement efforts have shown that lead emissions from GA airports can persist up to 900 m downwind and may be above the background and the NAAQS.

Unlike criteria gases, $PM_{2.5}$ concentrations in and around airports seem to vary significantly.

Although health impacts of $PM_{2.5}$ have been found to be higher than others, further research is necessary on the influence of PM chemical composition and size distribution.

- $PM_{2.5}$ or fine particles are a serious concern for health impacts as they dominate air quality health risks (e.g., by orders of magnitude over HAPs). The levels found in airport measurement studies vary, ranging from relatively low levels to those that are close to the NAAQS, and in some cases exceeding the standards.

  In addition to the variability of $PM_{2.5}$ contributions, the various components and types of PM including black carbon, nitrates, sulfates, volatiles, etc., need to be recognized as well.

Modeling studies suggest that some of the PM (secondary PM) may form much farther downstream (many miles). As such, the total health impacts from airport-emitted PM and PM precursors requires regional-scale atmospheric modeling. Also, although the general health effects of PM regarding both morbidity and mortality are established, there is greater uncertainty regarding the influence of chemical composition and size distribution of PM on health outcomes.

PM_{10} is also a health concern, but because coarse particles ($PM_{10\text{-}2.5}$) are filtered to a greater extent by the upper respiratory tract in humans, there is less focus on its impacts.

- Ultrafine PM is a suspected major health concern but there is little data available on both particle concentrations and resulting health effects. However, existing studies indicate that ultrafine particle concentrations are highly elevated at an airport (i.e., near a runway) with particle counts that may be orders of magnitude higher than background with some persistence many meters downstream (e.g., 600 m).

Although ultrafine PM is a suspected major health concern there is little data currently—more research is necessary. But from existing studies, ultrafine levels have been found to be elevated (above background levels) in the vicinity of airports.

- While HAPs or air toxics have less risk than $PM_{2.5}$, they still pose a health concern, in part due to the potential for cancer and premature death endpoints. Measurement studies indicate that concentration levels can vary significantly from one airport to another. Although some studies suggest monitored concentrations may be comparable to background levels (depending on where the measurements were conducted), there is also enough evidence to suggest that airport contributions are not negligible.

As with other pollutants, more studies are necessary to measure concentration levels of HAPs near airports. Although some studies indicate that HAP emissions from airports may be negligible (i.e., resulting in concentrations comparable to background levels), there appears to be enough evidence that suggests otherwise.

CHAPTER 6

Conclusions

Since all airports are different, it is very difficult to make general statements about airport air quality contributions and health impacts. Airport contributions to air quality can depend on many different factors including, but not limited to, airport source types (e.g., aircraft fleet mixes), airport layout and location, geography, and meteorology. Contributions to population health impacts depend on these factors as well as population patterns and vulnerability attributes.

Although there have been increasing amounts of research on airport contributions to local air quality health impacts, more research is necessary. Although the current state of research allows one to "paint a picture" of current understanding in this area, it should be considered as a snapshot in time since future research may provide further details. The current research efforts appear to be aligned with the prioritization of pollutant health risks. Based on the relative number of studies and the recent focus, available resources appear to be correctly being applied to PM and HAPs research, with consideration of ozone for regional-scale analyses.

Regarding airport contributions to local air quality, studies have shown that airport emissions and resulting concentration contributions can be well correlated to airport operations (e.g., aircraft usage) as part of source identification and apportionment work. The more pertinent issue is in quantifying the contributions. The current research efforts appear to be aligned with the need for further measurements and an understanding of health impacts.

Risk assessments have shown that fine PM ($PM_{2.5}$) dominates the overall health risks posed by airport emissions. The risk for fine particles is orders of magnitude higher than that for the closest HAP, formaldehyde, although the ability to quantify the non-cancer health effects of HAPs is limited. $PM_{2.5}$ levels have been found to vary significantly at different airports. Although PM_{10} is a health concern, the fact that much of the coarser portion is filtered out by the upper respiratory tract in human beings makes it of less concern than the finer particles.

Studies appear to indicate that most criteria gases (e.g., CO, NO_2, and SO_2) generated from airports generally tend to result in similar concentrations to background (or urban) levels in surrounding communities, although with appreciable contributions closer to the emission sources and variable conclusions depending on background levels. Although health effects of criteria gases are well defined, quantitative health risk assessments for these gases are relatively limited in comparison to ozone and PM.

Because of the nature of ozone chemistry, ozone levels around airports tend to be lower than background levels (i.e., airports tend to be a sink for ozone). Although ozone levels in the vicinity of an airport may be depressed, airports can contribute to the formation of ozone on a larger regional level, thus resulting in increased health impacts.

Lead is a concern at GA airports and will continue to be an issue as AvGas continues to be used. Current studies indicate that lead emissions can noticeably persist at distances close to

1,000 meters downwind of an airport. As such, studies indicate that lead contributions near GA airports may not be negligible.

Studies indicate that secondary PM may form at significant distances downstream from an airport (many miles), adding to health impacts thus, requiring large-scale (e.g., regional) modeling to determine overall PM health impacts. In addition, the impacts of different PM components including black carbon, nitrates, and sulfates need to be taken into account as well as PM size distributions.

In addition to the suspected health concerns of ultrafine PM (along the lines of the current understanding of $PM_{2.5}$), measurement studies have shown that ultrafine concentrations tend to be highly elevated near an airport (near runways) with persistence above background levels at distances of 600 meters downwind of an airport. As such, ultrafine PM generated by airports is suspected of having a broader impact than that generated by roadway vehicles.

Concentrations of HAPs at airports seem to vary. Although some studies suggest that HAP concentrations near airports may be similar to background levels, there appears to be enough evidence suggesting otherwise, however, there are noticeable uncertainties concerning the actual concentration levels.

Health assessments involving a system-level scope (i.e., involving many airports) appear to provide useful statistics on both total and average airport risks with the understanding that individual airport studies also need to be conducted, the results of which may differ significantly.

CHAPTER 4

Air Quality Health Impacts and Risks

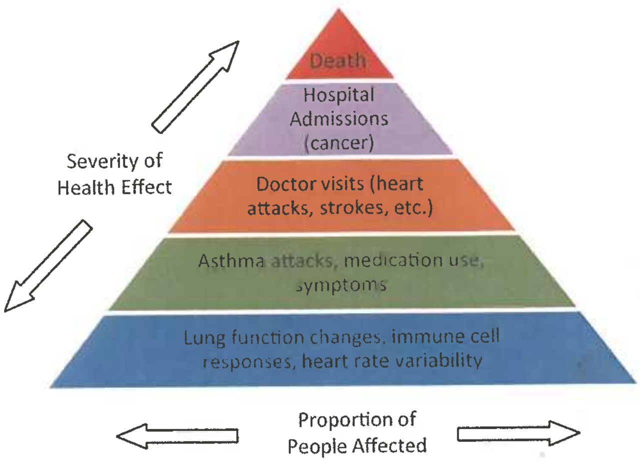
This chapter serves as a primer on understanding potential air pollutant health impacts and health risks.

4.1 Pollutant Health Impacts Overview

Each of the pollutants targeted in this report can be categorized as either a criteria pollutant or a hazardous air pollutant (HAP). HAPs are also referred to as air toxics or as both criteria pollutants and HAPs (e.g., Lead, Pb, is regulated as a criteria pollutant but Pb-based compounds are on the EPA's HAPs list). Each of these pollutants has health effects that range from mild to severe chronic and acute health effects, as well as premature death. Figure 4-1 provides an overview of the population proportions associated with the severity of health effects—in general, the more severe the effect, the smaller the proportion of the population affected. The figure describes different degrees of health effects, and it should be understood that different pollutants will have different health impacts and levels of severity. The following sections describe the potential health effects of each pollutant.

There are six (6) criteria pollutants. A discussion of concerns over their public health impacts follow:

- **Carbon monoxide (CO)** is a colorless and odorless gas that can cause various physiological damages by displacing oxygen in the bloodstream. At high concentrations, CO has known health effects including dizziness, unconsciousness, and death. At lower concentrations more typical of ambient settings in the United States, individuals with cardiovascular disease are at risk of myocardial infarctions (heart attacks) or other exacerbations.
- **Lead (Pb)** is a soft, malleable metal in the "heavy metal" category. Pb is a concern for its ability to cause a range of neurological damage from all exposure pathways (inhalation, ingestion, and dermal contact).
- **Nitrogen dioxide (NO_2)** is one of the nitrogen oxides (NO_x) that is part a family of gases, mainly represented by NO and NO_2, that can contribute to respiratory disease exacerbations. In addition to its direct health impacts, NO_x is well known as a precursor to ozone (O_3) formation. Furthermore, NO_x also contributes to the formation of nitrate aerosols that can have respiratory and cardiovascular health effects.
- **Ozone (O_3)** is a pollutant that generally is not directly emitted from most sources. Within the troposphere, it is formed through a complex interaction (chemical reaction) mainly involving NO_x, and volatile organic compounds (VOCs) in the presence of sunlight. O_3 can contribute to respiratory health effects through inflammation of airways and decrements in lung function, with evidence of increased respiratory symptoms among sensitive individuals such as asthmatics and those with chronic obstructive pulmonary disease, as well as evidence of increased



Source: Adapted from Environmental Health & Engineering, Inc. (EH&E) (2011). "Emissions of Hazardous Air Pollutants from Coal-Fired Power Plants." EH&E Report 17505. Prepared for the American Lung Association, Washington, D.C., March 7.

Figure 4-1. Severity of health effects versus proportion of people affected.

hospitalizations and premature deaths. Because of the formation of O_3 from directly emitted pollutants (from many different sources) within a relatively large area, O_3 is characterized as a regional issue even though it is a local air quality concern.

- **Particulate matter (PM) is tiny solid, liquid, or mixed solid and liquid particles suspended** in the air. These are of concern since ambient concentrations of PM have been shown to be correlated with serious respiratory and cardiovascular illnesses and premature mortality. PM sizes (aerodynamic diameters) range from greater than 100 μm to the ultrafine range of below 0.1 μm. The smaller the size, the deeper they are able to penetrate into the respiratory system, possibly even resulting in blockages of the gas–blood interfaces within the lungs. Figure 4-2 provides an overview of the portions of the respiratory system affected by the different PM size ranges. While the discrete PM size ranges shown generally correspond to different degrees of respiratory penetration, it should be understood that different size ranges can be deposited

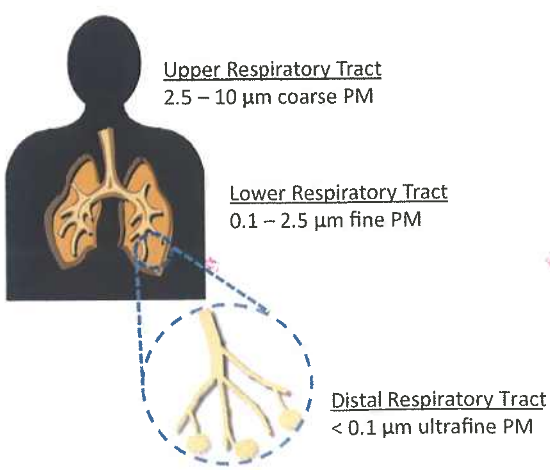


Figure 4-2. PM penetration into the human respiratory system.

throughout the respiratory system. PM with a size range of 10 μm or less are referred to as PM_{10} and those with a size range of 2.5 μm or less are referred to as $PM_{2.5}$. NAAQS concentrations are currently only specified for these two size ranges. In addition to these regulated size ranges, PM in the ultrafine range (less than 0.1 μm in diameter) is thought to contribute to health effects. Ultrafine particles are of particular concern at airports because of relatively higher concentrations (higher than background) found near aircraft operations. Other PM types and components include nitrates, sulfates, and black carbon (BC). Also known as elemental carbon (EC), BC is composed of pure carbon clusters and is differentiated from organic carbon (OC), which is composed of organic compounds. BC is a significant contributor to the health effects caused by $PM_{2.5}$ and ultrafines. Nitrates and sulfates can penetrate deep in the respiratory system and can also react with other chemicals to form harmful compounds (e.g., acids).

- **Sulfur dioxide (SO_2)** is a sulfur oxide (SO_x). So_x refers to a family of gases mainly represented by SO_2 that can act as irritants to the respiratory system and can contribute to asthma attacks and other health outcomes. As with NO_x, concerns about SO_x often relate to its ability to form sulfate aerosols in the atmosphere, with the corresponding health effects seen for fine particulate matter.

HAPs are generally defined as those pollutants that are known or suspected of being able to cause serious health effects such as cancer, birth defects, etc. The EPA maintains a list of close to 200 HAPs comprised of VOCs, aldehydes, polycyclic aromatic hydrocarbons (PAHs), dioxins, furans, metals, acids, etc. A discussion of the formation and concerns over these pollutants follows:

- **Volatile organic compounds (VOCs)** are comprised of a large group of carbon-based compounds with relatively high vapor pressures. The EPA further defines these as chemicals that participate in atmospheric photochemical reactions. They are emitted through evaporation from certain operations (e.g., painting, dry cleaning, etc.) and through incomplete combustion of fossil fuels. Indoor concentrations of VOCs are usually higher than outdoor concentrations—up to 10 times higher. Health effects depend on the specific species as well as exposure duration, but some short-term effects may include headaches, nausea, sore throat/eyes/nose, etc. Long-term effects may include cancer. Examples of VOCs include benzene, toluene, xylene, 1,3-butadiene, etc.
- **Aldehydes and ketones** are subsets of VOCs. Sometimes they are treated separately, which is in part due to the different methods required to measure these compounds. Both groups of compounds are made up of a double-bonded carbon-oxygen core (C=O). An aldehyde has at least one hydrogen bonded to the carbon atom while a ketone has two hydrocarbon groups attached to the carbon atom. Aldehydes are used in production of commercial applications including the production of alcohols, resins, detergents, perfumes, etc. Ketones have industrial uses as solvents, polymer precursors, and pharmaceuticals, etc. As VOCs, both groups have relatively high vapor pressures, and their health effects are similar: irritation of the eyes and air passages under short-term exposure and lower concentrations. Long-term exposures and/or high concentrations can cause depressions of the central nervous system and cancer. Examples of aldehydes are formaldehyde, acrolein, and acetaldehyde. Examples of ketones are acetone and acetophenone. Methyl ethyl ketone (MEK) is also a ketone but not a HAP—EPA removed this from their official list.
- **Polycyclic aromatic hydrocarbons (PAHs)** are comprised of a group of compounds that generally have more than two benzene rings (a ring of six carbon atoms). They tend to stick to solid particles (e.g., soot) and are formed from incomplete combustion processes such as those from coal burning, automobile gasoline combustion, forest fires, coke and coal tar processing, etc. Animal testing has indicated that it is reasonable to expect PAHs to cause birth defects and cancer. Examples of PAHs include anthracene, benzo-a-pyrene, naphthalene, chrysene, etc. Of these, only naphthalene is currently listed on the EPA HAPs list.