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# Integrating Childhood and Adult Blood Lead Surveillance to Improve Identification and Intervention Efforts

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## Abstract

The Centers for Disease Control and Prevention (CDC) collects information on blood lead levels (BLLs) in the United States (U.S.) through the Childhood Blood Lead Surveillance (CBLS) system [<16 years of age] and the Adult Blood Lead Epidemiology and Surveillance (ABLES) program [≥16 years of age]. While both of these state-based national programs share the mutual goal of monitoring and reducing lead exposure in the U.S. population, blood lead data for children and adults are maintained in separate data collection systems. This limits the ability to fully describe lead exposure in the U.S. population across these two distinct population groups from sources such as take-home and maternal-child lead exposure. Additionally, at the state level, having a unified system to collect, maintain, and analyze child and adult blood lead data provides a more efficient use of limited resources. Based on feedback from state partners, CDC is working to integrate CBLS and ABLES data collection systems at the national level. Several states have developed or are developing an integrated child and adult blood lead data collection system. We highlight efforts undertaken in Wisconsin, Minnesota, North Carolina, Iowa, and Oregon to investigate workplace and take-home lead exposure. Integrating blood lead surveillance data at the national level will enhance CDC's ability to monitor sources of lead exposure from both the home and work environments including paint, water, soil, dust, consumer products, and lead-related industries. Together, an integrated child and adult blood lead surveillance system will offer a coordinated, comprehensive, and systematic public health approach to the surveillance and monitoring of reported BLLs across the U.S. population.

### Keywords

blood lead; environmental health; lead poisoning; occupational health; surveillance; lead exposure

The authors declare no conflicts of interest.

## Introduction

The Centers for Disease Control and Prevention (CDC) collects information on blood lead levels (BLLs) in the United States (U.S.) through the Childhood Blood Lead Surveillance (CBLS) system and the Adult Blood Lead Epidemiology and Surveillance (ABLES) program. BLLs in children and adults are monitored to identify and remediate potential sources of lead exposure. The most common sources of exposure to lead for U.S. children are lead-based paint and lead-contaminated dust in older homes.[1] Contaminated air, water, and soil are other potential sources, as are consumer and imported products such as pottery, toys, cosmetics, spices, and traditional remedies. Among adults with known lead exposure, over 90% have an occupational source of exposure.[2]

CDC's surveillance strategy focuses on improving the value of public health data for action at the local, state, and federal levels, beginning with how CDC interfaces with states where information is collected and then reported to on behalf of jurisdictions within their state. In 1995, the Council of State and Territorial Epidemiologists (CSTE) designated elevated BLLs as the first noninfectious condition to be voluntarily "notifiable" at the national level and CDC included elevated blood lead levels as a condition in the National Notifiable Diseases Surveillance System.[3–5] Elevated blood lead levels are currently defined as BLL ≥5 μg/dL.[1]

The National Center for Environmental Health (NCEH) supports Childhood Lead Poisoning Prevention Programs (CLPPPs) in states and local health agencies that are required to report CBLS data to CDC. CBLS accepts blood lead surveillance data for children <16 years of age; however, the majority of reports focus on BLLs among children <6 years of age. BLLs for adults ≥16 years of age, mostly related to occupational exposures, are reported by state health and/or labor departments on a voluntary basis to the National Institute for Occupational Safety and Health (NIOSH) ABLES program. There is overlap in the state and local agencies that submit blood lead data to CBLS and ABLES (Figure). Additionally, the objectives of the national child and adult blood lead surveillance systems overlap (Table).

While the primary goal of both CBLS and ABLES is to monitor and reduce lead exposure, BLL data for children and adults are maintained in separate data collection systems at the national level and in most states. This limits the ability to describe the full spectrum of lead exposure across the U.S. population and to discern across these two distinct population groups, from potential sources such as take-home and maternal-child lead exposures. Parents or other family members employed in lead-related industries (e.g., construction, mining) may take lead dust home on their skin, hair, clothes, or tools.[2] Additionally, pregnant and breastfeeding women may pass lead to their unborn baby or breastfeeding infant.[6] Based on feedback from state and local partners, and to further the understanding of lead exposure across the lifespan of a person, CDC is working to integrate CBLS and ABLES data collection systems at the national level. This paper describes how integrating childhood and adult lead surveillance systems serves to improve monitoring and reduction of lead exposure from both the home and work environments.

## Methods

Blood lead reporting is a critical component of surveillance, but requirements vary according to state and local statutes and regulations. BLL data is used for programmatic purposes such as describing incidence, monitoring the follow up care of individuals, evaluating the effectiveness of interventions, identifying local program needs and/or areas to target for interventions, and tracking programs' progress toward meeting objectives. In order to maintain the large amount of blood lead and case follow-up data, programs have computerized systems for collecting and managing blood lead surveillance data.

### CBLS

CBLS collects a standard set of de-identified, individual-level case management and follow-up data from participating state and local programs that includes laboratory-reported BLLs for children in their jurisdiction.[1] Currently, CDC funds 48 state and local health departments CLPPPs for lead prevention and surveillance activities. Each state has their own requirements for blood lead testing and reporting to state health departments. Additionally, clinical action levels and elevated BLL case definitions vary from state to state. Mandatory laboratory reporting of all blood lead test results, not just "elevated" BLLs, to state health departments is an essential element of successful CBLS programs because it allows programs to calculate the denominator of children tested in the state. According to Federal law, all children enrolled in Medicaid are required to receive blood lead tests at ages 12 months and 24 months. Any child between 24 and 72 months with no record of a previous blood lead test must receive a "catch-up" blood lead test.

Population surveillance of children's BLLs provides information on how well we are protecting children from exposure to lead and provides critical information needed to identify and care for those individual children who are already exposed. A consistent "case" definition for elevated blood lead levels is applied at CDC to monitor short-term trends, progress toward elimination of lead hazards, and to oversee programmatic activities. These data do not provide for valid nationally representative incidence or prevalence estimates due to differences in states' screening practices and laboratory reporting requirements. However, when a consistent case definition is applied, these data are useful for estimating needs at the Federal, state, and local level, which is important for establishing national program goals and objectives.

### ABLES

ABLES is a long-standing state-based surveillance program of laboratory-reported adult BLLs aimed at addressing the national occupational lead exposure in the workplace health problem. The Occupational Safety and Health Administration (OSHA) mandates medical surveillance, including regular blood lead tests, for workers who are exposed to an airborne concentration of lead of 30 $\mu g/m^3$ for 30 or more days.[7] ABLES collects a standardized set of de-identified data from state health and/or labor departments.[7] All ABLES data submission is voluntary. While the current reference BLL is 5 μg/dL, obtaining work-relatedness and industry information for adults with BLLs <25 μg/dL is resource intensive. Few states are able to follow up on adult cases with BLL <25 μg/dL due to staffing and resource shortages. Therefore, NIOSH accepts any occupational data that states can provide. As 95% of lead exposure in adults is work related, ABLES data cannot be generalized to the U.S. population. In additional to sharing BLL data with ABLES, many states share occupational lead exposure data with the OSHA for enforcement and compliance assistance activities. They also use the data to provide guidance and information to workers and employers.

### System Integration

Combining data collected from CBLS and ABLES will enhance CDC's ability to identify and intervene for both childhood and adult lead exposure from environmental and occupational sources. An integrated system will streamline all blood lead data from laboratories into one data management system, reducing personnel needs and time spent for learning and managing two separate systems. In addition, an integrated system will further research by increasing our understanding of lead exposure across the lifespan. Several states have already developed or are developing an integrated data collection system at the state and local level to investigate child and adult lead exposures. Below we highlight efforts undertaken in Wisconsin and Minnesota, North Carolina, Iowa, and Oregon to investigate large scale, multiple person reports of elevated BLLs in their state.

## Case Studies

### Wisconsin and Minnesota

In 2016, the Wisconsin (WI) CLPPP and ABLES program, in coordination with the Minnesota (MN) CLPPP and ABLES program, investigated high levels of lead exposure among workers at a shipyard in Superior, Wisconsin near the MN border.[8] Renovation work that involved cutting, burning and welding areas that contained lead paint began in 2015 on a 690-foot carrier vessel in the shipyard. In March 2016, an emergency department provider consulted the MN Poison Control System about a worker with a BLL >60 μg/dL and the MN Poison Control System notified the MN Department of Health (MDH). Concurrently, the Wisconsin Department of Health Services (WDHS) received laboratory results on two workers who had BLLs >40 μg/dL. All three workers with elevated BLLs had been retrofitting the ship's engine room. MDH and WDHS opened an exposure investigation and collaborated with partners in state and local health departments, the Occupational Safety and Health Administration (OSHA), and other federal agencies. The coordinated response targeted all shipyard workers and their household members of any age with the goals of determining the scope and severity of the exposure by surveying workers and sampling their BLLs, sharing timely health messages with potentially affected populations, and determining risk factors for lead exposure. In addition to suspending work in the engine room, the shipyard facilitated access to blood lead testing for all current workers and hired lead abatement crews for lead clean up.

Of the 357 workers identified, 233 (65.3%) completed blood tests: 73.4% had BLLs ≥5 μg/dL (the current CDC's case definition for an elevated BLL), 64.8% had BLL ≥10 μg/dL, 14.2% had BLLs ≥40 μg/dL and two had BLL ≥60 μg/dL (median=16.0 μg/dL).[3,8] A jointly administered survey identified 341 household members with potential secondary exposures.

Only 46 (13.5%) household members were able to be tested; none had BLLs ≥5 μg/dL. In February 2016, an Occupational Safety and Health Administration (OSHA) enforcement investigation began and found that shipyard workers were exposed at ≥20 times the reduced permissible exposure limit of 40 μg/$m^3$ averaged over a 10-hour period for lead in air.[9]

This investigation highlights the need for lead industries to implement proper engineering controls, including training, provision, and use of personal protective equipment, and periodic BLL monitoring to protect workers and their families. It also highlights the importance of timely laboratory-based BLL reporting and efficient collaboration between CLPPP and ABLES programs – within and between states – to protect workers and their household members.

## North Carolina

The North Carolina (NC) Division of Public Health (DPH) CLPPP and ABLES programs have been working with NC DPH Information Technology for several years to integrate adult blood lead data into the NCLEAD surveillance system. NC CLPPP and NC ABLES maintain distinct but complementary roles in conducting surveillance, identifying and responding to exposures, and educating families.

In 2016, in response to multiple cases of children exposed to take-home lead from a lead oxide manufacturer (Company A) and lead-acid battery manufacturer (Company B) in the same region, NC DPH formalized the collaboration between the child and adult blood lead surveillance programs. Environmental sources of lead exposure were ruled out for these children. The investigation into the Company A is described in detail in a separate report.[10] Among children matched to Company B's employees, 14 of 47 children (30%) tested January 2012–June 2016 had a BLL confirmed ≥5 μg/dL (range of highest BLL 6–19 μg/dL). In 2016, approximately 64% of monitored workers (n=436) had BLLs ≥10 μg/dL. NC lead program staff toured the plant and reviewed policies. Company B had an elaborate and proactive safety program, thus NC DPH worked with the company to incorporate interventions to prevent take-home lead exposure.

Because of these investigations, NC DPH took the following step: NC CLPPP added dedicated fields to the NCLEAD system to indicate an occupational exposure and the related "company name" for children with an elevated BLL. These dedicated fields and workflows for childhood lead cases are visible to adult lead surveillance staff and have facilitated rapid identification and follow-up of new take-home lead exposure cases. Since June 2016, 4 new cases related to Company A and 10 new cases related to Company B have been found using these surveillance innovations.

Together, NC CLPPP and ABLES staff developed a response algorithm for occupationally-related childhood lead cases that guides actions by both programs based on the BLL and number of children involved. The adult lead program developed take-home lead exposure prevention materials to be used by NC CLPPP home investigators with affected families. Questions were added to adult lead exposure interviews to assist in family member linkage. NC DPH continues to use the now integrated systems to monitor reported BLLs among workers and associated children and act when cases are identified.

## Iowa

In 1992, Iowa began using laboratory-based and physician reporting for the surveillance of all BLLs. Results were recorded into two databases: one for children and one for adults. Iowa Code requires all blood lead test results be reported to the Iowa Department of Public Health (IDPH).[11,12] As all children are required to be tested for lead exposure prior to kindergarten, the Iowa CLPPP can calculate rates of elevated BLLs among all children in the state. These findings are used by state and county health departments to build community-wide coalitions and to develop and fund local CLPPPs. Data inform legislators of the need for authority to inspect and require remediation of lead hazards in homes where children with elevated BLLs live. As the Iowa CLPPP and ABLES programs evolved, it became apparent that a coordinated approach for child and adult BLL reporting would be beneficial. Therefore, in 2014, Iowa implemented a blended blood lead surveillance program where both child and adult BLLs are received into one database.

This blended program has distinct strengths for CLPPP and ABLES program staff, including increased collaboration through discussion of key issues and cases, sharing of subject matter expertise, and consistent child and adult messaging. In 2015, a local county CLPPP investigated a high BLL (26 μg/dL) in a young child. IDPH and the local county CLPPP collaborated to inspect the child's primary home, but no lead hazards were identified. However, staff learned of potential multi-generational exposures as the child spent a large amount of time at a relative's house. Investigation of that home identified many lead hazards. Despite the risks involved, the relatives decided to repair and renovate their 1900s home themselves after the investigation. Two months later, the relatives had confirmed BLLs of 69 μg/dL and 35 μg/dL, respectively. At this point, local CLPPP staff formally contacted the state ABLES program for follow-up. In response to the relatives elevated BLLs, CLPPP staff reassessed the child 6 weeks later and found that BLLs had increased to 53 μg/dL. The multi-generational CLPPP and ABLES household investigation was difficult to resolve because, although the family had been informed both orally and in writing that the child should not visit the relatives' house due to environmental lead hazards, the child regularly spent time there. The family was also referred to a U.S. Department of Housing and Urban Development (HUD) lead abatement program. With the use of the blended child and adult database, CLPPP and ABLES staff continued to monitor the family. In early 2018, the child's BLL was 7 μg/dL.

## Oregon

The child and adult lead programs in Oregon began using the state's reportable conditions data system (Orpheus) as the blood lead test registry in July 2013. In addition to making processing BLL records and identifying cases more efficient, Orpheus has case management features that improve the process of identifying and tracking take-home exposures. The system allows the user to easily link cases, which simplifies tracking a group of people who share an exposure source such as a family or the employees at a business location. The system also provides different ways to examine case lists including by address.

This type of functionality was originally intended for users who were tracking various infectious diseases and foodborne illnesses, but it has been helpful in linking adult cases with children in cases of take-home exposure. For example, a 2-year old child with a confirmed elevated BLL of 12 μg/dL in 2015 had been attributed to his father's work activities. The father was not a case at the time, but in August 2016 he was among a group of five employees at a window restoration company who came into the system with elevated results. The child's BLL had been declining, but ABLES staff who also use Orpheus to manage adult cases alerted the local health department who reached out to the family when the father became a case. That conversation revealed that the father's brother worked for the same company and that he was among the employees with an elevated BLL. The county then contacted the brother whose two children were then tested. His 1-year old child had elevated BLLs while the 10-year old did not.

## Discussion

Blood lead surveillance data provide information on how well we are protecting children and adults from lead exposure at the state and/or national level and, provides critical information needed to identify and care for those who are already exposed. Usage of CBLS and ABLES data promote primary prevention activities and support secondary prevention activities for children and adults, including blood lead testing, surveillance, and targeted population-based interventions for high-risk areas. Data generated and analyzed by these two programs provide critical information to monitor trends in BLLs over time. Preventable sources of lead exposures include drinking water, soil, lead dust, lead-based paint, traditional/folk medicines, fishing sinkers, bullets, materials used to make ceramics and stained glass, and take-home exposure from household members occupationally exposed to lead. Exposure risk factors vary by age with the majority of adults with BLLs ≥25 μg/dL having occupational exposure (90%).[2] Of adults with occupational exposures, about 90% are employed in four main industry sectors[1]: manufacturing, construction, services, and mining. Lead is also found in other occupational industries such as arts, entertainment and recreation (e.g., firing range), wholesale and the retail trade. The proportion of persons with elevated BLL ≥10 μg/dL from work exposure has declined over the years. However, many workers continue to have high BLLs that are associated with adverse health outcomes and workers exposed to lead may bring lead dust back to their cars and homes, exposing their children and other household members. Even BLLs <10 μg/dL can negatively affect the neurological, cardiovascular, and reproductive systems.[13]

States' investigations into elevated BLLs described above highlight a number of important reasons for integrating childhood and adult blood lead surveillance data at the state and national level. First, an integrated system could facilitate the linkage of high-risk children to parents with potential occupational lead exposure. In North Carolina, lead exposure in the workplace and consequential take-home exposure, put many employees and their household members at risk of elevated BLLs. The integrated system also allowed staff to maximize efficiency in Oregon. Second, an integrated system facilitates longitudinal follow-up of cases and their potentially affected household members. Even a few adult cases of elevated BLLs

[1]The North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. https://www.bls.gov/bls/naics.htm

linked to exposed workers could be indicative of a larger-scale workplace exposure involving many more employees and, potentially, their household members, as seen in Wisconsin and Minnesota. Finally, integration could help states, such as Iowa, investigate multi-generational exposures where a child's elevated BLLs are not due to lead exposures in the primary residence, but rather exposures in a caregiver's home.

CBLS and ABLES provide essential information for setting research and intervention priorities. Integrating data collected from CBLS and ABLES will enhance CDC's ability to identify and intervene for both childhood and adult lead exposure from lead paint, contaminated water, soil, dust, consumer products and from occupational exposures. Both programs have already contributed to the considerable progress in reducing the prevalence of elevated BLLs in the United States and will continue to do so in the future with an integrated data collection system.

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CDC Disclaimer:

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the Centers for Disease Control and Prevention or the Agency for Toxic Substances and Disease Registry.

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### Implications for Policy and Practice

- At the state and national levels, blood lead surveillance data provide important information on how well we are protecting children and adults from lead exposure.
- In addition, blood lead surveillance data provide critical information needed to identify and respond for those who are already exposed.
- An integrated child and adult blood lead surveillance system will offer a coordinated, comprehensive, and systematic public health approach to the surveillance and monitoring of BLLs in the U.S. population.

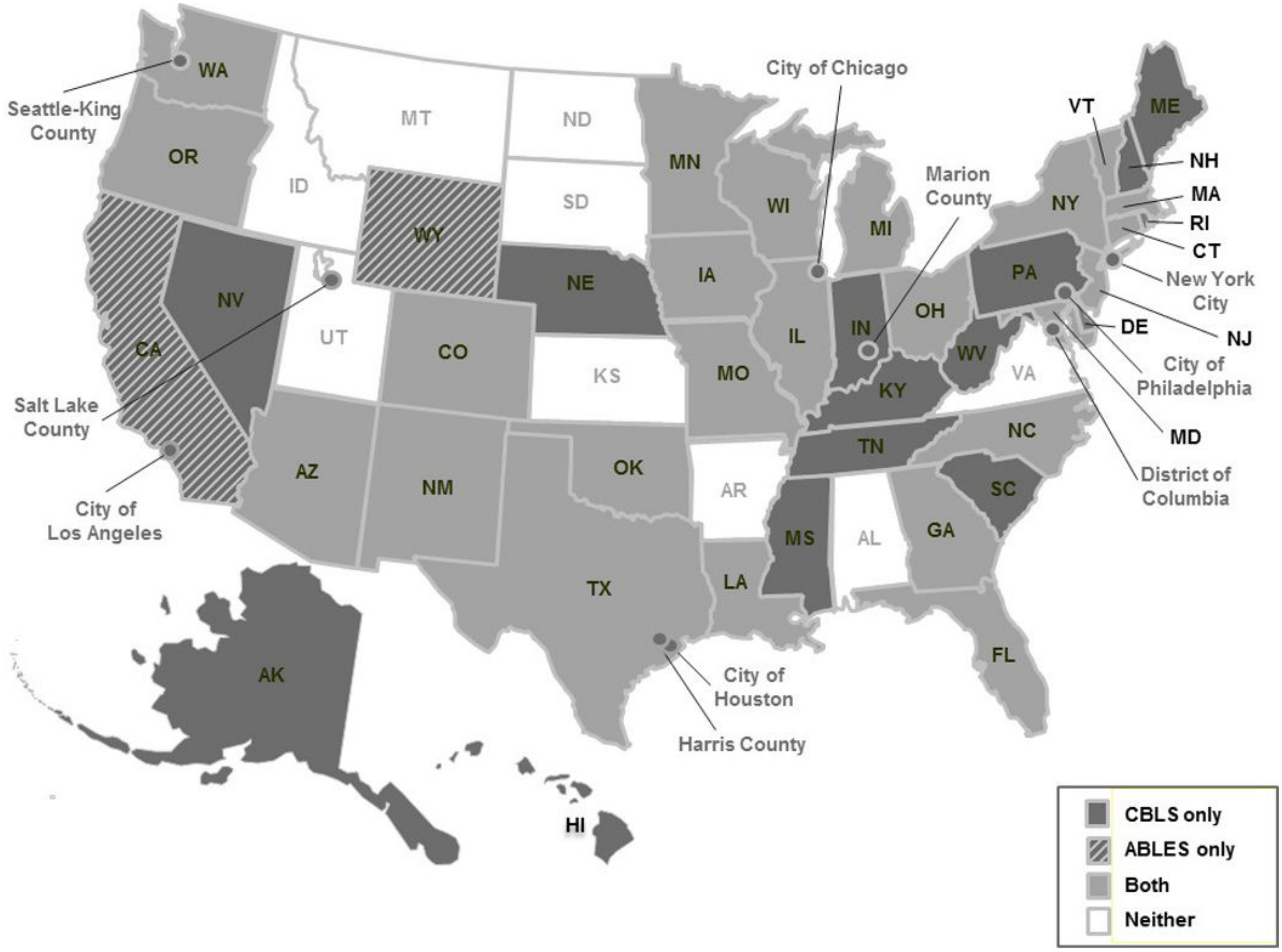


**Figure:**

Childhood Blood Lead Surveillance (CBLS) system and Adult Blood Lead Epidemiology and Surveillance (ABLES) program partners, 2017

**Table:**

Comparison of childhood and adult blood lead surveillance system objectives

| System | Objectives |
|---|---|
| Childhood Blood Lead Surveillance (CBLS) System | Objective 1: to build state capacity to initiate, expand, or improve childhood blood lead surveillance programs |
| | Objective 2: to promote blood lead testing, electronic laboratory reporting, and monitoring of BLLs in children |
| | Objective 3: to ensure that there is a comprehensive system in place for the identification, referral, and follow-up evaluation of lead-exposed children |
| | Objective 4: to reduce the proportion of children with elevated BLLs |
| Adult Blood Lead Epidemiology and Surveillance (ABLES) Program | Objective 1: to build state capacity to initiate, expand, or improve adult blood lead surveillance programs |
| | Objective 2: to reduce the proportion of persons with elevated BLLs from workplace lead exposure |