IMPACTS OF LEAD IN AVIATION GASOLINE

In July of 2011 Miranda et al. published a study (Miranda 2011 Study) analyzing blood lead levels of children living around airports in six counties of North Carolina. Their results suggest "that children living within 500 m of an airport at which planes use avgas have higher blood lead levels than other children. This apparent effect of avgas on blood lead levels was evident also among children living within 1,0000 m of airports."[i]

Aviation's dirty little secret

What most people don't know is that while leaded gasoline was phased out of use in the US by 1995, it is still permitted in aviation gasoline (avgas). Briefly, most piston-engine aircraft fall into the categories of either general aviation (GA) or air taxi (AT). GA and AT aircraft include a diverse set of aircraft types and engine models and are used in a wide variety of applications. Lead emissions associated with GA and AT aircraft stem from the widespread use of one hundred octane low lead (100LL) avgas. The lead is added to the fuel in the form of tetraethyl lead (TEL). This lead additive helps boost fuel octane and prevents valve seat recession which can be a significant concern from a safety standpoint. [ii]

"In the past, motor vehicles were the major contributor of lead emissions to the air. As a result of EPA's regulatory efforts to reduce lead in on-road motor vehicle gasoline, air emissions of lead from the transportation sector, and particularly the automotive sector, have greatly declined over the past two decades. Major sources of lead emissions to the air today are ore and metals processing and piston-engine aircraft operating on leaded aviation gasoline..."[iii]

In 2002 an estimated 622.8 tons of lead were emitted from aviation activity in the United States.[iv] This is approximately 45% of total lead emitted in the U.S. in 2002.[v] According to the EPA's Regulatory Announcement in April, 2010) lead from avgas is now the largest source of lead in the air (about 50%).[vi] In other words not only is general aviation the major source of lead pollution, its percentage contribution is increasing!

Once taken into the body, lead distributes throughout the body in the blood and is accumulated in the bones. The residence time of lead in bone can be decades. Depending on the level of exposure, lead can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. The lead effects most commonly encountered in current populations are neurological effects in children and cardiovascular effects (e.g., high blood pressure and heart disease) in adults. Infants and young children are especially sensitive to even low levels of lead, which may result in impaired cognitive, motor, behavioral and physical abilities. [vii]

The Miranda Study on Effects of Avgas on Childhood Blood Levels

The Miranda 2011 Study, entitled "A Geospatial Analysis of the Effects of Aviation Gasoline on Childhood Blood Lead Level" was conducted by the Children's Environmental Health Initiative, Nicholas School of the Environment, Duke University, Durham, North Carolina.

The Miranda 2011 Study analyzed blood lead surveillance data obtained between 1995 and 2003 which was available for 125,197 children. Of these children, 13,478 lived within 2000 meters of an airport in the six study counties. Blood lead levels were 3.88 ± 2.94 (μg/dL) in the children. [A blood lead level at 2 standard deviations above the mean therefore would be 9.76 μg/dl.] The children's ages ranged from 9 months old to 7 years old. Children living within 500 meters, 1000 meters, or 1500 meters of an airport had average blood lead levels that were 4.4%, 3.8%, or 2.1% higher, respectively, than other children.[viii]

The authors state that, "lead from aviation gasoline may have a small (2.1% - 4.4%) but significant impact on blood lead levels in children who live in close proximity to airports where avgas is used. Importantly, the magnitude of the estimated effect of living near airports was largest for those children living within 500 m [meters] and decreased in a monotonic fashion out to 1500 m [meters]."[ix]

The study concluded, "living within 1000 m [2/3 mile] of an airport where aviation gasoline is used may have a significant effect on blood lead levels in children. Our results further suggest that the impacts of aviation gasoline are highest among those children living closest to the airport."[x]

It should be noted that in the Miranda 2011 Study "the average estimated lead emissions across airport/heliport facilities was only 0.04 tons."[xi] The authors also note that at the Charlotte/Douglas International (CLT) airport, which they note has an estimated lead emission of 0.75 tons per year, a larger discrepancy in average blood lead levels was noted: "We found the largest discrepancy in average blood lead levels between children living within 1,500 m and those whose residence was beyond this threshold (4.39 versus 3.89 μg/dL, respectively)."[xii] This is an 11.4% difference.

Acceptable lead blood levels in children

According to the Centers for Disease Control, "The reduction of BLLs in the United States during 1970-1999, primarily because of implementation of federal and state regulations to control lead exposure, was one of the most significant public health successes of the last half of the 20th century. Nonetheless, some populations and geographic areas remain at disproportionately high risk for lead exposure.... A compelling body of evidence points to the limited effectiveness of waiting until children's BLLs are elevated before intervening with medical treatments, environmental remediation, or parental education.... However, because no level of lead in a child's blood can be specified as safe, primary prevention must serve as the foundation of the effort.."[xiii]

A work group established in 2002 by the CDC Advisory Committee on Childhood Lead Poisoning Prevention determined that, "The overall weight of available evidence supports an inverse (negative) association between BLLs [Blood lead levels] <10 μg/dL and the cognitive function of children...For health endpoints other than cognitive function (i.e., …other neurologic functions, stature, sexual maturation, and dental caries), consistent associations exist between BLLs <10 μg/dL and poorer health indicators."[xiv]

In a 2009 study, Miranda et all found that exposure to lead in early childhood significantly contributes to lower performances on end-of-grade (EOG) reading tests among minority and low-income children. "We found a clear dose-response pattern between lead exposure and test performance, with the effects becoming more pronounced as you move from children at the high end to the low end of the test-score curve." [xv]

The Miranda 2011 study[xiii] demonstrates a small but significant increase in blood lead levels in children living within 2/3 of a mile of an airport. In addition, the range of blood lead levels (3.88 ± 2.94 μg/dL) raises concern that, at least in North Carolina, children have worrisome blood lead levels. By comparison, in 1992 Smith et al. estimated pre-industrial blood lead levels of 0.016 μg/dL.[xvi]

Lead Levels at airport in Oregon

In Oregon, for 2002, the EPA has estimated[xvii] lead emissions from landing and takeoff activity of piston-engine aircraft as follows: Hillsboro Airport (0.6 tons / year, 30th highest in nation), Portland International Airport (0.4 tons / year), Eugene's Mahlon Sweet Field (0.2 tons / year), Aurora State Airport (0.2 tons / year), Scapoose Industrial Airport (0.2 tons / year), McMinnville Municipal Airport (0.2 tons / year), Troutdale Airport (0.2 tons / year), Medford's Rogue Valley International Airport (0.2 tons / year), Deschutes' Roberts Field (0.1 tons / year), Salem's McNary Field (0.1 tons / year), Astoria Regional Airport (0.1 tons / year), Polk County's Independence State Airport (0.1 tons / year), Clackamas' Mulino Airport (0.1 tons / year), Klamath Falls Airport (0.1 tons / year), Umatilla County's Eastern Oregon Regional Airport (0.1 tons / year), Lane County's Hobby Field (0.1 tons / year), and the Dalles' Columbia Gorge Regional Airport (0.1 tons / year). [xviii]

Notably, this data is an estimate of lead emissions, and neglects lead emitted during the cruise phase of flight. Further, it does not take into account accumulated ground contamination of lead, frequently traced to avgas spills, or the older common practice of bleeding off accumulated moisture from fuel tanks (with accompanying avgas) via bleeder valves directly into the ground.

A sense of the concentrations of lead emissions can be derived from the following table breaking down the 0.6 tons/year at Hillsboro airport into the various components of general aircraft operations (lead emissions are derived from fuel consumption).

Mode	Lead emissions
Taxi-Out	0.004 tons/year
Takeoff	0.063 tons/year
Climb out	0.235 tons/year
Approach	0.307 tons/year
Taxi-in	0.024 tons/year
Total	**0.632 tons/year**

The varying emission rates resulting from these modes of flight concentrate general aviation emissions around the active runways and over the most common flight paths used during takeoff (takeoff and climb out) and landing (approach and taxi in). This can be seen for Hillsboro Airport (HIO) in the following plot of the dispersal of lead emissions prepared by the Oregon Department of Environmental Quality (ODEQ) using air dispersion modeling (the CALPUFF modeling system).[xix]

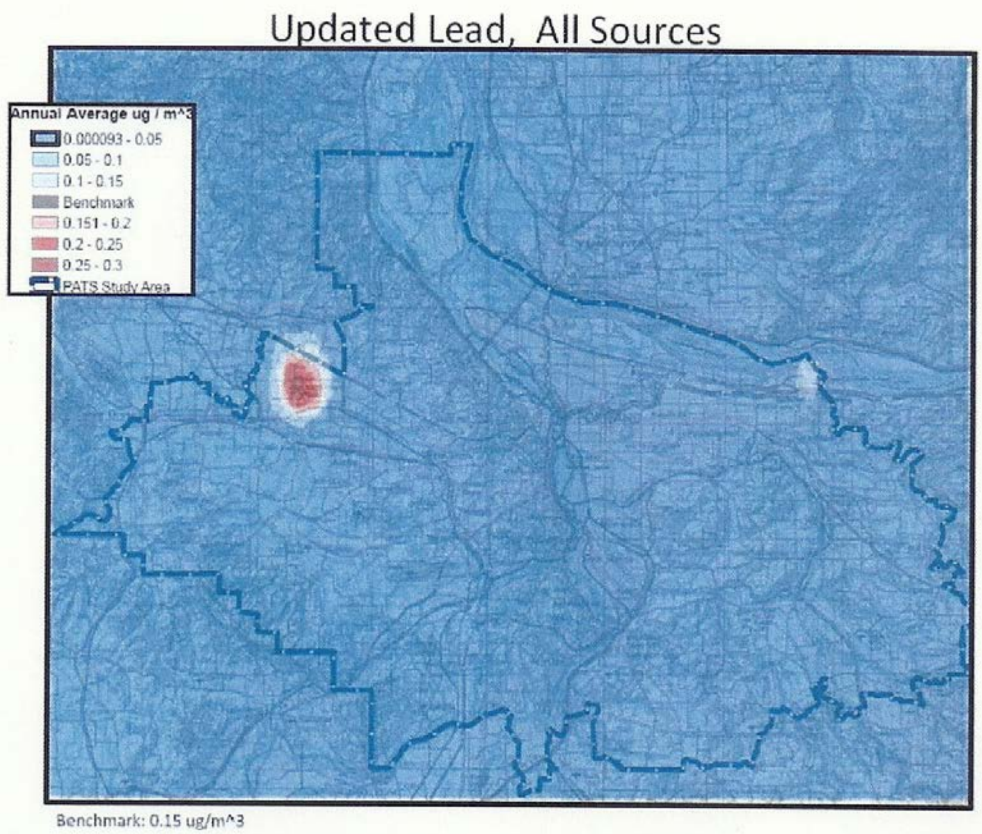

Figure 1-1
Results of ODEQ Modeling (provided by ODEQ)

Conclusion

General aviation airports are significant sources of airborne lead emissions. Living within 1,000 meters (3,300 feet) of a GA airport has been demonstrated to result in higher than normal blood lead levels (BLL), while living within 500 meters (1,650 feet) results in significant increases in BLLs. Increased BLLs have been demonstrated to result in negative neurological effects in children, which has been quantified in lower test scores in children with elevated BLLs. The continued use of avgas is the single largest source of airborne lead emissions in the United States. The busiest general aviation airports in Oregon are significant contributors of airborne lead emissions, and the majority of the general public are not aware of the continued use of lead in avgas, of the concentrations dispersed around General Aviation airports, nor of the related public health risks.

[i] Miranda ML, Anthopolos R, Hastings D 2011. A Geospatial Analysis of the Effects of Aviation Gasoline on Childhood Blood Lead Levels. Environmental Health Perspectives (ehp) 119:1513-1516. (7/13/11). http://dx.doi.org/10.1289/ehp.1003231

[ii] U.S. Environmental Protection Agency. Lead Emissions from the Use of Leaded Aviation Gasoline in the United States - Technical Support Document. (EPA20-R-08-020).(October 2008)Assessment and Standards Division Office of Transportation and Air Quality, pgs. 3 & 7, http://www.epa.gov/ttn/chief/net/tsd_avgas_lead_inventory_2002.pdf

[iii] Lead in Air, Basic Information, Nature and Sources of Lead. U.S. EPA at http://www.epa.gov/airquality/lead/basic.html

[iv] Lead Emissions from the Use of Leaded Aviation Gasoline in the United States; pgs. 3 & 7

[v] Ibid, page 9

[vi] Advance Notice of Proposed Rulemaking on Lead Emissions from Piston-Engine Aircraft Using Leaded Aviation Gasoline: EPA Regulatory Announcement, April, 2010 http://www.epa.gov/nonroad/aviation/420f10013.htm#3

[vii] Interpreting and Managing Blood Lead Levels <10 <10 μg/dL in Children and Reducing Childhood Exposures to Lead; CDC; http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5608a1.htm

[viii] Miranda; Op cit, "Results" section.

[ix] Miranda; Op cit,."Discussion" section.

[x] Miranda; Op cit,."Conclusions" section.

[xi] Jim Lubischer, M.D.; Personal communication with the Miranda Study authors, 10-9-11 email.

[xii] Jim Lubischer, M.D.; Personal communication with the Miranda Study authors 10-9-11 email.

[xiii] "Preventing Lead Poisoning in Young Children", A Statement by the Centers for Disease Control and Prevention, (August 2005), pg. 1. http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning.pdf

[xiv] Ibid., Appendix. "A Review of Evidence of Adverse Health Effects Associated with Blood Lead Levels <10 μg/dl in Children." pg.iv.

[xv] Source, Children's Blood-Lead Levels Linked to Lower Test Scores, Neurotoxicology, 2009

[xvi] Preventing Lead Poisoning in Young Children. A Statement by the Centers for Disease Control and Prevention. (August 2005), Appendix . "A Review of Evidence of Adverse Health Effects Associated with Blood Lead Levels <10 μg/dl in Children." pg. 3 .http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning

[xvii] Lead Emissions from the Use of Leaded Aviation Gasoline in the United States

[xix] "Hillsboro Airport Lead Study - Final Report," Port of Portland, Sept. 1, 2010; prepared by CDM