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Improving Lead Screening Rates in a Large Pediatric Primary Care Network

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Abstract

Introduction: Exposure to environmental lead continues to be a significant public health concern. Elevated blood lead levels can lead to neurocognitive delays and other adverse health outcomes. Unfortunately, screening rates in most communities remain low. This quality improvement project aimed to improve universal screening at 12 months of age and increase screening rates from 71% to 95%. The project team also aimed to improve risk-based screening at 24 months of age to increase screening rates from 41% to 70%. **Methods:** This project utilized the Model for Improvement. After identifying key drivers, the team designed, tested, and adopted a series of interventions to improve lead screening. Dynamic order sets were developed that pre-checked the lead order, if appropriate, based on the patient's age, previous results, and risk factors. Sites received regular feedback on their screening rates. **Results:** The percentage of patients receiving universal lead screening at their 12-month well visit increased from 71% to 96%. 70% of 2-year-olds were at risk for lead exposure based on ZIP code and insurance provider. Development of dynamic orders for patients at risk increased screening rates from 41% to 74% at the 24-month well visit. **Conclusions:** Utilization of clinical decision support tools within an electronic health record can significantly increase the percentage of children screened for lead toxicity. Similar tools could identify patients due for other screens or interventions, resulting in improved care and patient outcomes. *(Pediatr Qual Saf 2021;6:e478; doi: 10.1097/pq9.0000000000000478; Published online September 24, 2021.)*

INTRODUCTION

Lead remains a prevalent pediatric environmental toxin. Recent events in Flint, Michigan, where tap water exposed children to increased lead levels, have reinvigorated a national discussion about lead toxicity.[1–7] Exposure to lead in early childhood, during critical periods of neurocognitive development, can result in deficits in executive functioning, intelligence, and behavior.[8–12] Previous public policy interventions have reduced environmental exposures to lead, resulting in decreased average blood lead levels in children over the past 50 years.[13] Despite this progress, at least 37 million housing units in the United States contain lead-based paint. Children in those households are at increased risk of exposure to high levels of lead; as evidenced by the fact that 15% of children living in homes built before 1950 have elevated blood lead levels, compared with only 2.1% of children who lived in housing units built after 1978.[8,14]

Current American Academy of Pediatrics and Centers for Disease Control and Prevention (CDC) recommendations for lead screening include monitoring for lead toxicity in children 12 to 24 months of age who live in locations where greater than 25% of the housing stock was built before 1960 or over 5% of children have blood lead concentrations over 5 μg/dL.[15,16] While no lead level is considered safe, the current level requiring intervention in Ohio is ≥5 μg/dL based on the 97.5th percentile of the last 2 National Health and Nutrition Examination Surveys (NHANES). Bright Futures guidelines recommend a screen for elevated blood lead levels in children 12 and 24 months of age who live in high-prevalence areas or are insured by Medicaid. Additionally, patients identified by lead exposure risk assessment should be tested. Numerous state and local statutes outline screening rules. Ohio Administrative Code 3701-30 mandates screening of children less than 6 years of age who live in high-risk ZIP codes, children insured by Medicaid, or children who are high-risk based on lead exposure risk assessment.[17,18] In 2012, only 50% of eligible children in Ohio were appropriately screened for elevated blood lead.[19] Previous studies have identified common barriers to screening, including a lack of family awareness of the

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causes and effects of lead poisoning and provider misperceptions of geographic risk.[20,21]

Akron Children's Hospital has a network of 30 primary care locations across 15 counties with a total panel size of over 220,000 patients and with over 450,000 visits per year. In 2015, Akron Children's Hospital's primary care network screened 71% of children 12 months of age and 41% of children 24 months of age for lead. This result exceeded the state of Ohio benchmarks but fell short of clinical expectations.[22] Of the children who were not screened at 12 and 24 months of age, 53% and 75% respectively warranted lead screening according to Ohio law. Locally identified barriers to higher screening rates (identified by providers) included the difficulty of identifying high-risk patients and an inconsistent process for ordering and collecting blood samples across practice locations. Few previously published works have addressed improvements in office-based lead screening practices.[23,24] To provide high-quality, evidence-based screening, we sought to improve appropriate lead screening and management in our primary care network.

The improvement aim was to increase lead screening rates at 12-month well visits from 71% to 95% and at 24-month well visits from 41% to 70% by 12/31/2017. We intended to perform universal screening at 12 months of age and set a goal of 95% to account for families unable or unwilling to be tested. Data analysis demonstrated that around 70% of our patients required screening at 2 years of age by state law, and we established a screening goal of 70%.

METHODS

Informed by our baseline 2015 data on lead screening rates derived from our shared electronic health record (Epic, Epic Systems Corp, Verona, Wis.), a multidisciplinary improvement team was assembled in 2016, and their work continued through 2017. The improvement team included primary care pediatricians, a physician informaticist, electronic health record (EHR) builders, a quality improvement consultant, a toxicologist, data analysts, laboratory personnel, and nurses. The team utilized the Model for Improvement to guide the improvement work.[25] A process map illustrated the current state. A key driver diagram guided the improvement process, highlighting the aim, key drivers, and possible interventions (Fig. 1), Following the identification of multiple key drivers, the team chose interventions that focused on identifying patients who required screening, provider education, and providing clinical decision support surrounding laboratory ordering and follow-up.

Measurement

Lead screening measurements focused on 2 cohorts—children presenting for 12- or 24-month well visits. The screening rate was defined as the percentage of children seen in 1 of the 30 primary care offices with a chief complaint of a 12-month or 24-month well visit who had a capillary blood lead test ordered at the visit. This rate does not include patients who did not present for preventive care. Screening rates for each age group were tracked on a run chart. Standard run chart rules to identify special cause variation were utilized, specifically 8 consecutive points on either side of the median. The primary intervention focused on ordering workflow. Therefore, the team decided to track ordered tests rather than resulted tests. Some patients obtained blood work at independent labs, and those results would not be immediately available in our EHR. Our offices operate under the Patient-Centered Medical Home model, which includes a robust, centralized process where orders without results are tracked to promote the completion of outstanding tests.[26] Additionally, all offices provide phlebotomy services or have access to a nearby laboratory, and 97% of ordered lead tests are drawn on the date of service.

Interventions

Many EHRs allow for the creation of standardized order sets. These order sets can be used to group relevant diagnoses, laboratory tests, imaging orders, medications, and follow-up in 1 location. We developed order sets for all our well visits, and these are suggested for use by providers based on the patient's chief complaint. Providers already used these order sets over 99% of the time to select appropriate diagnoses, orders, and levels of service for their visits. We expected that having the lead laboratory orders preselected in the order sets would significantly increase the reliability of screening.

Although Ohio law only requires patients who are *at risk* for lead exposure to be screened at 12 and 24 months, and the US Preventive Services Task Force found insufficient evidence to assess the balance of benefits and harms of screening, local experts recommended universal screening at 12 months of age due to regional prevalence of older homes with lead paint and to ensure that every patient was tested at least once.[27]

In the order set for 12-month well-visits, the capillary blood lead laboratory test was prechecked for all patients. Because providers struggle to identify patients on Medicaid consistently and cannot memorize the list of 500+ high-risk ZIP codes in Ohio at risk for lead exposure, we developed rules within the EHR that would precheck the order in the 24-month order set if Medicaid was the primary payor, if the patient's primary address was in a ZIP code at high-risk for lead, or if they had a positive response to any of the lead risk screening questions in our history of present illness electronic documentation template. Screening questions were adapted from the state of Ohio recommendations with input from local subject matter experts. All builds were extensively tested in an EHR test environment. The team managed communication regarding the interventions and outcomes through primary care staff meetings, daily leadership huddles, and monthly emails to all providers regarding their screening rates.

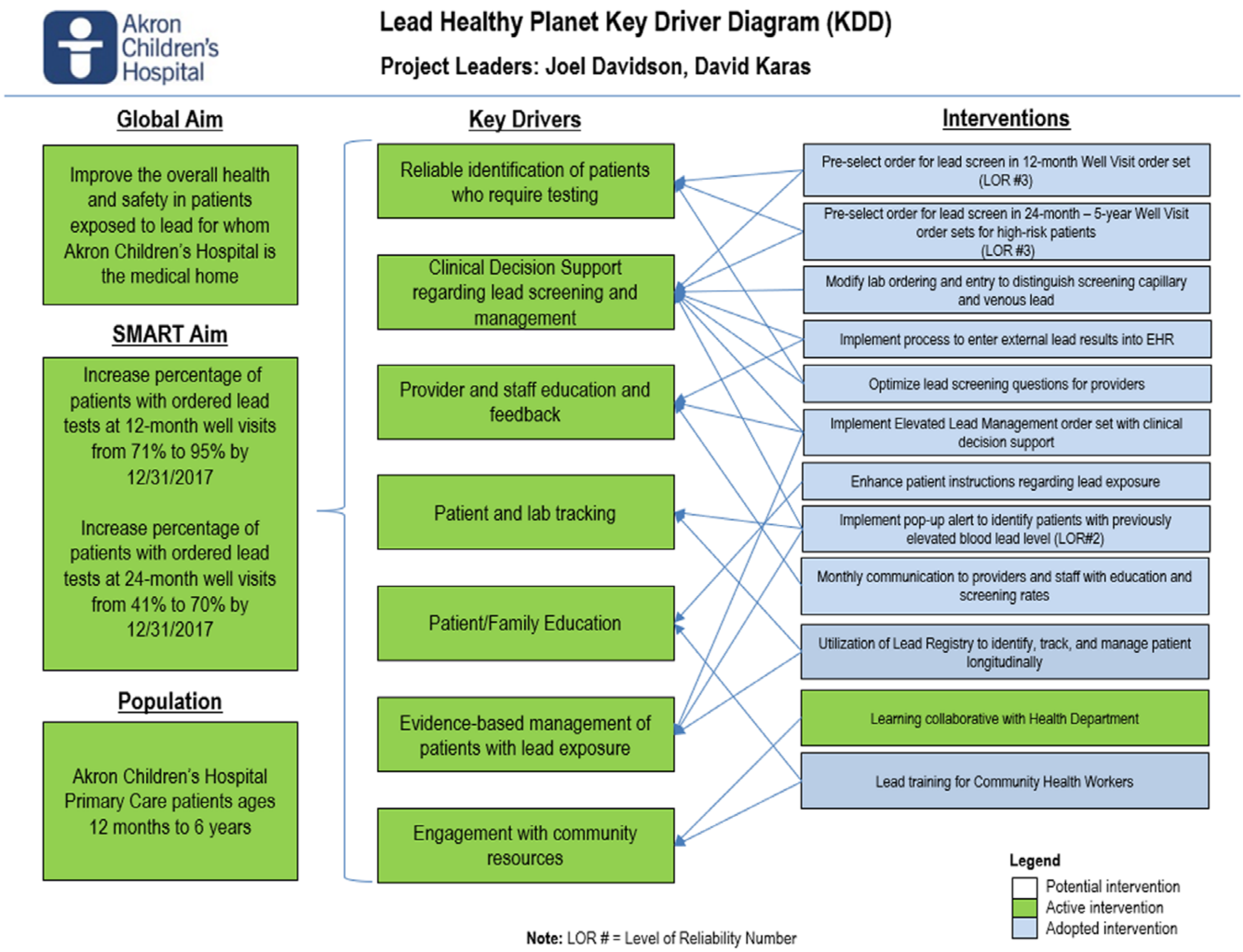

Fig. 1. Key Driver Diagram demonstrating global aim, SMART aim, the target population, key drivers, and necessary interventions to achieve the SMART aim.

The implementation of prechecked orders was the first Plan-Do-Study-Act (PDSA) cycle. In the next PDSA cycle, we identified offices that routinely sent patients to outside laboratories. Rules were amended in the EHR to configure the orders properly for these specific sites. Tools and workflows were developed to ensure that outside results received by fax were manually entered into the patient record, closing the loop on an open order. Next, we implemented pop-up alerts to notify providers if the patient's last lead test was elevated—clinical decision support built into the alert provided guideline-based recommendations on appropriate follow-up for these patients.

Finally, we identified providers that were not consistently ordering the lead tests when indicated. Some sites had previously been testing at 9 months of age, and these offices were asked to change to the standardized age of 12 months. Other providers had been deleting the prechecked lead orders because they did not feel that their patients were at high risk when in fact, they were. The team provided education regarding state requirements for lead testing.

This quality improvement project was reviewed and determined to be nonhuman subjects research and thus exempt from Institutional Review Board oversite.

RESULTS

12-month-old Patients

Lead screening at 12 months of age increased from a median of 71%–96% and was sustained throughout the improvement project. Figure 2 depicts the annotated run chart for 12-month lead ordering compliance. Population demographics and average results for 12 months pre- and postintervention are in Table 1. Patient's families self-reported race and ethnicity. These data differ slightly from the run charts, where the median screening rate is displayed over a longer time.

For patients who missed well visits or screening at 12 months, or failed to complete the lead screening as ordered, the lead capillary order remained prechecked at well-child visits until a lead level was resulted. Subsequent analysis revealed a 7.7% rate for lead screening at the 15-month visit; these results represent those children not

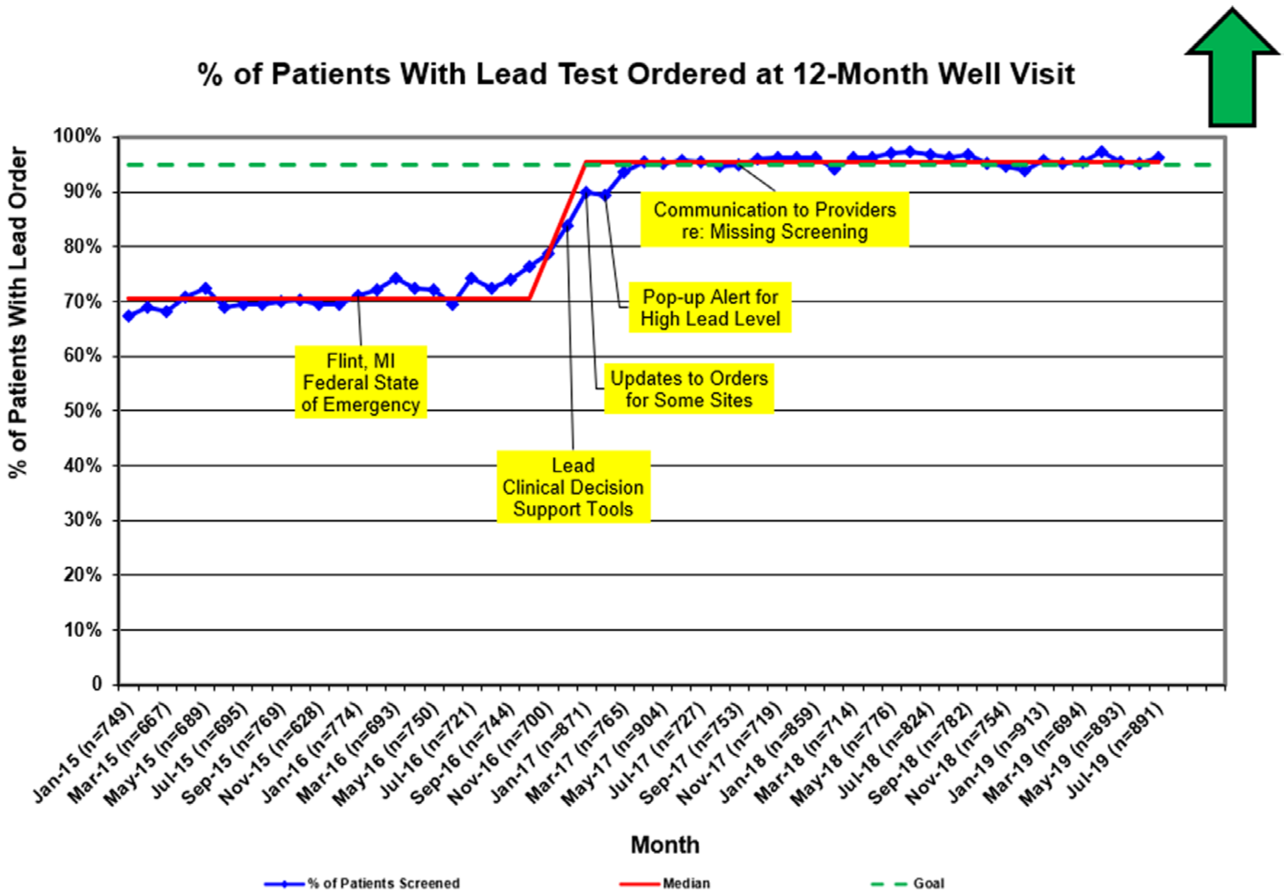

Fig. 2. Run chart depicting the percentage of patients with a lead test ordered at the 12-month well-child visit. The upward arrow demonstrates the direction of the desired improvement. Annotations identify the timing of key interventions. The dashed green line denotes the goal. The solid red line is the median screening rate and shifts according to the standard run chart rules.

screened during the 12-month visit, those who did not attend the 12-month visit, and those new to the primary care practice network. At 18-month well-child visits, the lead screening rate was 6.5%.

24-month-old Patients

At 24 months of age, the improvement team transitioned the screening focus from universal screening to risk-based screening based on insurance status, ZIP code, and the lead screening questionnaire. The impacts of these interventions are shown in the run chart in Figure 3. We identified a statistically significant shift in screening rates before our intervention that was likely due to increased provider and family awareness due to the Flint water crisis. For 24-month-old children, the lead screening rate improved from a baseline median of 41% to 74% through the improvement study. Analytic tools developed as part of the intervention to identify high-risk children showed that 70% of our population of 24-month-old children was at risk for exposure to lead. Table 2 lists demographics and average results for 12 months pre- and postintervention for patients at the 2-year well visit. Similar to the strategy used to capture patients who did not have universal screening performed at 12 months of age, high-risk patients who did not have a lead level completed and resulted continued to have a lead level order prechecked until the 5-year-old well-child check. At the 3-year well-child visit, providers ordered lead tests on 13.8% of children due to high-risk status and no previous lead screen.

The sustainability of lead screening in both populations continued to be tracked with monthly reporting through the EHR and regular review at primary care quality meetings.

Table 1. Demographics and Results for Children Seen for 12-Month Well Visits 1 Year Pre-intervention (10/2015–9/2016) and 1 Year Post-intervention (4/2017–3/2018)

	Pre-intervention (n = 8732)	Post-intervention (n = 9309)
Men (%)	4488 (51.4)	4794 (51.5)
Women (%)	4244 (48.6)	4515 (48.5)
White (%)	7003 (80.2)	7447 (80.0)
Black (%)	1266 (14.5)	1387 (14.9)
Hispanic (%)	288 (3.3)	373 (4.0)
Medicaid (%)	4418 (50.6)	4822 (51.8)
Lead tests ordered (%)	6269 (71.8)	8902 (95.6)
Lead tests resulted (%)	No data	8090 (86.9)
Percentage of ordered tests resulted	No data	90.9

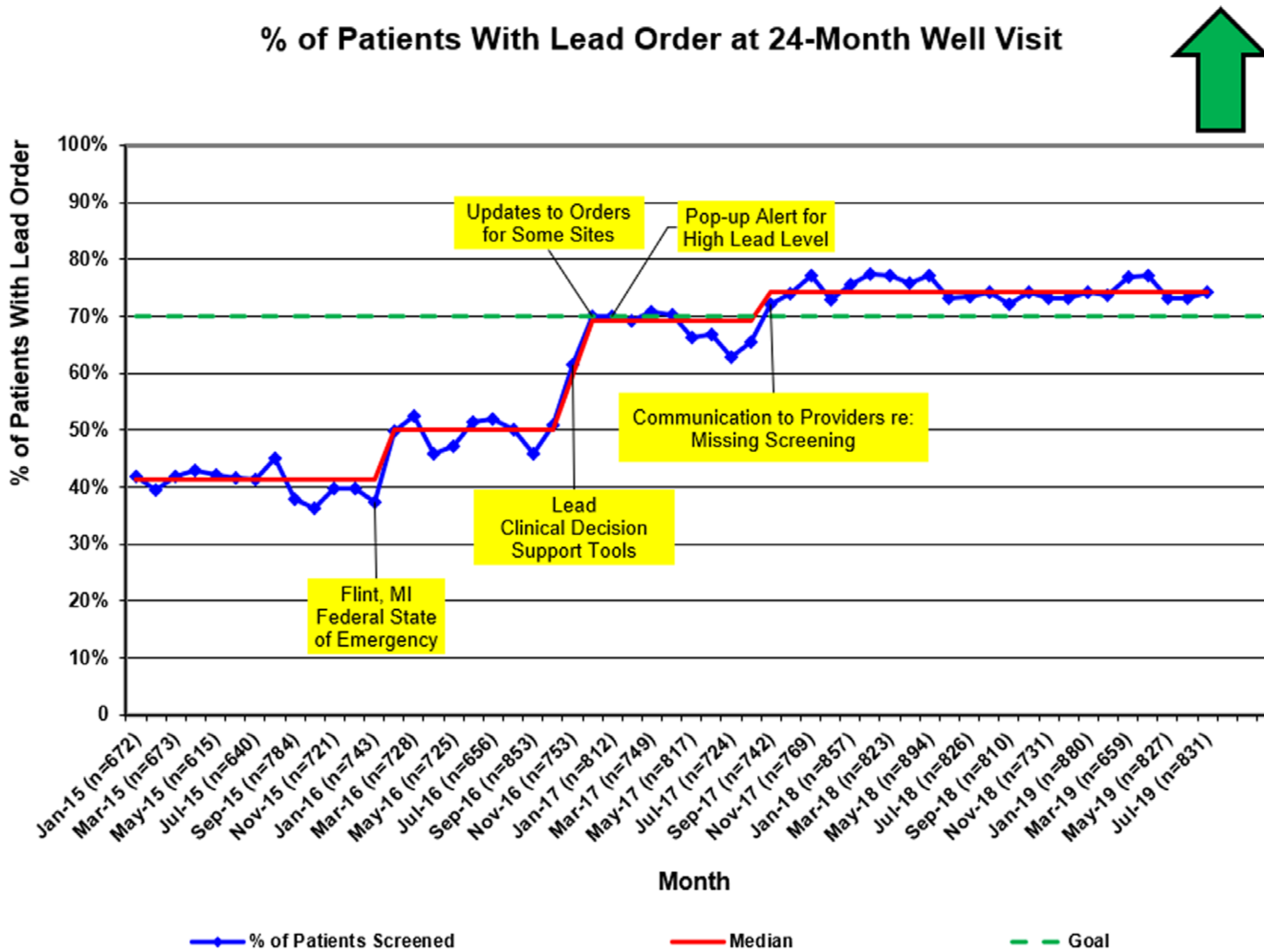

Fig. 3. Run chart depicting the percentage of patients with lead order at the 24-month well-child visit. The upward arrow demonstrates the direction of the desired improvement. Annotations identify the timing of key interventions. The dashed green line denotes the goal. The solid red line is the median screening rate and shifts according to the standard run chart rules.

DISCUSSION

We successfully achieved the goal of sustained improvement in lead screening for primary care patients at 12 months (from 71% to 96%) and 24 months (from 41% to 74%) by implementing a suite of electronic health record clinical decision support (CDS) tools. These data suggest that for universal and targeted screening needs, prechecking orders and aligning the orders with the resources available uniquely at each practice location can improve screening reliability.

In the electronic health record era, CDS has accelerated the adoption of better practices both in screening and treatment scenarios. For example, Burdick et al demonstrated CDS use to improve behavioral health screening in the primary care setting.[28] Karas et al further demonstrated the impact of CDS in a pediatric primary care network by doubling the Chlamydia screening rates for at-risk patients.[29] McGrath et al reported the CDS impact on lead screening in primary care settings in a small study that utilized provider reminders to increase ordered screens from 21 to 49% but with less impact on actual testing results (17% baseline to 18% postintervention).[24] We believe our study demonstrates a more significant impact on lead screening in a larger primary care practice network.

As healthcare decisions continue to become more complex, leveraging CDS in the patient-care environment is crucial. In Ohio, over 500 ZIP codes denote a higher risk of lead exposure, beyond the capacity of any provider to memorize. Another example unique to pediatrics is the

Table 2. Demographics and Results for Children Seen for 24-month Well Visits 1 Year Pre-intervention (10/2015–9/2016) and 1 Year Post-intervention (4/2017–3/2018)

	Pre-intervention (n = 8872)	Post-intervention (n = 9350)
Men (%)	4622 (52.1)	4787 (51.2)
Women (%)	4250 (47.9)	4563 (48.8)
White (%)	6973 (78.6)	7415 (79.3)
Black (%)	1349 (15.2)	1393 (14.9)
Hispanic (%)	257 (2.9)	309 (3.3)
Medicaid (%)	4383 (49.4)	4591 (49.1)
Lead tests ordered (%)	4054 (45.7)	6681 (71.5)
Lead tests resulted (%)	No data	6043 (64.6)
Percentage of ordered tests resulted	No data	90.5

immunization schedule. The rules surrounding vaccine timing and spacing are complex. And while the adoption of CDS for immunizations has been improving, historically, vaccine errors have been common.

Lead screening is only part of the work needed to reduce the risks of lead toxicity in children. The next steps include improvement work to ensure the reliable response to elevated blood lead levels and to partner with lead abatement resources, similar to work published by Brown et al[23]

LIMITATIONS

A multi-site practice network with a single electronic health record accomplished this improvement work. Successful implementation could be more complicated for organizations with multiple or variable electronic health record systems or limited informatics infrastructure. Second, the described interventions align with the requirements of Ohio law. Other state recommendations for screening may be different, requiring the implementation of alternative strategies. Additionally, this work focused on children receiving care at well-visits, excluding children seen in ambulatory or inpatient settings outside of the primary care practice or those children seen at the primary care practice for sick visits. This study lacks a baseline screening rate for high-risk children at the 24-month well visit due to a lack of historical risk data. Therefore, we measured the screening rates across the entire 2-year-old population. No balancing measures were tracked, so it is unknown if this project increased the rates of unnecessary testing. Nor did we study the impact on office workflows. Lastly, because improvement goals were reached, several possible key drivers were not addressed. No interventions surrounding patient education were implemented. Such efforts might improve patient compliance with testing.

CONCLUDING SUMMARY

This study demonstrates a successful increase in lead screening rates for children 12 and 24 months of age through the use of a multidisciplinary improvement team, the Model for Improvement methodology, and leveraging the electronic health record and decision support systems. Healthcare organizations can use similar clinical decision support tools to improve screening for lead toxicity and other prevalent conditions. Moving forward, we will seek to improve our systems for laboratory tracking and management of children identified as having high blood lead levels.

DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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