The Effect of COVID-19 Pandemic Restrictions on Lead Screening in a Primary Care Clinic

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Introduction: Coronavirus disease 2019 (COVID-19) has disrupted outpatient pediatrics, postponing well-child care to address immediate patient safety concerns. Screening for lead toxicity is a critical component of this care. Children may be at increased risk for lead exposure at home because of social restrictions. We present data on how COVID-19 restrictions have impacted lead screening in a primary care practice.
Method: Lead testing data on 658 children in a primary care practice were analyzed to determine the effect of COVID-19 restrictions on lead screening rates, levels, and deficiencies.
Results: Lead screening significantly decreased during peak restrictions, leading to increased screening deficiencies. Despite this decrease, screening lead levels increased during peak restrictions.
Discussion: These data show how COVID-19 restrictions have disrupted routine care and highlight the importance of continued lead screening in at-risk populations. The electronic medical record can be leveraged to identify deficiencies to be targeted by quality improvement initiatives. J Pediatr Health Care. (2022) *36*, 64−70

KEY WORDS

Lead exposure, screening, well-child care

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) has dramatically impacted outpatient pediatrics (Chanchlani, Buchanan, & Gill, 2020; American Academy of Pediatrics, 2020). Well-child care (WCC) and subcritical follow-up visits have been canceled or postponed for patient safety reasons; however, the age-appropriate WCC performed at these visits is critical for long-term health outcomes (Hagan, Shaw, & Duncan, 2007; Melnyk et al., 2012). Missed or delayed routine childhood vaccinations because of COVID-19 have received significant attention (Santoli et al., 2020; Saxena, Skirrow, & Bedford, 2020), but an additional critical component of WCC is screening for lead exposure in at-risk individuals (Council on Environmental Health, 2016).

Lead is a potent toxin with neurological, cardiac, gastroenterologic, hematologic, and other effects (Flora, Gupta, & Tiwari, 2012). Recent statements from the Centers for Disease Control and Prevention and National Toxicology Program highlight that although the severity of toxicity is dose-dependent, even lead levels below the standard cutoff of 5 μg/dL can lead to behavior problems and impaired cognitive function (Centers for Disease Control and Prevention, 2012; Lanphear et al., 2005; Lanphear, 2015). To combat this, many states have passed legislation mandating testing that focuses on screening children. In Connecticut, annual screening is mandatory from 9 months to 3 years of life and advised at provider discretion until 6 years of life (Connecticut Department of Public Health, 2013).

Pediatric exposure to lead primarily comes from environmental sources. Major contributors are lead paint, drinking water, contaminated dust, and contaminated soil. The risk of exposure from these sources is linked to the age and setting of housing, with a higher risk for older housing in urban settings (Mielke & Reagan, 1998; O'Connor et al., 2018). Federal legislation banned lead in residential paint and in the pipes and solder used for drinking water in 1978 and 1986, respectively (Levin et al., 2008; O'Connor et al., 2018), although older houses may pose a risk if mitigation efforts have not been performed. Lead in soil arises from pulverized paint and deposition of lead compounds from industrial facilities and exhaust from the combustion of leaded gasoline (Clarke, Jenerette, & Bain, 2015; Mielke & Reagan, 1998; O'Connor et al., 2018). Contaminated soil surrounding houses can then be tracked indoors and contribute to lead dust. Collectively, older housing stock in areas of high vehicle traffic, as is often found in urban areas, is associated with an increased risk of exposure (Levin et al., 2008). Exposure to lead in the home environment raises unique concerns in light of social changes introduced by restrictions during the COVID-19 pandemic. Quarantines and virtual schooling may have increased time spent at home where these exposures are most likely to occur.

We sought to quantify the degree to which COVID-19 restrictions impacted routing lead testing and determine if changes to social settings contributed to a change in lead exposure. In this paper, we provide an electronic medical record (EMR)-based retrospective analysis of lead screening data from a primary care practice in a resident clinic. We analyzed the volume of lead screening tests and ages of children screened during the COVID-19 pandemic compared with matched control periods. We also examined screening lead levels to assess for evidence of changes in exposure. Finally, we quantify how this change in lead screening has affected the number of children with deficiencies based on state and national guidelines.

METHODS

Setting

This study was performed at a community hospital-based resident primary care clinic in Connecticut. Patients were seen by both attending physicians and resident physicians with an attending physician precepting. Point of care (POC) lead screening is performed in-office, and venous testing for confirmation or follow-up is available in-office or on the same campus.

Electronic Medical Record

Clinical documentation is performed in the commercially available Epic EMR (Epic Systems Corporation, Verona, WI). Data were extracted using the Reporting Workbench, which allows users to create queries to compile data on patients within their practice on the basis of defined criteria.

Data Collection

Lead testing data was obtained for all patients between 9 months and 6 years of age between January 1, 2019 and December 1, 2020. This allowed seasonal-matched comparison of testing during periods of COVID-19 restrictions to control for potential seasonal variations in lead levels or testing volume. Custom reports were created in the Epic Reporting Workbench, which provided data on all children meeting the age criterion and lead testing performed during this period.

This study was approved as a quality improvement project by Trinity Health of New England Institutional Review Board Trinity Hea, the sponsoring agency of the practice.

Test Annotation

Each lead test was annotated by method and class. Testing methods were POC or venous testing. Testing class refers to whether the test was used for screening, confirmation of an elevated screen, or follow-up of a known elevated venous level. Screening denotes a POC lead test with either no prior test or a normal prior test. Confirmation denotes a venous lead test following a screening test with a value $\geq 5\ \mu g/dL$. Follow-up denotes a venous lead test following a test with a venous lead level $\geq 5\ \mu g/dL$.

Testing Deficiencies

Deficiencies in testing were determined on the basis of Connecticut state law and Centers for Disease Control and Prevention recommendations. In Connecticut, annual screening is mandated between 9 months and 35 months of age. A screening deficiency was considered any screen performed at $\geq$ 13 months of age or $\geq$ 13 months from the prior screen or last venous lead sample with a value $\leq 5\ \mu g/dL$.

Periods

Periods for analysis of the effect of COVID-19 on lead screening were defined on the basis of ordinances passed within Connecticut that limited activity. The period between January 1, 2020 and March 20, 2020 was considered pre-restriction. On March 20, 2020, strict stay-at-home orders were passed and persisted until June 6, 2020; this period was labeled as peak restriction. The period from June 6, 2020 to December 1, 2020 was used to mark the period with ongoing effects but fewer mandated restrictions, labeled as relaxed restrictions. Because of potential seasonal variations in well-child visit volume and known variation in lead levels (Yiin, Rhoads, & Lioy, 2000), these same periods from 2019 were used as controls.

Statistical Methods

To assess differences in test quantity, observations were binned by period, and statistical tests were performed between matched periods from 2019 and 2020. Statistical differences in counts were examined using the rate ratio (RR) test. Age difference in these bins was assessed using the nonparametric Mann-Whitney U test because of the nonnormal distribution of data. Lead screening test values

TABLE 1. Demographic and testing information

Demographics	Patients, N = 658
Sex	
Male	348
Female	310
Race/ethnicity[a]	
White non-Hispanic	66
Black non-Hispanic	154
Hispanic	383
Asian	7
Other	110
Testing Information	**Tests (*n* = 1,261)**
Test type	
Screening	1,113
Confirmation	102
Follow-up	46
Age at test	
9–24 months	387
24–36 months	269
36–48 months	208
48–72 months	387

[a]*Sum greater than* N = *658 as patients may self-identify with more than one race.*

were discretized into 5-μg/dL ordinal bins for statistical comparison using the asymptotic linear-by-linear association test. This was because most screening test values fell below the limit of detection, which limited the use of statistical tests which require continuous variables. Venous lead sample values for confirmatory tests were analyzed with the same discretized method. The number of outstanding confirmatory tests between periods was assessed using Fisher exact test. Period assignment confirmatory tests were based on the associated screening test date. Differences in testing deficiency prevalence between matched periods were assessed using a two-sample proportional test. Differences in the rate of incidence for new or resolved deficiencies were assessed using the RR test. Statistical testing was performed in R (R Core Team, 2013).

RESULTS

During the study period, 658 children from 9 months to 6 years of age were evaluated in-clinic, and a total of 1,261 lead tests were performed on 561 unique children. Tests were classified as screening, confirmation, or follow-up as defined in Methods. Demographic data and testing type distribution are summarized in Table 1.

To determine the effect of the COVID-19 pandemic on lead screening, periods with differential social restriction mandates were created. The period between January 1 and March 19 was defined as pre-restriction; the period between March 20 and June 6 was defined as peak restriction; the

FIGURE 1. The effect of coronavirus disease 2019 (COVID-19) restrictions on lead screening volume. Monthly lead screening test quantities for 2019 and 2020 are shown. Vertical dashed lines separate pre-restriction, peak restriction, and relaxed restriction periods. Statistical significance was tested between 2019 and 2020 for each period using the rate ratio (RR) test. Test quantity was significantly decreased during peak restrictions (RR 0.48, *p* =.0002) but not during the pre-restriction or relaxed restriction time periods (RR 0.99, *p* = 1.0, and RR 1.03, *p* =.79, respectively)

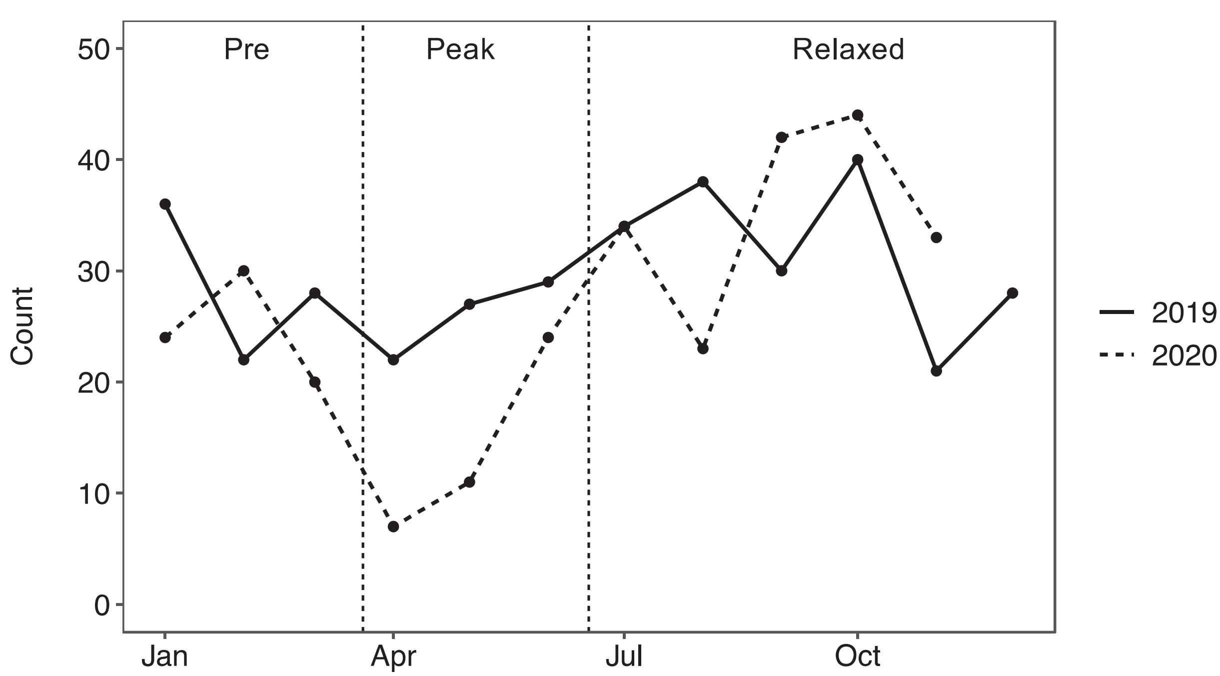
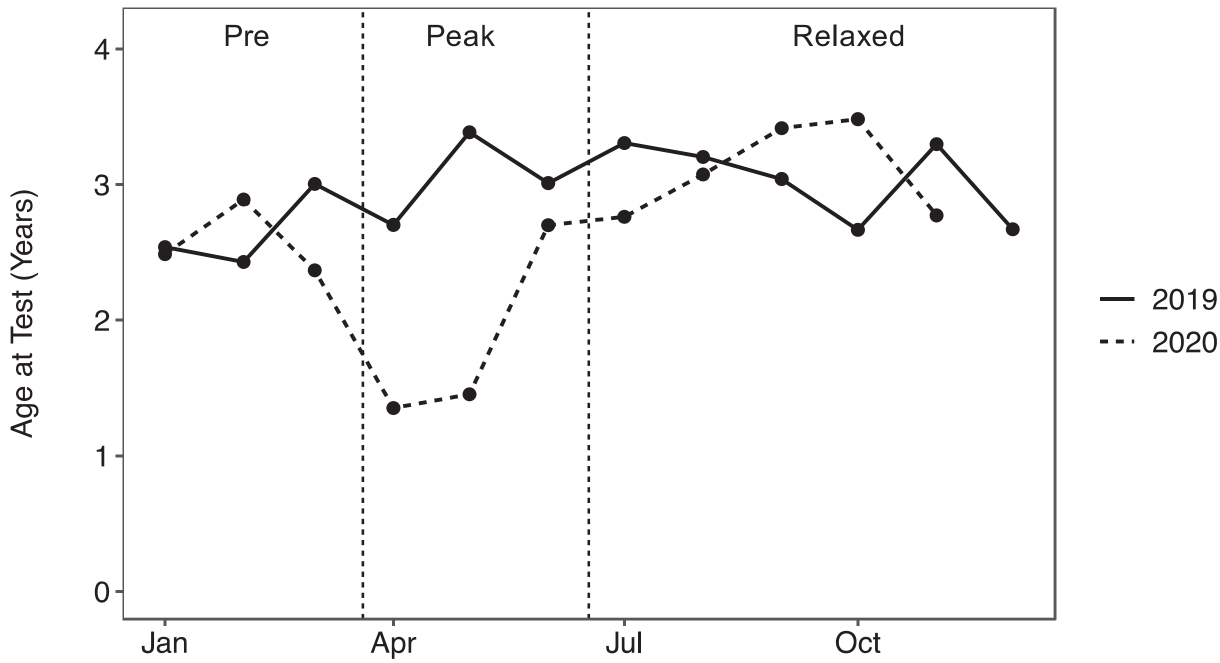


FIGURE 2. Effect of coronavirus disease 2019 (COVID-19) restrictions on mean age at screening. The monthly mean age of children screened for lead exposure is shown for 2019 and 2020. Vertical dashed lines separate pre-restriction, peak restriction, and relaxed restriction periods. The mean age of children screened for lead exposure significantly decreased during peak restriction (mean age 2.0 years vs. 2.8 years, *p* =.002) but not during the pre-restriction or relaxed restriction periods.

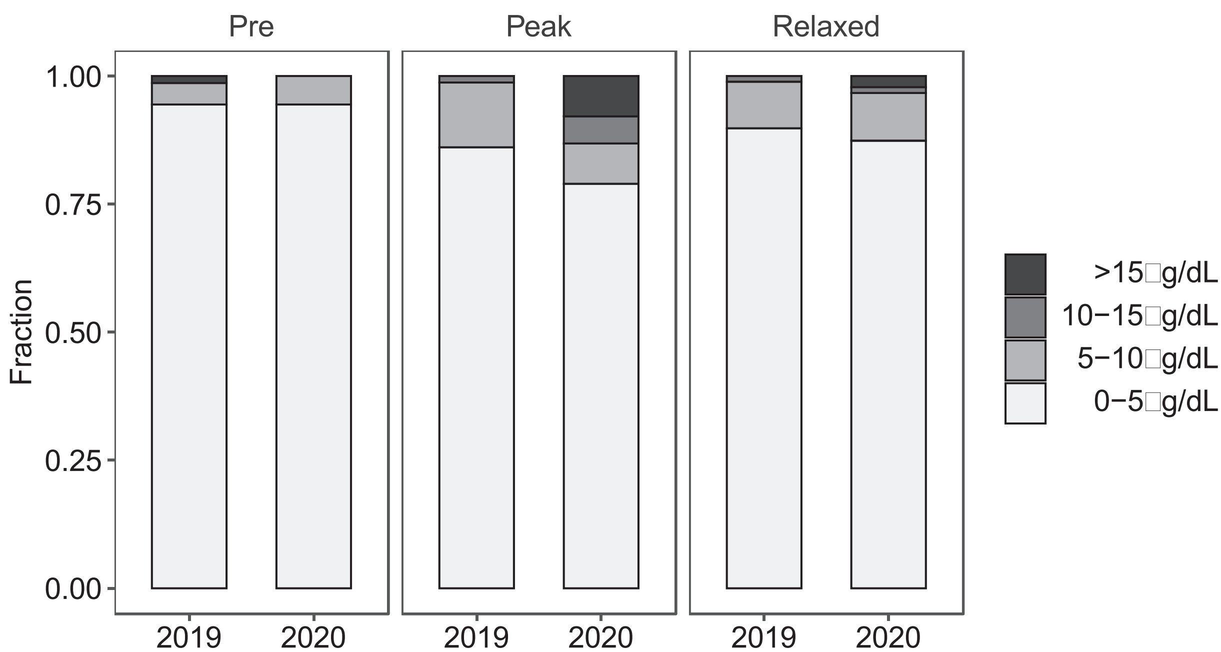


period between June 6 and December 1 was defined as relaxed restrictions on the basis of executive orders limiting activity. These intervals from 2020 were compared with the equivalent periods during 2019 to control for seasonal variations in lead testing levels and quantity (Yiin et al., 2000). Monthly screening test volume was reduced during peak restriction to approximately half of the prior year value (RR = 0.48, *p* =.0002) but not during the pre-restriction or relaxed restriction period (RR = 0.99, *p* = 1.0, and RR = 1.03, *p* =.79, respectively) as shown in Figure 1. We also observed a significant reduction in mean age at screening during peak restriction (mean age 2.0 vs. 2.8 years, *p* =.002) but not during pre-restriction or relaxed restriction periods, as shown in Figure 2. This indicated that although testing was preserved for youngest children, older children were screened less often during peak restriction.

During peak restriction, the normal daily activities of patients and families dramatically changed with school and daycare closures. This potentially led to more time spent at home, where lead exposure is known to occur. We, therefore, examined screen lead levels to determine if there was evidence of increased exposure (Figure 3). The frequency of tests with a lead value of ≥ 5 μg/dL significantly increased during peak restriction (*p* =.02). During the relaxed restriction period, there was a trend toward an increase, but this did not meet statistical significance (*p* =.1). Blood lead levels from confirmatory tests for positive screens were analyzed by limited by the number of outstanding tests. We found no significant difference in the number of outstanding tests between periods. With the caveat of significant numbers of outstanding tests, we did not observe significant differences in confirmatory samples with blood lead levels of ≥ 5 μg/dL during any period (Supplementary Figure).

In addition, we explored the effect of COVID-19 on meeting mandated screening requirements. Definitions for deficiencies in each category are detailed in the Methods. The proportion of children aged from 9 months to 3 years of age with active screening deficiencies increased significantly during the COVID-19 pandemic (Figure 4). The increase started but was not significant during peak restrictions and became statistically significant during the Relaxed restriction period (0.46 vs. 0.67, *p* <.0001). The total number of active deficiencies during a period represents both new deficiencies that occurred during the period and those carried over from a prior period without being resolved. To separate these scenarios, the rates of deficiency occurrence and resolution were compared between periods. The rate of occurrence for new deficiencies during peak restrictions neared significance (RR, 1.87; *p* =.07) and was significant during the relaxed restrictions period (RR, 2.27; *p* =.0002). The rate of deficiency resolution increased during the relaxed restrictions period as well (RR, 1.61; *p* =.04), representing a return to increased screening. Full RRs and significance levels are shown in Table 2.

FIGURE 3. Screening test lead levels by period. Point of care screening values were discretized into ordinal categories, 0–5 μg/dL, 5–10 μg/dL, 10–15 μg/dL, and $\geq$ 15 μg/dL. The fraction of tests in each lead level category is shown for each coronavirus disease 2019 restriction period and year. There was no significant difference during the pre-restriction period (asymptotic linear-by-linear association test, *p* =.61). During peak restriction, there was a significant increase in the fraction of tests with higher lead levels (asymptotic linear-by-linear association test, *p* =.03). During the relaxed restriction, a greater fraction of values were $\geq$ 5 μg/dL, but this association was not significant (asymptotic linear-by-linear association test, *p* =.17)



DISCUSSION

This study shows the effect of restrictions imposed during the COVID-19 pandemic on lead screening within a primary care clinic in an urban setting in Connecticut. We found that lead screening volume was dramatically reduced during the peak restrictions of the COVID-19 pandemic. This reduction primarily affected screening in older children, as evidenced by a decrease in the mean age of children being screened. This likely reflects the prioritization of WCC visits from birth to 15 months old, in which most critical vaccines are administered. Although screening volume has returned to baseline, the number of children not meeting screening recommendations has continued to increase, indicating that the backlog of missed tests is continuing to have an effect. We also find that even as screening volume has declined, the proportion of screening tests with elevated lead levels has increased. One mechanism of primary concern is whether the change in the daily social structure that restriction put in place to address the spread of COVID-19 has created a potential for increased lead exposure. With fewer daycares and schools open, children aged from 9 months to 6 years of age may be spending more time at home. This may increase exposure in two related ways. First, increased time spent in an environment containing lead may directly increase exposure risk. Second, lead exposure is known to be seasonal and related to the tracking of contaminated dust into the home (Yiin et al., 2000). Changes to activities of older siblings and relatives during COVID-19 restrictions may have increased lead-contaminated dust loading. Furthermore, it is likely that home visits to identify lead exposure and subsequent mitigation efforts have also been affected by the same restrictions imposed by COVID-19 precautions.

There are weaknesses that may limit the generalizability of the findings. First, this study was conducted at a single site, so lead exposure risk, and the magnitude and timeline of COVID-19 restrictions are specific to the study location. Second, this study was retrospective and used an EMR-based label of assigned primary care physician to determine patients that were included. Therefore, patients who transferred practices during this period without a change to the primary care physician would appear as having testing deficiencies, and any laboratory testing performed outside of the medical system would not appear. Third, because of smaller sample sizes, we are not able to confidently examine trends in confirmation or follow-up testing. Fourth, these data focus on screening tests and not data from confirmatory venous blood levels. Preliminary analyses (Supplementary Figure) showed no significant difference

FIGURE 4. Effect of coronavirus disease 2019 (COVID-19) restrictions on lead testing deficiencies. Monthly counts of active screening deficiencies are shown for 2019 versus 2020 across the periods of differential COVID-19 restrictions. There was a significant increase in the proportion of patients with any duration of screening test deficiency during the relaxed restriction period (0.41 vs. 0.55, *p* <.004) but not pre-restriction or peak restriction (0.44 vs 0.40, *p* =.48; 0.40 vs 0.43, *p* =.66, respectively). Proportions are based on the total number of children aged between 9 months and 3 years during each period.

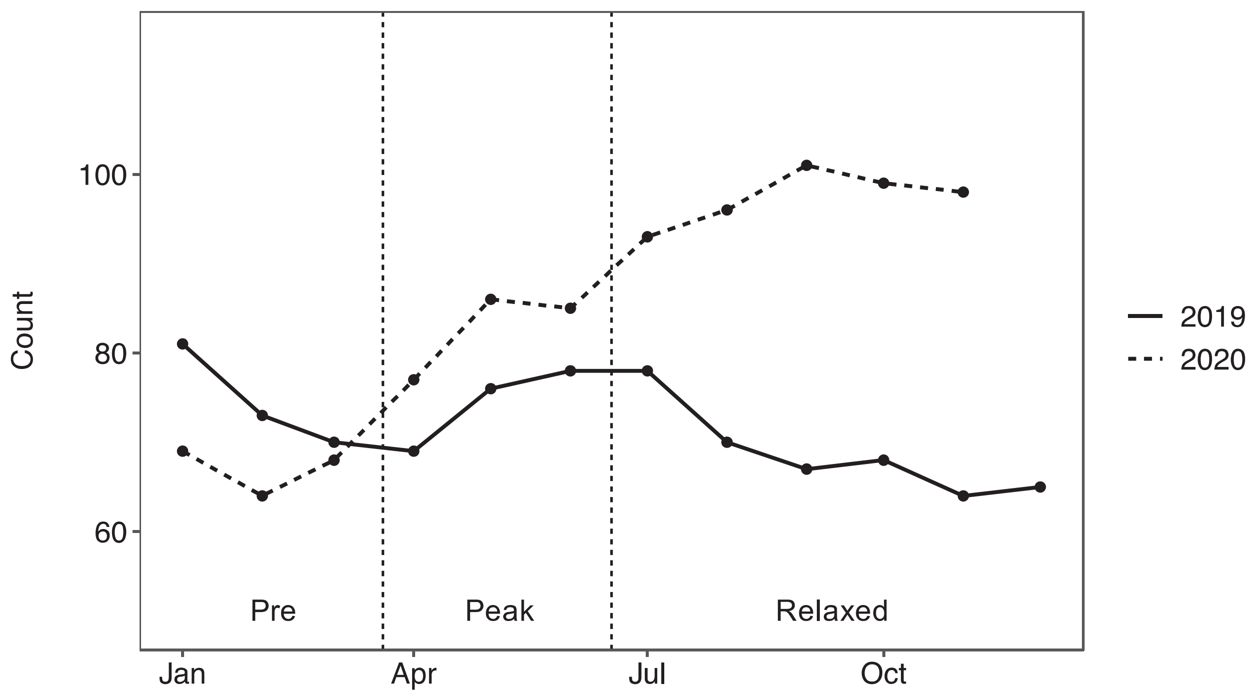


TABLE 2. New and resolved lead test deficiencies

	New Deficiencies				Resolved Deficiencies			
Screening	2019 (N)	2020 (N)	RR	*p*	2019 (N)	2020 (N)	RR	*p*
Pre[a]	15	19	1.28	.58	19	15	0.8	.63
Peak	15	28	1.87	.07	13	8	0.61	.38
Relaxed	30	68	2.27	.0002	31	50	1.61	.04

Note. *RR, Rate Ratio test*.
[a]*Periods were defined as follows: pre-restriction from January 1 to March 20; peak restriction from March 20 to June 6; and relaxed restriction from June 6 to December 1.*

in the venous blood levels for confirmatory tests during these periods; however, the number of positive screening tests was small, and there were a significant number of outstanding confirmatory tests.

Despite these limitations, this study shows that COVID-19 has significantly delayed an important component of WCC during a time when social restrictions may have increased the amount of time in environments where exposure may occur or altered the exposure profile of these environments. We do not argue that patient safety should be compromised to maintain prepandemic lead screening but rather provide these data to increase awareness of the effect of pandemic-related restrictions on WCC. The methodology employed serves as a model for how the EMR can be leveraged to direct panel management when the sequence of normal WCC is interrupted. Patients with deficiencies can easily be identified remotely, and quality improvement structures can be created to resolve patients at the highest risk.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.pedhc.2021.03.004.

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