

Children's Health Study: Latest Findings and Implications

October 29, 2004

California Air Resources Board



California Environmental Protection Agency

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Thank you Ms. Witherspoon, and good morning Chairman Lloyd and members of the Board. Today I want to share with you the latest findings from the Children's Health Study. And since some of the new Board members may not be familiar with the results of this study, I'll also provide some background and review of previous study results. This study of children's health and air pollution, funded with \$18 million from the Air Resources Board and co-funding from the South Coast district and the US EPA, continues to produce vital information on the chronic effects of air pollution on one of our most sensitive population groups -- our children.

Why Did ARB Fund CHS?

- Air Standards Setting
- Children are a Vulnerable Population
- Long-term Effects Unknown



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Three motivating factors led us to fund the Children's Health Study:

First, the need for information to support our ambient air quality standards setting.

Second, our concern about children's health effects.

And last, the lack of information on chronic health effects from long-term exposure to air pollution.

Let me explain in some more detail.

Air Quality Standards

- **Public Health Protection Goal**
- **Protect Vulnerable Subgroups**
- **Supported by ARB Research**



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As you know, the Air Resources Board establishes ambient air quality standards separate from the U.S. EPA. California standards are set at levels that protect the health of the citizens of California. Importantly, these standards are designed to protect our most sensitive population subgroups which may be more vulnerable to air pollution effects. Our research is designed to give us information on the potential impact of air pollutants on the sensitive populations in the state so standard setting decisions can logically and authoritatively be made. Of particular interest are those persons considered most sensitive due to age, pre-existing disease, or exposure.

Children and Air Pollution

- **Children are sensitive to air pollution**
 - growing and developing
 - more time outdoors
 - more active and greater exposures



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Children have been found to be more sensitive to the effects of air pollution.

Children are not simply small adults. They are a unique population and are at greater risk because they are still growing and developing. In particular, their respiratory and immune systems are still developing through their teenage years.

Children are more active and spend more time out-of-doors than adults and their breathing rates are higher. Therefore, they will receive more exposure to air pollution than adults under the same circumstances.

Also, children are at the beginning of their lives. Lung damage can result in health effects that may persist throughout their lifetime.

Long-term Effects

- Little was known about long-term effects of air pollution on children
- Most previous studies based on short-term exposures to adults



As of the late 1980s when the CHS was conceived, little research had been targeted to effects on children. Nor was there much known about chronic health effects. Most studies of the health effects of air pollution had been based on short-term effects, and often primarily in adults. Long-term studies were needed to help determine how chronic exposure to ambient air pollution can affect our children.

Southern California Children's Health Study

- **10+ year study of air pollution impact on lung health and growth**
- **Over 5,500 children studied**
 - **12 communities with different pollution profiles**
 - **increased community monitoring**
 - **lung function testing and questionnaires**



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The Southern California Children's Health Study began in 1992 to investigate these air pollution health concerns. For more than 10 years, this study has investigated the air pollution impacts on over 5,500 children. Students were recruited from the fourth, seventh, and tenth grades and followed through high school. These children have been studied in 12 communities chosen for their differing pollution profiles. I will talk more about this in the next slide. To achieve the desired long-term results the study was designed to have a stable population base, in other words the study subjects were selected so that there would be as much subject retention as possible. To maintain a stable population base most subjects were from middle income families. Similar populations were recruited from the different communities. Health measurements include annual lung function tests and questionnaires to determine changes in their home environment. The annual questionnaire asks demographic questions such as the number of siblings or changes in their home. The questionnaire also asks health information such as a doctor diagnosis of asthma and if the child has suffered from a chronic cough.



As you can see the sites are scattered around the Los Angeles Basin and the surrounding areas. Sites were chosen for their differing pollution profiles. Alpine and Lake Arrowhead have the highest ozone levels. Mira Loma has the highest particulate matter (PM) level. Lompoc and Santa Maria are the cleanest sites. Communities which are mainly impacted by transported pollution and pollutants after undergoing atmospheric chemical reactions are the communities down wind of major pollution source areas and include Mira Loma, Riverside, San Dimas/Glendora, and Upland.

Annual Lung Function Testing



The major test of respiratory health and lung development used in the Children's Health Study is an annual lung function test using a spirometer as shown here. A spirometer is an instrument that can measure the volume of air a person can breathe in and out and the rate at which they breathe.

By the age of 18 girls' lungs have nearly matured, and the growth of boys' lungs has slowed considerably and will be fully mature by their early 20s. Lung function naturally plateaus until a person's late 20s, after which a decline of about 1% per year occurs.

Lung Function Growth

- 1% per year deficits in lung function growth associated with mix of pollutants (PM, NO₂, acids)
- 2nd group study replicated results of first (plus effects from elemental carbon)

Gauderman WG et al. 2000. Association between air pollution and lung function growth in southern California Children. *Am J Respir Crit Care Med* 162:1383-1390.

Gauderman WG et al. 2002. Association between air pollution and lung function growth in southern California Children: Results from a second Cohort. *Am J Respir Crit Care Med* 166:76-84.



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Now let me discuss some of the study results.

In 2000, the investigators reported that children in the communities with the highest levels of PM₁₀, nitrogen dioxide (NO₂), and atmospheric acidity, as compared to those in the communities with the lowest levels, had reduced lung function growth, about 1% lower growth per year.

In 2002, USC reported results for a second cohort of children which found similar results to those found in the first cohort. This second analysis also found that higher exposures to the elemental carbon component of PM_{2.5} -- a parameter not available in the first analysis -- in addition to the pollutants from the first study, were significantly associated with slower lung function growth.

Confirmation of reduced lung function growth in the second group significantly strengthens the evidence supporting the adverse effects of air pollution on lung function growth. The slower lung growth associated with higher exposures to elemental carbon may indicate a specific respiratory effect of diesel PM or other combustion exhaust.

Lung Function at Age 18

- Reduced lung function growth from age 10-18
- Children in high air pollution areas had significantly lower values on lung function tests at age 18
- Associated with mix of pollutants (PM_{2.5}, NO₂, acids, elemental carbon)
- Motor vehicle link to pollutants

Gauderman WG et al. 2004. The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age. N Engl J Med 351:1-11.



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Due to the long-term nature of the Children's Health Study, the investigators have been able to recently publish findings on 8 years of follow-up of the children in the study. The investigators found a 7.9% risk of 20% or greater reduction in lung function growth between the ages of 10 and 18 in both boys and girls exposed to higher levels of a correlated set of pollutants that included nitrogen dioxide, acid vapor, PM_{2.5}, and elemental carbon, but not ozone.

The primary source of these pollutants in the South Coast Air Basin is motor vehicles, especially diesel emissions.

Implications

- 18 year olds are nearing the end of their lung development
- Likely that changes are permanent
- Long-term health implications
- Greatest effect may occur later in life (reduced lung function - a risk factor for adult respiratory illness and death)

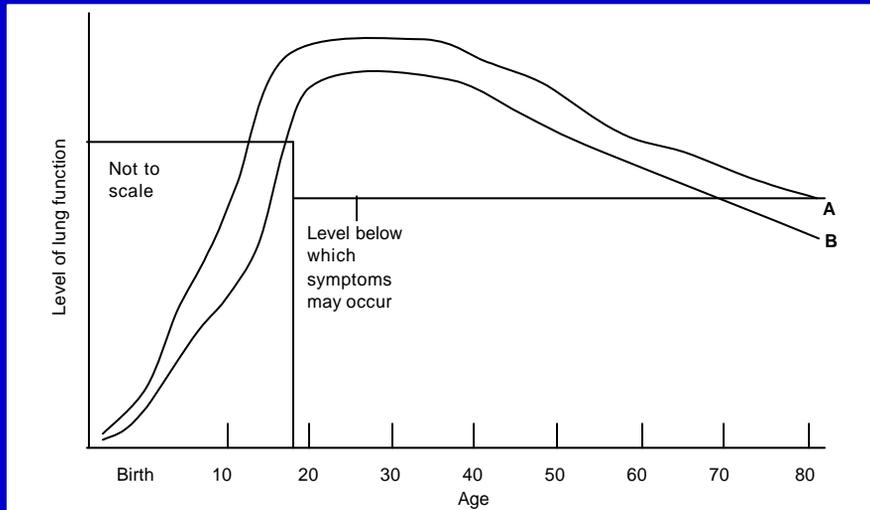


Children who were exposed to higher levels of the pollutants noted, plus PM10, but not ozone, had significantly lower values on lung function tests administered at age 18, an age when the lungs are nearly mature.

Lung capacity is over-engineered in the sense that lung function deficits do not greatly effect daily life for most persons. However, for sensitive persons reduced lung function in childhood or young adulthood may increase the risk of respiratory illness or increase the severity of symptoms and is a strong risk factor for respiratory complications and death during adulthood.

After lung maturation, lung function naturally declines at a rate of about 1% per year. Therefore, a 20% decrement in lung function, the decrement level seen in the study, means that an 18-year old, having grown up in a polluted area, has the lung function of a person nearly 40 years old. So they are starting out their adult life at a respiratory disadvantage.

Lung Function Growth



Adapted from Strachan et al 1997; Courtesy of USC
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This slide illustrates the generalized, typical growth of a person's lung function during their life. Line A shows normal lung function growth and later life decline. Line B shows the reduced lung function growth that may be attained with air pollution exposure. Line B is projected into later life and assumes that later life declines are not exacerbated by continued exposure.

Lung Function Growth “The Solution”

- **2001 Study on Relocation**
 - relocation to lower PM10 areas associated with increase in lung function growth
 - air quality improvements can improve children’s health

Avol EL et al. 2001. Respiratory effects of relocating to areas of differing air pollution levels. Am J Respir Crit Care Med 164:2067-2072.



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There is a solution to these lung function results. In a paper published in 2001 the investigators found that lung function growth changed if the children in the study relocated to areas with different PM10 levels. If children moved from a community with high PM10 to an area with low PM10, their lung function growth increased, although this increase may not make up for the adverse effects of their previous exposures.

Asthma

- **Asthma causation related to high ozone and exercise**
- **Bronchitic symptoms related to air pollution only in asthmatics**
- **High traffic increased risk of asthma**

McConnell R, et al. 2002. Asthma in exercising children exposed to ozone: a cohort study. *Lancet*. 359:386-91

McConnell R, et al. 1999. Air pollution and bronchitic symptoms in southern California children with asthma. *Environ Health Perspec* 107:757-760.

McConnell R, et al. 2003. Prospective study of air pollution and bronchitic symptoms in children with asthma. *Am J Respir Crit Care Med* 168:790-797.

McConnell R, et al. 2002. Traffic and asthma prevalence in children. *Amer J Respir Crit Care Med*. 165(8) A492



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A number of effects were seen on asthmatic children in the study. While we have known for some time that air pollution can exacerbate existing cases of asthma, the Children's Health Study is the first to indicate a possible causal role of air pollution in asthma development. In their 2002 publication, the CHS investigators showed that active children playing multiple team sports in high ozone communities were at three times greater risk of developing asthma. No other pollutants showed this relationship with the development of asthma. These results emphasize the importance of ozone advisories to reduce exposure in children.

In cross sectional studies, PM10 was significantly associated with bronchitis in asthmatics. There were also positive, but weaker associations of PM2.5, NO2, and acidic pollutants with bronchitis and significant associations of this suite of pollutants, but not ozone, with congestion or phlegm. These associations were not seen in non-asthmatics.

In analyses where local traffic was modeled, the investigators observed marginally significant associations between asthma and traffic related pollutants at the home. In these analyses large increases in physician-diagnosed asthma reported by the parent were associated with the top 10% of exposure.

School Absenteeism

- **School absenteeism associated with ozone increases**
- **Upper and lower respiratory symptoms and illness**

Gilliland FD, et al. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. *Epidemiology* 12:43-54.



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Ozone exposure was associated with a substantial increase in school absenteeism from both upper and lower respiratory illnesses. We have estimated that reducing current ozone levels to meet the state 1-hour standard could prevent 3.3 million school absences annually throughout California.

Gender Differences

- Boys more susceptible to respiratory symptoms and asthma
- Girls more susceptible to lung function development effects



The results from the study suggest that boys in general are more susceptible to adverse respiratory symptoms and asthma outcomes than girls; while girls appear to have greater susceptibility for adverse effects on lung function development.

Conclusions

- **Air pollution associated with:**
 - short- and long-term respiratory effects in children
 - reduced lung function growth
 - asthma causation
- **Air quality improvement leads to better lung function in children (and adults)**
- **Greatest impact of lung function deficits may be in adulthood**



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In summary, air pollution has been found to affect the short- and long-term respiratory health of children. In addition to affecting their lung function development, air pollution has also been shown to be associated with the causation and exacerbation of asthma.

These effects were seen to be alleviated by reduction of pollution exposure. However, by about age 18, lung development is largely complete and deficits in lung function development may be permanent and may impact life-long respiratory health.

Since the pollutants studied are the products of primary fuel combustion, and since they are present at similar levels in many other areas, the results are believed to be applicable to children living outside of Southern California, for example in the San Joaquin Valley where high levels of particulate matter and ozone also exist.

Although the ARB's involvement will be much less, the follow-up study, referred to as CHS II will continue these investigations and continue to follow the children into adulthood.

Thank you



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We have provided you with a DVD about the Children's Health Study and one from our Public Information Office about the health effects of SMOG. These DVD's are also available to the general public free of charge in the lobby and from our web page.

Thank you for your time. We would be pleased to answer any questions you may have.