# Report to the Legislature

# Children's Environmental Health Program

## Office of Environmental Health Hazard Assessment

## California Environmental Protection Agency

## February 2014

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## Executive Summary

Protecting the health and future of our children is important to all Californians. In recognition of the fact that children are often differentially impacted by environmental contaminants, the Children's Environmental Health Program was established in the California Environmental Protection Agency (Cal/EPA) by the Children's Environmental Health Protection Act (Escutia, Chapter 731, Statutes of 1999). The program is responsible for ensuring that Cal/EPA's existing expertise and programs specifically protect children's health in California. The Children's Environmental Health Program serves as a resource for Cal/EPA and the State of California, performs outreach and education for the medical and public health community as well as for the general public, and coordinates with the Cal/EPA boards and departments to promote policies and efforts that protect children's health.

Children can be more affected by environmental chemicals than adults. They eat, drink, and breathe more per pound of body weight than adults. Thus, children's exposures to contaminants in our air, water, and food are higher than an adult in the same setting. Because children are still growing and developing, they can be more sensitive to the adverse health effects of chemicals than an adult. In some cases, the effects are irreversible. It is increasingly recognized that exposures early in life affect adult health. Thus, the work of the Cal/EPA Boards, Departments and Offices (BDOs) reducing children's exposures to environmental chemicals benefits Californians throughout their lifetime.

This report summarizes information from recent studies on the status of children's health as well as effects of environmental contaminants on California's children. The report focuses on four areas of health and development that can be impacted by environmental contaminants: asthma and respiratory disease, adverse birth outcomes, neurodevelopment, and cancer. These are of concern to all parents, and are burdensome in terms of medical and educational costs, life-long health and potential. These diseases have large impacts personally to the children, their families, and communities. Often children of lower socio-economic status are most highly exposed and least resilient in overcoming the impacts associated with exposure to environmental contaminants. In each section, the report highlights Cal/EPA BDO programs that protect the health of California's children.

Cal/EPA BDOs must continue to reduce exposures to environmental chemicals to enhance public health. These actions improve quality of life and reduce health care costs. While we have made strides in cleaning our air, water, and land, much more remains to be done. Specifically, Cal/EPA BDOs should continue to:

- evaluate and reduce the impacts of contaminants in our air, water, soil, food, and consumer products on children's health, including in the home, school, and daycare environments

- evaluate and reduce the cumulative burdens on children of environmental contaminants, climate change, and health disparities; it is essential that Cal/EPA continue its work to evaluate how cumulative burdens increase vulnerability to environmental chemical exposures
- measure the chemicals in our bodies through biomonitoring to more fully understand exposures to common environmental contaminants
- focus efforts on reducing waste and greenhouse gas emissions, and increasing reuse and recycling to reduce our environmental footprint for future generations
- improve the flow of information from the Children's Environmental Health Research Centers and other researchers to Cal/EPA scientists and policymakers in order to help address children's environmental health

## The Changing Nature of Children's Health

Relative to acute infectious diseases, the proportion of chronic childhood illnesses such as asthma, cancer, and neurodevelopmental disorders has increased greatly in the past few decades. The increases in these disorders, some dramatic (e.g., asthma, autism), cannot be wholly attributed to improvement in diagnostic tools, and therefore scrutiny has increased on the contribution of environmental contaminants to these disorders and on child health generally.

This report focuses on the effects of environmental exposures on four areas of child health (asthma and respiratory disease, adverse birth outcomes, neurodevelopment, and cancer) that result in a majority of childhood illness and related health care costs and are a major concern of parents throughout the state. In each section of the report, we provide a few selected examples of Cal/EPA BDO activities that protect children's health.

### Children are Uniquely Susceptible to Environmental Hazards

Infants and children are at particular risk for exposure to multiple environmental contaminants through the food and water they consume, the schools and outdoor areas where they learn and play, and even the homes where they are raised. Breastfeeding, child-specific behaviors like mouthing of toys and household objects, and types of outdoor play make them vulnerable to unique exposures not experienced by adults[1]. Even when exposed to the same levels of contaminants as the adults around them, children experience higher exposures. Per pound of body weight, children inhale more air, eat more food, and drink more water than adults. Infants have a surface area to body weight ratio that is twice as high as adults, making them especially vulnerable to toxicants that are absorbed through the skin.

In addition to experiencing higher exposures, children can be more sensitive to the adverse effects of environmental chemicals than adults. Environmental exposures may be especially damaging if they occur during critical windows of susceptibility in developing organs such as the brain and lung, and systems such as the immune and endocrine. Some environmental exposures that occur during critical periods of in utero development are known to affect a child's health at birth or in infancy. Environmental exposures during pregnancy and infancy can also lead to poor health outcomes later in life [2,3]. Other particularly susceptible stages of development include early childhood and adolescence. Exposure to environmental contaminants during any of these critical developmental periods may alter the structure or function of organs and organ systems.

### Children in California: Our Most Vulnerable Population

As of 2011, California has over 9 million people age 18 years or younger, or 25% of the population. Fifty-two percent are Hispanic/Latino, 27% White, 11% Asian American, 6%

African American, 0.4% each American Indian and Hawaiian/Pacific Islander. Approximately 2.5 million Californians are under the age of five (Figure 1)[4].

In 2011, 23 % of California's children lived in poverty, which equates to more than 2 million children [5]. Children living in poverty are more likely to be exposed to multiple environmental hazards than children from economically stable backgrounds. Low-income children may be more likely to live in older housing stock contaminated with lead, near freeways with high levels of traffic pollutants, or in farming communities near high levels of agricultural chemical use. They are also less likely to have access to nutritious food, clean water, and regular medical care. These disadvantages, as well as social stressors associated with poverty, such as exposure to violence, may exacerbate the effects of exposure to environmental toxicants.

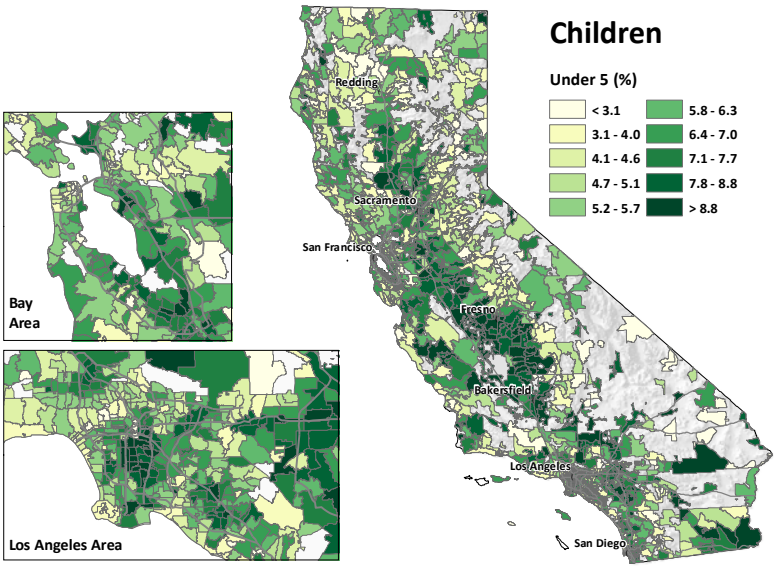


Figure 1. Percent of population under age five in California, 2010.[6]

The California Communities Environmental Health Screening Tool (CalEnviroScreen) (California Environmental Protection Agency 2013) combined indicators of exposure (e.g., presence of environmental hazards, levels of air pollution), indicators of population health (e.g., rates of emergency department visits for asthma, rates of low birth weight), and socioeconomic factors to develop a score for each zip code in the state[6]. The analysis indicates that there are proportionately more children in the populations in zip code areas with scores in the highest 10%. This means that more children tend to live where there is a higher pollution burden and in lower income communities.

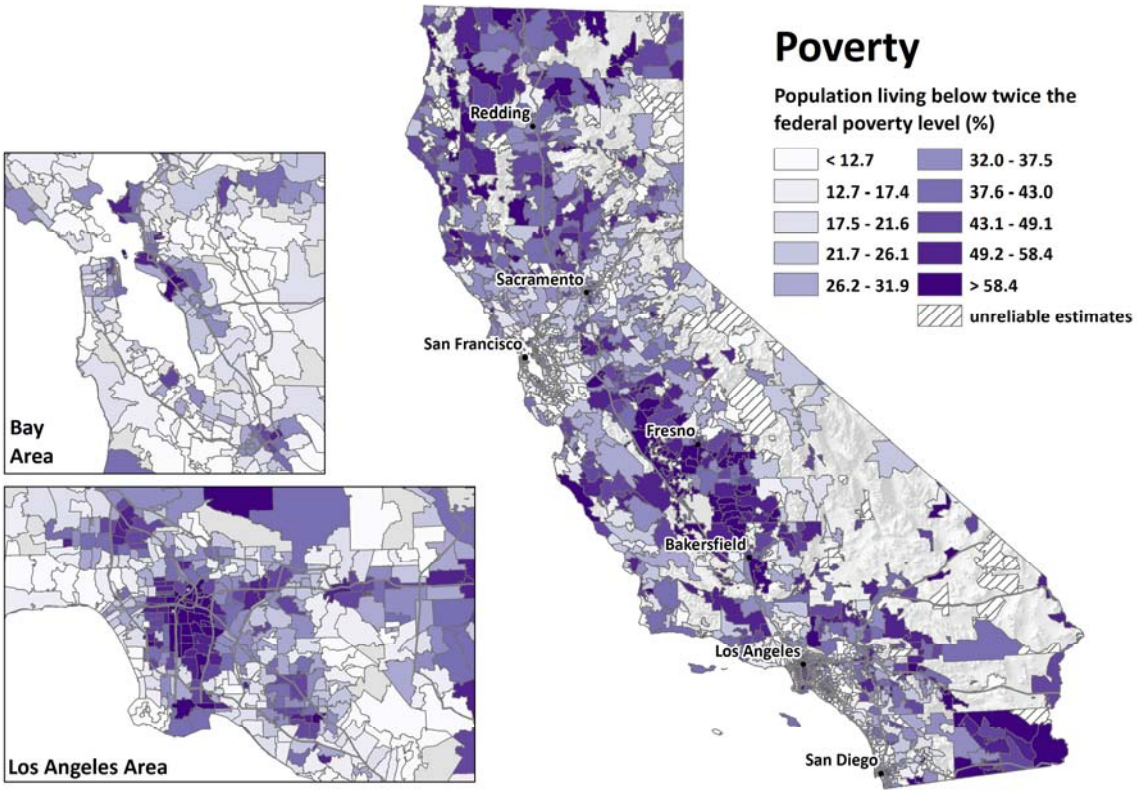


Figure 2. Percent of the population living at less than two times the federal poverty level, 2006-2010[6].

## California: A Leader in Protecting Children from Environmental Hazards

The Children's Environmental Health Program is the first established state program to explicitly address impacts of environmental contaminants on infants and children. The program is responsible for ensuring that Cal/EPA BDO's existing expertise and programs specifically protect children's health in California. In 2012, Cal/EPA delegated the Children's Environmental Health Program to the Office of Environmental Health Hazard Assessment (OEHHA). In January 2012, as its first activity in operating the program, OEHHA hosted the first of an annual series of symposia on children's environmental health. The topics addressed emerging research and implications for risk assessment and policy. California is home to six Children's Environmental Health Research Centers (CEHRCs), funded by U.S.EPA and the National Institutes of Health. These research Centers evaluate the impacts of environmental contaminants on children, including exposure to multiple chemicals and social stress. The first symposium featured speakers from five University of California-based CEHRCs, presenting study results to update state scientists on the latest relevant science. The research results of the CEHRCs and other university researchers provide relevant data useful to the assessments of risks of environmental contaminants to children. In 2013,

OEHHA held another symposium on the topic of cumulative impacts and children's health, again with the participation of several of the CEHRCs.

## Selected Activities of Cal/EPA BDOs that Address Children and Their Environment

### Office of Environmental Health Hazard Assessment (OEHHA)

- OEHHA performs health risk assessments that explicitly incorporate children's unique exposures and susceptibility to toxic chemicals. The assessments provide the scientific basis for state air-quality and drinking-water standards and health advisories.
- OEHHA maintains a list of Toxic Air Contaminants that disproportionately impact children. The Air Resources Board works to ensure that measures promulgated to control airborne emissions of these chemicals adequately protect children.
- OEHHA develops guidelines for assessing health risks for use in several programs, including the Air Toxics Hot Spots program and school site assessments; these guidelines explicitly consider infants and children.
- OEHHA lists chemicals that are developmental and reproductive toxicants under Proposition 65.

California Biomonitoring Program

The California Department of Public Health, OEHHA, and the Department of Toxic Substances Control work collaboratively to operate the Biomonitoring California program. This program, which analyzes environmental chemicals in blood, urine and other samples from Californians, is helping to answer such questions as:

- Which chemicals are in people's bodies and how high are the levels?
- Are there groups of people in California (including children and pregnant women) that have higher exposures to certain chemicals?

### Air Resources Board (ARB)

- ARB sets Ambient Air Quality Standards for pollutants (such as ozone and particulate matter) that are specifically intended to protect infants and children.
- ARB develops air-pollution regulations that consider children's exposures and special susceptibilities.

- ARB's research program includes research grants to study both the short-term and long-term impacts of air pollution on children, including development of the lung and asthma.
- ARB conducts special studies on exposure of children to indoor air pollutants in schools, daycares, and school buses.
- ARB is implementing the landmark climate change legislation, AB 32, which is reducing greenhouse gas emissions and will protect future generations of children from adverse impacts of climate change, while providing co-benefits of reducing traditional air pollutants and protecting public health.
- ARB maintains an extensive website to educate children about the adverse health effects of air pollution and climate change. The ARB's Knowzone website (www.arb.ca.gov/knowzone/knowzone.htm) includes lesson plans and activities for teachers and students of all grade levels.

## Department of Resource Recycling and Recovery (CalRecycle)

- CalRecycle brings environment-based education into kindergarten through twelfth grade (K-12) classrooms via the Education and the Environment Initiative (EEI) Curriculum. EEI addresses the importance to human health of the air we breathe, the water we drink, and the food we eat.
- CalRecycle works with local government to implement school/district waste prevention, reuse, recycling, and composting.
- CalRecycle coordinates with the Department of Pesticide Regulation and the Department of Toxic Substances Control on integrated pest management to reduce children's exposure to pesticides.

## Department of Pesticide Regulation (DPR)

- DPR evaluates the potential human health hazards associated with pesticide exposure explicitly considering both exposure and special susceptibility of children.
- DPR conducts special investigations of exposure to pesticides in rural farming communities, including children's exposures.
- DPR promotes use of reduced-risk pesticides and integrated pest management at schools and child-care centers to decrease pesticide exposures of children.
- Before a pesticide can be registered for use in California, DPR evaluates toxicity information and requires submission of test results to determine whether the pesticide has adverse effects on development or produces birth defects.

## State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards (RWQCBs)

- The Water Boards provide general regulation of water quality of our lakes, streams, rivers, coastal waters, and groundwater. The standards set for bacterial contamination are important to protect children, who are often more susceptible to bacterial disease and are frequent users of our lakes and beaches.
- The Water Boards work to reduce contamination of groundwater with nitrates, to which infants are particularly susceptible.
- SWRCB has a public participation effort to educate and engage children in keeping our water clean and safe.

## Department of Toxic Substances Control (DTSC)

- DTSC is responsible for assessing, investigating and cleaning up proposed school sites. Their actions ensure that selected properties are free of contamination or, if the properties were previously contaminated, that they have been cleaned up to a level that protects the students and staff who will occupy the new school. The assessments specifically include exposure and unique susceptibility of children to environmental chemicals.
- DTSC developed regulations for safer consumer products and will explicitly consider children as a vulnerable population when implementing the regulation.

## Asthma and Respiratory Illness

### National Statistics Show Disproportionate Impact of Respiratory Illnesses on Children

Children spend more time outside and inhale more air for their size than adults, which makes them particularly vulnerable to respiratory illnesses that are exacerbated by, environmental air pollution exposures[1,7]. In the United States, respiratory disease is the leading cause of hospitalization for children ages one to nine. One of the most common respiratory illnesses in the US is asthma, a chronic airway disorder that can be controlled, but not cured. In 2010, the U.S. Centers for Disease Control and Prevention estimated that 7.7% of American adults and 9.5% of American children (age 18 and younger) have received an asthma diagnosis at some point in their lives and still have asthma[8]. Asthma places a significant burden on the US healthcare system, economy, and education system. Bronchitis and asthma are common causes of hospitalization for children in the United States, despite the fact that only a fraction of children with asthma and other respiratory illnesses are admitted to the hospital[9,10]. In 2009, the average yearly cost of care for a child with asthma was $1039[11]. In 2008, American children missed 10.5 million days of school due to their asthma[12].

Asthma prevalence is higher for African-American children and persons with lower income. Between 2005 and 2008, non-Hispanic black children were seen in the emergency department and admitted to the hospital for asthma and other respiratory problems at much higher rates (1240/10,000 for emergency room (ER) visits, 84/10,000 for hospital admissions (HA)) than non-Hispanic white children (487/10,000 for ER visits and 52/10,000 for HA)[9].

### California Respiratory Illness Rates Higher Among Minorities, Low-Income Families

Asthma is an important health issue in California, where 13.1% of adults and 12.5% of children have been diagnosed with asthma[13]. In 2007, California children missed 1.47 million school days due to their asthma[14]; children living below 200% of the Federal Poverty Line (FPL) missed twice as many days as children living at or above 400% FPL[15].

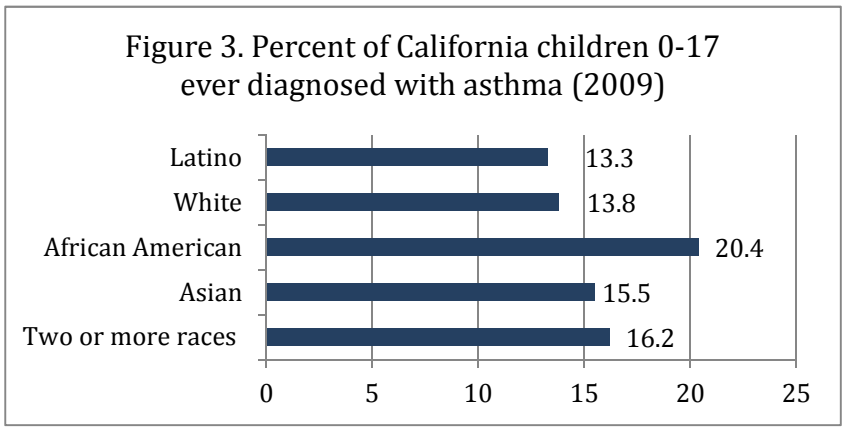


Figure 3. California children diagnosed with asthma.

From: California Health Interview Survey, 2009 [16]

Emergency department visit and hospitalization rates are useful indicators of whether a person with asthma is receiving appropriate asthma care, which includes health insurance, continuity of care, and avoidance of asthma triggers (see next section). Statistics show that non-white Californians and those with lower incomes tend to be less likely to receive appropriate asthma care. Asthma hospitalization rates are highest among African Americans[17], and persons living in lower income areas are much more likely to experience severe asthma symptoms and be hospitalized for their asthma compared to persons living in higher income areas. Children from low-income and minority families not only suffer higher incidences of respiratory illness and less access to medical care[13], but are also more likely to be exposed to environmental pollutants that may cause or exacerbate their conditions.

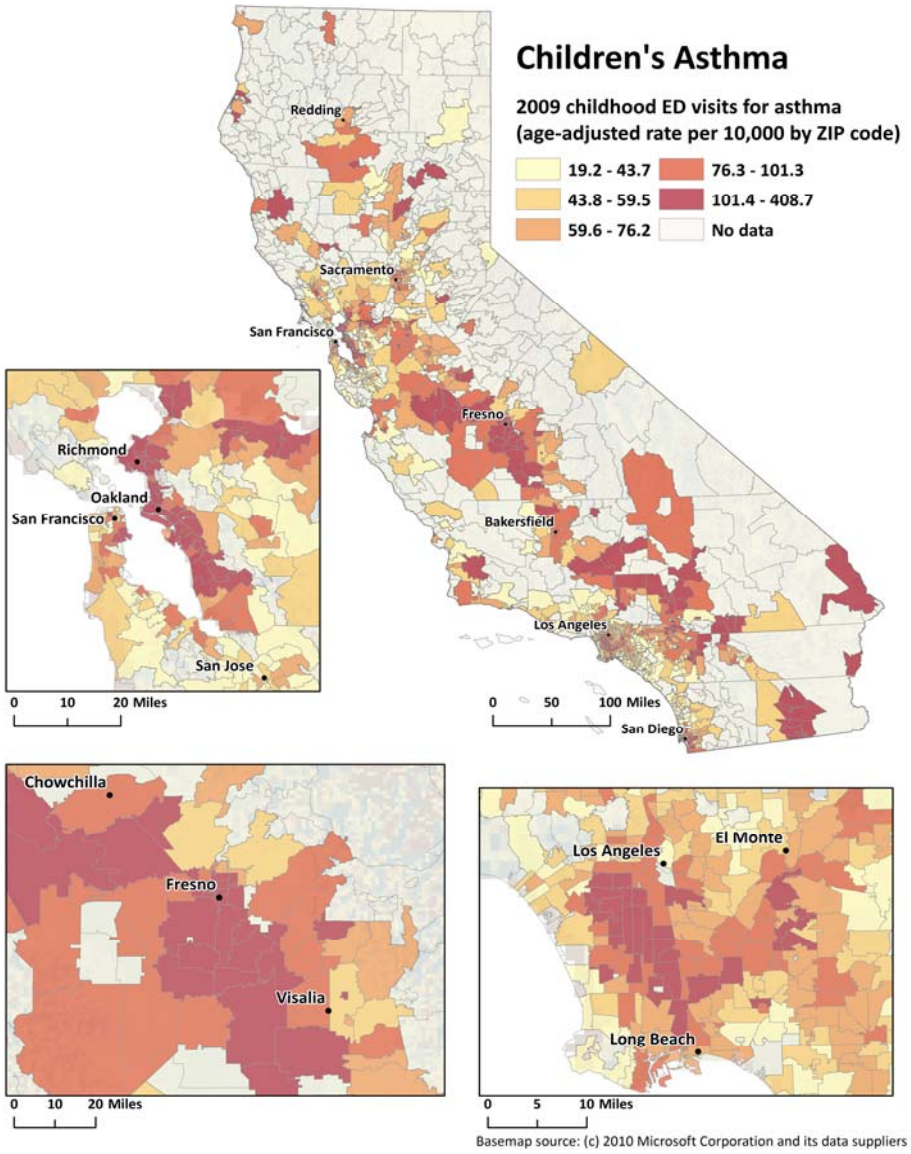


Figure 4. Rate (per 10,000) of emergency department visits for asthma, 0-17 years (2009).

Map derived from California Environmental Health Tracking Program, California Department of Public Health based on data from California Office of Statewide Health Planning and Development

## Environmental Exposures are a Key Cause of Respiratory Illness

Because asthma is a disorder of the airways, airborne substances that irritate the airway can be triggers for an asthma attack. Studies have linked exposure to air pollution to development of asthma, increased severity and frequency of asthma attacks, bronchitis, bronchiolitis, and decreased growth of lung function in

children[9,18,19,20]. Because lung function in infancy and childhood partially predicts lung function in adulthood, persons whose lung function growth is decreased in childhood may suffer from poor health throughout their lifetime[21]. Infants spend the majority of their time indoors, where they may be exposed to mold, animal allergens and dust mites, environmental tobacco smoke, and household chemicals[22, 23]. In addition to these indoor asthma triggers, school-age children are also exposed to outdoor pollutants, especially during the time they spend outdoors for play and sports. These include toxic air contaminants, pesticides, traffic emissions, and the criteria air pollutants (e.g., particulate matter, ozone, nitrogen oxides, sulfur oxides). All of these exposures have been linked to exacerbation of asthma symptoms or to causing asthma[9, 24]. Outdoor pollutants come indoors through windows and other openings, and can therefore affect infants and other vulnerable populations who do not spend as much time outdoors[23].

## Environmental Exposures in California More Severe for Vulnerable Populations

Statewide exposure monitoring has found that ambient concentrations of ozone, particulate matter, and other traffic and industrial related pollutants are higher in areas of California that are home to greater numbers of non-white persons and persons living below the national poverty level[25,26]. The East Bay Children's Respiratory Health Study, conducted by OEHHA and partially funded by ARB, found that children who live and/or attend school near heavily trafficked roadways are at greater risk for asthma and bronchitis symptoms than children who are less exposed to heavy traffic pollution[24]. A Southern California study obtained similar results and also noted greater asthma susceptibility when children were exposed to traffic emissions before two years of age[27]. These results hold true even in areas of California with good regional air quality[28]. The Fresno Asthmatic Children's Environment Study further found that asthmatic children whose residences are located near highways experience significantly diminished lung function[29]. Schools closer to major California highways have higher percentages of non-white and low-income students than schools further from roads with heavy car and truck traffic[30].

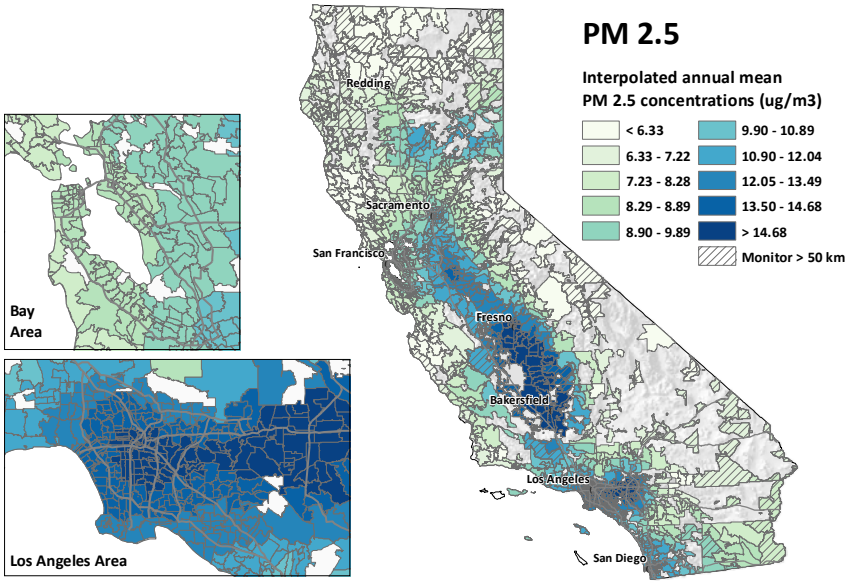


Figure 5. Average annual mean concentration of PM 2.5 (2007-2009)[6]

## Select Cal/EPA BDO Activities That Improve Respiratory Health of Children

- OEHHA's health-based recommendations have been the basis of the California Ambient Air Quality Standards (AAQSs) promulgated by the Air Resources Board, most recently for particulate matter (2003), ozone (2006), and nitrogen dioxide (2008). The health-based recommendations specifically protect children's growing lungs and reduce asthma triggers. OEHHA also maintains and regularly updates a list of Toxic Air Contaminants (TACs) that disproportionately increase illness, including asthma, in infants and children.
- ARB establishes Airborne Toxics Control Measures for chemicals identified as Toxic Air Contaminants, with special emphasis on those chemicals that adversely impact infants and children; the list includes chemicals that are linked to asthma, such as diesel engine particulate matter.
    - ARB's efforts to reduce diesel engine exhaust have been quite successful based on both measurements of particulate matter near major sources, such as ports and roadways, and emissions estimates from newer diesel engines using California diesel fuel (Figure 6).

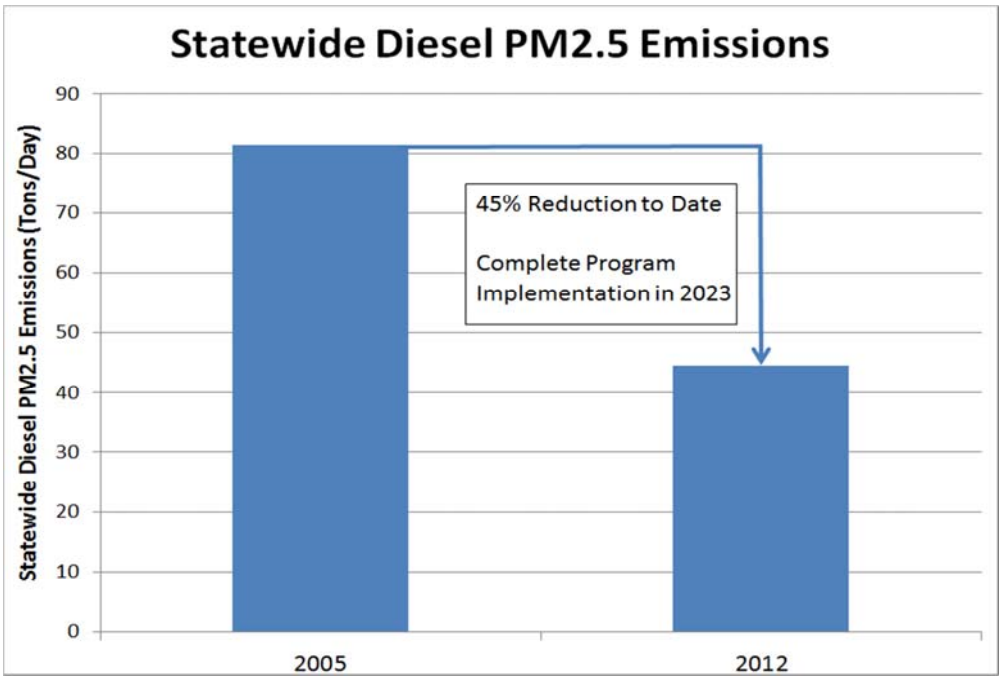


Figure 6. Estimated statewide emissions of diesel PM2.5 in tons per day.

Source: California Air Resources Board.

- OEHHA developed and updated procedures to assess health risks to children from exposure to airborne contaminants. These procedures give special consideration to chemicals that cause asthma or trigger asthma attacks.
- DPR developed an ambient air monitoring network for pesticides in agricultural areas to compare monitored levels to child-specific health-based screening levels. In a 2011 pilot, 29 pesticides were detected, all well below the screening levels (except for acrolein due to non-pesticide sources).
- OEHHA published a number of epidemiological research papers evaluating the impacts of air pollution on the health of children.
    - For example, OEHHA examined the relationship between specific chemical components of fine particulate matter (PM 2.5) and pediatric respiratory hospitalization, which was used by the U.S. Environmental Protection Agency in its Integrated Science Assessment of particulate matter.

- Through the East Bay Children's Respiratory Health Study, OEHHA identified air pollution related to heavily trafficked roadways close to schools and homes as increasing children's risk for respiratory symptoms. This informed legislation requiring an evaluation of potential air pollutant exposure during the school siting process in California.
- OEHHA evaluated the scientific evidence on the health effects of secondhand smoke in children as part of ARB's listing of Environmental Tobacco Smoke as a Toxic Air Contaminant. OEHHA subsequently listed secondhand smoke as a TAC to which infants and children may be especially susceptible. ARB identified in-vehicle exposures as potentially very high. Subsequently in 2007, California passed legislation for smoke-free cars when children are present.

> The Southern California Children's Health Study (CHS), partially funded by ARB, conducted by researchers at USC and UCLA found that children living in high air pollution communities had reduced lung function growth compared to children living in communities with cleaner air. Although it remains unknown whether this will impact the future respiratory health of these children, smaller than average lung size is a risk factor for development of chronic lung disease. ARB has funded several studies that continue to investigate this critical topic.

- It is well known that several common air pollutants, particularly ozone, particulate matter, and traffic related pollutants can exacerbate asthma in children, and that these pollutants can get indoors. In 2012, ARB provided funding to U.C. Davis researchers for a study that is investigating whether air filtration to reduce indoor exposure to air pollution leads to reduction in asthma exacerbation and improved asthma control in school age children.
- In 2012, ARB provided funding to U.C. Berkeley researchers for a California study of children's exposures to environmental contaminants (including volatile organic chemicals (VOCs), pesticides, flame retardants) in 40 daycare centers. Concentrations of most were comparable to levels previously measured in California homes and schools, but formaldehyde, was elevated well above health benchmark levels. Chemicals from cleaning products and personal care products were found at relatively high levels (A fact sheet and final study report available at http://www.arb.ca.gov/research/single-project.php?row_id=64830).
- An ARB funded study of asthmatic adults and children, conducted by UCLA researchers and published in 2013, which linked health data in the California Health Interview Survey with air pollution data, found lower-income, Latino, and American Indian/Alaska Native children, as well as African-American and

Asian/Pacific Islander adults and children, were more vulnerable to the effects of air pollution exposures compared to high income white children and adults of the same ages (see: http://www.arb.ca.gov/newsrel/newsrelease.php?id=419).

## Adverse Birth Outcomes: Low Birth Weight, Preterm Birth, and Birth Defects

### Proper Fetal Development Important for Lifelong Health

The fetal-development period is an important determinant of lifelong health. Some adverse effects are immediately apparent at birth or in infancy (e.g., birth defects), while others are not apparent for many years (e.g., learning disabilities). Scientists still do not know the cause of most birth defects. However, both animal and human studies indicate that environmental pollution contributes to developmental problems.

Birth defects and other health problems in newborns resulting from adverse conditions during pregnancy and birth are the leading causes of infant death in the United States. Beyond infant mortality, poor fetal development can result in birth defects, developmental and learning delays in childhood, and increased lifetime risk of many adult-onset diseases. Two of the most common indicators of a healthy pregnancy are birth weight and length of pregnancy. Birth weight has a wide normal range, but in general, infants born weighing less than 2500 grams (about 5.5 pounds) are considered low birth weight. Low birth weight may occur in pregnancies of normal length (small for gestational age) or in conjunction with pre-term birth. Normal length pregnancies, which may range from 37 to 41 weeks, are important because they allow adequate time for full fetal development. In the United States, 8.2% of all babies are born low birth weight, and 12.2% are born preterm[31]. In 2006, the Institute of Medicine estimated that preterm births cost the United States about $26 billion annually[32].

Many studies have found an association between low birth weight and cardiovascular illnesses in adulthood. Coronary heart disease, atherosclerosis, hypertension, and stroke have all been found to occur more frequently in adults who were born weighing less than 2500 grams, regardless of gestational length[33]. Low birth weight has also been linked to insulin resistance and type II diabetes in adulthood[2].

The negative effects of adverse birth outcomes are not limited to extreme cases. Even moderately low birth weight and moderately preterm birth place infants at risk for physical, mental, and behavioral issues throughout their lifetimes. Moderate to late premature birth (between 32 and 36 weeks) is associated with developmental delay and related disabilities, and academic difficulties throughout the school years and into adulthood; children of lower socioeconomic status are at highest risk[34,35,36]. Moderate to late preterm birth is also associated with increased rates of respiratory illness in adulthood, resulting from inadequate lung development in utero and subsequent deficits in lung function throughout infancy and childhood[37,38].

Moderately low birth weight (1,500 to 2,499 grams) and moderate to late preterm births account for the majority of low birth weight and preterm births in the US[31,39]. Incidence of preterm birth is highest among African-Americans and Native Americans. Complications of preterm birth and low birth weight are the leading cause of death for African-American infants in the United States[32,40].

## Adverse Birth Outcomes Disproportionately Affect African Americans, and those with Low Income in California

California has lower rates of low birth weight (6.9%) and preterm birth (9.2%) than the United States as a whole. However, African-American children are at greater risk for both outcomes: 12.6% of African American children in California are born weighing less than 2500 grams and 12.3% are born at less than 37 weeks gestation, compared to 6.5% low birth weight and 8.7% preterm for white children. Children born to mothers age 15 and younger are also more likely to be born weighing less than 2500 grams[41].

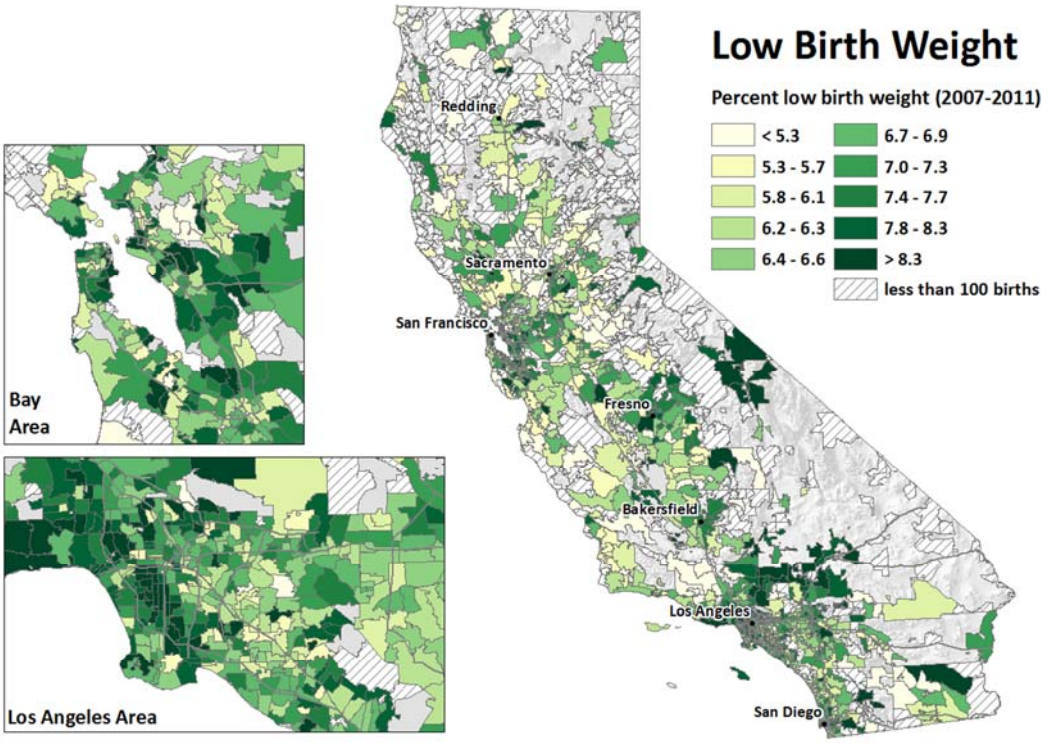


Figure 7. Average low birth weight as percent of live births in California, 2007-2011[6]

## Environmental Exposures Are a Factor in Adverse Birth Outcomes in California

There is a growing body of evidence to suggest that adverse birth outcomes are associated with maternal environmental exposures. Two well-documented associations

are that of exposure to tobacco smoke (as a result of smoking during pregnancy) and to second-hand smoke, also known as environmental tobacco smoke (ETS). Infants whose mothers were exposed to ETS are more likely to weigh less than 2500 grams than non-exposed infants, even if the mothers did not themselves smoke[42,43]. OEHHA estimates that every year in California, ETS exposure causes 4,700 preterm births and 1,600 cases of low birth weight [44]. In addition, there is evidence that suggests that ETS exposure during pregnancy increases risk of miscarriage and decreases fetal growth. Recent studies indicate infants born to mothers who smoke during pregnancy may be more likely to be born with birth defects including intestinal defects and cleft palate[45].

Ambient air pollutants and traffic contaminants have also been linked to adverse birth outcomes in California and elsewhere[46,47]. A Southern California study found higher rates of heart defects in infants whose mothers were exposed to higher levels of ambient carbon monoxide during pregnancy[48]. A study performed in the San Joaquin Valley found exposure to air pollution to be associated with increased risk for neural tube defects[49]. Carbon monoxide and particulate matter exposure during pregnancy have also been shown to increase the risk of preterm birth. A study in the South Coast Air Basin found that second- and third-trimester exposure to acute air pollution from the 2003 Southern California wildfires was associated with a moderate reduction in birth weight[50]. Research in Los Angeles County found that women living near high-traffic roads are at much higher risk of having low birth weight and preterm babies than women living further away from high-traffic roads[47].

Drinking water can also become contaminated with chemicals that may impact infants and children's health. For example, there is evidence in the literature for associations between trihalomethanes (created during disinfection) in drinking water and smaller babies, miscarriages, and neural tube defects[51]. Evidence from animal toxicology studies indicates that some chemicals in drinking water have the potential for inducing birth defects.

Climate change may also impact adverse birth outcomes in California. A study performed by OEHHA found that high ambient temperatures were significantly associated with preterm births, especially among younger mothers, African Americans, and Asian Americans. These associations were independent of other environmental factors like air pollution[52].

## Select Cal/EPA BDO Activities That Improve Birth Outcomes

- OEHHA conducts epidemiological studies of the effects of air pollution and ambient temperature on adverse birth outcomes.
    - OEHHA found a relationship between higher temperatures and preterm birth. The results were included in the California Energy Commission's report on the effects of climate extremes in California and will aid in developing climate change mitigation strategies.

- OEHHA's studies of the relationship between exposure to traffic-related pollution, and fine airborne particles and adverse birth outcomes such as spontaneous abortion, low birth weight, preterm birth and stillbirth provide data useful for the regulation of air pollutants.

- DPR evaluates the potential for pesticides to produce birth defects and other developmental problems before allowing a pesticide to be registered for use in California. DPR requires pesticide manufacturers to provide the necessary data.
- Under Proposition 65, OEHHA lists chemicals that are known to cause birth defects and other reproductive harm.
- OEHHA sets Reference Exposure Levels for airborne contaminants, and Public Health Goals for drinking water to protect against effects on development where data indicate the possibility of adverse birth outcomes from exposure.
- ARB's many measures regulating ambient air pollution reduce the risk of adverse birth outcomes in California's children.
- The Water Boards' protection of ground and surface waters reduce exposures of pregnant mothers and infants to contaminants like nitrates that adversely affect the health of infants and children. The State Water Board recently adopted a statewide septic system policy to address, in part, direct water quality impacts due to nitrate and nitrite contamination from these systems.
- Studies by OEHHA and other investigators have shown that exposure to excessive heat results in adverse birth outcomes such as premature delivery. Both OEHHA and ARB participated in developing a multi-agency report preparing California for increased heat - *Preparing California for Extreme Heat: Guidance and Recommendations,* California Heat Adaptation Workgroup, October 2013. (available at:http://www.climatechange.ca.gov/climate_action_team/reports/Preparing_California_for_Extreme_Heat.pdf). This report provides guidance to local and state agencies with respect to reducing community vulnerabilities to excessive heat.

## Neurodevelopmental Disorders

### Nationwide Prevalence of Neurodevelopmental Disorders on the Rise

The prevalence of neurodevelopmental and behavioral disorders (such as autism, learning disabilities, and intellectual disability) is on the rise in American children. These include moderate to severe deficits in one or more of the following: learning, executive function (ability to plan, organize, pay attention to details and respond appropriately), and social-skills development in infancy and childhood. Such deficits may be found in children diagnosed with autism, attention-deficit/hyperactivity disorder (ADHD), intellectual disability (mental retardation) and other disorders. Children with neurodevelopmental and behavioral deficits struggle in school and with social interactions, and often require a combination of school-based special education services, therapists, medication, and social-services case management continuing into adulthood.

Based on surveys by the U.S. Centers for Disease Control and Prevention (CDC), about 1 in 6 American children have a neurodevelopmental disorder; many of these children have more than one condition[53]. Between 1997 and 2010, the number of children age 5 to 17 years diagnosed with ADHD increased substantially (Figure 8)[9]. The prevalence of autism increased substantially during the same time period. CDC recently estimated that 1 out of every 88 children is diagnosed with an autism spectrum disorder (ASD), though autism remains rare in comparison to other neurodevelopmental/behavioral disorders [54]. Male children and Medicaid-insured children have higher prevalence of ADHD or Learning Disabilities than female children and those with private insurance or no health coverage [9,55]. In 2005, Medicaid per capita expenditures for children with ASDs were six times higher than expenditures for children without an ASD diagnosis[56].

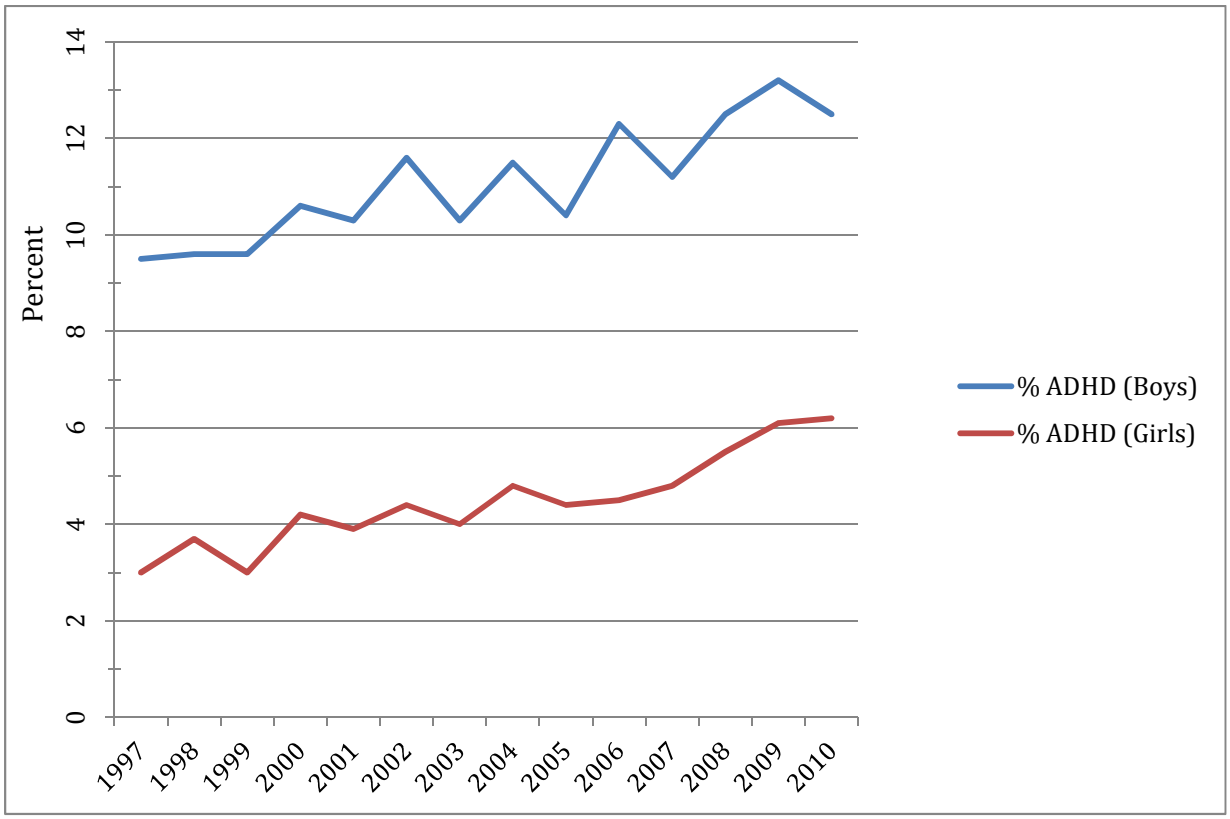


Figure 8. Percentage of children age 5-17 years reported to have attention-deficit/hyperactivity disorder in the United States, 1997-2010.

Adapted from America's Children and the Environment Third Edition, United States Environmental Protection Agency. Based on data from the National Health Interview Survey, National Center for Health Statistics, Centers for Disease Control and Prevention.[9]

## Neurodevelopmental Disorders Increasing, Particularly Among Males, in California

Neurodevelopmental disorders are also a pressing health, education, and economic issue in California. As diagnosis has improved over time, these disorders are being diagnosed earlier in children's lives, offering hope for improved outcomes with early intervention. Yet, the state still carries a substantial burden of providing services for the life of the child.

Male children in California are more likely than female children to experience a developmental disorder and require social services. In 2007, 61% of all persons receiving housing, education, and therapeutic services through the Department of Developmental Services (DDS) were male, and that discrepancy is projected to increase[57]. From 1987 to 2007, the number of persons receiving services for an autism spectrum disorder increased almost twelve-fold (Figure 8). Male children receiving

services for an autism spectrum disorder outnumbered female children by nearly five to one[58].

The ethnic breakdown of developmentally disabled persons in California roughly follows the ethnic distribution of California as a whole. The majority of DDS service recipients are White, although this fraction has been decreasing as the number of Hispanic service recipients has increased in the last 15 years. In 2007, 40% of service recipients were under 13 years of age, with 57% being under 21 years of age[54].

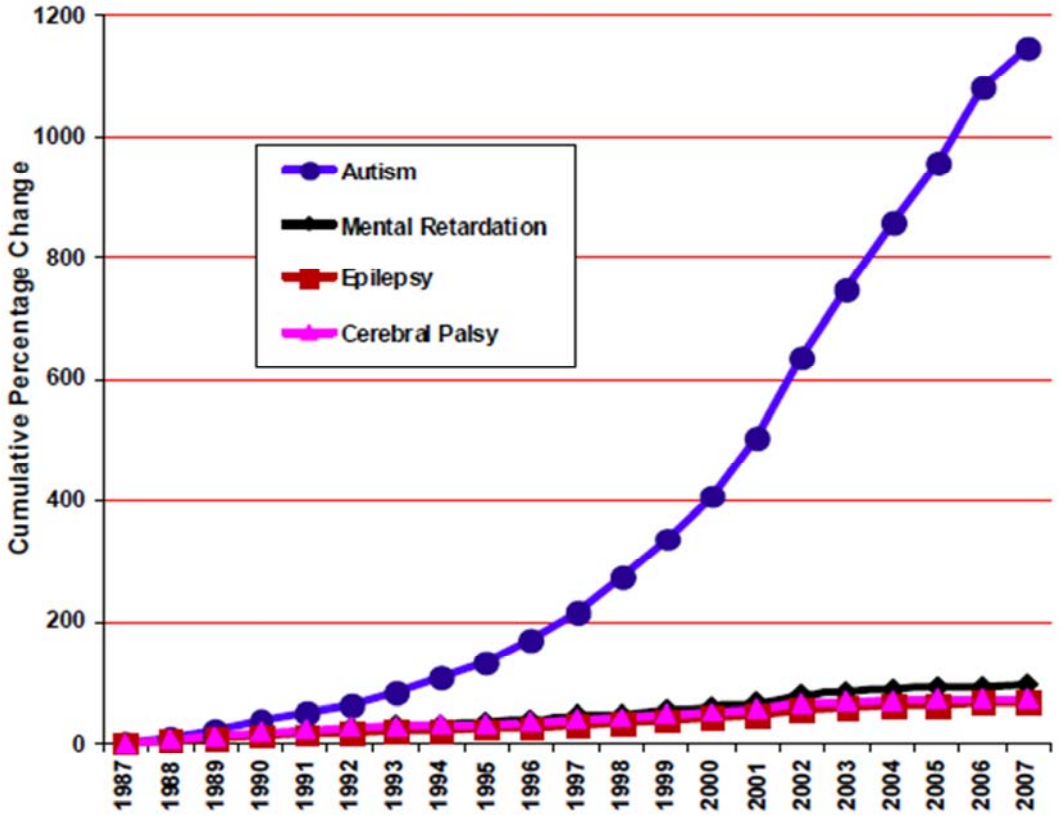


Figure 9. Cumulative percentage change in those served by California Department of Disability Services with diagnoses of autism, cerebral palsy, epilepsy, and mental retardation over two decades.

From: Autism Spectrum Disorders: Changes in the California Caseload. An Update: June 1987-June 2007[58]

## Environmental Exposures Implicated in Neurodevelopmental Deficits

The increasing prevalence of autism, ADHD, intellectual disabilities, and other neurodevelopmental disorders may be partially related to changes in diagnostic criteria and techniques, but these changes cannot account for the entirety of the rapid increase in the last few decades. Thus, scientists are concerned that the environment is playing an important role in the increasing prevalence of these disorders. There has been much

historical focus on classic neurodevelopmental toxicants such as lead and mercury and the class of pesticides known as organophophates. A number of regulatory efforts have focused on reducing exposure to these toxic chemicals. Even so, there are still many sources of lead and mercury in our everyday lives and children continue to be exposed. Moreover, there is mounting evidence that exposure to many common chemicals and environmental toxicants in the womb and during childhood is associated with neurodevelopmental deficits. For example, studies have found that children exposed as a fetus to polycyclic aromatic hydrocarbons (PAHs), a component of traffic emissions, at levels present in U.S. cities, perform worse on cognitive and psychomotor development tests in infancy and early childhood[59,60].

Concern is also growing around many industrial and household chemicals that are ubiquitous in children's home and school environments. Phthalates are a family of chemicals widely used in the manufacture of plastic products and other consumer goods including cosmetics and fragrances. Studies show that children born to women with high phthalate levels during pregnancy may experience psychomotor delay and behavioral difficulties in early childhood[61,62,63]. Prenatal exposures to other industrial chemicals like polychlorinated biphenyls (PCBs) and dioxins have been linked to cognitive deficits in preschoolers, lower IQ scores, difficulty with reading comprehension, attention and behavior deficits, and impaired fine motor skills in school-age children[64,65,66,67,68].

Another class of chemicals that is of particular concern in California is flame retardants, which are added to many household products, including furniture foam, baby products, and the plastic casings of consumer electronics. California's children have some of the highest measured body burdens of flame retardants of any population in the world[69]. Pre- and post-natal exposure to polybrominated diphenyl ethers (PBDEs), a common family of flame retardant chemicals, is associated with reduced IQ scores and delayed motor and cognitive development[70,71]. Children may be exposed from house dust where they play as well as via breast milk. Of note, the value of these chemicals in fire prevention has been questioned by experts[72].

## Select Cal/EPA BDO Activities That Protect the Neurodevelopment of Children

- Many pesticides have adverse effects on the nervous system. DPR developed an Integrated Pest Management (IPM) Toolkit and trainings for child

In order to minimize childhood exposure to pesticides, DPR conducts Integrated Pest Management training for school districts throughout the state. Approximately 82% of the state's school districts have received training in these methods for least-hazardous pest management practices.

care providers in collaboration with UC San Francisco, School of Nursing and UC Berkeley.

- In estimating exposures to airborne and waterborne pesticides, DPR explicitly includes estimates for children since they may have higher exposures due to higher inhalation rates, and higher food and water consumption per pound. In estimating exposures to pesticides used on lawns, carpets, and pets, DPR includes specific child behaviors such as putting hands or objects in mouths.
- DPR often regulates pesticides based on effects on the developing nervous system, including the organophosphates and carbamates.
- At DPRs request, ARB conducts air monitoring for pesticides that are candidate or identified toxic air contaminants at sites that often include schools. Ambient air monitoring is conducted in specific areas, and specific monitoring is conducted during periods of high expected use of the target pesticide(s). DPR uses the data to determine if ambient levels are within safe levels, or if additional mitigation is needed.
- OEHHA developed Reference Exposure Levels (levels of exposure in air that are considered safe) for a number of developmental neurotoxins, including mercury and manganese. Further, OEHHA's drinking water Public Health Goal for perchlorate is based on concern for neurodevelopmental effects.
- OEHHA has listed a number of chemicals under Proposition 65 that cause developmental neurotoxicity.
- Since being established in 2006, Biomonitoring California (a collaborative effort of DTSC, OEHHA, and CDPH) has:
    - Identified *priority* chemicals for biomonitoring that are of concern because of potential effects on the fetus or the developing child. These include chemicals toxic to the developing nervous system:
        - Metals, such as lead and mercury
        - Bisphenol A (BPA)
        - Phthalates
        - Flame retardants, such as polybrominated diphenyl ethers (PBDEs)
        - Pesticides, such as pyrethroid and organophosphate pesticides
    - Biomonitoring California collaborates with the UC Davis MARBLES (Markers of Autism Risk in Babies–Learning Early Signs) study to investigate possible biological and environmental exposures that may contribute to the rising incidence of autism.

- OEHHA identifies chemical contaminants commonly found at school sites that are of greatest concern based on child-specific exposure and physiological sensitivities. OEHHA prepares child-specific health guidance values for use by DTSC and other state and local agencies to assess exposures and health risks at existing and proposed school sites. Recent child-specific health guidance values have been

completed for a number of neurotoxic chemicals such as chlorpyriphos, lead and manganese.

- DTSC developed a tool, LeadSpread, for evaluating exposure and the potential for adverse health effects resulting from exposure to lead in the environment. The tool explicitly considers children as well as women of child-bearing age.
- DTSC has taken enforcement action against a wide variety of discount stores, department stores, gift shops and vending machine operators for selling children's jewelry containing lead.

## Cancer

### Cancer: A Leading Cause of Disease-Related Death in the United States

There is evidence that early-life exposures to carcinogens may in some instances be much more potent than exposure occurring in adulthood. Exposure to environmental carcinogens in the womb and during childhood may increase risk of cancers throughout life, including in old age. A growing and developing child is more susceptible to the types of cell damage that lead to cancer[73].

Cancer can happen at any age, though some cancers are more common in certain subsets of the population and cancer incidence increases as we age. In children, leukemia and brain/central nervous system cancers together account for about half of the childhood cancer burden in the United States[9]. Cancer is the leading disease-related cause of death in American children under 15 and women between 15 and 39, and the number two disease-related cause of death in American men between 15 and 39[74,75]. Survival rates have increased in the past few decades due to improvements in screening and treatment, but disparities in survival persist; African Americans have the poorest five-year survival rates for all cancers of any racial or ethnic group. Childhood cancer survivors are especially at risk for lifelong illnesses, including neurocognitive deficits, fertility issues, and other cancers, due to the harsh effects of early chemotherapy and radiation on still-developing bodies[9, 76,77].

### Cancer Also a Leading Cause of Death in California Children

In California, approximately 24% of all annual deaths are cancer-related, making cancer the second leading cause of death in the state. It is the leading cause of death among children under 14. Leukemia and brain/central nervous system cancers account for half of the state's childhood cancer burden[78]. The incidence of leukemia among all California children age 0-14 has been increasing about 1% per year between 1999 and 2009 and is highest in Hispanic children. The rate of leukemia has increased about 1% and 1.7% per year among Hispanic and African-American children, but has not significantly increased in white children[79]. Brain and central nervous system cancers, while still

extremely rare, increased in incidence about 1.9% per year between 2001 and 2009. White and Asian/Pacific Islander children experienced statistically significant increases in these cancers of 2.6% and 3.2% respectively. Similar increases were not noted in other groups.

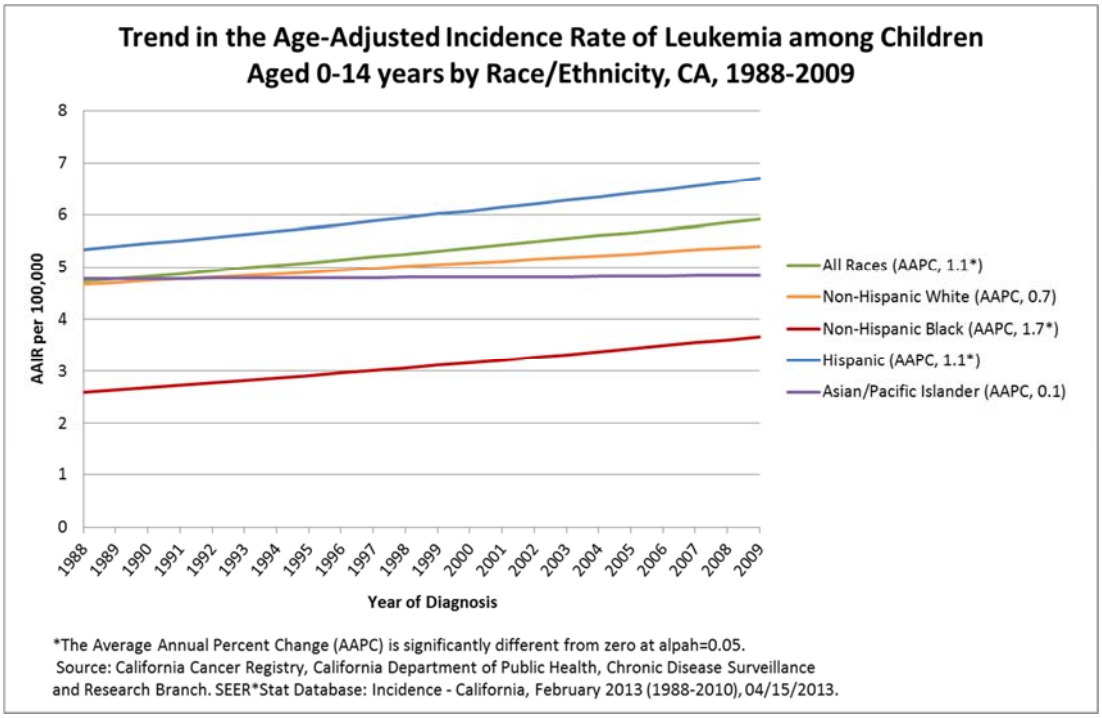


Figure 10. Incidence rates per 100,000 of leukemia in California children 0-14, by race, 1988-2009[80].

Based on data from the California Cancer Registry, California Department of Public Health.
*Statistically significant result.

## Toxic Exposures Increasingly Linked to Cancer Incidence in Children and Adults

It is difficult to ascertain the exact causes of many cancers because of their long latency period (time between exposure and clinical diagnosis). Despite this difficulty, there is a growing body of evidence to suggest that environmental exposures may play a role in the incidence of many cancers, especially when those exposures occur early in life during critical windows of development. While it has been well understood for some time that tobacco use causes lung, mouth, and esophageal cancers as well as adult myeloid leukemia, both the US Surgeon General and OEHHA have also found evidence suggestive of a causal association between secondhand tobacco smoke and childhood lymphomas and brain cancer[80,44] . Paternal smoking prior to conception has also been associated with increased risk of childhood acute lymphoblastic leukemia[81,82].

Benzene, a common industrial solvent and component of both gasoline and diesel fuel, is a known human carcinogen. Adults exposed to benzene in the workplace are at increased risk of developing acute and chronic myeloid leukemia [83]. More recent understanding of the way benzene affects bone marrow indicates that exposure to benzene, a ubiquitous air pollutant, may contribute to childhood leukemia.[84,85,9]. Exposure to household insecticides and indoor pesticides while in the womb has also been linked to increased risk of childhood leukemia[86].

Endocrine-disrupting chemicals are toxicants that disrupt hormonal systems, including hormones involved in reproduction and development and which regulate metabolism. Endocrine disruptors include some common chemicals that we are all exposed to, such as bisphenol A ( a component of polycarbonate plastics), the halogenated "dioxins" (products of combustion), certain brominated flame retardants, and polychlorinated biphenyls (PCBs) (used in electrical transformers and elsewhere). Exposure to PCBs in household dust may be associated with an increased risk of childhood leukemia[87]. Exposure to endocrine-disrupting chemicals during critical periods of development, (gestation, puberty, and pregnancy) has been linked to changes in breast development that may place women at increased risk of breast cancer later in life[88]. Aside from skin cancer, breast cancer is the most common cancer in women, and one of the most common causes of death in women.

Overall cancer incidence and mortality rates (for all ages) in California have decreased by 11% and 23% respectively between 1988 and 2009[89], but these decreases have not been seen in all ethnic groups. For example, though the overall California incidence rate for breast cancer has declined 7% since 1988, the Asian/ Pacific Islander community has seen a 26% increase in breast cancer incidence during this period[89]. This disparity in incidence for different ethnic groups may reflect differences in both environmental and genetic factors.

## Select Cal/EPA BDO Activities That Protect Children from Exposure to Carcinogens

- In 2009, OEHHA analyzed the scientific evidence from animal studies to compare the cancer risk from exposure to carcinogens in the womb and early after birth with exposures occurring only during adulthood. The data reveal higher lifetime risk when exposures occur during development. Based on this analysis, OEHHA's risk assessment guidelines recommend adjustments,

> Under Proposition 65, the Office of Environmental Health Hazard Assessment maintains a list of chemicals known to cause cancer and/or reproductive toxicity. As of 2012, the list contains over 900 chemicals, including many common solvents, pesticides, and industrial chemicals.

called Age Sensitivity Factors, which recognize the increased risk of developing cancer when exposure occurs early in life.

- There are a number of Public Health Goals in drinking water (set by OEHHA) that are based on carcinogenic effects. For some Public Health Goals, including benzo(a)pyrene and hexavalent chromium, OEHHA applies Age Sensitivity Factors to account for greater sensitivity of infants and children.
- The ARB, in consultation with OEHHA, has formally identified over 200 substances as Toxic Air Contaminants, most of which are carcinogens.
- The ARB has developed a number of Airborne Toxics Control Measures (ATCMs) for Toxic Air Contaminants that are carcinogens in ambient air. Included in these are diesel engine exhaust and formaldehyde, both of which are Toxic Air Contaminants listed by OEHHA as disproportionately impacting children.
    - ARB has promulgated numerous ATCMs for sources of diesel including trucks, buses, stationary engines; these measures have greatly reduced exposure to diesel engine exhaust carcinogens (Figure 6).
- As part of its mandate to evaluate possible contamination at proposed school sites, DTSC assists school districts in conducting site assessments and, if necessary, remediation to protect students from hazardous chemicals, including carcinogens.
- DPR promulgates regulations to restrict exposure to a number of pesticides based on their carcinogenicity.

## Conclusions

Cal/EPA's many programs and activities are at the forefront of protecting children from environmental contaminants. The Children's Environmental Health Program at OEHHA will continue to provide scientific support to Cal/EPA BDOs and other state and local agencies for their actions that reduce exposures to environmental chemicals in air, water, food, and consumer products. The actions of environmental chemicals, the influence of an individual's genetics, and of other factors in a person's environment on fetal and child development are areas of continued scientific exploration. As new evidence becomes available, the Children's Environmental Health Program can be a conduit for that information to the Boards and Departments at Cal/EPA and to other state agencies. Policies and regulations that impact children's health should be based on the best scientific information available. Our children are California's future and deserve to be protected from environmental contaminants that impact lifelong health.

While we have made great strides in cleaning our air, water, and land, much more remains to be done. Specifically, Cal/EPA BDOs should continue to:

- evaluate and reduce the impacts of contaminants in our air, water, soil, food, and consumer products on children's health, including in the home, school, and daycare environments
- evaluate and reduce the cumulative burdens on children of environmental contaminants, climate change, and health disparities; it is essential that Cal/EPA continue its work to evaluate how cumulative burdens increase vulnerability to environmental chemical exposures
- measure the chemicals in our bodies through biomonitoring to more fully understand exposures to common environmental contaminants
- focus efforts on reducing waste and greenhouse gas emissions, and increasing reuse and recycling to reduce our environmental footprint for future generations
- improve the flow of information from the Children's Environmental Health Research Centers and other researchers to Cal/EPA scientists and policymakers in order to help address children's environmental health.

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