ATSDR Case Studies in Environmental Medicine

Taking a Pediatric Exposure History

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Taking a Pediatric Exposure History

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Key Concepts

- Pediatricians and other child health care providers need the expertise necessary to
  - deliver anticipatory guidance to prevent childhood exposures,
  - take a relevant environmental history when necessary,
  - include environmental factors in differential diagnoses,
  - conduct appropriate risk-based laboratory tests for environmental illnesses, and
  - refer patients for workup of pediatric illnesses related to environmental factors.

Environmental Medicine	hazardous substances in the environment and to promote the adoption of medical practices that aid in the evaluation *and care of* potentially exposed patients. The complete series of *Case Studies in Environmental Medicine* is located on the ATSDR Web site at URL: www.atsdr.cdc.gov/csem/. In addition, the downloadable PDF version of this educational series and other environmental medicine materials provide content in an electronic, printable format. This may be useful for persons with slower Internet service.
How to Apply for and Receive Continuing Education Credits	Visit http://www2.cdc.gov/atsdrce/ for more information about continuing medical education credits, continuing nursing education credits, and other continuing education units.

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How to Use This Course

Introduction	The goal of *Case Studies in Environmental Med*icine (CSEM) is to increase the primary care provider's knowledge of hazardous substances in the environment and to help in evaluating and treating potentially exposed patients. This CSEM focuses on taking a pediatric exposure history.
Availability	Two versions of *Taking a Pediatric Exposure History* CSEM are available. • The HTML version http://www.atsdr.cdc.gov/csem/csem.asp?cse

	m=26&po=0 provides content through the Internet. • The downloadable PDF version [895 KB] provides content in an electronic, printable format. This may be useful for persons with slower Internet service. • The HTML version offers interactive exercises and prescriptive feedback to the user.
Instructions	To make the most effective use of this course, we recommend that you • Take the Initial Check to assess your current knowledge about taking a pediatric exposure history, • Read the title, learning objectives, text, and key points in each section, • Complete the progress check exercises at the end of each section and check your answers, and • Complete and submit your assessment and post-test response online if you wish to obtain continuing education credit. Continuing education certificates can be printed immediately upon completion of the assessment and the post-test.
Instructional Format	This course is designed to help you learn efficiently. Topics are clearly labeled so that you can skip sections or quickly scan sections you are already familiar with. This labeling will also allow you to use this training material as a handy reference. To help you identify and absorb important content quickly, each section is structured as follows:

Section Element	**Purpose**
Title	Serves as a "focus question" that you should be able to answer after completing the section
Learning Objectives	Describes specific content addressed in each section and focuses your attention on important points

Text	Provides the information you need to answer the focus question(s) and achieve the learning objectives
Key Points	Highlights important issues and helps you review
Progress Check	Enables you to test yourself to determine whether you have mastered the learning objectives
Answers	Provide feedback to ensure that you understand the content and can locate information in the text

Learning Objectives	Upon completion of the *Taking a Pediatric Exposure History* CSEM, you will be able to

Content Area	Objectives
Overview	• Clearly define the role of pediatricians in addressing illnesses related to environmental hazards such as toxic substances.
Purpose of the pediatric exposure history	• Describe the importance of taking a pediatric exposure history.
Exposure prevention	• Identify steps pediatricians should take to help patients prevent hazardous exposures.
Included in well child visits	• Describe how to take a screening exposure history for a well-child visit.
Suspicion of exposure-related illness	• Identify exposure-related questions to ask during a sick visit.
Clinical assessment	• Describe how to conduct an "exposure assessment" (medical and environmental evaluation) of a child with exposures (known or suspected) to hazardous substances.
Patient	• Describe medical management of a child

management	exposed to hazardous substances.

* This CSEM uses the term *pediatrician* to designate the clinician. The content, however, is applicable to all child health clinicians.

Initial Check

Instructions

This Initial Check will help you assess your current knowledge about taking a pediatric exposure history. To take the Initial Check, read the case and then answer the questions that follow. More information about the case is provided with subsequent questions as you work through this section.

John's previous medical history is unremarkable. His birth was full-term by a normal spontaneous vaginal delivery without complications. His height and weight have been consistently in the 40th percentile for his age. He met his developmental milestones appropriately. His immunizations are up to date. He is not taking medications, dietary supplements, or herbal medicines. Although his mother is a former smoker, she stopped when she was pregnant with John. No one smokes in the house now. The family history is negative for migraine headaches. His maternal aunt has asthma and seasonal allergies. The mother denies family problems with alcohol, drugs, or domestic violence, nor are there any metabolic or genetic diseases. A review of systems and a brief assessment of family function are noncontributory. No one in the family has been traveling in a foreign country.

Physical examination reveals a somewhat tired-appearing but otherwise healthy 8-year-old boy with some mild nasal congestion. His height is 50 inches and his weight 52 lbs (both 50th percentile for age). His temperature is 98.3°F (36.8°C), blood pressure is 100/60 mmHg, and the pulse is 100. His skin and mucous membranes are normal. His neck

is supple, without enlarged nodes, masses, or thyromegaly. No other adenopathy is noted. Head, eyes (including fundoscopic exam), ears, nose, and throat are within normal limits except for some mild nasal congestion. The lungs are clear to auscultation except for an occasional scattered wheeze. The heart rate is regular without murmurs. His abdomen is soft, and it is not distended or tender to palpation; there are no abdominal masses or hepatosplenomegaly. Genitourinary exam is normal. His joints have a full range of motion and no signs of inflammation. Neurologic examination reveals normal cranial nerves, sensory function, motor strength and tone, cerebellar function, gait, and deep tendon reflexes. Babinski reflexes are downgoing bilaterally. Vision screening is normal (20/20 bilaterally).

Case

A pregnant mother presents with her 8 year-old son who has headache, fatigue, nasal congestion, and decreased interest in school.

A mother who is two months pregnant brings her 8-year-old son, John, to the pediatrician. He has been complaining of headache, weakness, and less interest in school this fall. His symptoms have continued for several weeks. He feels nauseous, but has no vomiting, diarrhea, abdominal pain, or fever. The headache is bifrontal and pounding. It is present in the morning when he wakes up. His teacher says he appears sleepy and does not seem to be paying attention in class, although he does begin to perk up somewhat in the afternoon. The teacher did not mention problems with classmates or adjustments to the beginning of a new year at school. Although his mother tried putting him to bed earlier, it did not seem to help. At first, she thought John's symptoms were related to a viral syndrome or were a reaction to her pregnancy, since she has been more fatigued and irritable and therefore a bit short with him. She herself complains of considerable "morning sickness" that she describes as headache and vomiting in the morning. Her husband has been traveling more during the past month. In the last few weeks, John's headaches have become worse. His mother has wondered if he has a medical problem like sinusitis, especially since he has been coughing at night.

John's previous medical history is unremarkable. His birth was full-term by a normal spontaneous vaginal delivery without complications. His height and weight have been consistently in the 40th percentile for his age. He met his developmental milestones appropriately. His immunizations are up to date. He is not taking medications, dietary supplements, or herbal medicines. Although his mother is a former smoker, she stopped when she was pregnant with John. No one smokes in the house now. The family history is negative for migraine headaches. His maternal aunt has asthma

	and seasonal allergies. The mother denies family problems with alcohol, drugs, or domestic violence, nor are there any metabolic or genetic diseases. A review of systems and a brief assessment of family function are noncontributory. No one in the family has been traveling in a foreign country. Physical examination reveals a somewhat tired-appearing but otherwise healthy 8-year-old boy with some mild nasal congestion. His height is 50 inches and his weight 52 lbs (both 50th percentile for age). His temperature is 98.3°F (36.8°C), blood pressure is 100/60 mmHg, and the pulse is 100. His skin and mucous membranes are normal. His neck is supple, without enlarged nodes, masses, or thyromegaly. No other adenopathy is noted. Head, eyes (including fundoscopic exam), ears, nose, and throat are within normal limits except for some mild nasal congestion. The lungs are clear to auscultation except for an occasional scattered wheeze. The heart rate is regular without murmurs. His abdomen is soft, and it is not distended or tender to palpation; there are no abdominal masses or hepatosplenomegaly. Geniourinary exam is normal. His joints have a full range of motion and no signs of inflammation. Neurologic examination reveals normal cranial nerves, sensory function, motor strength and tone, cerebellar function, gait, and deep tendon reflexes. Babinski reflexes are downgoing bilaterally. Vision screening is normal (20/20 bilaterally).
Initial Check Questions 1-4	1. What is the differential diagnosis for this patient? 2. What additional questions relevant to the environment would you gather by interview? 3. What would you include in this patient's problem list? 4. At this point, what tests would you order to investigate the possibilities on your differential diagnosis?

Initial Check Answers 1-4

1. Leading diagnostic possibilities include

   - allergies and/or sinusitis,
   - migraine or tension headache,
   - social adjustment to new school and/or mom's pregnancy and/or dad's absence, and
   - carbon monoxide poisoning.

   Other possible diagnostic possibilities include

   - brain tumor,
   - anemia,
   - leukemia,
   - reactions to possible environmental pollutants, and
   - lead poisoning.

   More information for this answer can be found in the "Clinical Assessment—Establish a Problem List" section

2. What additional questions relevant to environmental exposures would you ask of John and his mother?

   John's physical exam is normal except for mild nasal congestion and some wheezing. His findings are not consistent with a brain tumor. Because carbon monoxide poisoning (CO) is a top consideration and lead poisoning and solvent exposure also come to mind, this presentation prompts the need for more questions concerning the home environment and surroundings. Questions include

   - age and condition of the home;
   - heating sources;
   - ongoing or planned renovations;
   - water damage;
   - hobbies done at home;
   - water source; and
   - nearby outdoor environment of house, school exposures, and

- parental occupations.

The house is a single-family dwelling built around 1960. It has old paint, but none is peeling. The family has lived here for 5 years. The heating source is forced hot air from a gas furnace installed when the house was built. There has been some ductwork repair done a few months previously, at the end of the summer. There is a fireplace in the living room, but the family has not yet used it this year. The chimneys have not been checked or cleaned since the family moved in. The family has smoke detectors but no CO detectors. There have been no current renovations, but the parents are planning to fix up a room for the new baby. There is no history of water damage, nor use of indoor or outdoor pesticides. The family drinks town water. John's hobbies include putting together model trains, but he rarely uses glues that have solvents. He plays baseball in a nearby field. The school had no recent renovation projects, and John had not been there since the preceding year. The home is in a predominately residential area. Two blocks away, a company is digging an underground parking lot. The neighbors say there are leaking chemical barrels buried there. John's father works in a biotechnology company. Previously, he was a senior "bench" lab scientist. In the last year, he has been involved with administrative matters related to contracting with pharmaceutical companies and has been traveling, so that he has no exposures to chemical or biological agents. The child's mother works half-time as a graphic designer at a local company, with no exposure to toxic agents. For hobbies, his mother paints with acrylics. She cleans up with soap and water, not with solvents.

More information for this answer can be found in the "What Types of Questions Should Be Asked if an Exposure-related Illness Is Suspected?" section.

3. What would you include in the patient's (and family's) problem list?

The problem list includes

- John's symptoms of
  - headache,
  - fatigue,
  - nausea,
  - nasal congestion.
- His mother's symptoms of
  - headache,
  - fatigue, and
  - nausea that occur in the context of first trimester pregnancy.

  More information for this answer can be found in the "Clinical Assessment—Establish a Problem List" section.

4. At this point, what tests would you order to investigate the possibilities on your differential diagnosis?

Laboratory testing (biological monitoring)

- Complete blood count (CBC) with differential,
- Carboxyhemoglobin (COHb) level (A specialist in pediatric environmental health in a poison control center was consulted and suggested that the COHb level should be drawn shortly after John has spent several hours at home, such as first thing in the morning),
- Blood lead level, and
- Magnetic resonance imaging (MRI) of the brain to be considered if above testing is unremarkable, and consultation with a neurologist.

Because of your concern for the possibility of carbon monoxide or lead exposure, you would also

recommend that the mother be tested with a COHb and blood lead.

More information for this answer can be found in "Clinical Assessment—Characterize Exposure by Laboratory and Environmental Testing" section.

Laboratory Tests

John's CBC and differential were unremarkable. His blood lead level was 3ug/dl—which is about background for city dwellers (< 2ug/dl). His blood COHb drawn in the morning, about one hour after leaving his house, was elevated at 15% (normal = 1–3%). His mother's COHb was 10%, and her blood lead was undetectable.

The COHb is the clinical biological monitoring test used to establish exposure. Background levels range from 1–3% in non-smokers [Ernst and Zibrak 1998]. John clearly has an elevated level, suggesting carbon monoxide poisoning (Table 1).

Table 1*

Health Effects Associated with Carboxyhemoglobin Levels in Adults

Blood Carboxyhemoglobin Level (%)	Possible Health Effects with Each Level
<1%	No effects
5–10%	Visual disturbances
10–30%	Headaches
40–50%	Fainting and collapse
50–60%	Coma and convulsions
60–80%	Possible death

* Adapted from Government of Alberta Work Safe Alberta site. Available at: http:/www./employment.alberta.ca/documents/WHS/WHS-PUB_ch031.pdf

Medical Management

Once an elevated carbon monoxide (CO) level in the home is recognized, the situation must be treated as a medical emergency. The family must be advised to leave the home *immediately.* The family is not to return home until the source of the problem is found and the problem is definitively remediated. Failure to act promptly can be life-

threatening to John, his mother, and other family members, as well as to her fetus.

The family leaves the home and stays with relatives. The gas company is called and comes to the house. Elevated CO levels are traced to a problem with incomplete combustion in the furnace exacerbated by the design and condition of the ductwork, resulting in CO leaking into the house. The gas company immediately shuts down the furnace and works to remedy the problem. The family does not return until the problem is remedied. In some locales, the utility company is required to report an elevated CO level to the local municipality, which may order the building evacuated until the situation is remedied.

Principles of Biological Monitoring

This example illustrates several points relevant to the choice of effective biological monitoring (laboratory tests) for adverse health effects from possible environmental exposure:

- **Choose a measure that most accurately reflects exposure and ideally correlates the best with symptoms**.

  Although CO leads to tissue hypoxia, the arterial oxygen tension (PaO_2, a measure of the amount of oxygen dissolved in plasma) is typically normal and unaffected by CO poisoning. Thus, although easy to do, the PaO2 is NOT a good biological monitor for CO poisoning. Carbon monoxide binds to hemoglobin (200x more tightly than oxygen), and the COHb level, although more difficult to perform, is a good measure of exposure.

- **The test must occur within a timeframe that will reflect the occurrence of the exposure and take into account the half-life of the biological indicator.**

  The half-life of COHb for someone breathing room air is about 4 hours. In this case, John's

COHb was drawn after he spent the night at home and within about 2 hours of leaving the home; it is therefore expected to be a good measure of home exposure. If the COHb was drawn after school, perhaps 8 hours after exposure, the level may have already declined to near background level and the diagnosis may have been missed.

- **Ideally, the measured level of the biological indicator should correlate well with adverse health effects (dose-response).**

  Low and moderately increased COHb levels do not necessarily correlate with the severity of the illness, and there is much individual variability [Ernst and Zibrak 1998]. In this case, John's COHb is definitely elevated: his symptoms of headache and fatigue are consistent with a blood COHb of 15%. His level may have been higher if measured sooner after exposure.

  Pediatricians may need to use resources for guidance in choosing the best biological monitoring tests for environmental exposures in children. These include Regional Poison Control Centers (1-800-222-1222), Pediatric Environmental Health Specialty Units (http://www.aoec.org/PEHSU.net), toxicology documents from ATSDR (http://www.atsdr.cdc.gov), and relevant textbooks [Lauwerys and Hoet 2000; Olson 2004].

Environmental Assessment	Environmental monitoring is often an important component in assessing exposure. Sometimes it is the major one when biological monitoring is not possible or adequate. Environmental monitoring includes air monitoring (as for CO) and monitoring such other media as water and soil when necessary. Reference ranges are available for acceptable levels of contaminants in drinking water [US Environmental Protection Agency 2003], ambient (outdoor) air (http://www.epa.gov/ttn/naaqs/), and indoor air (http://www.epa.gov/iaq/co.html). For example, EPA has an ambient air quality index chart suggesting a level of concern for CO levels of 9 parts per million (ppm) over 8 hours. There are no agreed-upon standards for indoor home air, but average levels in homes without gas stoves vary from 0.5 to 5 ppm, while levels near properly adjusted gas stoves are often 5−15ppm (http://www.epa.gov/iaq/co.html). For the work site, the US Occupational Safety and Health Administration (OSHA) set the allowable CO standard at 50 ppm for an 8-hour time-weighted average. The American Conference of Governmental Industrial Hygienists set 25 ppm as an 8-hour time-weighted average.

Diagnosis:

CO poisoning is the primary diagnosis, and it is potentially life-threatening.

CO is an odorless, non-irritating, and colorless gas generated from the incomplete combustion of carbon-based fuels. It can be generated from a variety of sources, including

- forced air furnaces,
- unvented or poorly vented kerosene and gas space heaters,
- poorly ventilated natural gas stoves and gas fireplaces,
- gas water heaters,
- wood stoves, and
- automobiles with poorly functioning exhaust systems with emissions that accumulate in attached garages when a car is running.

CO poisoning is one the most common types of unintentional poisoning in the United States, accounting for thousands of emergency department visits and some 800 deaths annually [Ernst and Zibrak 1998; Piantadosi 2002].

Acute effects of mild CO exposure include non-specific flu-like symptoms (headache, dizziness, weakness, nausea, vomiting) along with dizziness and confusion. Higher and more prolonged exposure can lead to seizures, coma, and death. Delayed cognitive effects have been reported as sequelae of severe CO poisoning, accompanied by loss of consciousness and/or seizures [Kwon et al. 2004].

CO toxicity results from a combination of tissue hypoxia and direct CO-mediated damage at the tissue level [Ernst and Zibrak 1998]. CO competes with oxygen for binding to hemoglobin, and CO binds 200x more tightly than oxygen, leading to less oxygen released at the tissue level and consequently to tissue hypoxia.

Special Susceptibility of Infants and Children	Infants and children have increased susceptibility to the effects of CO because of higher metabolic rates. Children with such underlying pulmonary conditions as asthma and those with anemia are more susceptible to CO effects. The fetus is very susceptible because fetal hemoglobin has a higher affinity for CO than adult hemoglobin.
Initial Check Question 5	5. What actions would you recommend now to treat mild carbon monoxide poisoning?
Initial Check 5 Answer	5. Recommended actions now to treat mild carbon monoxide poisoning. Immediate removal from exposure—no return to the house until repaired. 100% oxygen for John and his mother, either on-site or in the emergency department. Treatment with hyperbaric oxygen to prevent long term neurological sequelae is controversial. Most authorities would not recommend hyperbaric oxygen treatment at the levels seen in John's case. COHb levels must reach more than 15% in pregnant women [Ernst and Zibrak 1998] and more than 25% in others [Thom 2002; Weaver et al. 2002] before hyperbaric oxygen treatment would be considered. This advice should be considered with caution because many studies excluded children under age 18 and pregnant women [Weaver et al. 2002]. *More information for this answer can be found in the "How Do You Manage a Child with Known Environmental Exposures?" section.*
Continuation of Case Study	After treatment with oxygen and repair of the furnace, John and his mother felt much better. John's headache and fatigue completely resolved, but his nasal congestion persisted. He is now with some dry cough and slight breathlessness with activity**.**

Initial Check Question 6

6. Although the primary diagnosis was carbon monoxide poisoning, what other diagnoses need to still be considered?

Initial Check 6 Answer

6. Allergies and asthma also need to be considered once the life-threatening CO situation has been remedied.

CO explains headache and fatigue but does not explain nasal congestion and wheezing. Allergies and asthma may be additional conditions to consider. Environmental triggers of asthma include irritants and allergens found in outdoor or indoor environments (for further information, see the ATSDR CSEM "Environmental Triggers of Asthma"). Indoor allergens include dust mites, animal allergens, cockroaches, and molds [Rosenstreich et al. 1997; Etzel 2003]. Indoor irritants include second-hand smoke (SHS), wood smoke from fireplaces, nitrogen oxides from space heaters or gas-fueled cooking stoves, and volatile organic compounds (from building materials, pesticides, home solvents, and cleaners) [IOM 2000; IOM 2004]. Outdoor allergens include pollens, molds, and organic materials such as soybean dust [Anto et al. 1989; Anto, Sunyer et al., 1993]. Such ambient air pollutants as particulates, ozone, and sulfur dioxides increase asthma exacerbations and decrease exercise tolerance in children [Delfino 2002; McConnell et al. 2002; Committee on Environmental Health 2004].

More information for this answer can be found in "What Types of Questions Should Be Asked if an Exposure-related Illness Is Suspected—Final Follow-up Questions?"

Initial Check Question 7

7. What recommendations would you give to prevent such environmentally related problems as carbon monoxide poisoning?

Initial Check Answer 7

7. Steps to prevent CO poisoning.

- Advise parents to check all fuel-burning appliances once a year or as recommended by the manufacturer. This includes forced air furnaces, gas water heaters, gas stoves, gas clothes dryers, fireplaces, and wood stoves. Carbon monoxide detectors are also recommended but are not a substitute for regular inspections of appliances.
- Have parents purchase CO alarms that meet the standards of the Underwriters Laboratory (UL2034). These are the most reliable (U.S. Consumer Product Safety Commission: http://www.cpsc.gov).
- Identify and reduce environmental risk factors for asthma. With John's symptoms noted in the fall, triggers could be dust mobilized when the heating system is used, mold on leaves spread by wind, or volatile toxicants released during household use or from such other nearby sources as a leaking underground storage tank.
- Be extremely careful concerning home renovation because of potential risks of increasing lead exposure, particularly to the mother (and fetus) and John. Given the age of the home, it probably has lead paint, so that testing of the paint is recommended before renovations begin. Efforts to de-lead or repair and contain lead paint must be done by a contractor certified to remove lead safely.

More information for this question can be found the "How Do You Manage a Child with Known Environmental Exposures?—Public Health Reporting" section.

What Is the Role of Pediatricians in Addressing Illnesses Resulting from Environmental Factors?

Learning Objective	Upon completion of this section, you will be able to • Clearly define the role of pediatricians in addressing illnesses related to environmental hazards such as toxic substances.
Introduction	Pediatricians play an important role in preventing environmental exposures by asking the right questions and providing anticipatory guidance. Pediatricians treating a sick child must be aware that most diseases related to hazardous exposures in adults and children manifest as common medical problems or have nonspecific symptoms. Because environmental causes may not enter into the differential diagnosis, pediatricians may miss opportunities to make correct diagnoses or prevent disease.
Spectrum of Harm	A spectrum of harm to those exposed can be caused by hazardous substances in the environment. These substances include • allergens, • ionizing radiation, • toxicants, or • ultraviolet (UV) radiation. Effects of exposure can range from no effects or sub-clinical effects to frank poisonings. These levels of harm are usually related to the amount or dose of the substance to which the child or group has been exposed [Guidotti and Ragain 2007]. For example, a rise of 10 ug/dL in blood lead results in the loss of 2 IQ points in a child [Sattler et al. 2003]. Exposure can also lead to frank poisoning with obvious clinical symptoms (i.e., such as

	results from a blood lead level of >60/dL of lead) [Centers for Disease Control 2005; AAP 2005]. At a population level, very low levels of toxic chemicals may increase an exposed population's probability that a certain number of people will develop an illness.
The Exposure-Disease Model	No matter how toxic, no chemical can harm a person unless *exposure* occurs. The exposure disease model outlines actions that must occur for exposure to an environmental toxicant to eventually cause disease. These actions are • Environmental contamination: This is the physical source of the contaminant within the environment that creates the potential for exposure. • Biologic uptake: This occurs at the point of contact between the person and the physical source of contamination in the environment. The uptake creates a completed exposure pathway. • Absorbed dose: The amount of the toxicant absorbed after an exposure occurs. • Biologic changes: Toxic mechanisms that cause damage to tissues following an exposure and an absorbed dose. For example, hypoxia is caused by carbon monoxide (CO) exposure. • Target organ: An organ affected by exposure to the toxicant. The "critical organ" is the organ that is the most sensitive to the exposure. • Clinical disease: Overt symptoms that result, given a sufficient absorbed dose of a toxicant.
Roles of the Pediatrician in Environmental Health	Pediatricians have several important roles in environmental health. 1. *Primary prevention*—preventing the development of risk factors that may lead to

the onset of a negative health condition. The major role of pediatricians is to provide advice to families on how to prevent, reduce, or mitigate potential exposures to hazardous substances in order to prevent an adverse health effect. Examples include

- giving advice about maintaining fuel-burning appliances on a regular basis to prevent CO poisoning,
- counseling parents to have paint in older homes tested for lead before a child is exposed, and
- counseling parents to stop smoking to prevent a child's asthma exacerbations due to second-hand smoke (SHS) exposure.

Pediatricians may also provide pre-conception counseling on avoiding environmental exposures, such as second-hand smoke (SHS), to couples considering having children. Counseling during pregnancy and lactation may also be part of the pediatrician's role.

2. *Secondary prevention*—identifying and treating asymptomatic children who have already developed risk factors or preclinical disease but in whom the condition is not clinically apparent. One example is screening asymptomatic children for lead poisoning before the onset of symptoms, as outlined by the Centers for Disease Control and Prevention (CDC) and the American Academy of Pediatrics (AAP).

3. *Tertiary prevention*—activities involving the care of established disease, with attempts made to restore to highest function, minimize the negative effects of disease, and prevent disease-related complications. Such

prevention includes giving oxygen to a child with symptomatic CO poisoning.

In order to prevent, reduce, or mitigate exposures and diagnose and manage environmentally related health effects, pediatricians need to hone certain skills. These skills include

- Developing expertise in screening for possible environmental exposures commonly found in pediatric practice.
- Knowing how to take a full pediatric exposure history in cases of suspected exposures.
- Creating a complete differential diagnosis, including possible environmental factors as causes of signs and symptoms.
- Developing the ability to conduct a medical evaluation and an environmental risk assessment in cases where a frank poisoning or an environmentally mediated disease such as asthma is strongly suspected.
- Learning how to identify and work with consultants during an environmental workup. Consultants may include industrial hygienists, environmental medicine specialists, and pediatric toxicologists.
- Accessing expert consultants in pediatric environmental medicine to help with the medical management of more complicated cases.

Key Points

- The major role of the pediatrician is to provide counseling and anticipatory guidance to families about common environmental hazards in order to prevent children's exposures.
- Pediatricians can screen for certain common exposures and related adverse health effects.
- Pediatricians can also provide individual clinical interventions in case of harm to the individual patient from hazardous substances.

	• Pediatricians can work to develop more expertise in recognizing and managing diseases related to environmental exposures.
Progress Check	1. Roles of the pediatrician in environmental health include which of the following? A. Providing pre-conception advice and counsel to couples on how to help their unborn children avoid exposures. B. Learning how to screen children in their medical practice for exposures to harmful substances in the environment. C. Developing expertise in recognizing and managing diseases related to environmental exposures. D. All of the above. E. None of the above. *To review relevant content, see "Roles of the Pediatrician in Environmental Health" in this section.*

What Is the Purpose of a Pediatric Exposure History?

Learning Objective	Upon completion of this section, you will be able to • describe the importance of taking a pediatric exposure history.

Introduction

Because most environmental or occupational illnesses manifest as common medical problems or have non-specific symptoms, an environmental etiology for a sign, symptom, or disease may be missed. Therefore, it is important to take an exposure history, especially if an illness has been unresponsive to therapy or has an atypical presentation.

In a practical sense, an extensive environmental exposure history is beyond the scope of a general pediatrician's expertise. However, asking a few screening questions will alert the pediatrician to a possible environmental cause. The pediatrician can then contact experts in pediatric environmental medicine for further guidance for diagnosis, treatment, and management of complicated or unusual cases (see Pediatric Environmental Health Specialty Units (PEHSU) and Poison Control Center in the "For More Information" section later is this CSEM).

Purpose of the Pediatric Exposure History

The purpose of taking a pediatric exposure history is to detect environmental toxicants that can be risk factors for pre-clinical changes before overt toxicity occurs. In addition, pediatricians should include screening questions directed toward identifying and preventing common childhood adverse environmental exposures on the well child visit. Typical environmental exposure questions focus on environmental sources of

- carbon monoxide (CO),
- lead,
- methyl mercury in fish (diet),
- pesticides, and
- second-hand smoke (SHS).

When there are symptoms or an illness, taking a careful exposure history may allow the pediatrician to identify the specific agent causing the toxicity or poisoning.

What can a pediatrician do to improve his/her ability to recognize diseases related to current or past environmental exposures?

- First, pediatricians must *think about* the possibility of environmental factors in the etiology of disease by adding environmental causes to a list of differential diagnoses.
- Additional questions will be prompted according to the child's life stage (e.g., asking about water used to make up formula is relevant for an infant; school-based exposures are relevant for an older child; occupational exposures may be relevant to working teenagers or to toxicants a parent unknowingly brings home from work).

Conducting an Environmental Medicine Evaluation

In cases in which an environmental exposure is strongly suspected, there is a step-wise process to the pediatric environmental medicine evaluation:

1. Taking a full exposure history to define possible exposures.
2. Conducting appropriate laboratory testing (after consulting with experts in pediatric environmental medicine and toxicology).
3. Performing a thorough risk assessment regarding possible sources of exposure.
4. Obtaining guidance and consultation regarding ending ongoing exposure and appropriately treating toxicity.

Pediatricians should continue to expand their skills in

- taking a pediatric exposure history,
- delivering anticipatory guidance,
- conducting appropriate risk-based laboratory tests (in consultation with pediatric environmental specialists as necessary) according to the specific toxicant, exposure status, and clinical presentation of the child, and
- treating or managing patients with environmentally related illness in consultation with pediatric environmental health specialists.

The general pediatrician is frequently the person who initially suspects the role of environmental factors in disease. Investigations that require the help of an environmental medicine specialist often begin in the primary care provider's office. Help is available from specialists in Pediatric Environmental Health Specialty Units (PEHSUs) or from other sources (see the "For More Information" section later in this CSEM).

Including Environmental Etiologies in

Clinicians rarely see a child with a symptom or disease that is pathognomonic for environmental exposure—such as fetal alcohol spectrum disorder

the Differential Diagnosis

or acrodynia (a manifestation of chronic elemental mercury poisoning). As illustrated by the child in this case study, an environmental exposure case can present with non-specific signs and symptoms for which there is an extensive differential diagnosis.

> The key to making an accurate diagnosis is to include environmentally related possibilities when one is thinking about the differential diagnosis.

Examples of common conditions that may result from exposure to environmental contaminants include

- Headaches caused by mild CO intoxication or solvent exposure.
- Seizures as the result of severe lead poisoning or severe CO intoxication.
- Learning disabilities from one factor or multiple contributing environmental factors, such as intrauterine alcohol exposure and lead or mercury intoxication.

- Asthma exacerbated by exposure to

  - allergens (such as animal dander, mites, cockroaches),
  - irritants (such as SHS, indoor air fresheners, or cleaners),
  - outdoor air pollutants (such as ozone, PAH, and other particulates), and
  - exposures from hazardous substances in the nearby environment (e.g., an industrial emission or waste processing sites).

- Eczema and other skin conditions exacerbated by environmental factors (e.g., an adolescent works with solvents in an auto mechanics class at a trade school).

Etiology distinguishes a disorder as an environmental illness. Unless the clinician pursues an exposure history, the environmental etiology may be missed, treatment may be inappropriate, and exposure can continue.

When to Take an Environmental Exposure History

Opportunities for the pediatrician to ask exposure-related questions.

- Pre-conception. The purpose of a preconception history is to
  - identify hazards in the environment to which a child may be exposed,
  - educate and counsel regarding how to avoid exposure risks during pregnancy, and
  - educate the prospective parents about how to provide a healthy environment for their future children.

  Important examples include advising future parents to stop smoking and counseling a future mother to avoid consuming mercury-containing fish.

- Pediatric prenatal visit. Pediatricians may see mothers before a baby is born. An environmental exposure history includes asking the expectant mother if she
  - smokes cigarettes,
  - is exposed to SHS,
  - consumes mercury-containing fish, and
  - is planning renovations (possibly releasing lead or asbestos from renovation debris) to prepare for the baby.

- Initial well child visit. This is an opportunity to take a screening history to identify potential environmental exposures.
- Periodic well child visits. Pediatricians see children for routine well child visits at least 6

		times in the 1st year of life, 3–4 times in the 2nd year, twice in the 3rd year, and every year thereafter. These visits provide opportunities to update information about the child's surroundings and exposures. • Adolescent well visits. Many teenagers work after school and on weekends, potentially resulting in environmental exposures. Well visits also provide the opportunity for the pediatrician to inquire about active smoking and SHS exposure. Preconception counseling is relevant to some teens. • Sick child visits. These visits provide opportunities for pediatricians to ask exposure-related questions to determine if environmental hazards could play a role in the child's illness. A full exposure history should follow if exposure is suspected. • Follow-up visits for symptoms or illness. Pediatricians should consider an environmental etiology if there o is an unusual presentation of a common disease, o are persistent or puzzling symptoms unresponsive to treatment modalities, or o are multiple people in the immediate environment with the same symptoms.
Key Points		• When environmental causes may be playing a role in symptoms or disease, clinicians should ask screening environmental exposure questions, consider environmental factors as etiological causes of disease, and learn how to take a full exposure history. • Unless a pediatric environmental exposure history is pursued, pediatricians may miss a diagnosis, treatment may be inappropriate, and exposure may continue.
Progress Check	2.	When developing a differential diagnosis, pediatricians should

A. Consider environmental etiologies and ask screening questions.
B. Take a full pediatric exposure history.
C. Administer an antidote for the suspected but not confirmed poison.
D. All of the above.
E. None of the above.

To review relevant content, see "Conducting an Environmental Medicine Evaluation" in this section.

What Actions Should Be Taken to Prevent Hazardous Exposures to Children?

Learning Objectives

Upon completion of this section, you will be able to

- identify steps pediatricians should take to help patients prevent hazardous exposures.

Introduction

An important role of the pediatrician (and of allied health professionals in their office) is to provide information on how parents can prevent harmful environmental exposures to their children [Sattler et al. 2003].

Preconception and Prenatal Counseling

Preconception and prenatal counseling sessions present opportunities to prevent exposures that could lead to possibly devastating and lifelong effects. The March of Dimes and the U.S. Surgeon General recommend that preconception and prenatal counseling be done by all primary care physicians [March of Dimes 2008; Office of Surgeon General 2008].

General pediatricians providing preconception and prenatal counseling should include a screening environmental exposure history to assess basic environmental information about the home, occupations, and hazardous hobbies of parents and other adults living in the home. This can guide discussion about the risks for the developing child in the particular home, neighborhood, or school.

Prenatal Environmental Checklist

Pediatricians should provide parents with a prenatal environmental hazards checklist to be used to prepare the home for the arrival of the baby. The checklist should include.

- Discuss hazards associated with remodeling (e.g., lead poisoning or asbestos exposure).
- Discuss adverse effects to the fetus if a mother smokes during pregnancy and the dangers of second-hand smoke (SHS).
- Warn parents about the intake of potentially contaminated foods, such as mercury-contaminated fish. Resources for this topic include local public health advisories or those provided by the US Food and Drug Administration, the Agency for Toxic Substances and Disease Registry, or the US Environmental Protection Agency http://www.epa.gov/mercury.

- Counsel parents and other caregivers about the use of

  - prescribed and over-the-counter medications (e.g., Tylenol, aspirin, and cough suppressants that contain alcohol),
  - alternative remedies, and
  - other "natural" treatments during pregnancy.
- Review and discuss the hazards of alcohol and controlled substance use and abuse during pregnancy. Additionally, SHS can adversely affect fetal health [AAP 2003].

For the Well Child

For the *well child*, a developmentally appropriate environmental checklist may be used to identify the child's potential exposure risks. Age-appropriate environmental anticipatory guidance should be provided, and risk-based screening tests for lead poisoning should be performed according to the Centers for Disease Control and Prevention (CDC) [1997] guidance. All Medicaid-eligible children must be screened with a blood lead test at 1 and 2 years of age [AAP 2005].

More extensive guidance can be found in [AAP] American Academy of Pediatrics Committee on Environmental Health. 2003. Pediatric Environmental Health. Elk Grove Village, IL: American Academy of Pediatrics.

Key Points

- Prenatal and preventive counseling, guided by a discussion of risks defined by an environmental checklist, is recommended to prevent hazardous exposures to children.

Progress Check

3. During a prenatal counseling session, pediatricians should

   A. Give detailed, highly scientific risk information about trace amounts of contaminants in fish.
   B. Provide practical advice about how to reduce exposures to common environmental hazards in the home.
   C. Expound on all possible exposures that a child could face.
   D. All of the above.
   E. None of the above.

To review relevant content, see "Preconception and Prenatal Counseling" in this section.

What Exposure Questions Should Be Included in a Well Child Visit?

Learning Objective

Upon completion of this section, you will be able to

- describe how to take a screening exposure history for a well-child visit.

Taking a Screening Exposure History for the Well Child

Pediatricians should take two environmental medicine actions for every well child who presents to an office or a clinic.

1. A routine screening history for potential environmental exposures.
2. If necessary, age-appropriate risk-based screening for lead poisoning, using the Centers for Disease Control and Prevention's (CDC) lead poisoning prevention guidelines [CDC 1997].

A general pediatrician's practice allows little time for an extensive environmental exposure history. However, initial and subsequent well child visits do give pediatricians opportunities to provide parents and caregivers with educational materials on preventing exposures and actions to take if an exposure occurs. Table 2 lists recommended screening questions and appropriate corrective actions. A written checklist completed by parents may be used to facilitate obtaining the history.

An example of this checklist is the National Environmental Education Foundation Screening Environmental History Form at: http://www.neefusa.org/assets/files/PEHI/PedEnvHistoryForm_complete.pdf

Table 2. Screening Questions for the Well Child Screening Exposure History

Any Age—First Visit	Corrective Actions

Where does your child live and spend most of his/her time?	• The home, day care, school, and, for adolescents, the job setting may have unique environmental hazards.
What is the age and condition of your home?	• If the home was built prior to about 1978, discuss risks of lead exposure from lead paint. • If parents are unsure of the age, they can test paint with an instant lead paint tester.
Are renovations planned or in progress?	• If a parent is planning renovation, advise how to avoid lead paint exposure. • If paint is old, peeling, or in poor repair, the parent should consider de-leading by using a certified contractor. • If a patient has been exposed to lead paint, consider blood lead testing for pregnant women and children under age 6.
Do you have fuel-burning appliances and/or chimneys regularly inspected and maintained?	• If not, advise of the need for regular maintenance to avoid the hazards of carbon monoxide (CO) and other hazardous emissions. • Ask about proper ventilation for combustion products from fireplaces, wood stoves, gas stoves, and gas dryers, etc.
Do you have smoke detectors and CO detectors?	• If there are none, advise parents to purchase and install smoke detectors and carbon monoxide detectors. When a parent is purchasing CO

		detectors, advise to look for UL certification 2034.
	Has your home been tested for radon?	• If not, advise about how to test to avoid radon exposures that may increase cancer risks (see EPA http://www.epa.gov/radon).
	Does anyone in the family smoke?	• If yes, provide smoking cessation advice and help. • If a smoker can't stop now, advise that smoker to smoke outside in order to decrease the risk to children and the spouse. • The car should be smoke-free. • Make sure to advise smokers to change clothes and wash hands before interacting with children. • If the smoker is pregnant, strongly urge the smoker to quit smoking in order to avoid health risks to the fetus.
	What are the occupations of adults in the household? Is there an occupational exposure that could affect children's health?	• If yes, advise the parents about information sources for job exposures.

Is there an occupational exposure that could affect reproduction?	• If the occupation is known for exposures that can cause reproductive injury, discuss use of protective equipment and temporary change of duties during the pregnancy.
Is there a chance of take-home contamination from work-related toxicants on clothing?	• If there is potential for take-home contamination, advise showering (if possible) and changing to clean clothing and shoes before returning home. • Have the adult associated with potential take-home clothing contaminant check with the employer regarding laundering work-related clothes. Provide advice to not wash work-related clothes at home if hazardous exposures could result.
Do you have concerns about environmental hazards in your home or in the surrounding neighbor-hood?	• Environmental hazards in the home or surrounding neighborhood may include ○ air quality issues ○ drinking water contamination (check source of drinking, cooking, and bathing water), ○ exposure to hazardous waste sites, ○ toxic releases from industrial facilities, ○ Recent spills or chemical accidents near the home, school, day care, or play areas. ○ Environmental health issues at school or day care or play areas. • Advise parents to call the environmental section of their

		local health department or the regional EPA if they have concerns about environmental hazards in the surrounding neighborhood. • For information on health concerns related to environmental exposures, you or the parents may call the nearest Pediatric Environmental Health Specialty Unit (PEHSU).
	For the mother—Do you eat fish?	• If yes, inquire about the type of fish eaten and how often it is eaten.
	Does your child eat fish?	• If yes, reinforce the value of eating fish for nutritional benefits but advise that fish with known high levels of methylmercury, such as swordfish, shark, king mackerel, and tilefish, should be avoided in the child's diet. Women who are pregnant or nursing and young children should completely avoid eating these fish (for more information see http://www.fda.gov/Food/FoodborneIllnessContaminants/Metals/ucm351781.htm Also advise patients to follow local fish advisories for other types of fish or types of contamination, such as high levels of polychlorinated biphenyls (PCBs) in some farm-raised salmon.

Do you take herbal remedies or Ayurvedic (a system of health care native to the Indian subcontin-ent) medications? If so, which ones?	• Advise against uses of potentially toxic herbal remedies. • If a patient is using Ayurvedic or other folk remedies, check blood lead level, or if the patient is using azogue, check urine elemental mercury levels in consultation with PEHSU experts (http://aoec.org/PEHSU).
Do you put creams that could contain paints, pigments, or heavy metals on your skin?	• Some folk remedy creams or cosmetics can contain lead. • If suspicious, check blood lead levels of mother and/or children.
Is your child at risk for lead exposure?	• If answers to CDC screening questions are positive, check the blood lead level [CDC 2005]. • Federal law requires screening of all Medicaid-eligible children for blood level leads at ages 1 and 2 [AAP Statement on Lead 2005].
Is your child at risk for sunburn?	• Sunburns during childhood and adolescence raise the risk of melanoma later in life. • Whenever possible, outdoor activities should occur during non-peak sun exposure hours (before 10 AM and after 4 PM). • Advise parents to protect children from sunburn with

	clothing and hats whenever feasible, to have children wear ultraviolet protective sunglasses, and to have children use sunscreen with frequent reapplication (National Council on Skin Cancer Prevention—http://www.skincancerprevention.org).

Questions for Well Baby Visits

The following questions can help pediatricians assess environmental exposures especially relevant to infants.

Table 3. Additional Questions for a Well Baby Visit

Well Baby Visit Questions	Corrective Actions
Are you breastfeeding?	If yes, potentially exposed mothers should still breastfeed, since the benefits of breastfeeding still outweigh the risks from exposure in most instances.

	Do you bottle-feed the baby, or are you planning to introduce bottle-feeding? If yes, what water will you be using to mix with the formula—tap water, bottled water, or well water? If tap water, is it from the municipal water system?	If a parent is using well water, it is important to know if there are harmful contaminants, such as nitrates, that can cause methemoglobinemia in young infants. If tap water is used, advise against over-boiling to avoid concentrating such contaminants as lead. One minute of a rolling boil is sufficient. Alternatively, water may be tested for lead.
	If well water, have you had it tested for the presence of contaminants, such as bacteria, lead, and nitrates?	If the well water has not been recently tested, advise parents to use municipal water, bottled spring water, or distilled water to mix baby formula and to use as the baby's drinking water until the well is tested and shown safe for infant feeding.

Questions to Ask Parent During a Well Toddler and Young School-age Child Visit

For a routine well toddler or young school-age visit, pediatricians should ask the following screening questions in order to determine if any toxic exposures are occurring:

Table 4. Screening Questions for Well Toddler and Young School-age Visit

Toddler and Young School-age Questions	Corrective Actions

Any changes in your home surroundings or jobs?	If yes, advise appropriately per initial visit guidance.
Where does the child spend most of his/her time?	If the child stays in a child care setting with a neighbor or a relative, ask about exposure to second-hand smoke or lead paint and the presence of CO meters.
Do you have concerns about potential environmental risks?	Draw blood and check lead levels if the child is at risk, per CDC guidelines [CDC 2005].
Are pesticides used inside or outside your home? If yes, what type of pesticides? Where are they stored?	Advise parents to store pesticides out of the reach of children. Be sure that pesticides are not applied in areas where children crawl or play.
Does the child eat fish?	Some children may eat excessive amounts of fish high in mercury or other contaminants—advise parents about safer alternatives.
Is the child protected from excessive ultra violet (UV) exposure?	Children in child care or pre-school may play outside without adequate UV protection—advise parents about timing activities, using clothing and hats, and proper use of sunscreen.

Questions for Well Adolescent Visit

The following screening questions should be asked during all well adolescent visits.

Table 5. Screening Questions for the Well Adolescent Visit

Well Adolescent Questions	Corrective Actions
Does the adolescent work? If yes, what is the type of work?	Inform the parent and adolescent about rules regarding child labor restrictions (both national and state regulations).
Does the work expose the adolescent to toxic chemicals, fumes, or dusts or does it involve excessive musculoskeletal stress or work with slicing machines?	Encourage use of protective measures, if indicated.
Does the adolescent smoke? Is there exposure to SHS?	Advise about the dangers of active and passive smoking.
Is the adolescent protected from excess UV exposure?	Advise about protective measures. Strongly discourage visits to tanning salons—UV rays from tanning salons are carcinogenic.

Key Points

- An initial well child visit presents an excellent opportunity to ask basic screening questions about common environmental hazards, including lead exposure.

	• It is important to incorporate age-appropriate questions about environmental hazards during other routine office visits.
Progress Check	4. Which of the following statement(s) about taking screening exposure histories is/are true? A. It is necessary to ask all the screening questions at every visit. B. A pediatrician should perform age-appropriate risk-based screening for lead poisoning during an initial well child visit, if necessary. C. There is no need to ask age-specific screening questions because all children are exposed equally. D. All of the above. E None of the above. *To review relevant content, see "Taking a Screening Exposure History for the Well Child" in this section.*

What Types of Questions Should Be Asked if an Exposure-related Illness Is Suspected?

Learning Objectives	Upon completion of this section, you will be able to • identify exposure-related questions to ask during a sick child visit.
Introduction	For the *sick child*, the pediatrician should consider an environmental agent as potentially related to a child's current illness. This is particularly true when the illness does not follow a usual pattern or when more than one family member or a schoolmate is affected.
General Exposure-Related Questions	The first step in evaluating whether an illness is related to an environmental exposure is to elicit a connection between exposure(s) to an environmental hazard and specific symptoms. This

can be accomplished by asking the patient or parent the following questions:

- Location—Do symptoms subside or worsen in a particular location (e.g., home, school, day care, playground, or neighborhood)?
- Temporal relationship—Do symptoms remit or worsen during a particular period of time? At a particular time of day? On weekdays or on weekends? During a particular week or season of the year?
- Activity—Do symptoms worsen during a particular activity, such as playing outdoors, being at school, or engaging in a hobby?
- Are others affected?—Do adults, siblings, or children with whom your child spends time have the same symptoms as your child? [AAP 2003]

Follow-up Questions Regarding Location

Questions to help gather further details from the patient or parent about the physical setting where a child may be exposed are the following:

- Do you think that you or a family member may have a health problem caused by the home? If yes, then continue with the following questions.
- What type of building do you live in (e.g., single family dwelling, condominium, apartment, mobile home, multi-family dwelling)?
- Is it a one- or two-story home? Are cars parked in an attached garage?
- What is on the lowest level of the home?
- In what year was the home built?
- Where is it located?
- Have you renovated or added on to your home recently?
- How do you heat your home? Oil, wood, coal, solar, heat pump, natural gas?
- Do you have a secondary heat source in the home?
- Do you have a wood stove or fireplace? If so, how often do you use it/them?

- Do you or a family member run a hobby or home business that might involve hazardous exposures?
- Is any part of your home damp or have you had a major leak or flood in your home recently?
- Do you use pesticides or herbicides in or around the home?
- Has your home been tested for lead paint and/or radon?
- What is the source of your water supply?
- Are there any family members who could bring home contamination from work on clothing or shoes?
- Is your child in day care? A relative's or a friend's house?
- Is your child in school?
- Is your home located near industrial facilities, commercial orchards or farms, hazardous waste sites, municipal landfills, or underground storage tanks?
- Does your child spend time outdoors? [Children's Environmental Health Network 1999]

Temporal Relationship	Timing and duration of exposure can be important in determining whether an illness results. If the exposure is known, it is important to ask how long someone was exposed to a toxic substance and how often the child was exposed (daily, weekly, monthly, etc.). In order to establish that environmental exposure is the cause of the illness, it is necessary to ask if the exposure to the substance of concern occurred before the onset of the health condition. To complicate matters, for many toxic substances, there is a latent period between time of exposure and the appearance of a health effect. It is therefore not enough to ask if the exposure occurred before the health effect, but rather to determine if the exposure occurred within the latent period for that substance's health effect(s). For example, exposure to asbestos may result in asbestosis, lung cancer, or mesothelioma (a cancer of the pleura), but not until a latent period of 20–40 years has passed (This form of cancer occurs mainly in occupationally exposed adults and is not generally seen in children).
Are Others Affected?	Others similarly affected can point to a possible environmental exposure-related cause at home, at child care, at school, or the workplace. For public health reporting purposes, the appropriate authorities must be notified if an illness is found to be related to an environmental exposure.
Final Follow-up Questions	After completing the screening exposure history and asking more specific exposure-related questions, the pediatrician should then answer these questions to ascertain whether the illness might be exposure-related: • What is the child's specific health condition? • Is the substance(s) that the child was exposed to known to cause this type of health problem? • If so, what is the weight of scientific evidence linking that health condition to a particular substance?

- Did any other exposures occur that might be related to the identified signs and symptoms?

If the answers to these questions and the physical findings point to a link between an illness and an exposure, the pediatrician should consult with a specialist in pediatric environmental medicine (one source of consultation is http://aoec.org/PEHSU/). The pediatrician should then move ahead with ordering laboratory testing

- for possible markers of exposure (if they exist for that substance),
- for possible toxicant-related biological effects, and
- of the child's environment for the exposure source.

Progress Check	5. If an exposure seems probable after the pediatrician asks a set of screening questions, the pediatrician should do which one of the following next? A. Follow up the initial set of questions with a full environmental medicine workup. B. Refer immediately to a specialist in a PEHSU for further workup. C. Complete a full exposure history focused on questions about location, temporality, activities, and others affected. D. None of the above. *To review relevant content, see "General exposure-related Questions" in this section.*

Clinical Assessment—Clinical Evaluation of a Child with a History of Known or Suspected Exposures

Learning Objective	Upon completion of this section, you will be able to • describe how to conduct an "exposure assessment" (medical and environmental evaluation) as part of the clinical evaluation of a child with exposure (known or suspected) to hazardous substances.
Introduction	If an environmentally related problem seems likely, a full evaluation will be needed. What follows is a description of the complete clinical evaluation of a child with a known or suspected environmental exposure. This process includes an "exposure assessment" as part of a pediatric environmental medicine clinical assessment. This section also discusses what is feasible within the pediatric generalist's practice and what is usually referred to a specialist in pediatric environmental medicine.

Identify Specific Health Concerns	The first step in evaluating a possibly exposure-related health concern is taking an exposure history. For the *child with a history of a known exposure*, *with or without symptoms,* concerned parents may visit their child's pediatrician with worries that their child may become sick in the future. The parents may inquire about signs and symptoms associated with exposures.

Establish a Problem List

Pediatricians can use the history, physical examination, and problem-specific laboratory tests to establish a problem list and a differential diagnosis.

The evaluation may identify an environmentally related condition such as headache and fatigue related to carbon monoxide exposure, as illustrated by the case study. Common environmentally related conditions are asthma (related to second-hand smoke (SHS) exposure or indoor air pollutants from a wood stove or fireplace) and otitis media (related to SHS exposure). Eczema may possibly be related to an adolescent's job exposure.

In other situations, the initial problem list may include only signs, symptoms, and laboratory test results. The pediatrician who has experience with environmental toxicants may quickly suspect that a disease or syndrome (such as asthma or acute lead toxicity) is associated with a hazardous environmental exposure. The problem list should still be used, however, to keep the differential diagnosis broad in the beginning. Any and all specific exposures identified by the child's parents or caregiver(s) or suspected by the pediatrician should be listed.

Pediatricians who suspect an unusual environmental cause for an illness will often find it useful to contact an expert in pediatric environmental medicine. Pediatric Environmental Health Specialty Units (PEHSU), located in the ten Federal Regions of the United States and in Canada and Mexico, can provide information, assistance, and referral for clinical evaluation if environmental exposures are verified (see the "For More Information" section later in this CSEM for additional information regarding the PEHSU and visit http://www.aoec.org/PEHSU/).

Identify All Routes of Environmental Exposure

Pediatricians should identify all the routes by which a child may be exposed to chemicals. The child may be exposed via

- the oral route (ingestion),
- the respiratory tract (inhalation), or
- through the skin (dermal exposure).

Taking a careful environmental exposure history is the key to establishing to which chemicals the child may have been exposed and the route(s) of exposure.

When considering environmental health hazards relevant to children, pediatricians should keep in mind that exposures may have occurred during the preconception period, transplacentally during the prenatal period, or via breastfeeding. These past exposures are not generally of primary relevance during an acute illness but they can contribute to chronic illnesses.

Pediatricians are advised to collect information about all possible exposures to environmental hazards, even if a parent is focused on a specific exposure. For example, in this monograph's case study, even though the major focus was on carbon monoxide, the patient also had symptoms suggestive of allergy and/or asthma. After the acute and potentially life-threatening exposure is remedied, the pediatrician can ask additional questions about allergens or irritants at school, the playground, or the home. Given time constraints of a busy practice, asking these additional questions may be most appropriate at a follow-up visit. As with other areas in pediatrics, it is important to prioritize the issues.

The pediatrician should be alert to clusters of cases presenting to the office; these situations will prompt further investigations.

When parental occupations may result in the parents' bringing home a toxicant on clothes or

	shoes ("take-home exposures"), the pediatrician may recommend that parents request copies of Material Safety Data Sheets (MSDS) from the employer. MSDS provide key information regarding substances used at work that may be hazardous. An MSDS describes routes of exposure for specific hazardous substances. The route of exposure often determines whether an environmental contaminant will cause harm. For example, a child might bite and break a mercury thermometer and swallow its liquid contents. Fortunately, elemental mercury is relatively nontoxic when ingested because it is not well absorbed by the intestinal tract. However, because of its high absorption by the respiratory tract, elemental mercury is highly toxic when it volatilizes and is inhaled. A child will have greater exposure by playing with a tiny ball of mercury than by eating it. REMEMBER: No matter how toxic, no chemical will cause harm unless there is exposure (biologic uptake) and subsequent target organ contact that causes biologic changes that may result in disease. Preventing exposure is the key to stopping further harm. If you suspect that an exposure is occurring, you should move quickly to stop further exposure. Experts from Poison Control Centers and/or the PEHSU can give advice on how to stop further exposure from occurring.
Characterize Exposure using Biologic and Environmental Testing	The exposure assessment as part of the clinical assessment of a patient exposed or potentially exposed to hazardous substances generally relies on three tools: 1. the exposure history, 2. diagnostic testing of blood, urine, or other body fluids or tissues from the exposed person, and 3. environmental testing. After compiling a list of chemicals to which the child may have been exposed, you may find it necessary to perform testing. Diagnostic medical

laboratory testing for exposure and/or effect along with environmental testing of environmental contamination levels can help determine the presence, estimate dose, and assess the effects of harmful contaminants.

Principles of diagnostic medical laboratory testing.

Dose-response refers to the extent of a biologic effect in relation to the received dose of an agent.

- Generally, the higher the dose, the greater the effect (although variations exist).
- One exception, as discussed in the *Principles of Pediatric Environmental Medicine*, is that low doses of some substances at critical periods of organ development (such as *in utero* or early in life) may have a greater effect than higher doses at other times.
    - An example of the greater effect of a substance early in life is lead toxicity. Compared to the adult brain, the developing brain of the fetus and the young child is especially sensitive to the effects of lead.

An exposure assessment as part of the clinical assessment of a patient exposed or potentially exposed to an environmental toxicant seeks to estimate as closely as possible the absorbed dose. The estimation is usually done in consultation with specialists, including industrial hygienists, environmental public health assessors, or pediatric environmental medicine specialists. Exposure intensity, duration, and frequency all contribute to the received dose. Testing for health effect can provide valuable information for the clinician, especially when testing for exposure is not available.

There are published national biologic levels of many environmental contaminants. The levels are derived by testing a sample of the population as part of the National Exposure Report from CDC's National Health and Nutrition Examination Survey (NHANES). These levels can be accessed at: http://www.cdc.gov/exposurereport .

As described in the case study, it is important to choose a laboratory test of exposure that is based on principles of biological monitoring, in such a way that the measure

- accurately reflects exposure,
- can be collected before the substance is excreted from the body,
- correlates the dose with the health effect, and
- is the least painful and inconvenient.

Laboratory testing that may be used in the clinical assessment of an exposed patient includes determining *biomarkers of exposure* that measure the substance in the body directly and *biomarkers of effect* that assess the effects of the substance on the body's organs and systems.

Biomarkers of exposure: Many environmental contaminants do not have specific tests for their levels in the body after exposure. For others, there is often the need to

- have specialized and well-timed collection procedures (24 hour urines, or collection procedures to avoid contaminants),
- use specialized laboratories, and
- consult with a specialist to determine the type of measure needed and how to interpret results [Hoffman et al. 2007].

Biomarkers of effect: In order to correctly interpret these results, pediatricians must understand how the substance acts in the body (its toxicology) and the limitations of the tests ordered.

Information about a substance's toxicokinetics (its metabolism and excretion) can help to predict the type of biologic monitoring that may be useful to measure exposure and effect. Information about half-life can help a pediatrician interpret results of biologic testing. Information about animal and human toxicities helps to focus laboratory testing on organs known to be affected.

Table 6. Examples of Laboratory Tests of Exposure

Substance	Specimen Required	Factors Affecting Levels	Levels of Concern in Children
Carbon monoxide (CO)-carboxyhemoglobin	Blood	Cigarette smoking	See table in initial check.
Lead	Blood		Blood lead level >10 ug/dl.*
Mercury**	24 hour urine	Fish consumption; dental amalgam fillings	No safe levels in children identified.
Arsenic—inorganic**	24 hour urine	Organo-arsenic from seafood (abstain 3 days before testing)	No safe level of inorganic arsenic identified

* The current level of concern; however, this level is under investigation and may be revised downwards.

**Testing for mercury and/or arsenic is not generally done in the context of a general pediatrician's practice. Consultation with experts in pediatric environmental medicine is recommended if excessive exposure to mercury and/or arsenic is suspected.

NOTE: Several tests, e.g., fat levels of dioxins, are not readily interpretable on a clinical level. These tests are conducted in research settings and should not be ordered for clinical reasons. Similarly, testing hair and nail samples for exposures to such substances as heavy metals should not be done because the results can be inaccurate and hard to interpret.

Environmental Monitoring

Environmental monitoring is often an important component of assessing or estimating exposure dose. Sometimes it is the major component when biological monitoring is not possible or adequate. Such environmental monitoring might include air monitoring (as in the case of CO) and monitoring of such other media as water and soil. Reference ranges are available for acceptable levels of contaminants in drinking water [EPA 2003], ambient (outdoor) air (http://www.epa.gov/ttn/naaqs/), and indoor air (http://www.epa.gov/iaq/co.html).

It is not expected that a pediatrician in a busy practice perform or interpret environmental monitoring data. However, awareness that this information is often used, if available, to estimate exposure dose is relevant. Consultation with pediatricians with expertise in environmental medicine regarding interpretation of this type of

data for use within a clinical context is recommended.

Research the Properties of the Identified Toxicants	After identification of the relevant environmental contaminant by history and testing, its properties must be researched. If the pediatrician is not familiar with the contaminant or if the case is complex or unusual, consultation with a specialist is indicated. Relevant specialists include experts in pediatric environmental medicine, the poison control center, and/or a toxicologist. See the "For More Information" section later in this CSEM for additional resources. Physical and chemical properties of a contaminant help to determine the likelihood of exposure and subsequent absorption, metabolism, and excretion. For example, knowing that CO is well absorbed through the respiratory tract and that it binds tightly to hemoglobin implies excellent respiratory absorption of carbon monoxide. Air monitoring can contribute to understanding the extent of the exposure to CO.

Characterize the Significance of the Exposure

After reviewing the results of laboratory tests and environmental monitoring, the pediatrician needs to evaluate whether sufficient exposure has occurred and whether the exposure could have resulted in the child's illness. Several questions may clarify the possible relationship between an environmental exposure and a disease.

- Has the chemical been associated with the patient's health effects in other people? If so, how strong is the association?
- How does the child's estimated absorbed dose compare with what is known about dose-response relationships? Is there published information on human exposure and disease for this chemical? NOTE: if only occupational exposure standards exist, be aware that adult occupational standards are not usually considered to be protective of child health.
- Does the child have any factors that could increase or decrease susceptibility to illness from exposure to this chemical?
- Are there other exposures occurring to shift the risk of disease in this child?
- How does the environmental contribution to this illness compare with other possible causes?

For John, the child described in the case study, CO exposure has been strongly associated with health effects, including death. John's symptoms correlate with the measured level of carboxyhemoglobin in his blood. As with many environmental toxicants, infants and children are more susceptible to the effects of CO. A child's rapid metabolism makes children more susceptible to CO effects; fetuses are especially vulnerable. There are other possible causes for his symptoms, but CO exposure is the most likely. It is life-threatening and must be swiftly remedied.

In other environmental exposures, no certain conclusions can be drawn about the role of the

chemical in causing a symptom or an illness. In these cases, the probability that the chemical is playing a role in the child's illness must be considered. The pediatrician's task in such cases is to

- find out as much as possible about the chemical,
- explain the possible risks to the best of the physician's ability, and
- determine whether abatement steps are possible and/or necessary.

NOTE: More detailed information regarding the environmental exposure history, biologic monitoring, environmental monitoring, communicating about risk, and assessing a child's risk goes beyond what most general pediatricians will realistically know and do in a busy practice. Resources are provided later in the case study to help expand pediatricians' knowledge about the role of environmental health professionals and to enable communication with others. Resources include staff at state or local health departments, Poison Control Centers, the Agency for Toxic Substances and Disease Registry, the Association of Occupational and Environmental Clinics, and PEHSUs.

Key Points

- An exposure assessment is performed to confirm an environmental exposure and/or to estimate absorbed dose.
- The clinical assessment for exposed or potentially exposed patients is a logical, stepwise approach that includes an exposure assessment in exploring the likelihood of environmentally related illness.
- The exposure assessment relies on three main tools:
  - the exposure history,
  - biological testing of blood, urine, or other body fluids or tissues from an exposed child, and

		○ environmental monitoring performed on environmental samples.
Progress Check	6.	Which of the following statements about exposure assessment is/are true? A. In children, the dose of the chemical is the sole determinant of harm. B. The particular route of exposure to a chemical can determine whether an environmental contaminant will cause harm. C. Specialized laboratory tests for environmental chemicals are easily collectable and are widely available. D. All of the above. E. None of the above. *To review relevant content, see* "Identify All Routes of Environmental Exposure" *in this section.*

How Do You Manage a Child with Known Environmental Exposures?

Learning Objective	Upon completion of this section, you will be able to • describe how to medically manage a child exposed to hazardous substances.
Introduction	Six clinical interventions are recommended to manage a pediatric environmental medicine problem. 1. Ending or minimizing the offending exposures. 2. Delivering standard symptomatic supportive medical therapy. 3. Determining and delivering substance-specific medical interventions. 4. Referring to specialists in toxicology and pediatric environmental medicine.

5. Educating the family and communicating risk.
6. Public health reporting.

Ending or Minimizing Exposures

The pediatrician has a key role in orchestrating the elimination or reduction of a child's ongoing exposure.

For example, if hospitalizing a child poisoned by a heavy metal such as lead is necessary, the pediatrician initiates hazard reduction by removing the child from the offending environment. Before returning the child to the home, however, pediatrician must ensure elimination or mitigation of the environmental hazard. Whenever possible, the offending chemical should be entirely removed. Substitution should be made if the chemical serves an important function and it is possible to substitute a less toxic alternative. For example, homeowners and public health authorities must ensure that leaded paint is replaced with a non-lead alternative.

A toxicant is hazardous only to the extent exposure occurs. Measures other than removal can often accomplish the goal of hazard reduction more quickly and inexpensively. Measures may include

- blocking pathways of exposure—e.g., friable asbestos insulation on pipes may be encapsulated to reduce indoor air asbestos contamination,
- putting household chemicals out of children's reach and using a charcoal filter to manage certain contaminants in tap water, and
- running the water a few minutes before drinking.

In many cases, pediatricians can provide information and guidance to the family in order to make an environment safer for a child. Information from the American Academy of

Pediatrics and other organizations will help pediatricians:

- inform parents about reducing environmental asthma triggers,
- reduce hazards of pesticides and other household chemicals, and
- properly store medicines.

Improper attempts by untrained persons to mitigate environmental contaminants can lead to dramatic exposures. For example, an untrained individual who attempts to remove lead paint might acutely increase contamination levels of exposure for children and pregnant women, and such levels could cause acute poisoning. The untrained individual can even poison himself/herself if not taking proper protective measures. Pediatricians should always collaborate with specialists in pediatric environmental medicine and public health agencies to obtain names of licensed remediation specialists.

In some acute exposures, exposure cessation involves medical interventions. For example, first responders to a person exposed to a hazardous pesticide must

- first assess the scene and protect themselves and others near the scene,
- then remove the individual from the contaminated environment,
- then remove tainted clothing, and
- finally grossly decontaminate the individual's body (e.g., by giving the individual a shower).

More refined decontamination then continues in the medical setting. First responders must always be mindful of their own safety in these situations because an offending chemical may cause symptoms, or even death, in responders.

	Some medical interventions aim to stop the absorption of certain toxicants. Interventions for acute ingestions include using • activated charcoal, • gastric lavage, emetics, and • cathartics for acute ingestion. It is important to remember, however, that these measures are *not* recommended for all toxicants and might be contraindicated for some. It is important to consult an up-to-date resource, such as a poison control center or pediatric toxicologists, for substance-specific treatment recommendations.
Standard Supportive Medical Therapy	Standard supportive medical protocols and pharmaceuticals are used to treat the majority of environmental illnesses. In most situations, the environmental contribution to an illness will not be immediately apparent. Standard therapies pending determination of an environmental cause or trigger are called for in cases of • respiratory failure, • cancer, • asthma, • contact dermatitis, and • other medical conditions. Even then, medical treatment only rarely involves the use of medical therapies specific to a particular chemical agent. The *Medical Management Guidelines for Acute Chemical Exposures* [ATSDR 2001] reviews the appropriate medical management of many of the most common acute chemical exposures. A pediatrician should strongly consider consultation for many acute *known* exposures when or if the child is very ill or for *unknown* exposures when the child's signs and symptoms do not follow a usual pattern. Such consultation can be with • pediatric emergency specialists, • pediatric intensive care specialists,

	• medical toxicologists, and/or • pediatric environmental medicine specialists (e.g., PEHSUs).
Substance-specific Medical Therapy	Although only relatively few substances have specific medical therapies, the use of such therapies can • enhance the elimination of an agent, • block its absorption, • reverse its effect, or otherwise • render it less harmful. After identifying the offending agent, the pediatrician should consult specialists, texts, electronic databases, appropriate agencies such as the Agency for Toxic Substances and Disease Registry (ATSDR), or other experts to ascertain whether specific therapies exist for the exposure. Telephone hotlines through regional poison control centers and ATSDR provide 24-hour support for clinical decision-making in cases of acute exposure.
Referrals	The pediatrician's privileged position of trust provides an opportunity to effectively communicate with parents and coordinate medical care in the event of an exposure. The pediatric generalist, however, will rarely have the specialized knowledge needed to manage less common environmental problems. The pediatrician should work with specialized professionals to develop and support an appropriate therapeutic plan. Indications for referral to a pediatric environmental medicine specialist or government or private organization include • uncertainty about the extent and nature of relevant exposures, • uncertainty about an environmental relationship to a specific health problem, • uncertainty in how to characterize a child's risk of exposure and illness (risk characterization),

	• the need for assistance in how to accurately and understandably communicate a child's risk to parent (risk communication), • presentation of similar problems from similar environments for several children, • the need for specialized diagnostic or therapeutic interventions, • the need for expensive environmental mitigation management, and • consideration of a novel environmental diagnosis from a hazardous exposure with public health implications.
Family Education and Risk Communication	Effective communication is essential in the formation of a therapeutic alliance between the pediatrician and the family. Unlike standard health education and risk communication, environmental risk communication has its own unique aspects. Among these aspects are • physician unfamiliarity with environmental risk assessment, and • lack of information on the child health effects of many chemicals [Kilpatrick et al. 2002; Galvez et al. 2007]. The pediatrician may need more than one visit to fully inform parents of the possible consequences of their child's exposure. Thus, after delivery of specific, understandable information about the risks due to a child's exposure, it is also important to give accurate written information to be reviewed by parents at a later time. It is wise to schedule a follow-up appointment to share results of any medical screening tests and to answer questions. The follow-up visit will also provide the opportunity to ask how the child and parents are feeling and to give the family the chance to discuss the emotions the members have experienced. The main goals of these interactions are to give accurate information that enables parents to understand relative risk and to help

the family gain and maintain a sense of control over its health risks and concerns.

For concerned parents of well children and for parents whose children *may have* been exposed to an environmental toxicant, a good way to prevent further exposure is by using problem-focused risk communication.

Among the common substances to which children may be exposed in the home, school, or such outdoor environments as playgrounds are

- second-hand smoke,
- mold ,
- radon (indoors),
- carbon monoxide,
- lead,
- mercury,
- pesticides, and
- other chemicals.

Talking to parents about ways to safely prevent exposure (hazard mitigation, removal of hazardous substances, substitution of less toxic products) and referring them to accurate sources of information are good ways to prevent pediatric exposures.

Specific pointers on how to deliver information about environmental risk.

- Use familiar terms to discuss risk (i.e., use *air pollution* rather than *PM2.5* (particulate matter less than 2.5 microns in diameter) or *PM10 particulates* (particle matter less than 10 microns in diameter). Avoid medical and technical jargon and abbreviations.
- Anxious or upset people can process only a limited amount of information in a short time. Use the rule of threes—present only three main items of information in the first visit.
- Keep messages short and simple.

- Provide concrete steps that parents can take to prevent exposures to their children or to limit health effects from past exposures.
- Provide take-home written materials for parents. Such materials should address exposure-specific information, child sick care, and risk reduction actions needed. Pick materials with visual information, materials that have been developed by experts who have scientific expertise *and* health education and communication expertise [Galvez et al.2007].

Public Health Reporting

Many states require reporting of *specific* environmental illnesses, such as lead or pesticide poisoning. Beyond these requirements, however, every case of environmental illness that a pediatrician identifies presents the opportunity to prevent further harm to the patient and to others. If one household member is exposed, others in the household or community may also be exposed. Pediatricians should initiate an appropriate environmental investigation, in consultation with environmental health specialists, in such cases to prevent additional exposures. In cases where public health reporting is not an issue (e.g., urging parents to eliminate exposure to second-hand smoke or removing animals from the home), anticipatory guidance is sufficient. In complex situations, the pediatrician should report environmental exposures and illnesses to public health authorities.

Key Points

- Six interventions are recommended to manage a pediatric environmental medicine problem:

  1. Ending or minimizing offending exposures.
  2. Delivering standard symptomatic supportive medical therapy.
  3. Determining and delivering substance-specific medical interventions.
  4. Referring to specialists in toxicology and pediatric environmental medicine.

5. Educating the family and communicating risk.
6. Public health reporting.

Progress Check

7. Which of the following is/are among the steps that a pediatrician can take to manage a child affected by environmental exposures?

   A. Administering standard supportive therapy if no antidote exists.
   B. Immediately stopping or reducing ongoing exposures.
   C. In case of a complex case, referring the patient to a pediatric specialist in toxicology.
   D. All of the above.
   E. None of the above.

   To review relevant content, see all content in this section.

For More Information

Pediatric Environmental Medicine Resources

Please refer to the following Web resources for more information on taking a pediatric exposure history and addressing environmental exposures of children.

- Agency for Toxic Substances and Disease Registry http://www.atsdr.cdc.gov
  - For chemical, emergency situations

- **CDC Emergency Response: 770-488-7100 and request the ATSDR Duty Officer**

  - For chemical, non-emergency situations

    - CDC-INFO http://www.cdc.gov/cdc-info/index.html
    - 800-232-4636 TTY 888-232-6348 - 24 Hours/Day
    - E-mail: cdcinfo@cdc.gov

      PLEASE NOTE
      ATSDR cannot respond to questions about individual medical cases, provide second opinions, or make specific recommendations regarding therapy. Those issues should be addressed directly with your health care provider.

- Pediatric Environmental Health Specialty Units (PEHSU) http://www.pehsu.net

  - The PEHSU's provide education and consultation for health professionals, public health professionals, and others about the topic of children's environmental health.
  - The PEHSU staff members are available for consultation about potential pediatric environmental health concerns affecting both the child and the family. Health care professionals may contact their regional PEHSU for clinical advice.

- Poison Control Center

  - The American Association of Poison Control Centers (AAPCC) may be contacted for questions about poisons and poisonings. The Web site provides information about poison centers and poison prevention. AAPCC does not provide information about

	treatment or diagnosis of poisoning or research information for student papers. ○ American Association of Poison Control Centers (1-800-222-1222 or http://www.aapcc.org). • American Academy of Pediatrics ○ The AAP is a professional membership organization of 62,000primary care pediatricians, pediatric medical sub-specialists, and pediatric surgical specialists dedicated to the health, safety, and well-being of infants, children, adolescents, and young adults. • American College of Medical Toxicologists (ACMT) http://www.acmt.net is a professional, nonprofit association of physicians with recognized expertise in medical toxicology.
General Environ-mental Medicine Resources	Please refer to the following Web resources for general information on environmental medicine: Agency for Toxic Substances and Disease Registry http://www.atsdr.cdc.gov • Taking an Exposure History CSEM http://www.atsdr.cdc.gov/csem/csem.asp?csem=33&po=0 • To view the complete library of CSEMs http://www.atsdr.cdc.gov/csem/csem.html • Centers for Disease Control and Prevention (CDC) http://www.cdc.gov ○ CDC works to protect public health and the safety of people, by providing information to enhance health decisions, and promotes health through partnerships with state health departments and other organizations.

- CDC focuses national attention on developing and applying disease prevention and control (especially infectious diseases), environmental health, occupational safety and health, health promotion, prevention, and education activities designed to improve the health of the people of the United States.

- National Center for Environmental Health (NCEH) http://www.cdc.gov/nceh/

  - NCEH works to prevent illness, disability, and death from interactions between people and the environment.
  - It is especially committed to safeguarding the health of populations that are particularly vulnerable to certain environmental hazards—children, the elderly, and people with disabilities.

- National Institute of Health (NIH) http://www.nih.gov

  - A part of the U.S. Department of Health and Human Services, NIH is the primary federal agency for conducting and supporting medical research.

- National Institute of Occupational Safety and Health (NIOSH) http://www.cdc.gov/niosh/

  - NIOSH is in the U.S. Department of Health and Human Services. Part of CDC, it is an agency established to help assure safe and healthful working conditions for working men and women by providing research, information, education, and training in the field of occupational safety and health.

- American College of Occupational and Environmental Medicine (ACOEM) http://www.aoec.org

- ACOEM is the nation's largest medical society dedicated to promoting the health of workers through preventive medicine, clinical care, research, and education.
- Its members encompass specialists in a variety of medical practices united by the college to develop positions and policies on vital issues relevant to the practice of preventive medicine, both within and outside the workplace.

- American College of Preventive Medicine http://www.acpm.org

  - The American College of Preventive Medicine (ACPM) is the national professional society for physicians committed to disease prevention and health promotion.
  - ACPM's 2,000 members are engaged in preventive medicine practice, teaching, and research.

- Association of Occupational and Environmental Clinics http://www.aoec.org

  - The Association of Occupational and Environmental Clinics (AOEC) is a network of more than 60 clinics and more than 250 individuals committed to improving the practice of occupational and environmental medicine through information-sharing and collaborative research.

Posttest

Posttest

There may be more than one correct answer. Select the best answer or all that apply for each question below.

1. Pediatricians can help prevent harm to children from environmental agents by

   A. Counseling expectant parents about how to prevent in utero exposures to harmful substances.
   B. Providing diagnostic work-ups to exposed children.
   C. Advising parents on how children can avoid toxic exposures.
   D. Screening children for common exposures, e.g., lead poisoning
   E. All of the above.

2. When choosing a lab test to look for health effects of toxicants, one should

   A. Know the half-life of the substance in the body and test during that time frame.
   B. Use normal laboratory tests only.
   C. Consult with experts, such as poison control centers and pediatric toxicologists.
   D. Use only environmental monitoring to measure levels in the external environment.
   E. All of the above.

3. The purpose of a pediatric environmental exposure history is to

   A. Help pinpoint the possible environmental agents leading to an illness.
   B. Help guide epidemiological investigations.
   C. Avoid the necessity of expensive laboratory testing.
   D. All of the above.
   E. None of the above.

4. Some of the topics covered in a pediatric environmental hazards checklist are

   A. Use of alcohol during pregnancy.
   B. Checking the home for common environmental hazards.
   C. Avoiding exposure of children to pesticides in the environment.
   D. Asking about the safety of day care and school environments.
   E. All of the above.

5. Typical screening questions to rule out environmental hazards during a well-child visit may include questions about

   A. Exposures of the parents to tanning booths.
   B. Bottle-feeding or breastfeeding.
   C. Proximity to power lines.
   D. Presence of lead-related hazards in the home or day care.
   E. None of the above.

6. When taking the history of a child suspected of having an illness with a possible environmental etiology, the physician should ask questions about

   A. Locations where the symptoms occur.
   B. When symptoms occur or worsen.
   C. Whether other members of the family are affected by similar symptoms.
   D. All of the above.
   E. None of the above.

7. After a pediatrician completes a pediatric exposure history for a child suspected of having an environmentally related condition, the next steps to conduct a clinical assessment would be

   A. Construct a problem list based on the detailed exposure history.
   B. Always perform environmental testing to rule out exposures.

C. Define if exposure has occurred by diagnostic testing.
D. All of the above.
E. None of the above.

8. What is the chief way to manage a pediatric illness known to be associated with an environmental exposure?

A. Immediately administer an antidote.
B. End or minimize the offending exposure.
C. Educate the family about environmental exposures.
D. All of the above.
E. None of the above.

Literature Cited

[AAP] American Academy of Pediatrics, Committee on Environmental Health. 2003. *Pediatric Environmental Health, 2nd Edition.* Etzel, RA, Balk, SJ, editors. Elk Grove Village, IL: AAP.

[AAP] American Academy of Pediatrics, Committee on Environmental Health. 2005. Lead exposure in children: prevention, detection, and management. Pediatrics 116(4):1036–1046.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001. Managing Hazardous Materials Incidents (MHMI). Atlanta, GA: US. Department of Health and Human Services, Public Health Service.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001a. Summary report for the ATSDR soil-pica workshop, June 2000. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2007. Case studies in environmental medicine: lead toxicity. Atlanta, GA: US Department of Health and Human Services.

Anto J, Sunyer J, Rodriquez-Roison R, Suarez-Cervera M, Vazquez L, et al. 1989. Community outbreaks of asthma associated with

inhalation of soybean dust. New England Journal of Medicine 320(17):1097–1102.

Anto JM, Sunyer J, Reed CE, Sabria J, Martinez F, Morell F, et al. 1993. Preventing asthma epidemics due to soybeans by dust-control measures. New England Journal of Medicine 329(24):1760–1763.

Binder S, Sokal D, Maughan D. 1986.Estimating soil ingestion: the use of tracer elements in estimating the amount of soil ingested by young children. Archives of Environmental Health 41:341–345.

[CDC - NCEH] Centers for Disease Control—National Center for Environmental Health. Preventing lead poisoning in young children. Atlanta GA [updated 2005 August; accessed 2008 June 11]. Available from:http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning.pdf.

[CDC – NCEH] Centers for Disease Control—National Center for Environmental Health. 2009. Fourth National Report on Human Exposure to Environmental Chemicals. [Accessed 2010 December 7.] Available from: http://www.cdc.gov/exposure report.

[CEHN] Children's Environmental Health Network. 2006. Training manual on Pediatric Environmental Health: Putting It Into Practice. Accessed on September 22, 2008 at www.cehn.org/cehn/manual-front.html.

[EPA] Environmental Protection Agency. 2003. Sources of indoor air pollution—basic information—carbon monoxide. Washington DC [updated 2008 May 27; accessed 2008 June 11]. Available from: http://www.epa.gov/iaq/co.html.

Ernst A, Zibrak JD. 1998. Carbon monoxide poisoning. New England Journal of Medicine 339(22):1603–1608.

Galvez MP, Peters R, Graber N, Forman J. 2007.Effective risk communication in children's environmental health: lessons learned from 9/11. Pediatric Clinics in North America 54:33–46.

Government of Alberta. August 2007. Carbon monoxide at the work site. Workplace Health and Safety. Workplace Health and Safety Bulletin. Accessed 2008. Available from: *employment.alberta.ca/documents/WHS/WHS-PUB_ch031.pdf*

Guidotti TL, Ragain L. 2007. Protecting children from toxic exposure: three strategies. Pediatric Clinics of North America 54:227–235.

Hoffman HE, Buka I, Phillips S. 2007. Medical laboratory investigation of children's environmental health. Pediatric Clinics of North America 54:399–415.

Jusko T, Henderson C, Lanphear B, Cory-Slechta D, Parsons P, Canfield R. 2008. Blood lead concentrations < 10 µg/dL and child intelligence at 6 years of age. Environmental Health Perspectives 116(2):243–248.

Karr CJ, Solomon GM, Brock-Utne AC. 2007. Health effects of common home, lawn, and garden pesticides. Pediatric Clinics of North America 54:63–80.

Kilpatrick N, Frumkin H, Trowbridge J, Escoffery C, Geller R, Rubin L, et al. 2002. The environmental history in pediatric practice: a study of pediatricians' attitudes, beliefs, and practices. Environmental Health Perspectives 110(8):823–827.

Knight S, Junkins EP, Lightfood AC, Cazier CF, Olson LM. 2000. Injuries sustained by students in shop class. Pediatrics. 106:10–13.

Kwon OY, Chung SP, Ha YR, Yoo IS, Kim SW. 2004. Delayed postanoxic encephalopathy after carbon monoxide poisoning. Emergency Medicine Journal 21(2):250–251.

March of Dimes. 2008. Preconception Health Care. Accessed September 22, 2008 at www.MarchofDimes.com

[NIOSH] National Institute of Occupational Safety and Health. NIOSH alert: preventing death, injuries and illnesses of young workers. Cincinnati OH [updated 2003 July; accessed 2008 June 11] Available from:http://www.cdc.gov/niosh/docs/2003-128/2003128.html.

Office of Surgeon General. 2001. The Surgeon General's call to action to promote sexual health and responsible sexual behavior. Accessed September 22, 2008 at http://www.surgeongeneral.gov

Piantadosi CA. 2002. Carbon monoxide poisoning. New England Journal of Medicine 347(14):1054–1055.

Sanborn M, Abelsohn A, Campbell M, Weir M. 2002. Identifying and managing adverse environmental health effects: 3. Lead exposure. Canadian Medical Association Journal 166(10):1287–1292.

Sanborn M, Cole D, Abelsohn A, Weir E. 2002. Identifying and managing adverse environmental health effects: 4. Pesticides. Canadian Medical Association 166(11):1431–1436.

Sattler B, Afzal B, Condon M, Belka E, McKee T. 2003. Children's health and the environment: environmentally health homes and communities. Medscape: Ejournal. Available from: http://www.medscape.com/viewprogram/2660_pnt.

Schreiber JS. 2001. Parents worried about breast milk contaminants: what is best for baby? Pediatric Clinics of North America 48(5):1113–1128.

Selevan SG, Kimmel CA, Mendola P. 2000. Identifying critical windows of exposure for children's health. Environmental Health Perspectives 108 (Suppl 3):451–457.

Thom SR. 2002. Hyperbaric-oxygen therapy for acute carbon monoxide poisoning. New England Journal of Medicine 347(14):1105–1106.

Weaver LK, Hopkins RO, Chan KJ, Churchill S, Elliott CG, Clemmer P, et al. 2002. Hyperbaric oxygen for acute carbon monoxide poisoning. New England Journal of Medicine 347(14):1057–1067.

Weitzman M, Gortmaker SL, Sobol AM, Perrin JM. 1992. Recent trends in the prevalence and severity of childhood asthma. Journal of the American Medical Association 268:2673–2677.

Woolf AD, Goldman R, Bellinger DC. 2007. Update on the clinical management of childhood lead poisoning. Pediatric Clinics of North America 54:271–294.

Additional Suggested Reading

Pediatric environmental medicine

[AAP] American Academy of Pediatrics. 1997. Breastfeeding and the use of human milk. Pediatrics 100:1035−1039.

[AAP] American Academy of Pediatrics Committee on Drugs. 2001. Transfer of drugs and other chemicals into human milk. Pediatrics 108(3):776−789.

Anderson LM, Diwan BA, Fear NT, Roman E. 2000. Critical windows of exposure for children's health: cancer in human epidemiological studies and neoplasms in experimental animal models. Environmental Health Perspectives 108 (suppl 3):573−594.

Avery AA. 1999. Infantile methemoglobinemia: reexamining the role of drinking water nitrates. Environmental Health Perspectives 107:583−586.

Bearer CF. 1995a. Environmental health hazards: how children are different frm adults. Future Child 5(2):11−26.

Braue EH, Boardman CH, Hurst CG. 2008. Decontamination of chemical casualties. In: Medical Aspects of Chemical Warfard. S.D. Tourinsky, editor. Washington, DC, Office of the Surgeon General, United States Army: 527−557.

Committee on Environmental Health 2004. Ambient air pollution: health hazards to children. Pediatrics 114(6):1699−1707.

Committee on the Health and Safety Implications of Child Labor, Institute of Medicine. 1998. Protecting youth at work. Washington, DC: National Academy Press.

Cook DG, Strachan DP. 1999. Health effects of passive smoking: summary of effects of parental smoking on the respiratory health of children and implications for research. Thorax 54:357−366.

DeBaun MR, Gurney JG. 2001. Environmental exposure and cancer in children: a conceptual framework for the pediatrician. Pediatric Clinics of North America 48(5):1215−1222.

Delfino RJ. 2002. Epidemiologic evidence for asthma and exposure to air toxics: linkages between occupational, indoor, and community air pollution research. Environmental Health Perspectives 110 Suppl 4:573−589.

Dietert RR, Etzel RA, Chen D, Halonen M, Holladay SD, Jarabek AM, et al. 2000. Workshop to identify critical windows of exposure for children's health: immune and respiratory systems work group summary. Environmental Health Perspectives 108 (suppl 3):483–490.

Etzel RA. 2003. How environmental exposures influence the development and exacerbation of asthma. Pediatrics 112(1):233–239.

Etzel RA. 2001. Indoor air pollutants in homes and schools. Pediatric Clinics of North America 48(5):1153–1166.

Gitterman BA, Bearer CF. 2001. A developmental approach to pediatric environmental health. Pediatric Clinics of North America 48(5):1071–1084.

Guzelian PS, Henry CJ, Olin SS, editors. 1992. Similarities & Differences Between Children and Adults: Implications for Risk Assessment. Washington, DC: ILSI Press.

Hudson PJ, Vogt RL, Brondum J, Witherell L, Myers G, Paschal DC. 1987. Elemental mercury exposure among children of thermometer plant workers. Pediatrics 79:935–938.

Hwang YH, Bornschein RL, Grote J, Menrath W, Roda S. 1997. Urinary arsenic excretion as a biomarker of arsenic exposure in children. Archives of Environmental Health 52:139–147.

[IOM] Institute of Medicine. 2000. Clearing the air: asthma and indoor air exposures. Washington, DC: National Academies Press.

[IOM] Institute of Medicine. 2004. Damp indoor spaces and health. Washington, DC: National Academies Press.

Landrigan PJ, Lioy PJ, Thurston G, Berkowitz G, Chen LC, Chillrud SN, et al. 2004. Health and environmental consequences of the world trade center disaster. Environmental Health Perspectives 112(6):731–739.

Landrigan PJ, Kimmel CA, Correa A, Eskenai B. 2004. Children's health and the environment: public health issues and challenges for risk assessment. Environmental Health Perspectives 112:257–265.

Lemasters GK, Perreault SD, Hales BF, Hatch M, Hirshfield AN, Hughes CL, et al. 2000. Workshop to identify critical windows of exposure for children's health: reproductive health in children and adolescents work

group summary. Environmental Health Perspectives 108 (suppl 3):505–509.

McConnell R, Berhane K, Gilliland F, London SF, Islam SF, Islam T, et al. 2002. Asthma in exercising children exposed to ozone: a cohort study. Lancet 359(9304):386–391.

[NRC] National Research Council. 1993a. Pesticides in the Diets of Infants and Children. Washington DC: National Academy Press.

[NRC] National Research Council. 1993b. Measuring lead exposure in infants, children, and other sensitive populations. Washington DC: National Academy Press.

Paulson JA, Gitterman, BA, editors. 2007. Children's health and the environment, Part 1. Pediatric Clinics of North America 54(1):1–212.

Paulson JA, Gitterman BA, editors. 2007. Children's health and the environment, Part 1. Pediatric Clinics of North America 54(2):213–424.

Pediatric Clinics of North America. Pediatric clinics of North America homepage. Philadelphia PA [accessed 2008 June 11]. Available from http://www.pediatric.theclinics.com.

Pope CN, Liu J. 1997. Age-related differences in sensitivity to organophosphorus pesticides. Environmental Toxicology Pharmacology 4: 309–314.

Quang LS, Woolf AD. 2000. Children's unique vulnerabilities to environmental exposures. Environmental Epidemiology and Toxicology 2:79–90.

Rice D, Barone S Jr. 2000. Critical periods of vulnerability for the developing nervous system: evidence from humans and animal models. Environmental Health Perspectives 108 (suppl 3):511–533.

Salam MT, Li Y-F, Langholz B, Gilliland FD. 2004. Early-life environmental risk factors for asthma: findings from the children's health study. Environmental Heath Perspectives 112:760–765.

Scheuplein R, Chamley G, Dourson M. 2002. Differential sensitivity of children and adults to chemical toxicity. I. Biological toxicity. Regulatory Toxicology and Pharmacology 33:429–447.

Solomon GM, Weiss PM. 2002. Chemical contaminants in breast milk: time trends and regional variability. Environmental Health Perspectives 100:A339–347.

Weiss B. 2000. Vulnerability of children and the developing brain to neurotoxic hazards. Environmental Health Perspectives 108 (Suppl 3):375–381.

Weitzman M, Gortmaker SL, Sobol AM, Perrin JM. 1992. Recent trends in the prevalence and severity of childhood asthma. Journal of the American Medical Association 268:2673–2677.

Wolff MS. 1983. Occupationally derived chemicals in breast milk. American Journal of Industrial Medicine 4(1–2):259–281.

Woolf AD, Garg A, Alpert H, Lesko S. 2001. Adolescent workplace toxic exposures: a national study. Archives of Pediatric and Adolescent Medicine 155:704–710.

Ground water and drinking water

[EPA] US Environmental Protection Agency. Ground water & drinking water. [updated 2008 June 5, accessed 2008 June 11] Available from: http://www.epa.gov/safewater.

[EPA] US Environmental Protection Agency. 2003. Water on tap: what you need to know. EPA: 36.

Lead

[CDC] Centers for Disease Control and Prevention. Preventing Lead Poisoning in Young Children. Atlanta GA [updated 1991 October 01, accessed 2008 June 11] Available from: http://wonder.cdc.gov/wonder/prevguid/p0000029/p0000029.asp

[CDC - NCEH] Centers for Disease Control and Prevention—National Center for Environmental Health. Facts on lead

Atlanta GA [accessed 2008 June 11] Available from: http://www.cdc.gov/nceh/lead/guide/1997/docs/factlead.htm.

[EPA] US Environmental Protection Agency. Lead hotline—the national lead information center. Washington DC [updated 2008 April 15,

accessed 2008 June 11]. Available from: http://www.epa.gov/lead/pubs/nlic.htm.

Shannon MW, Graef JW. 1992. Lead intoxication in infancy. Pediatrics 89:87–90

Silbergeld EK. 1991. Lead in bone: implication for toxicology during pregnancy and lactation. Environmental Health Perspectives 91:63.

Walter SD, Yankel AJ, von Lindern IH. 1980. Age-specific risk factors for lead absorption in children. Archives of Environmental Health 35: 53–57.

Pesticides

[EPA] US Environmental Protection Agency. EPA Office of Pesticides. EPA—pesticides homepage. Washington DC [updated 2008 Jun 11, accessed 2008 June 11]. Available from: www.epa.gov/pesticides.

Fear NT, Roman E, Reeves G, Pannett B. 1998. Childhood cancer and paternal employment in agriculture: The role of pesticides. British Journal of Cancer 77(5):825–829.

Karmaus W, DeKoning EP, Kruse H, Witten J, Osius N. 2001. Childhood determinants of organochlorine concentrations in school-aged children. Pediatric Research 50:331–336.

Karr C, Solomon GM, Brock-Utne A. 2007. Health effects of common home, lawn, and garden pesticides. Pediatric Clinics of North America 54:63–80.

Pesticide Action Network North America. PAN pesticides database. San Francisco CA (updated 2008 April 22, accessed 2008 June 11). Available from: http://www.pesticideinfo.org

Pogoda JM, Preston-Martin S. 1997. Household pesticides and risk of pediatric brain tumors. Environmental Health Perspectives 105(11):1214–1220.

American Association of Poison Control Centers. American association of poison control centers homepage. Alexandria VA [accessed 2008 June 11] Available from: http://www.aapcc.org/DNN/.

Radon

[EPA] US Environmental Protection Agency. A citizen's guide to radon: The guide to protecting yourself and your family from radon. Washington DC [updated 2007 May, accessed 2008 June 11]. Available from: http://www.epa.gov/radon/pubs/citguide.html

Tables

Table Number	Table Title
1.	Health effects associated with caroxyhemoglobin levels in adults
2.	Screening questions for the well child screening exposure history
3.	Additional questions for a well baby visit
4.	Screening questions for well toddler and young school age visit
5.	Screening questions for well adolescent visit
6.	Examples of laboratory tests of exposure
7.	Medical management for specific blood lead levels

Glossary

Acute exposure	A one-time exposure of relatively short duration.
Biomarker	An identifiable change at the chemical, biochemical, or cellular level due to an exposure to an environmental toxicant.

Chronic exposure	An exposure to a chemical or hazardous substance that occurs over a period of time.
Developmental stages	Temporal intervals in distinct anatomical, physiological, behavioral, or functional characteristics that can contribute to potential differences in vulnerability to environmental exposures.
Dose	The amount of a contaminant that is absorbed or deposited in the body of an exposed person for an increment of time. Total dose is the sum of doses received by a person from a contaminant in a given interval and resulting from interaction with all environmental media that contain the contaminant.
Macroactivity	Highly general description of what a child does during a specific period of time or developmental stages—i.e., playing, school attendance, crawling, toddling, etc.
Microactivity	A very detailed description of an activity that could lead to an exposure. Some examples of microactivities leading to childhood exposures are mouthing of objects and crawling on the floor with subsequent hand contact with dirt.
Microenvironment	Location a child occupies for a specified period of time—e.g., outdoors on a lawn versus outdoors on a school playground.
Paraoccupational exposure	The transmission of potentially toxic quantities of industrial agents from occupational settings to homes and residences is referred to as take-home contamination. Take-home contamination has been more vividly called "fouling one's own nest."
Pica	The intentional ingestion of soil and other non-nutritive substances.

Poisoning	A patient has a defined pattern of symptoms corresponding to toxic effects from a poisonous substance at a mid- to high level of exposure.
Toxicant	A poisonous substance not derived from the metabolism of a living organism.
Toxicodynamics	The study of the cellular and molecular mechanisms of the action of a poison.
Toxin	A poisonous substance produced by the metabolism of an organism, such as a spider, a snake, a scorpion, a plant, a fungus, or bacteria.
Toxicity	Any adverse effect from a poisonous substance, whether the effect is subclinical or it takes the form of frank clinical symptoms of a poisoning.
Toxidrome	A defined constellation of symptoms characteristic of a certain class of toxic exposure.