Santa Monica Airport
Health Impact Assessment (HIA)

A health-directed summary of the issues facing the community near the Santa Monica Airport

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We are pediatricians currently in our residency training at the UCLA Medical Center. We are members of UCLA CHAT (Community Health and Advocacy Training) program and as part of this training, we participate in community service-learning opportunities to improve children's health. As part of our community service-learning opportunity on environmental health, we evaluated the health impact of the Santa Monica Airport on the surrounding Santa Monica and Los Angeles communities. Many members of these communities seek care from our medical clinics, and we have a vested interest in their health and well-being. This project was supervised by faculty from the UCLA Department of Pediatrics. None of the resident authors or faculty received funding or financial support for this assessment nor do they have any economic interests in the Santa Monica Airport.

Methods

This rapid non-participatory Health Impact Assessment was conducted during the month of February 2010. Our research methodology included empirical and scientific literature reviews; review of public standards, regulations and guidance relevant to airport planning and health; the use of expert consultants; review and analysis of public comment and testimony; and participation in community forums and meetings. Our primary resources for the literature review were found via the online databases PubMed, Lexus-Nexus, OVID, and CSA Environmental Sciences and Pollution Management. The expert consultants had expertise in the areas of health effects of jet exhaust, air quality, as well as atmospheric and environmental science.

Executive Summary

The Santa Monica Airport (SMO) has been located within a highly populated urban area for many decades. Nearby residents have long held concerns regarding the impact of the airport on their community. However, due to a recent growth in the number of jet operations, the community is increasingly worried about the health effects of both noise and air pollution on neighboring children and families. It is therefore important to examine how the continuation of current airport activity affects the conditions required for optimal health.

The proximity of SMO to schools, daycare centers, and parks, in addition to residential homes, poses great exposure risks to children and their families. In response to concerns from residents living around SMO, we have developed this Santa Monica Airport Health Impact Assessment (HIA) in order to organize, analyze, and evaluate existing information and evidence regarding SMO's impact on adverse health effects. The report includes an analysis of the impacts on three issue areas: lack of an airport buffer zone, noise, and air quality.

We recognize there is significant public controversy associated with the continuation of Santa Monica Airport activity. Our goal is for the Santa Monica Airport Health Impact Assessment to provide constructive recommendations in the interest of supporting communities that promote health.

Key Findings

1. Airport operations, particularly jet take-offs and landing, are contributing to elevated levels of black carbon in the area surrounding Santa Monica Airport. Elevated exposure to black carbon is associated with:
   - increased rates of respiratory and cardiovascular disease including asthma, bronchitis, and increased risk for sudden death
   - irreversible decrease lung function in children
   - increased carcinogenic risk
2. Elevated levels of ultrafine particles (UFP) are associated with aircraft operations and jet takeoffs and are found in the area surrounding Santa Monica Airport. Elevated exposure to UFPs are associated with:
   - increased inflammation and blockage of blood vessels in mice models
   - greater lung inflammation with exposure to UFPs than exposure to larger particulates in rodent models
3. Elevated levels of polycyclic aromatic hydrocarbons (PAH) are found in the area surrounding Santa Monica Airport. Exposure to PAH has been associated with:
   - increased carcinogenic risk
   - disruption of the hormonal balance in adults.
   - reproductive abnormalities with exposure during pregnancy
   - lower IQ scores in children.
4. Levels of noise due to plane and jet take-offs from Santa Monica Airport are above Federal Aviation Airport thresholds. Excessive noise is associated with:
   - hearing loss.
   - higher levels of psychological distress
   - impaired reading comprehension and memory among children.

5. There is no buffer zone between the airport airfield and the surrounding community as observed in many other municipal airport communities.

Recommendations

1. Eliminate or significantly decrease the number of jet takeoffs to reduce exposure to both the byproducts of jet fuel exhaust and the loud “single event” noise of jet takeoff.
2. Install HEPA (high efficiency particulate absorbing) filters in surrounding schools and residential homes to mitigate the exposure to PAHs and particulate air pollution.
3. Enforce Federal Aviation Airport noise thresholds by implementing additional noise abatement strategies such as soundproofing of schools and significantly affected homes near SMO that would protect residents from hearing loss, psychological distress, and learning problems in children.
4. Adopt the precautionary principle, given the evidence of the potential harm of UFPs and other byproducts of airport pollution on animal and human health.
5. Notify all potential property buyers, residents, and affected community members in the vicinity of SMO of the noise and air pollution health risks.
6. Maintain a runway buffer zone of at least 660 meters to protect surrounding residents from the harmful health effects of jet fuel exhaust byproducts during idling and take-off.
7. Closure of SMO would eliminate all health risks associated with airport air and noise pollution.

Introduction

History

Santa Monica Airport (SMO) has been a presence in the city of Santa Monica for many decades, serving functions that have ranged from recreational flying to military use. It was originally built in 1919 and named *Clover Field*, which was the home base of the Douglas Aircraft Company. Today, SMO serves as a general aviation “reliever airport” for Los Angeles International Airport (LAX) and is primarily used by private operators. In recent history, a steady increase in the number of jet plane operations has resulted in increased air pollution and noise burden on the surrounding community, resulting in legal action by community members against the City of Santa Monica.

SMO is unique among airports, from a legal and contractual standpoint, as well as from a geographic and operational standpoint. SMO is owned and operated by the City of Santa Monica. In the early 1980s, after a Federal Court ruled against the city’s total ban on jet planes, the city initiated efforts to close the airport entirely.[1] However, the Federal Aviation Administration (FAA), along with other aviation interests, threatened suit against the city. In 1984, a compromise agreement ensued, which committed the city to keeping the airport operational as a general reliever airport until July 1, 2015. The agreement also included decibel limits to noise from take-offs and landings and limited the operating hours by instituting a night curfew on departures and a voluntary night curfew on arrivals.[2]

Since the 1984 agreement, SMO has significantly expanded its jet plane operations, increasing from 1,176 in 1983 to over 18,000 in 2004. The number has since decreased to about 16,000 in 2008.[3] The increase in the number of flight operations has been accompanied by an increase in noise as well as air pollution, creating a greater burden on the surrounding residential communities.[4]

The Affected Community

The airport is located at the southeast corner of the City of Santa Monica with the southern and eastern perimeter of the airport bordered by the City of Los Angeles. An estimated 150,000 residents live within a 2-mile radius of SMO. While the northern edge of the airport is primarily bordered by commercial buildings, residential neighborhoods surround the remainder of the airport. Within a 1-mile radius around the airport, there are at least 9 preschools and daycares, 11 elementary schools, 4 middle schools, 5 colleges or universities, 1 learning center, and 6 parks. Two of these parks are located right on the border of the airport. Clover Park is situated on the airport's northwest border, immediately abutting the path used by planes when taxiing to their gates. On the southeast end of the airport is the Airport Park, which includes an area built specifically for small children.

While reports of odors have come from all areas surrounding the airport[3], North Westdale, the Los Angeles neighborhood immediately downwind of the airstrip, has suffered the most from jet fuel exhaust. The area includes roughly 1,000 homes, with residents ranging from small children to the elderly. There are several daycares in the community, primarily run out of homes, as well as an elementary and middle school.

During the mid 1990s, a few North Westdale residents videotaped footage of jets taking off from the Santa Monica airport and the effect these planes had on the surrounding neighborhood. One piece of footage taken from a resident's backyard shows a jet in close proximity awaiting clearance to take-off. As the jet's engine idles, a trail of black soot blows into the camera's lens and the wind from the jet vigorously sways the surrounding trees. The footage then goes on to show the grass covered in black ash, the resident's overturned patio furniture, and a neighbor's destroyed fence.[3]

Numerous letters complaining about the noise and exhaust from the jets are posted on the website "Concerned Residents Against Airway Pollution," a site created by a Los Angeles based grassroots group to advocate against the SMO air and noise pollution. These complaints date from 2003 to February of 2010 and come from residents who live both across the street from the airport and those residents who reside more than a mile away. Common problems include complaints of the jet exhaust lingering in their yards and penetrating into their homes. Physical complaints include burning of the eyes, nose, and throat and headaches because of the jet exhaust. Many parents report frequently keeping their children indoors due to the overwhelming exhaust and noise. Nearby residents state they are unable to hear their television or have conversations in their homes because of the loud noise from overhead planes. Individuals also report that their sleep is interrupted multiple times, secondary to planes flying overhead as early as 6 a.m. and as late as midnight during all seven days of the week. Lastly, residents express fear regarding the limited amount of space at the Santa Monica Airport and the lack of a buffer/safety zone for planes who runoff the airport runaway, potentially placing nearby communities in danger.[3]

SMO: A unique problem

Legal and Contractual Agreements and City Boundaries

The legal and contractual agreements pertaining to SMO, as well as the airports location within both the communities of Santa Monica and Los Angeles, make efforts to mitigate the burden of noise and aircraft emissions difficult. Such efforts have been countered by the City's claim that it lacks the authority to regulate the airport's environmental impacts due to the terms of the 1984 Agreement as well as the Airport Noise and Capacity Act of 1990 (ANCA), which significantly limits proprietary rights for airport operators. These positions have been maintained despite legal analysis documenting that the city retains proprietary rights over the airport in areas not specifically denied in the 1984 Agreement, which primarily gave the rights over noise regulation to the FAA. Furthermore, the contractual agreement between the city and the FAA prevents the FAA from invoking ANCA to limit the city's rights. Nonetheless, the City has requested numerous times that the FAA impose stricter rules and regulations on SMO, only to be met by inaction from the FAA, which states that their sole charge is "to direct aircraft flight patterns and ensure safe and efficient use of navigable space."[5] The airports location results in divided political representative boundaries on the local, state and congressional levels, thereby also complicating the political process of addressing the airport's impacts.

Proximity to Homes, Parks, and Schools – Lack of a Buffer Zone

The location of the airport contributes to the burden on the community. First, unlike other Los Angeles area airports, there is no buffer zone between the airfield and the surrounding community which, as mentioned above, is primarily comprised of homes, schools, and parks (see Figure 1). On both the western and eastern ends of the runway, planes are separated from houses by only a single street. Moreover, the eastern end of the runway sits on land that is elevated above the bordering street, Bundy Drive. Planes, which primarily idle and takeoff from this eastern end, therefore blow exhaust over the street and directly into the North Westdale neighborhood. Because of this impact, SMO erected a blast wall in 2002 at the eastern end of the runway. However, the community members reported no appreciable benefit from the wall.[6] FAA recommendations for buffer zones do exist and depend on the type of aircraft flying in and out of a given airport as well as their landing and takeoff speeds**.** However, existing airports are not required to follow these recommendations.[7] Nonetheless, similar municipal airports in the Los Angeles area such as those in Van Nuys and Long Beach do utilize significantly larger buffer zones between their runways and surrounding residences (see Figures 2 and 3). Reviewing maps of the Van Nuys, Long Beach, and Santa Monica airports reveal that the distance to the nearest homes on either side of the runways is 0.2 miles, 0.25 miles and 0.04 miles respectively indicating a 5-fold difference in the buffer zone between SMO and other local existing airports.

Rules regarding proximity to critical jet blast areas for personnel working on airports have also existed in the past. According to a Department of Transportation/FAA interdepartmental memo written in May 1989, "since prolonged exposure to jet fumes is dangerous to the health of personnel working on the systems, it is necessary to minimize this deleterious effect. Therefore, no jet aircraft shall be permitted to park or hold within 300 feet of the ILS [instrument landing system] equipment shelters, the localizer antenna array, or the glide slope antennas." The document also stated that "vegetation growth shall not be permitted to exceed 12 inches in height in the ILS critical areas within 2000 feet of the localizer and 800 feet from the glide-slope antennas."[8] While this policy has since been amended, such a policy to protect the health of airport personnel raises concern for the safety of residents, many of whose homes currently sit less than 300 feet from both ends of Santa Monica Airport's runway.

The impact of aircraft exhaust on the surrounding community is further exacerbated by flight takeoff procedures at SMO. In 1990, new takeoff procedures required planes taking off from SMO to await permission from air traffic control at LAX because of the convergence of flight paths from these two airports.[9] Local residents have noted an increase in jet emissions due to the idling of jets awaiting permission for takeoff, especially since the idling jets are located close to the east end of the runway when in the hold pattern, and at the eastern most end of the runway during takeoff with the engines facing Bundy Drive and the houses just beyond.[3]

Exposure to Jet Fuel Exhaust

Various studies have examined jet fuel and the exhaust it creates. Jet fuel, supplied by JP-8 and JetA1 fuel for major aviation engines and civil aviation engines respectively, consists of a complex mixture of many components, including napthalenes, diaromatics, cycloalkanes, straight chain alkanes, and branched chain alkanes.[10] The exhaust from jet fuel contains dangerous compounds, including black carbon (BC), particle-bound polycyclic aromatic hydrocarbons (PB-PAH) and ultrafine particles (UFPs).

Researchers have investigated jet fuel byproducts' environmental effects, including air quality. A number of studies find that air quality near major airports can be significantly affected by emissions from air mobile sources. This research becomes increasingly important as the number of jet flights have heavily increased at Santa Monica Airport over the last decade. Eickhoff's study in 1998 looked at mass concentrations of polychlorinated dibenzo-*p*-dioxines (PCDD)/polychlorinated dibenzofurans (PCDF) and particle-bound polycyclic aromatic hydrocarbons (PB-PAH) in jet engine emissions and found that levels were higher during idling and take-off of jet aircraft.[11] Another study looking at the air quality around Zurich airport found that carbon monoxide concentrations in the vicinity of the terminals are dependent on aircraft motions and engine status (idling vs. take-off vs. landing).[12] Westerdahl's research found that concentrations of UFPs were markedly elevated in the vicinity of Los Angeles International Airport, particularly downwind of the takeoff runways.[13]

Even though research studies reveal elevated pollutant concentrations in the surrounding downwind areas around large commercial airports, some questioned if the same would be true for smaller airports. One study at a small regional airport in Warwick, RI that receives primarily commercial aircraft traffic measured black carbon concentrations at five monitoring sites surrounding the airport between July 2005 and 2006. Results from the study suggested "significant positive associations between hourly departures and arrivals at the airport and BC concentrations within the community, with departures having a more substantial impact."[14]

Additional research has been done around the Santa Monica airport indicating the elevated pollutant concentrations associated with smaller airports. The South Coast Consortium of the Air Quality Management District conducted a study of the area exposure to total suspended particles (TSPs), lead, and UFP around Santa Monica and Van Nuys airports.[15] The researchers of this particular study revealed there was no discernible elevation of 24-hour averaged PM2.5 mass.

Significantly higher levels of total suspended particulate lead were found surrounding the airport. The source of lead exposure is primarily due to aviation gas used by piston-engine planes. Immediately adjacent to the takeoff area, lead levels were found to be up to 25 times higher than background lead levels and in the remainder of the residential area, lead levels were found to be 7 times higher than background lead levels. Despite these elevations from baseline, lead concentrations in and around SMO were still below the Lead National Ambient Air Quality Standard (NAAQS), as established by the EPA.[16] Ultrafine particle number concentrations were also found to occur in significantly high spikes during jet departures although there are currently no standard guidelines or regulations related to UFP exposure.

Additional research by Hu et al. 2009 has demonstrated the correlation between UFPs and aircraft activity of the Santa Monica airport.[17] Using electric vehicle mobile platforms, Hu et al. measured real time air pollutant concentrations in the surrounding areas of Santa Monica Airport in 2009. Their research found markedly elevated peak concentrations of UFPs downwind of Santa Monica Airport with an effect extending at least 660 meters downstream in the direction of the wind's trajectory. Aircraft operations led to an increase of 10 and 2.5 times the concentration of UFP over background levels at 100 and 600 meters downwind, respectively. Though aircraft operations did not significantly elevate average BC and PAH levels, spikes in concentration of these pollutants were seen during jet takeoffs. Jet departures showed peak levels of UFP, PB-PAH, and BC elevated by factors of 440, 90, and 100, respectively.[17]

<u>Health Effects of Jet Fuel Exhaust</u>

Given the above findings of decreased air quality from jet fuel emissions, it is important to understand the burden of health risks on the surrounding community. A large body of evidence on the effects of air pollution as a whole has clearly linked air pollution to adverse medical outcomes. However, in recent years, there has been increasing interest in defining the medical outcomes associated with specific components of pollution. As there are documented elevated levels of black carbon, ultrafine particles, and PAH in the neighborhood surrounding the Santa Monica airport, examining the health effects of these pollutants for residents in this community is critical.

Black Carbon

Black carbon is one component of jet fuel exhaust and has the ability to persist in the environment for days to weeks.[18] As mentioned above, black carbon levels correlate with ariport activity, particularly with airplane departures. Multiple studies have linked black carbon to respiratory and cardiovascular disease. A study from the University of Southern California explored the long term effect of black carbon on lung development. In this study, children between the ages of 10 and 18 from multiple communities in southern California were evaluated over an eight-year period. Researchers observed a reduction in both lung capacity and forced expiratory velocity in the first second (FEV_1), both of which are medical measurements of lung function, after prolonged exposure to black carbon and other pollutants. The decreased lung function noted in these subjects held true for individuals without asthma or a history of smoking.[19] Moreover, given that lung development is essentially complete in both girls and boys by the age of 18, this suggests that these changes in pulmonary function are irreversible.

Reduced lung function is a strong risk factor for medical complications and death in adulthood. Given the number of children exposed to jet fuel exhaust in homes and schools around SMO, the health impact from increased black carbon exposure is substantial.

Another study focusing on women residing in urban areas found a correlation between black carbon and reduced lung function. This effect was stronger in the summer months, when people were more likely to spend time outdoors, highlighting the acute effect of increased exposure on pulmonary capacity.[20] The East Bay Children's Respiratory Study demonstrated that even in San Francisco, an area with relatively good air quality, exposure to black carbon was associated with higher rates of asthma and bronchitis in school-aged children. Importantly, this association was stronger for children who had been living in this neighborhood for more than one year, indicating that prolonged exposures may have additive effects.[21] The increased number of flights at SMO is significantly elevating residents' exposure to black carbon and thus the risk of respiratory disease.

Additional studies have investigated the cardiovascular effects of black carbon. One such study found a strong correlation with black carbon and decreased heart rate variability, a risk factor for sudden death. The study also suggests that individuals with a history of cardiovascular problems, such as prior heart attacks, may be especially susceptible to the negative effects of black carbon on the heart.[22] Similar studies have shown the correlation between autonomic tone and black carbon.[23] This highlights the dangers of ambient pollution on cardiovascular autonomic function, particularly given the high rates of baseline heart disease in the general population.

More recent investigations have tied black carbon exposure to increased cancer risks. A study from the University of Milan showed that this exposure was associated with decreased DNA methylation in adult male blood samples. Global DNA hypomethylation has been found in patients with cancer as well as those with cardiovascular disease. In addition, in animal models, changes in methylation were found in sperm cells, indicating that the effects of these exposures could last multiple generations, even in the subsequent absence of the pollutant.[24] Another study evaluated the effects on black carbon on markers of inflammation, specifically soluble Vascular Cell Adhesion Molecule (sVCAM-1). The authors noted larger effects in obese individuals.[25] These studies propose mechanisms for environmental pollutants to cause long-lasting genetic changes and to predispose individuals to common multi-factorial diseases.

Ultrafine Particles

Along with black carbon, jet fuel exhaust contains particulate matter. There is strong epidemiological evidence linking the particulate components of air pollution to adverse human health effects. Particulate matter (PM) is composed of compounds varying in size, concentration, number, and chemical composition. The size of the PM is categorized according to their aerodynamic diameter PM 10 ("thoracic"), PM 2.5-10 ("coarse"), PM 2.5 ("fine") and UFP ("ultrafine particles", <0.2 micrometers). The numbers reflect maximum diameter, such that PM10 includes smaller particles like PM2.5 and UFP. Likewise PM2.5 as a class includes UFP. Multiple studies have been done linking the larger particulates with adverse health effects; studies involving ultrafine particles are emerging. As mentioned above, levels of UFP were significantly elevated in the community downwind of the Santa Monica Airport.

Exposure to PM10 has been clearly shown to increase morbidity and mortality from respiratory and cardiovascular diseases.[26] PM2.5 (a subset of PM10) are particularly dangerous given the ability of these smaller particles to reach deeper parts of the lungs, and have been shown to have similar adverse health effects.[27] Data from large epidemiologic studies of UFP have yet to be published, largely because scientists have only recently been able to measure these particles. Nonetheless, a growing body of evidence on the pathophysiologic effects of UFP leads us to expect significant adverse effects from exposure to these particles as well. For instance, studies in rodents have shown that UFP exposure results in even greater lung inflammation than does exposure to larger particulates.[28] Furthermore, research examining the interactions between insoluble ultrafine particles and biological systems (such as body fluids, proteins, receptors, and cells), have shown that not all particles deposited in the airway are cleared by the mucociliary transport system. To simulate inhalation of UFPs, test particles were inhaled as an aerosol bolus at the end of a breath of filtered air.[29] The studies clearly showed that the long-term retained fraction in airways depends on the particle size; the smaller the particle, the more the airways retained those particles. In short, residents near the Santa Monica Airport have increased exposure to particles known to be retained in human lungs which can cause significant airway inflammation.

Once retained in the airways, UFPs have the potential to affect other parts of the body. A review article by Araujo and Nel looked at the relationship between particulate matter and coronary artery disease.[30] Several studies showed that cardiovascular outcomes increase when exposures changed from PM 10 to PM 2.5 matter in animal models. Though there are few studies yet available for UFP exposure on human atherosclerosis, recent findings from the Southern California Particle Center (SCPC) are consistent with the idea of UFPs greater proatherogenic potential. Delfino et al. looked at residents in an independent living facility in Los Angeles with a history of coronary artery disease. They found positive associations of particle number and outdoor quasi-ultrafine PM 0.25 with markers of inflammation such as CRP, IL-6, and TNF-II.[31] In an animal study from the SCPC, Araujo et al. exposed mice to concentrated fine particles, UFP or filtered air for 5 hours a day, 3 days a week for 5 weeks. They found that UFP-exposed mice developed 25% and 55% more aortic atherosclerosis compared to PM 2.5 and filtered air-exposed mice.[30]

To explain the pathophysiology of why UFPs might induce blockage of blood vessels, several mechanisms have been proposed including free radical production, oxidative stress, and inflammation. Li et al.'s study showed that ambient UFPs trigger the induction of an enzyme [Nrf-2 regulated heme oxygenase-1 (HO-1)] in macrophage cells (part of the immune and inflammatory systems) to a greater degree than ambient fine or coarse particles.[32] HO-1 is associated with the first tier of defense in macrophages and epithelial cells. They also found that UFPs cause extensive mitochondrial damage in murine macrophages and human bronchial epithelial cells (see Table 4 below). In the study, mice were exposed to either UFP, fine particles or filtered air for 5 hours in a lab located in downtown Los Angeles. Whole-body images were then obtained of the mice after 3 hours and demonstrated that the HO-1 promoter gene was more readily induced in those animals exposed to concentrated UFP. The scans displayed increased emissions both in the chest and abdomen of the UFP exposed mice. Thus, it was postulated that UFPs have greater pro-oxidant effects, as they induce markers of inflammation and free radical production in mice.

There is clear evidence that particle deposition leads to systemic inflammation. However, there is little evidence to explain just how the particles get from the lungs into the bloodstream. Several articles propose mechanisms such as incorporation by alveolar macrophages or diffusion through lung tissue to reach the blood circulation. Unfortunately, no study has convincingly demonstrated the exact route and this area of research must be expanded further to provide the answer. However, it is clear that these particulates are most likely to be retained in the respiratory tract and that they likely have adverse health effects given the data from the previous studies on larger particulates.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAH) are another group of compounds found in jet fuel exhaust found to play a role in air pollution. PAH have been shown to be genotoxic (toxic to genes) and carcinogenic (cancer-causing). They have also been linked to disruptions of the endocrine system.[33] Though most of the research has been done on animal and adult models, some studies have shown that fetuses and infants are more susceptible than adults to the harmful effects of environmental toxicants. Because families live in homes surrounding the Santa Monica airport, the PAH in the air has serious implications for the health of the local children.

Prior laboratory and human studies in Central Europe have linked exposure of PAH during pregnancy to adverse birth outcomes.[34] In epidemiological studies, PAH exposure was associated with fetal growth reduction, including reduced birth weight and birth head circumference and/or small size for gestational age, in black, white, and Chinese newborns living in New York City.[35] In 2006, Perera and colleagues looked at the effect of prenatal exposure to PAH on neurodevelopment outcomes in the first 3 years of life in inner-city children. The mothers who participated in this study all had detectable levels of PAH in prenatal personal air samples. This study was able to show the likelihood that a child would have moderate mental delay at 3 years of age significantly increased as a result of PAH exposure.[36] The infants who had been exposed prenatally to the highest PAH levels scored significantly lower on the mental developmental index at 3 years of age than did those with lower levels of PAH exposure. Among the highly exposed children the odds of having moderate mental delay at 3 years of age were almost three times greater than the odds for children with no PAH exposure. However, this relationship was not seen at 1 and 2 years of age. This suggests that more exposed children are potentially at risk for learning and performing school deficits in their preschool years.

In 2009, Perera et al. followed up their previous study with another look at prenatal PAH exposure and the child's IQ at 5 years of age (same group of children studied in the 2006 study).[37] 249 children with PAH exposures ranging from 0.49 ng/m^3 to 34.48 ng/m^3 were studied. A total of 140 children were classified as having high PAH exposure (greater than 2.26 ng/m^3). The results of this study found that women with high exposure to PAH during pregnancy were more likely to have children with lower verbal and full-scale IQ scores when tested at age 5. The IQ scores were 4.67 points and 4.31 points lower for high- vs. low-exposure children. This again has implications for future learning and school performance deficits in these children exposed to PAH during pregnancy.

Carcinogenic Risks

The multiple studies on the health hazards of black carbon, particulate matter, and PAH highlight the key concerns surrounding the Santa Monica Airport, as the rapidly increasing number of flights from SMO exposes residents to these toxins in ever-increasing quantities. Moreover, there are additional harmful effects of airport pollution, such as an increased risk of cancer. A health risk assessment conducted in 1993 for the U.S. Environmental Protection Agency (EPA) reported that aircraft engines are responsible for approximately 10.5 percent of the cancer cases within a defined geographic location (approximately 16 square miles) surrounding Chicago's Midway Airport. The authors of the report additionally note that "it is no surprise that emissions from aircraft engines may have a significant impact on the people living in the study area, especially to people living at receptors adjacent to the airport."[38] The National Resources Defense Council (NRDC) commenting on the U.S. EPA assessment believes that "the same conclusion might apply to people living immediately adjacent to airports all over the country."

In addition, one study in 1999 investigated the health impact of emissions overall from the Santa Monica Airport on the surrounding community. The Los Angeles Unified School District (LAUSD) study found the carcinogenic risk surrounding the airport markedly increased above "acceptable risk". More specifically, "cancer risks for the maximum exposed individual who resides in proximity of the airport were twenty-two, twenty-six and thirteen in one million for the baseline, increased turbojet and piston operational scenarios, respectively. These values represent discrete cancer risks associated with airport related exposures. No background or ambient concentrations were incorporated into the risk quantification. In consideration of the Federal Clean Air Act, emissions associated with airport operations were clearly found to exceed the "acceptable risk criterion" of one in a million (1 x 10-6)." However, the study also found that the short-term (24 hour) and annual PM10 concentrations and lead quarterly concentrations would not exceed national standards.[39]

Although there remains a need for additional investigations to further delineate these risks, it is unwise to ignore the current evidence which suggests that airport-vicinity residents may be predisposed to respiratory, cardiovascular, and oncologic diseases as well as an increased rate of mortality. Using the knowledge we have thus far, we can make policy decisions that would prevent residents from further exposure to toxic pollutants and their negative health effects.

Exposure to Noise Pollution

In the past 30 years, there have been moderate advances in the development of noise policies in airport development, including those implemented at the Santa Monica Airport that attempt to reduce noise by eliminating flights over the residential area at night, checking noise monitors, and setting up a Noise Management Office to handle complaints.[40] While these changes are advances in a positive direction, the amount of noise exposure that remains is not inconsequential and has not been mitigated by these measures. The FAA, in agreement with SMO, currently adopts a noise threshold of 65 dB DNL (day-night average sound level) as compatible with residential areas.[41]

However, problems with this threshold have been identified since 1995, when the National Resources Defense Council found that the 65 dB DNL is based on an averaging of noise that does not account for the loud “single event” noise of aircraft takeoff (such as the 95 dB maximum emitted by a jet during takeoff from SMO). Furthermore, this threshold does not take into account the actual impact of this level of noise on the residents in airport communities. One quantitative study on the impact of noise around La Guardia Airport in New York found that residents living near the airport were exposed to up to four times the amount of noise as people in otherwise comparable communities; over 55% of residents living along the flight path were bothered by aircraft noise, with the majority of those residents living in areas exposed to less than 65 dB DNL.[42-43] Clearly, the 65 dB DNL limit currently adopted by SMO and the FAA does not recognize that this level, although perhaps improved as compared to previous standards, still has both physical and mental health effects on neighboring residents.

One of the efforts made by community airports to help reduce noise has been the practice of soundproofing, which to our knowledge has not been adopted by SMO as it has by other local airports. For example, according to the Los Angeles *Times*,[44] due to an increase in military flights through Long Beach airport, the city council had approved to soundproof homes most affected by the increased noise, including placement of acoustic windows and attic insulation. Another local airport, the Burbank Airport, publishes a Quarterly Noise Monitoring study, which in August 2009 evaluated the noise impact boundaries around the airport and identified 1080 acres of land exposed to 65 dB of noise. According to this study, the Burbank Airport has made attempts to acoustically treat all residences within the 65 dB contour, which included 1446 unit dwellings as of June 2007.[45] Residents near Los Angeles International Airport and Van Nuys Airport are also eligible to participate in a soundproofing effort to decrease the decibels of noise within homes.[46] In the literature, there are no such efforts to aid the residents living near Santa Monica Airport. Soundproofing is one consideration to help mitigate noise exposure around SMO when indoors, but unfortunately does not account for the possible adverse effects of noise pollution when outdoors around homes and parks. Although some regulations and programs are already in place at SMO to help limit noise exposure, further efforts at reduction are indicated given the significant risk of negative health effects of airport noise on surrounding communities.

Health Effects of Noise Pollution

The body of evidence supporting the harmful effects of excess noise on health is strong, especially in regards to its impact on children. As early as the 1980s, research has shown that chronic noise exposure creates both physical and psychological stress that manifests as elevated blood pressure, decreased memory, reading deficits, learned helplessness, and annoyance.[47] Children need quiet and appropriate environments to study and learn. According to the National Institute on Deafness and Other Communication Disorders (NIDCD), which is one of the National Institutes of Health, “long or repeated exposure to sounds at or above 85 decibels can cause hearing loss.”[48] Jet plane take-off is up to 120 decibels, far above 85 decibels. Numerous studies have demonstrated that impaired hearing causes learning difficulties. A 2010 study found that primary school students who have poor academic performance are also significantly more likely to have mild hearing loss.[49] Remarkably, another study has suggested that exposure to even 50 decibels of noise in the daytime is associated with relevant learning difficulties in schoolchildren, well below the noise level of jet plane take-offs. Researchers from this study suggest aiming for noise exposure maximum values of 55 decibels during the daytime in order to protect the more sensitive segments of the population, such as children and the elderly.[50]

Beyond hearing impairment, even those students with normal hearing who are exposed to aircraft noise have been demonstrated to have worse educational outcomes. An extensive cross-national study conducted in Europe showed a direct correlation between exposure to aircraft noise and impaired reading comprehension and recognition memory. Children living and attending school near airports fell behind their peers in reading by about two months for every 5 dB noise increase in their environments. The researchers concluded that “schools exposed to high levels of aircraft noise are not healthy educational environments.”[51] A similar study published in 2006 also found that “aircraft noise exposure at school was linearly associated with impaired reading comprehension; the association was maintained after adjustment for socioeconomic variables, aircraft noise annoyance, and other cognitive abilities.”[52] Given that reading is a basic building block for continued effective learning throughout life, exposure to airport noise has critical and serious implications for not only short-term but also long-term effects on education and learning in children. Finally, children are not only affected by noise at school, they are also affected within their own homes. A 2004 article showed a significant dose-response relationship between aircraft noise at home and performance on memory tests of immediate and delayed recall. These results “suggest that aircraft noise exposure at home may affect children's memory.”[53]

These studies are relevant in the case of SMO because not only are there private homes with children of all ages living right next to the airport, but also there are numerous schools for both children and young adults in the vicinity. There are two schools, Richland Avenue Elementary and Daniel Webster Middle School, that are located less than a ½ mile east of SMO and directly in the flight paths of SMO. Within two miles from the airport are Mar Vista Elementary School, Art Institute of Los Angeles, Walgrove Avenue Elementary School, Mark Twain Middle School, and Santa Monica College. Given the sheer number of students that these institutions serve, thousands of children are potentially being negatively affected.

Studies on the effects of airport noise pollution on adults is much more limited, but at present, a large 6000-subject study, the Hypertension and Exposure to Noise near Airports (HYENA) project, is under way to further delineate the negative health impacts of airport noise pollution on adults, particularly in terms of blood pressure and cardiovascular disease risk.[54] The outcomes from this study may also contribute to the growing body of evidence suggesting the negative effects of airport noise pollution on health beyond learning impairment in children. Regardless of the results of future studies, it is evident from the wealth of existing research that exposure to noise near airports has significant deleterious affects on physical and mental health, particularly for vulnerable populations such as children.

CONCLUSION

This Santa Monica Airport Health Impact Assessment serves to take into consideration scientific evidence concerning the link between public policy and health. While we do not claim to be able to provide definitive answers to all of the concerns raised regarding issues surrounding SMO, we do strive for this HIA to provide beneficial and constructive information to the stakeholders involved in determining SMO’s future role in the community.

Key Findings

1.Airport operations, particularly jet take-offs and landing, are contributing to elevated levels of black carbon in the area surrounding Santa Monica Airport. Elevated exposure to black carbon is associated with:

- increased rates of respiratory and cardiovascular disease including asthma, bronchitis, and increased risk for sudden death
- irreversible decrease lung function in children

2. Elevated levels of ultrafine particles (UFP) are associated with aircraft operations and jet takeoffs and are found in the area surrounding Santa Monica Airport. Elevated exposure to UFPs are associated with:
   - increased inflammation and blockage of blood vessels in mice models
   - greater lung inflammation with exposure to UFPs than exposure to larger particulates in rodent models
2. Elevated levels of polycyclic aromatic hydrocarbons (PAH) are found in the area surrounding Santa Monica Airport. Exposure to PAH has been associated with:
   - increased carcinogenic risk
   - disruption of the hormonal balance in adults.
   - reproductive abnormalities with exposure during pregnancy
   - lower IQ scores in children.
3. Levels of noise due to plane and jet take-offs from Santa Monica Airport are above Federal Aviation Airport thresholds. Excessive noise is associated with:
   - hearing loss.
   - higher levels of psychological distress
   - impaired reading comprehension and memory among children

5. There is no buffer zone between the airport airfield and the surrounding community as observed in many other municipal airport communities (See Figure 5)

Recommendations

In the interests of reducing exposure to toxic jet fuel exhaust byproducts and noise pollution and preventing their deleterious health effects, we recommend the following interventions:

1. Maintain a runway buffer zone of at least 660 meters to protect surrounding residents from the harmful health effects of jet fuel exhaust byproducts during idling and take-off.
2. Eliminate or significantly decrease the number of jet takeoffs to reduce exposure to both the byproducts of jet fuel exhaust and the loud “single event” noise of jet takeoff.
3. Install HEPA (high efficiency particulate absorbing) filters in surrounding schools and residential homes to mitigate the indoor effects of pollution
4. Implement additional noise abatement policies such as soundproofing of schools and significantly affected homes near SMO.
5. Adopt the precautionary principle, given the evidence of the potential harm of UFPs and other byproducts of airport pollution on animal and human health.
6. Notify all potential property buyers, residents, and affected community members in the vicinity of SMO of the noise and air pollution risks.
7. Closure of SMO would eliminate all health risks associated with airport air and noise pollution.

Figure 1: Santa Monica Airport

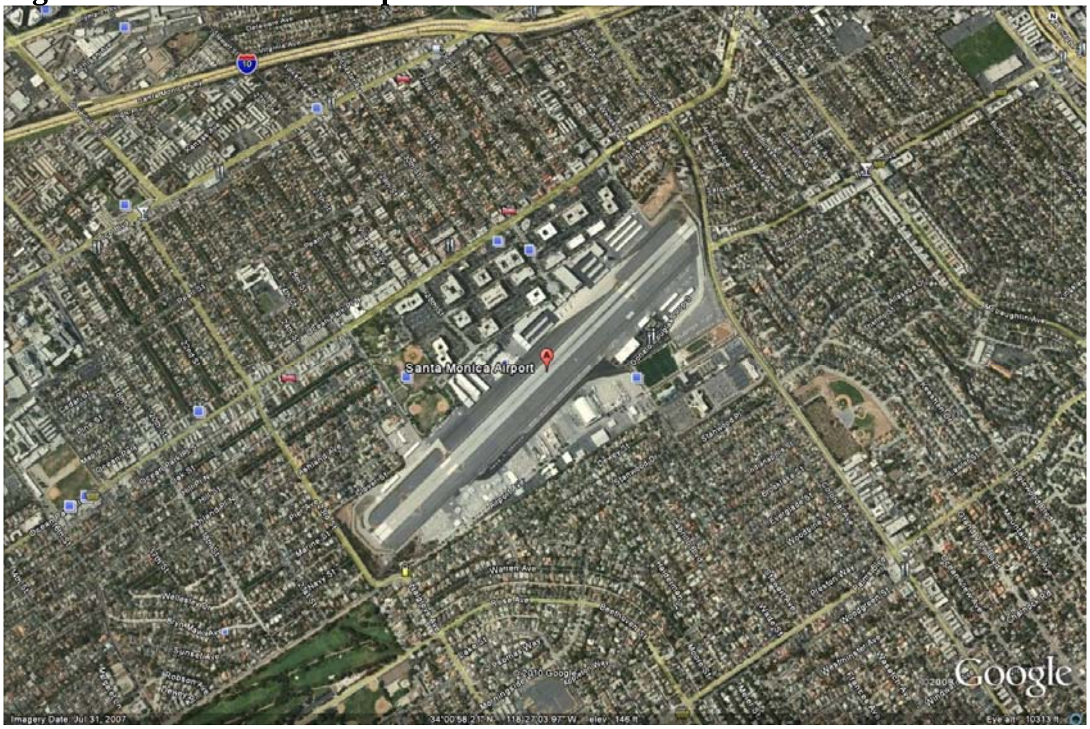


Figure 2: Long Beach Airport

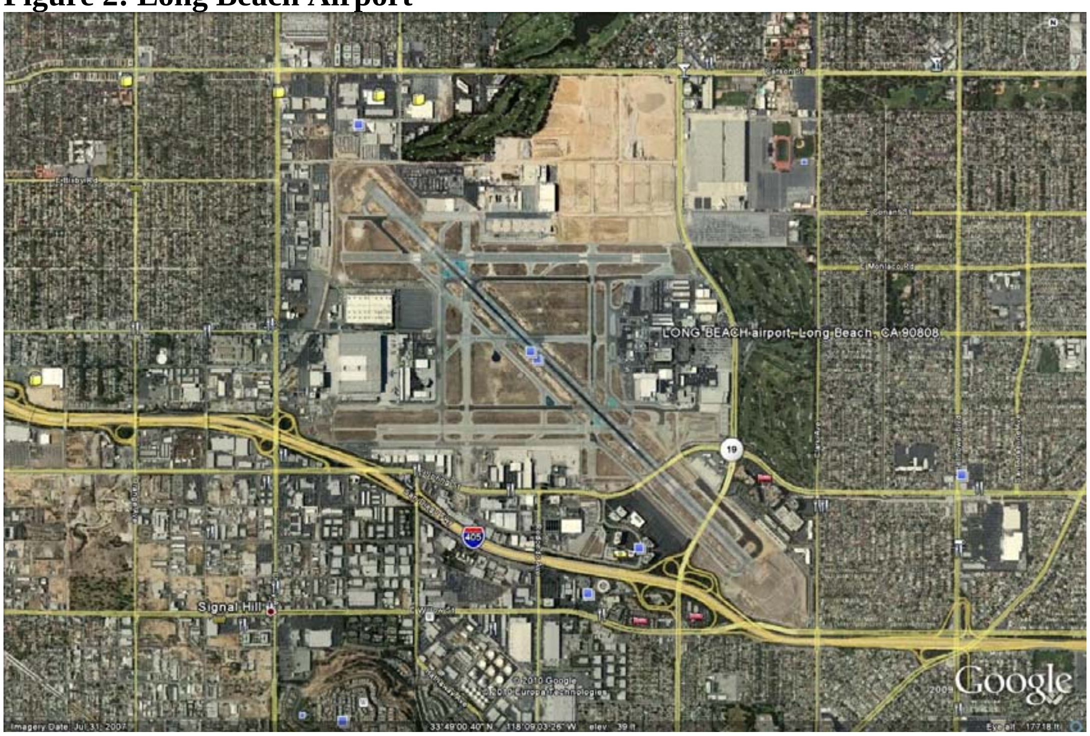


Figure 3: Van Nuys Airport

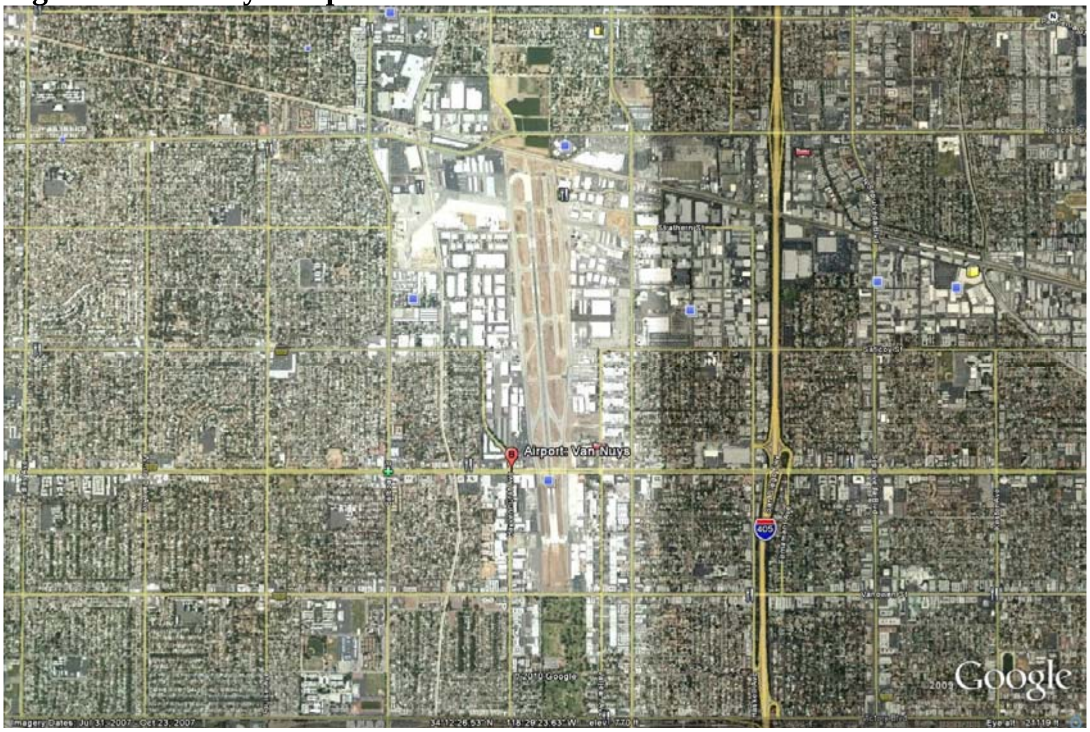
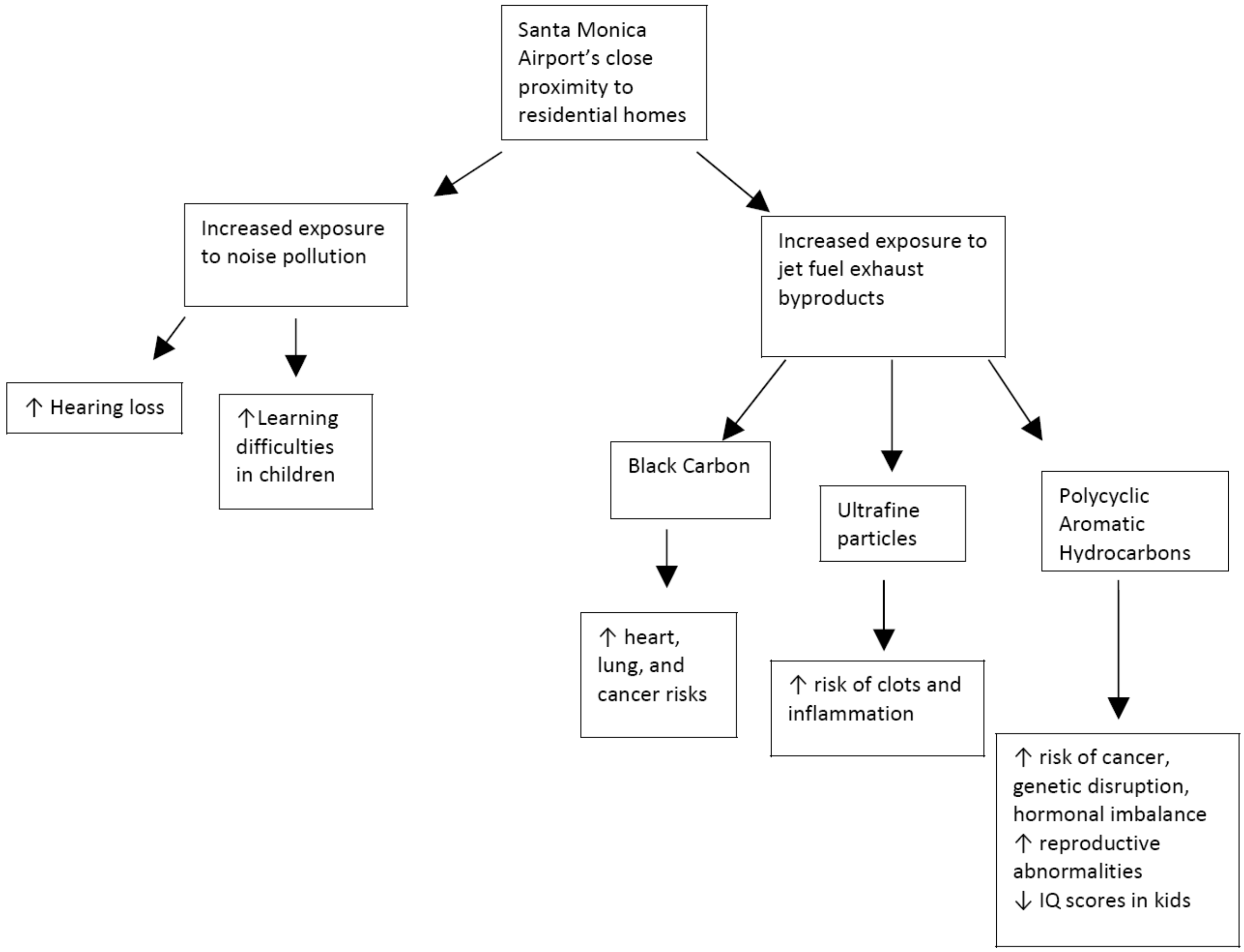


Table 1

Parameter	Coarse ($PM_{2.5-10}$)	Fine ($PM_{2.5}$)	Ultrafine
Size (μm)	2.5 - 10	0.15 - 2.5	< 0.15 μm
Number per μm^3	+	++	+++
Mass (μg) per μm^3	+++	++	+
Relative content (% of total mass) * Elemental carbon	+	++	+++
Organic carbon	+	++	+++
PAHs	+	+	+++
Metals	+++	++	+
Redox activity	+	++	+++
DTT assay **	+	++	+++
HO-1 induction#	+	++	+++
GSH depletion #	+	+++	+++
Mitochondrial damage#	None	Some	Extensive
Surface area	+	++	+++
Bioavailability of active compounds	+	++	+++
Lung penetrability	+	++	+++

Modified from Li et al [123]. * Relative content was estimated using mass concentration and fractional composition of CAPs collected on Teflon and quartz filters in two locations from the Los Angeles basin as reported [67]. ** DTT assay was performed on similar CAPs samples [67]. # HO-1 induction, GSH depletion and mitochondrial damage were determined in a murine macrophage cell line (RAW 264.7) and a transformed human bronchial epithelial cell line (BEAS-2B) exposed to similar CAPs samples [67].

Figure 5: Health Effects of Santa Monica Airport



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