

Report to the Legislature and Governor

Children's Environmental Health Center

February 2017



Office of Environmental Health
Hazard Assessment



California Environmental Protection
Agency

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Acknowledgement

We thank Carmen Milanes, M.P.H., for providing data and analyses for this report. We also would like to acknowledge Dr. George Alexeeff, OEHHA's director from 2011 until his passing in 2015. Dr. Alexeeff played a critical role in incorporating the protection of children's environmental health into OEHHA's programs and policies.

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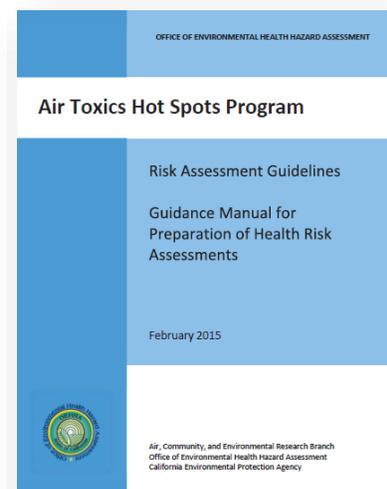
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EXECUTIVE SUMMARY

Protecting the health and future of our children is important to all Californians. In recognition of the fact that children are often impacted differently than adults by environmental contaminants, the Children's Environmental Health Center was established in the California Environmental Protection Agency (CalEPA) by the Children's Environmental Health Protection Act (Escutia, Chapter 731, Statutes of 1999) (the Act). The Center is responsible for ensuring that CalEPA's programs specifically protect children's health in California. In 2012, CalEPA delegated responsibility for the Center to the Office of Environmental Health Hazard Assessment (OEHHA). This report to the Legislature and Governor highlights the activities and some of the scientific understandings of children's environmental health developed by the Center over the past two years. The Act requires regular reporting on children's environmental health at CalEPA, particularly on the development and use of numerical guidance values that account for child vulnerabilities.

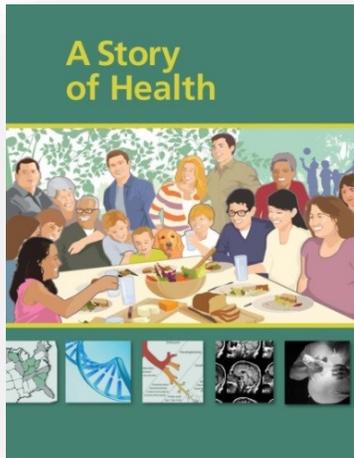
Children can be more affected than adults by exposure to environmental chemicals because children's exposure to contaminants in our air, water, and food is often higher than an adult's exposure in the same setting, and because children can be more sensitive than an adult to the adverse health effects of chemicals. The risk assessment and management efforts of OEHHA, the Air Resources Board (ARB), and other boards and departments within CalEPA, established now in risk assessment and risk management guidance, work to address the special vulnerabilities of children.

The report describes recent work by OEHHA and ARB to ensure that children are adequately protected from air toxics released from industrial facilities and other stationary sources. In addition, since the last report to the Legislature and Governor, OEHHA adopted 15 new guidance values for chemicals that utilized state-of-the-art methods to account for child vulnerability. These guidance values include a public health goal for perchlorate in drinking water, based on science establishing the critical need for infants to maintain adequate levels of thyroid hormone, and accounting for the high water consumption levels, relative to their body weight, of infants. The new guidance values also include revised reference exposure levels for benzene, a common



toxic air contaminant, accounting for children's vulnerability to this chemical.

The report also describes some other recent initiatives of CalEPA and its boards, departments, and office aimed at protecting children's environmental health. In 2015, funded by CalRecycle, OEHHA initiated a study of the potential health effects



from playing on synthetic turf fields. While lower watering requirements and less expensive maintenance are some of the advantages for using synthetic turf fields made from crumb rubber, concerns have been raised about potential exposures and risks from harmful chemicals to users of the fields, particularly school-age children and teenagers who play on these fields. The Department of Toxic Substances Control, as part of the Safer Consumer Products program, proposed regulations to formally add Children's Foam Padded Sleeping Products containing TDCPP or TCEP as the first product on the Priority Products list. Eliminating these flame retardants in products such as nap mats, play pens, and pillows should decrease

children's exposures to these carcinogens. In the fall of 2016, the Department of Pesticide Regulation released a proposed regulation to reduce a child's exposure to pesticides when he or she is at a school or day care center and had hearings around the state to collect public comments. In January 2017, the State Water Resources Control Board's Division of Drinking Water instituted a program under which schools may ask their community water systems to collect and analyze as many as five drinking water samples for lead at any school in their service area.

One important way to protect children's environmental health is to make physicians and other health providers aware of environmental pollutants that can harm children. The Children's Environmental Health Center partnered with several national organizations and with the University of California San Francisco (UCSF) to create [A Story of Health](#). This multi-media e-book and continuing education (CE) course harnesses the power of storytelling to increase environmental health literacy for health professionals. To date, more than 3,500 health professionals, including physicians, nurses, and health educators, have registered for the online course and have received 6,000 hours in CE credits.

The Children's Environmental Health Center also trains academicians and state scientists by conducting annual symposia on important children's environmental health issues. In 2014, the Program organized the symposium, "*Impacts of*

Environmental Chemicals on Development – Are complex interactions captured by traditional risk assessment practices?” The symposium explored many topics, including the interaction of the social environment and toxic pollutants on the developing brain and their contribution to autism and other neurological disorders and the effects of exposures early in life to arsenic in drinking water on the development of lung disease in later life. In 2015, a two-day symposium on the *“Impacts of Climate Change on Children’s Health”* brought together leading researchers and policy makers on children’s environmental health and climate change. The 2016 symposium focused on *“New Findings from California”* on children’s environmental health and featured presentations on brain development, prenatal exposure to flame retardants, and early-life exposures to pesticides.

OEHHA has conducted a number of original scientific studies relating air pollution and ambient temperature to health. Since the last Legislative Report, OEHHA has published five such studies. The OEHHA studies have contributed to an understanding of the impacts of environmental contaminants on the health of infants and children in California. Our studies have found that air pollution increases the risk of asthma attacks, hospitalizations and emergency room visits from respiratory illnesses in children. Other findings include elevated risk of preterm birth and miscarriage associated with air pollution. OEHHA studies have also focused on the impacts of heat on pregnancy and the health of the infant. These studies have shown that increased ambient heat results in increased preterm delivery and stillbirth, as well as infant mortality, tying reproductive health directly to climate change in a California population.

Children require a healthy environment—one that provides them with a sense of emotional and physical security—to acquire skills and behaviors that will enable them to eventually care for themselves. Climate change has the potential to disrupt communities and families, which is likely to negatively impact children’s development. Recognizing that climate change will most profoundly affect people in disadvantaged communities, CalEPA has incorporated environmental justice into its programs addressing climate change. Climate action has the potential to help mitigate the impacts of climate change on children, and also to produce significant positive results for health, particularly in disadvantaged populations. The focus on climate change in California, and results-oriented actions to reduce air pollution and greenhouse gases, and plan for adaptation, is needed to protect the health of California’s children.

INTRODUCTION

Protecting the health and future of children is important to all Californians. In recognition of the fact that children are often impacted differently than adults by environmental contaminants, the Children's Environmental Health Center was established in the California Environmental Protection Agency (CalEPA) by the Children's Environmental Health Protection Act (the Act) (Escutia, Chapter 731, Statutes of 1999).

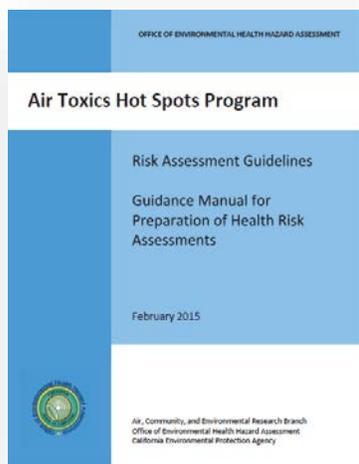
The primary purposes of the Center are:

- a) To serve as the chief advisor to the Secretary for Environmental Protection and to the Governor on matters within the jurisdiction of the Environmental Protection Agency relating to environmental health and environmental protection as each of those matters relates to children.
- b) To assist the boards, departments, and office within the Environmental Protection Agency to assess the effectiveness of statutes, regulations, and programs designed to protect children from environmental hazards.
- c) To coordinate within the Environmental Protection Agency and with other state agencies, regulatory efforts, research and data collection, and other programs and services that impact the environmental health of children, and coordinate with appropriate federal agencies conducting related regulatory efforts and research and data collection.

In January, 2012, the CalEPA Secretary delegated responsibility for the Children's Environmental Health Center to the Office of Environmental Health Hazard Assessment (OEHHA). The Children's Environmental Health Center serves as a resource for CalEPA 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 CalEPA boards and departments to promote policies and efforts that protect children's health.

The Act requires the Children's Environmental Health Center to regularly report to the Legislature and the Governor. This report highlights some of the activities and understandings of children's environmental health developed by the Center in 2014, 2015, and 2016.

1. ENSURING ADEQUATE PROTECTIONS FOR CHILDREN FROM AIR TOXICS AND ART HAZARDS



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's exposures 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. Therefore, the work of the CalEPA boards, departments and office to reduce children's exposures to environmental chemicals benefits

Californians throughout their lifetime. Since the last report, the Children's Environmental Health Center has had several important accomplishments.

New Risk Assessment and Risk Management Guidance to Protect Children

The Act requires OEHHA to ensure that the health risk assessments conducted for air toxics explicitly account for infants and children. OEHHA is responsible for the risk assessment guidelines that are used statewide to assess the health impacts of air toxics, specifically chemicals listed under the Air Toxics Hot Spots Act. OEHHA recently completed a multi-year project revising several risk assessment guidelines to incorporate new data on children's exposures and more explicitly account for their sensitivity to chemical toxicity. The guidelines ensure that when air toxics are released from facilities, the new risk assessment guidelines documents take into account:

- The fact that children are often more exposed to toxic chemicals due to their smaller body size relative to their intake of food, air, and water, and their hand-to-mouth behavior
- Physiologic differences in children that result in differences in metabolism and excretion of toxic chemicals
- Enhanced infant and child sensitivity to health effects from chronic toxicants
- Early life sensitivity to carcinogens for exposures to the fetus, infants and toddlers, young children and teenagers

The updated Air Toxics Hot Spots Risk Assessment Guidance Manual was finalized in 2015 and was rolled out in coordination with the Air Resources Board (ARB) and the local Air Quality Management Districts. ARB and the local Air Quality Management Districts, in response to the new Air Toxics Hot Spots Risk Assessment Guidance Manual have revised how they manage risks by issuing their own new risk management guidance. The new 2015 child-protective guidance documents are now being used statewide to assess risks of emissions from industrial facilities and other stationary sources. ARB is working with the local districts to ascertain whether additional emissions reductions may be necessary for some industrial facilities based on these new risk assessments.

Online Tool Facilitates Assessment of Risks to Children

ARB developed a software tool (the Health Assessment and Reporting Program or HARP) that includes the new guidelines for assessing risk to children. The tool was completed in 2015 and is available online. ARB and OEHHA conducted major outreach efforts in 2014 and 2015 to stakeholders who must now use the new guidelines to assess their emissions. OEHHA and ARB also worked throughout 2014 and 2015 with the California Air Pollution Control Officers Association to ensure all the air districts are familiar with the new guidance and model and understand how the changed methods increase protection for children.

Development of Health Values that Account for Child Susceptibility

The Act also requires that OEHHA establish and maintain a list of Toxic Air Contaminants that may disproportionately impact children. OEHHA has been evaluating chemicals under the air toxics programs to update the health values (Reference Exposure Levels and Cancer Potency Factors) used in risk assessment. During these evaluations, which are reviewed by the public and peer reviewed by the Scientific Review Panel on Toxic Air Contaminants, OEHHA assesses whether infants and children might be disproportionately impacted by each chemical. In 2014, OEHHA added benzene to the list of Toxic Air Contaminants that may disproportionately impact children.

In February 2015, OEHHA updated the public health goal (PHG) for perchlorate in drinking water. The new value of 1 part-per-billion (ppb), like the original 2004 public health goal of 6 ppb, was based on the inhibition of iodide uptake into the thyroid gland and the consequent disruption of thyroid hormone production. Infants and fetuses may be particularly susceptible to perchlorate or any alteration in thyroid hormone production. First, fetal and infant brains and nervous systems are rapidly developing and are critically dependent on thyroid hormone. Second, many infants

and pregnant women—and consequently the fetus—may not be getting enough iodide, making them especially susceptible to chemicals like perchlorate that can further reduce iodide levels in the thyroid. Third, infants have much less thyroid hormone in reserve than adults, so they may be less able to adapt to periods when iodide levels might be low. Information covering the second and third points was included in the 2015 update to provide support for recognizing that infants are likely to be significantly more susceptible to perchlorate than healthy adults. The 2015 update also incorporated updated drinking water ingestion rates for infants.

Since the last Report to the Legislature, OEHHA finalized PHGs on 12 compounds¹ utilizing methods that protect children's health, and identified a public health protective concentration for the chemical para-chlorobenzene sulfonic acid (pCBSA) in drinking water. pCBSA is a by-product of the production of dichloro-diphenyl-trichloroethane (DDT) and is found in soil at some former DDT manufacturing and waste disposal sites. pCBSA is highly water soluble and has contaminated aquifers beneath these sites. OEHHA also adopted new reference exposure levels for three chemicals², and an updated cancer potency value for perchloroethylene under the air toxics hot spots program.

Protecting Children from Art Hazards

California law (Education Code section 32064) prohibits the purchase of art or craft materials containing toxic substances for use by students in grades K-6, and requires that art products purchased for use by students in grades 7-12 are properly labeled to inform users of long-term (chronic) health risks and instructions for safe use. These purchasing requirements apply to schools, school districts, and governing authorities of private schools.

This law also requires OEHHA to develop a list of art and craft materials that cannot be purchased for use in grades K-6 (Education Code §32066). This list is a resource to assist schools in complying with the purchasing requirements. OEHHA updated the list of arts and crafts materials in September 2016. The update can be accessed at <http://oehha.ca.gov/risk-assessment/art-hazards>.

¹ Antimony, carbofuran, chlorobenzene, diquat, endothall, endrin, hexachlorocyclopentadiene, perchlorate, picloram, silvex, thiobencarb, trifluoromethane

² Benzene, toluene diisocyanate, methylene diphenyl diisocyanate

2. NEW INITIATIVES AT CALIFORNIA EPA TO PROTECT CHILDREN'S HEALTH

Synthetic Turf Study

Crumb rubber manufactured from recycled tires has been used for more than two decades as infill material in synthetic turf fields across the US and other countries. Health, environmental and economic benefits are claimed in association with this product, including reduced sport-related injuries, lower watering requirements and less expensive maintenance. Concerns, however, have been raised by the public about exposures of athletes (including school-age children and teenagers) and other field users to potentially harmful chemicals present in the crumb rubber infill, and the incidence of certain types of cancers. There have been similar health concerns about playground mats containing crumb rubber that are used by very young children.

OEHHA is working under contract with the Department of Resources, Recycling and Recovery (CalRecycle) to evaluate the complex chemical composition of crumb rubber infill material, the pathways of exposure and the potential health effects from the use of synthetic turf fields. This is the most extensive health assessment of synthetic turf conducted in the United States. The findings will also be used to assess potential health impacts associated with exposures to chemicals in playground mats. The study will help guide future decisions concerning the recycling and use of tire materials in synthetic turf and playground mats.

Under a four-year agreement between CalRecycle and OEHHA that was signed in 2015, the current study is designed to further our understanding of the chemicals that may be released from crumb rubber and artificial grass blades under various environmental conditions, and hence to assess human exposures to these chemicals and the associated health hazards and risks.

The current OEHHA study began with a series of three workshops in Northern and Southern California and a webinar to gather public input on the study. A Scientific Advisory Panel (SAP) first met in February 2016 in a public forum to provide expert scientific advice on the design and implementation of the study. The SAP is scheduled to hold its next meeting in March 2017, and it will meet several more times during the course of the study to provide input. Sampling of fields will be done in 2017, and the results will be incorporated into a full risk assessment that is scheduled for completion in 2019.

Safer Consumer Products Program

The Department of Toxic Substances Control (DTSC) is responsible for implementing the Safer Consumer Products (SCP) program. The goals of this program are to:

- Reduce toxic chemicals in consumer products
- Create new business opportunities in the emerging safer consumer products industry
- Improve consumer confidence in the safety of the products they buy.

The regulations that set up the SCP program were finalized in 2013. DTSC proposed an initial list of Priority Products that contain chemicals that have been identified as posing hazards to humans or the environment.

The initial Priority Products list announced in March 2014 includes three products. One of the products is used almost exclusively by children:

- Children's Foam Padded Sleeping Products containing the flame retardants Tris(1,3-dichloro-2-propyl) phosphate or TDCPP or tris(2-chloroethyl) phosphate or TCEP
- Spray Polyurethane Foam (SPF) Systems containing unreacted methylene diphenyl diisocyanates (MDI)
- Paint and Varnish Strippers, and Surface Cleaners with methylene chloride

DTSC has proposed regulations to formally add Children's Foam Padded Sleeping Products containing TDCPP or TCEP as the first product on the Priority Products list. Eliminating these flame retardants in products such as nap mats, play pens, and pillows is intended to decrease the concentrations of these carcinogenic chemicals in homes, day care centers, and schools. When the regulations are finalized, the manufacturers of such products will have 180 days to provide an Alternatives Analysis for DTSC's review or to provide a notice of intention to remove or replace the chemicals of concern. An Alternatives Analysis compares the Priority Product containing the chemical of concern with potential alternatives, including chemical substitution, product redesign or other innovations. DTSC will be evaluating the analyses to determine whether the chosen alternative reduces the potential for harm from the product. If manufacturers do not voluntarily eliminate, or replace these chemicals in children's sleeping products with safer alternatives, DTSC has the authority to ban or restrict the chemicals to protect children's health.

Reducing Children's Pesticide Exposure at Schools and Day-care Facilities

The Department of Pesticide Regulation has proposed a regulation that is intended to provide a statewide minimum standard of protection to school children and to increase communications between K-12 schools, licensed child day care facilities and production agriculture operations for the purpose of emergency preparedness. This proposed regulation is needed because of the recognition that children are especially vulnerable to the toxic effects of pesticides, some schools and facilities are located adjacent to farmland, and there have been documented incidents of pesticide drift to these sites. Growers and pest control contractors would be required to follow the regulation.

The two aspects of the regulation that would reduce children's exposures are application limitations and advance notifications. The application limitations would prohibit certain pesticide applications used in production agriculture within one quarter-mile of a school site on weekdays when children are likely to be present. The advance notification requirements would provide information to parents and teachers about applications before they occur. The notifications given to the schools and facilities would be both annual and application-specific. The written annual notification would have information on the expected applications of any pesticide for production agriculture within one quarter-mile of schools and licensed child-care sites during the upcoming school year. This notification would include details on which pesticides may be applied, where they may be applied, and contact information regarding who would make the applications. The application-specific notification would be more immediate, with more specific information submitted at least 48 hours prior to the application.

The Department conducted hearings around the state and received extensive written public comments on the proposal. It will make revisions to the proposal and plans to finalize the regulation in 2017.

Lead Sampling of Drinking Water in Schools

In January 2017, the State Water Resources Control Board's Division of Drinking Water (DDW) instituted a new program under which community water systems must collect and analyze up to five drinking water samples for lead at any school in their service area that requests testing. The testing is voluntary for schools and school districts, but if the schools or districts make a written request, the water systems must conduct the testing within three months and report the results back to the school. The water systems must also report the results to DDW. According to the

California Department of Education, there are 9,000 K-12 schools in the state; many of those are served by the more than 3,000 permitted community water systems.

Lead in drinking water continues to be a health concern and challenge for public water systems. While California has fewer issues with lead in drinking water than some other states, DDW recognizes the need for more safety measures to make sure children are protected. Lead can affect almost every organ and system in the body. The most sensitive is the central nervous system, particularly in children. Lead also damages kidneys and the reproductive system. The effects are the same whether lead is inhaled or swallowed.

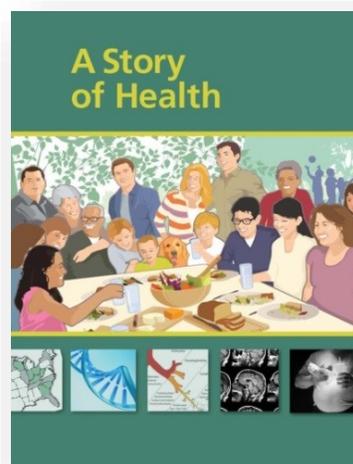
Most lead gets into drinking water after the water leaves the local well or treatment plant and comes into contact with corroded plumbing materials containing lead. These include lead pipe and lead solder (commonly used until 1986), as well as faucets, valves, and other components made of brass. Because California tends to have newer infrastructure and less-corrosive water than many other parts of the country, lead problems at the tap are uncommon in our state.

The community water system is responsible for all costs associated with collecting, analyzing, and reporting drinking water samples for lead testing, and is required to meet with the authorized school representative to develop a sampling plan and explain the sampling results. The water system must also re-test any sites with elevated lead levels to document if corrective actions are effective. Approximately \$9.5 million will be available from the DDW later in 2017 for affected schools in disadvantaged communities to install water bottle filling stations, install or replace drinking fountains, and for the installation of treatment devices that are capable of removing contaminants from drinking water.

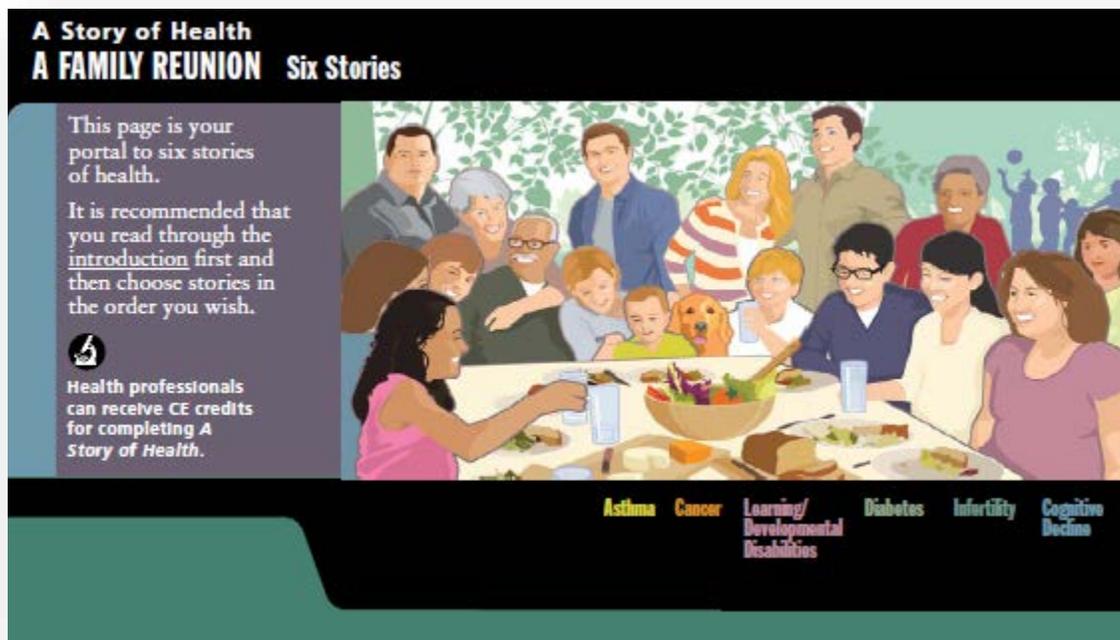
3. EDUCATING HEALTH PROFESSIONALS AND RISK ASSESSORS ABOUT ENVIRONMENTAL RISKS TO CHILDREN

The Multi-Media e-Book *A Story of Health*

The Children's Environmental Health Center partnered with the Agency for Toxic Substances and Disease Registry (ATSDR), the Western States Pediatric Environmental Health Specialty Unit at UCSF, the Collaborative for Health and the Environment, and the Science and Environmental Health Network to create [*A Story of Health*](#). This multi-media e-book and continuing education (CE) course is designed to harness the power of storytelling to increase environmental health literacy for health professionals, policy makers and health advocates, and encourage inclusion of anticipatory guidance in professional practice. Research shows that clinicians feel ill-equipped to meet needs of patients regarding environmental health questions. The course was designed to augment the limited education in environmental health during clinical training. *A Story of Health* received an award for "excellence in communication" from the Centers for Disease Control and Prevention (CDC) in 2016.



A Story of Health uses fictional stories to convey how multiple environmental factors interact with genetics to affect health across the lifespan. The first installment of the 150-page peer-reviewed e-book, which includes chapters on asthma (Brett's story); developmental disabilities (Amelia's story), and childhood leukemia (Stephen's story), was released in early 2015 and is available to download free online. Free CE credits are offered through the CDC and the Agency for Toxic Substances and Disease Registry (ATSDR) as an incentive for health professionals to become familiar with environmental health concepts and to use this information in their work.



The stories explore influences of the natural, built, chemical, food, economic, and social environments on health across the lifespan—from conception to elder years. The individual stories reveal how these environments and the impacts on our health are further influenced by education, family structures, housing, nutrition, access to health care, social supports or stressors, and more.

More than 3,500 health professionals, including physicians, nurses, and health educators, have registered for the online course at this writing, resulting in more than 6,000 hours of continuing education credits granted by the CDC. Evaluations have been overwhelmingly affirming. In an analysis of responses from the second quarter of 2015, more than 95 percent said these courses filled a gap in their skills or knowledge, and more than 89 percent said they will apply the new knowledge to develop strategies and interventions in their practices. *A Story of Health* is available at http://oehha.ca.gov/public_info/public/kids/storyofhealth.html.

Exposing Clinicians and Health Trainees to Environmental Pollution Issues

In the past two years, the Children's Environmental Health Center has hosted eight Pediatric and Occupational Environmental Medicine physicians who are doing their residency training. The Center has provided seminars for health care professionals at California hospitals and conference presentations at more than 20 meetings during the past two years.

Symposium on Assessing Complex Effects from Chemicals that Affect Children

Each year, the Children's Environmental Health Center sponsors a symposium on key emerging issues relevant to state scientists and policy makers in the field of children's environmental health. These symposia help keep our state scientists at the forefront of science and policy.

In 2014, the theme was "*Impacts of Environmental Chemicals on Development – Are complex interactions captured by traditional risk assessment practices?*"

Presentations at this meeting addressed interactions of the social environment of children with exposure to pollutants, and how the social environment affects the response to toxic pollutants. Researchers presented studies on many topics relevant to children's environmental health. These included:

- The interaction of the social environment and toxic pollutants on the developing brain and their contribution to the risk of neurodevelopmental disorders, such as autism spectrum disorder;
- The effects of exposures early in life to arsenic in drinking water on the development of lung disease in later life;
- The new toxicity testing paradigms and how they relate to assessing developmental toxicity of environmental contaminants.

Symposium on Climate Change and Children's Health

The symposium OEHHA organized in March 2015 was titled "*Impacts of Climate Change on Children's Health.*" The presentations at the 2015 meeting summarized how children's unique vulnerabilities and social circumstances interact with expected environmental impacts associated with climate change. Presentations explored adaptation strategies that address the needs of children and build partnerships between public health systems and others. An important theme that emerged from the symposium was the importance of child-focused adaptation to protect against the impacts of climate change on future generations. Each session was well attended. More than 100 individual sites also accessed the symposium via the Internet. Videos of the 2015 meeting presentations are posted on the OEHHA website at http://oehha.ca.gov/public_info/public/kids/2015symposium.html.

Symposium on New Findings from California

The February 2016 symposium explored emerging research on a variety of children's environmental health issues. The keynote address discussed the impact of toxic chemicals on brain development. Other presentations focused on prenatal exposure to flame retardants, links between air pollution and childhood obesity, early-life exposures to pesticides, and girls' exposure to endocrine-disrupting chemicals in cosmetics. Videos of the 2016 symposium presentations are posted on the OEHHA website at <http://oehha.ca.gov/risk-assessment/presentation/2016-childrens-environmental-health-symposium-presentations>

4. RESEARCHING THE IMPACT OF CLIMATE CHANGE AND AIR POLLUTION ON CHILDREN'S HEALTH

OEHHA has conducted a number of epidemiological studies relating air pollution or ambient temperature to health. The OEHHA studies have contributed to an understanding of the impacts of environmental contaminants on the health of infants and children. Our studies have found that air pollution increases the risk of asthma attacks as well as hospitalizations and emergency room visits from respiratory illnesses in children. Other findings include elevated risk of preterm birth and miscarriage associated with air pollution. OEHHA studies have also focused on the impacts of heat on pregnancy and the health of the infant. These climate change-related studies have shown that increased ambient heat results in increased preterm delivery and stillbirth, as well as infant mortality. Results of the heat-related studies are referenced in Section 4, which describes the unique vulnerability of infants and children to climate change. Studies published in the last few years by OEHHA scientists relevant to children's health include:

- Association Between High Ambient Temperature and Risk of Stillbirth in California. Basu R, et al. *Am J Epidemiol.* 2016

This study examined the relationship between temperatures and stillbirth during the warm season from 1999 to 2009. It found a 10% increase in risk of stillbirth for every 10° F increase in temperature.

Risks were greater for younger mothers, less-educated mothers, and male fetuses.

- A Study of Ambient Ozone Exposure and Emergency Department Visits for Specific Respiratory Diagnoses in California (2005-2008). Malig BJ, et al. *Environ Health Perspect.* 2015.

In this study, ozone levels impacted young children more than adults. The amount of ozone in the air was more strongly associated with emergency room visits for asthma and respiratory infections in those age zero to four years old than in adults.



"Infants and children are more vulnerable than adults to contaminants in our air, water and food – and to the impacts of climate change. Understanding these special vulnerabilities, and using that knowledge to improve our programs, will help us better protect the health of younger generations."

CalEPA Secretary
Matthew Rodriguez

- A Study of Temperature and Infant Mortality in California. Basu R, et al. *Paediatr Perinat Epidemiol.* 2015.

In this study, higher ambient temperatures increased infant mortality from multiple causes. The deaths were primarily related to premature birth and respiratory illnesses.

- Association of stillbirth with ambient air pollution in a California cohort study. Green R, et al. *Am J Epidemiol.* 2015.

This study found that exposure to air pollution, measured as levels of ozone, nitrogen dioxide, and particulate matter, during pregnancy increases the risk of stillbirth in California women.

- Effects of fine particulate matter and its constituents on low birth weight among full-term infants in California. Basu R, et al. *Environ Res.* 2014.

This research found that higher exposures to fine particle pollution in the air during pregnancy was significantly associated with reductions in birth weight. The researchers specifically studied full-term infants to avoid confounding by premature birth.

5. UNDERSTANDING THE DISPROPORTIONATE IMPACTS OF CLIMATE CHANGE ON CHILDREN

In March 2015, the Children’s Environmental Health Center conducted a two-day symposium on the “*Impacts of Climate Change on Children’s Health.*” This groundbreaking meeting brought together leading researchers and policy makers on children’s environmental health and climate change. This section briefly describes learnings from that symposium, as well as from research of OEHHA scientists, on why and how climate change impacts children disproportionately.



Changes to the global climate have the potential to impact California’s environment, public health, and economy. Human-generated greenhouse gases (GHGs) from fossil-fuel burning

and other activities enhance the heat-trapping capacity of the Earth’s atmosphere¹. Post-industrial rises in GHG emissions have been associated with accelerated increases in temperature; in California, average air temperatures have risen 1.5° F since 1895².

As of 2011, more than 25% of California’s population was age 18 or younger. Of these nine million children, 2.5 million were under the age of five³, and more than two million lived in poverty⁴. Children—particularly those under the age of five—depend heavily upon caregivers to provide them with a safe and healthy environment.

Climate change threatens human health and well-being, particularly for the most vulnerable members of our population, including infants and children.

Climate Change Complicates Pregnancy and Harms Infants

Pregnant women, the developing fetus, and young children are particularly vulnerable to health problems that will likely be exacerbated by climate change⁵. The risks of pregnancy complications are increased by factors such as air pollution, which is



“Taking significant amounts of carbon out of our economy without harming its vibrancy is exactly the sort of challenge at which California excels. This is exciting, it is bold and it is absolutely necessary if we are to have any chance of stopping potentially catastrophic changes to our climate system.”

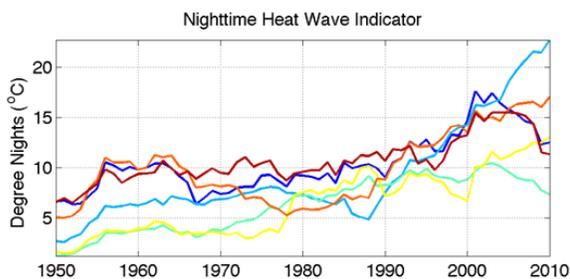
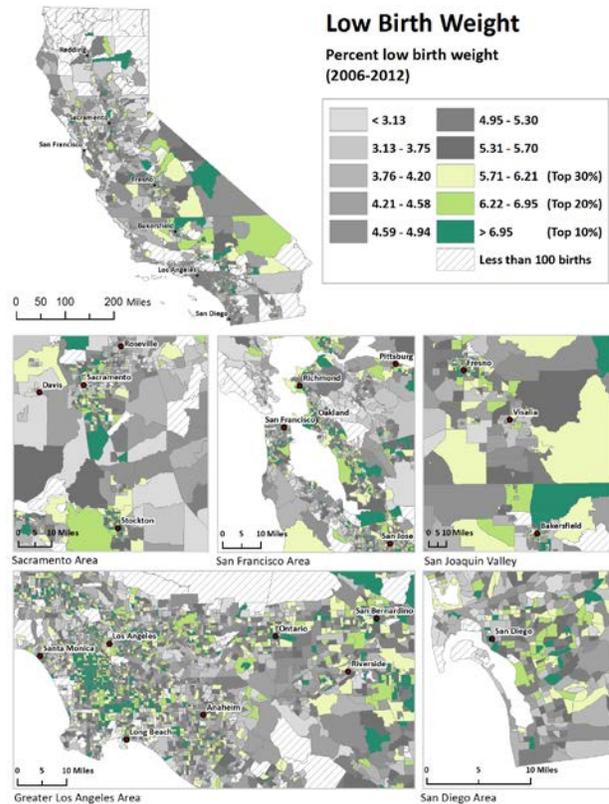
Governor Edmund G. Brown Jr.
2015 Inaugural Address

anticipated to increase in hotter weather, and exposure to heat events associated with climate change. These complications include low birth weight and premature delivery, which have consequent problems for the infant, and increase neonatal mortality^{5,6}.

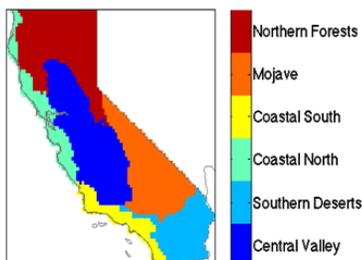
Pregnancy is affected by air pollution events related to climate change

In California, rising temperatures and drought have been accompanied by an increase in the frequency of large wildfires (1,000 acres and greater) and the length of the fire season. Air pollution from wildfire smoke can worsen asthma symptoms in mothers and in that way contribute to an increase in adverse birth outcomes including pre-eclampsia, preterm birth, and low birth weight^{7,8}.

Worsened air quality has been directly correlated with greater frequency of asthma-related emergency visits⁹. In California, 13.1% of adults have been diagnosed with asthma, and this burden falls more heavily on females¹⁰. A study in California's 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 weight¹¹.



Source: E. P. Maurer, A. W. Wood et al. (2002) (data updated to 2010), Gershunov, Cayan et al. (2009) (Heat Wave Indicator)



High ambient temperature increases risk of preterm birth.

In all climate regions in California, temperature extremes are increasing, with the largest increases found in coastal areas. The Intergovernmental Panel on Climate Change predicts more intense and frequent heat waves in the future¹². Studies exploring the health outcomes of pregnant women in

relation to ambient temperatures have found significant associations between high ambient temperature and preterm birth¹³ (delivery before 36 gestational weeks),

including a study conducted by OEHHA which found an 8.6% increase in preterm deliveries per 10°F increase in temperature¹³.



“Studies conducted by OEHHA scientists have found that the fetus and infant are particularly vulnerable to the changes in temperature expected from climate change.”

OEHHA Director
Lauren Zeise

Premature birth is commonly associated with neurologic and developmental disabilities in the infant during the first two years of life, as well as cognitive and neurological impairment at school age^{14,15}. Children of lower socioeconomic status are at highest risk^{16,17}. Even late preterm infants—those born at 35 and 36 weeks gestation—can experience subsequent

deficits in lung function throughout infancy and childhood^{18,19}. These infants require more hospital care, experience greater mortality, and are more likely to be re-hospitalized than term infants²⁰.

Higher ambient temperature increases infant mortality

Infants are limited in their ability to control their temperature. They depend on caregivers to remove layers or turn on air conditioning and fans, and have limited ability to communicate their needs.

A recent study in California, led by OEHHA, has indicated that infants less than one year of age are particularly vulnerable to heat exposure²¹. Neonatal (up to 28 days of age) and post-neonatal (up to one year of age) mortality, particularly that associated with respiratory and cardiovascular problems, increases with rising ambient temperatures in coastal and non-coastal regions of California.

Climate Change Adversely Affects Children’s Respiratory Health

Children spend more time outside, are more active, and inhale more air per pound of body weight than adults. This leads to higher exposures to air pollutants than adults and increased vulnerability to respiratory illnesses that can be caused or exacerbated by air pollution exposures. Further, the health of the adult they become is influenced by the health of the child. Lung function during childhood partially predicts lung

function in adulthood, and respiratory disease in children contributes to diseases in adults, such as chronic obstructive pulmonary disease (COPD).²²

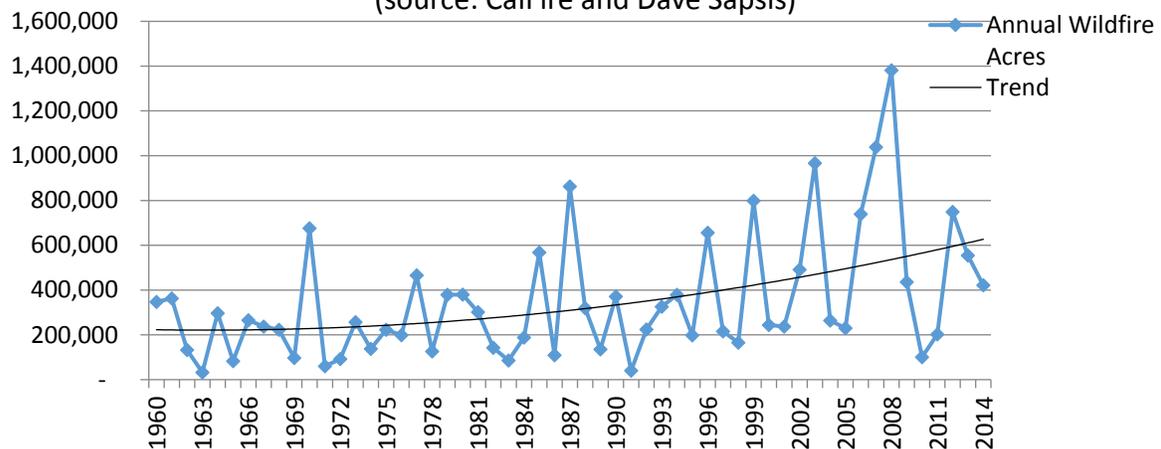
Asthma, a chronic airway disorder, affects 12.5% of children in California¹⁰. Children are particularly susceptible to asthma exacerbations, and have elevated risks from asthma compared to adults⁶. Air pollution from wildfires, ground level ozone, and allergens such as pollen—all environmental exposures that have been linked to asthma exacerbations and increased emergency visits for respiratory illness—are expected to increase as a result of climate change^{23,24,25}.

Air pollution from wildfire smoke linked to respiratory illness in children

Large wildfires generate huge quantities of toxic substances, which irritate airways and worsen respiratory illnesses such as asthma. OEHHA’s 2013 “Indicators of Climate Change in California” report shows that California has experienced intensification of the water cycle (dry years are drier and wet years are wetter), warmer annual temperatures, and more frequent extreme heat events as a result of climate change. These changes, which have resulted in a hotter, drier climate, are expected to increase in coming years resulting in further increases in wildfires².

Annual California Acreage Burned 1960-2014

(source: CalFire and Dave Sapsis)



Multiple studies have reported an association between wildfire smoke and asthma exacerbations, emergency visits, and hospitalizations²⁶. While none have specifically addressed these effects in infants and young children, a study conducted during the 2003 Southern California wildfires did investigate respiratory symptoms in high-school-age students²⁷. The study reported respiratory symptoms in both asthmatic

and non-asthmatic subjects. Given that younger children are more at risk for asthma, the observed effect in teens in this study would likely be magnified in these younger age groups.

Increasing temperatures make it more difficult to reduce ozone, an important cause of respiratory illness in children

Ground-level ozone (O₃) is the product of chemical reactions between nitrogen oxides and volatile organic chemicals, both of which are produced by the burning of fossil fuels²⁸. This reaction occurs more quickly at higher temperatures, suggesting that ground-level ozone will increase in tandem with the temperature increases that are expected in California^{2,29}.

There are well-documented associations between ground-level ozone and a variety of respiratory health effects. Short-term exposure has been associated with children's respiratory illness³⁰, induction of asthma, exacerbated asthma symptoms, airway inflammation^{25,31}, and increased asthma-related doctor and emergency department visits^{32,33,34}, as well as wheezing, cough, shortness of breath, and chest pain¹⁰. Aggravation of respiratory conditions caused by ground-level ozone can decrease a child's ability to perform exercise, and may lead to increases in school absences and use of medications¹⁰.

Climate change likely increases exposure to aeroallergens

Airborne allergens, such as pollen grains, are known as aeroallergens³⁵. Symptoms of allergies often include respiratory problems, such as hay fever and asthma. Children and infants are exposed to a variety of aeroallergens, both indoors and outdoors.

Warmer ambient temperatures are expected to increase the length of pollen seasons and alter the distribution of pollen-producing plants^{2,36}. Greater concentrations of atmospheric carbon dioxide (CO₂) are also expected to increase the allergen content of pollen grains^{6,25}. OEHHA's "Indicators of Climate Change in California" report provides evidence for vegetation distribution shifts and earlier wine grape bloom in California, both of which have been attributed to climate change. Such alterations in plant distribution and timing may be indicative of similar changes in other plant species in California². Scientists are concerned that increased aeroallergens and a prolonged allergy seasons will adversely impact allergies and asthma in children³⁷.

Daily ambient pollen concentrations have been associated with asthma exacerbations and respiratory-related emergency room visits³⁸. Notably, air

pollutants such as ozone can exacerbate these symptoms. This interaction is significant in light of the impact of both of these factors on climate change³⁹.

Climate Change Disproportionately Impacts Children

OEHHA's California Communities Environmental Health Screening Tool (CalEnviroScreen) has been used to identify the California communities that have the highest pollution burdens and vulnerabilities. More than 23% of children in California live below the poverty level and another 25% are only slightly above the poverty line. Children living in poverty can have reduced access to nutritious food and regular medical care, and are more likely to experience many social stressors associated with poverty. Moreover, children of color are more likely to live in communities with the highest pollution burdens. The proportions of different racial/ethnic groups of California's children living in the top 20 percent most disproportionately burdened communities identified by CalEnviroScreen are lowest for whites (1 in 14), and highest for Hispanics/Latinos and African Americans (1 in 3), followed by Native Americans (1 in 7) and Asians (1 in 8)². These disadvantaged communities have fewer resources to deal with climate-change-related environmental alterations. Children in these communities will be the most vulnerable to the adverse effects of climate change, ranging from heat waves and wildland fires to rising food prices and food insecurity resulting from climate-related impacts on agriculture.

Summary of Climate Change and Children's Environmental Health

Climate change produces a myriad of changes to biological and physical systems, some of which impact the health of our children⁴⁰. There is accumulating evidence that those most vulnerable, such as children and pregnant women are already suffering health impacts resulting from current conditions associated with climate change. The impacts include complications of pregnancy, such as increases in low birth weight, pre-term birth, and increased infant mortality, respiratory illness, asthma and allergies in children. These impacts can be expected to increase in coming years.

Climate action planning has the potential not only to mitigate the impacts of climate change on children, but also to produce significant positive results for health, particularly in minority and disadvantaged populations. California's efforts to address the impacts of climate change will go a long way toward protecting the health of our children.

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