Acceptability of an Asynchronous PowerPoint for Increasing Provider Knowledge of Childhood Lead Screening: A Quality Improvement Project

ACCEPTABILITY OF AN ASYNCHRONOUS POWERPOINT FOR INCREASING PROVIDER KNOWLEDGE OF CHILDHOOD LEAD SCREENING: A QUALITY IMPROVEMENT PROJECT

by

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by *Laura J. Kennicutt*, titled *Acceptability of an Asynchronous PowerPoint for Increasing Provider Knowledge of Childhood Lead Screening: A Quality Improvement Project* and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

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DEDICATION

This project is dedicated to my mom and dad for helping me to pursue my dreams.

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ABSTRACT

Purpose: The purpose of this DNP Project was to increase the number of children screened for lead toxicity by identifying and addressing barriers to guideline adherence.

Background: Elevated blood lead levels (BLLs) are associated with reduced intelligence, lower school achievement, and behavior disorders. Exposure to lead results in an estimated 400,000 deaths annually, comparable to the mortality from tobacco smoke. 500,000 U.S. children between 1 and 5 are estimated to have elevated BLLs, with low-income and minority families particularly affected. Locally, this issue is a priority because only 4.5% of children under 6 in Pima County's high-risk zip codes received both recommended blood lead tests in 2016.

Methods: A 15-minute electronic survey was emailed to four primary care providers at a family practice clinic. Informed by Ajzen's Theory of Planned Behavior, the survey included: 1) Knowledge of state and federal lead screening guidelines; 2) Attitudes regarding lead screening; and 3) Perceived barriers to consistent screening and reporting. All participants received a targeted educational PowerPoint presentation that included accurate information about lead toxicity and current lead screening guidelines, and were asked to complete a post-survey evaluating its effectiveness.

Outcomes achieved: Three health care providers responded to the survey (75% response rate), including two nurse practitioners and one physician. The mean knowledge score was 37%, with no correct responses to questions about the ages at which testing is required and unnecessary or wasteful testing procedures. Attitudes towards testing were generally positive. Identified barriers included not knowing where to find current guidelines, perceiving CDC guidelines as difficult to follow, and lack of provider education. The PowerPoint addressing these learning needs was

positively rated by participants. Project findings were shared with clinic site management to facilitate employee training and clinical processes.

Conclusions: Future directions include repeating this project with a larger sample of clinicians. Additional promising interventions from the literature include office system improvements, preventive care bundles, in-house capillary testing, and electronic medical record prompts. Nurse practitioners are notably absent from the literature on attitudes and barriers to lead screening, and future research should aim to be more inclusive of advanced practice nurses.

INTRODUCTION

Background

Lead toxicity is a national health care priority, affecting an estimated 500,000 children between the ages of one and five in the United States (Centers for Disease Control and Prevention [CDC], 2013a). Exposure to lead results in an estimated 400,000 deaths annually, comparable to the mortality from tobacco smoke (Lanphear, Rauch, Auinger, Allen, & Hornung, 2018). As an environmental health concern, lead poisoning lies at the intersection of public health and primary care. An ideal approach to reducing the burden of lead toxicity involves a combination of population - and community-based policies and programs, along with individualized provision of education and appropriate screening and treatment by primary care providers. Moreover, these efforts should be coordinated to ensure that care and follow-up of at-risk children is efficient, integrated, and accountable.

Infants and children exposed to lead suffer long-term consequences that may take years to become fully apparent. This exposure may come in the form of lead-based paint, soil, water, pottery, candy, alternative remedies, and other sources that are common to economically disadvantaged neighborhoods (World Health Organization [WHO], 2017). At high levels, lead toxicity may lead to coma or death (WHO, 2017), while lower levels may cause impairments and delays in intelligence, development, behavior, and academic achievement, as well as wide-ranging effects on body systems from endocrine and immune to cardiovascular (Advisory Committee on Childhood Lead Poisoning Prevention, Centers for Disease Control and Prevention [ACCLPP], 2012).

While primary prevention through lead paint abatement and parental education is key to achieving goals such as the Healthy People 2020 objectives related to reducing children's blood lead levels (BLLs) (HealthyPeople.gov, 2018), secondary prevention plays an equally vital role through early identification and treatment of children with elevated BLLs. To this end, guidelines have been developed including Medicaid's requirement that patients be screened at 12 and 24 months. Additionally, states have different guidelines and regulations for screening the rest of their pediatric populations (ACCLPP, 2012). The Arizona Department of Health Services (ADHS) currently mandates targeted screening at 12 and 24 months for children who reside in certain high-risk zip codes or meet other risk factors identified via a parent questionnaire (Arizona Department of Health Services [ADHS], 2018). Children may also be tested at 36-72 months if not tested in the past, or up to 16 years if they are new to the country (Arizona Department of Health Services, Childhood Lead Poisoning Prevention Program [CLPPP], 2017b). Health care providers who identify children with elevated BLLs are required to report these results within a set time period to ADHS and conduct follow-up testing and treatment in accordance with the recommendations of the Centers for Disease Control and Prevention (CDC) (ADHS, 2018).

To know the full burden of lead toxicity in Arizona, which determines whether the prevalence is below the threshold allowing the state to continue its targeted screening program rather than instituting a universal screening policy, it is essential that primary care providers adhere to the regulations regarding targeted lead screening. However, the 2016 surveillance report from ADHS' Child Lead Poisoning Prevention Program (CLPPP, 2017a) indicates that, statewide, only 24.2% of children in the high-risk zip codes received their 12-month screening,

14.8% were screened at 24 months, and just 6.0% received both required screenings (CLPPP, 2017a). Out of the 59,606 children screened in 2016, 347 of them had elevated BLLs, with 277 of those representing new incidences (CLPPP, 2017a).

Pima County, located in Southern Arizona, is recognized as being particularly affected by lead-based paint hazards, for which it was recently awarded a $1.65 million grant from the U.S. Department of Housing and Urban Development (HUD) (U.S. Department of Housing and Urban Development [HUD], 2017). Lead screening rates in Pima County were similarly low as those seen statewide, with 24.2% of those in high-risk zip codes screened at 12 months, 13.5% at 24 months, and 4.5% receiving both screenings (CLPPP, 2017a). Of the 7275 children screened, 37 were found to have an elevated BLL (CLPPP, 2017a).

The purpose of this project was to identify and address the barriers preventing primary care providers at a family medicine clinic in Pima County from performing childhood lead screening in accordance with state regulations. To accomplish this goal, health care providers at the clinic were sent an electronic survey assessing knowledge, attitudes, and perceived barriers in regard to lead screening. Based on the results of this survey, an educational presentation aimed at providers' responses was presented to, and evaluated by, the providers. Therefore, my study question was twofold: 1) What are the barriers to childhood lead screening among primary care providers in Tucson, Arizona; and 2) Is targeted provider education an acceptable method of promoting adherence to state and federal lead screening guidelines?

Data and Trends

Estimates of incidence and prevalence of lead toxicity among US children are based on population-based surveys and surveillance (test results reported to state and local health

departments), but such estimates are hindered by limited survey samples, low screening rates, and incomplete reporting of elevated BLLs (ACCLPP, 2012). The regional population-based survey data used for the purposes of research and setting thresholds are drawn from the National Health and Nutrition Examination Survey (NHANES), which surveys around 5000 people in 15 counties each year (ACCLPP, 2012; National Center for Health Statistics [NCHS], 2017). In 2016, the CDC released lead testing results for children under 72 months reported to state and local health departments from 1997 to 2015 which included data organized by state and by year (CDC, 2016a). Data completeness varied by state, and data at the national level for elevated BLLs between 5 µg/dL (currently the CDC's level of concern) and 10 µg/dL (the previous level of concern) have only been collected since 2010 (CDC, 2016a). Still, the data show an encouraging downward trend, with a decrease in the number of children under 72 months with elevated BLLs above 5 µg/dL from 282,434 (6.59%) in 2010 to 79,957 (3.31%) in 2015 (CDC, 2016a). The data from Arizona show a similar decrease in the number of children with BLLs above 5 µg/dL from 965 (1.40%) in 2010 to 525 (1.11%) in 2015 (CDC, 2016a).

Sources of Lead Exposure

Common risk factors for lead exposure are access to lead-based paint (typically in pre-1950s housing), proximity to industrial lead sources like smelters and mines, occupational exposure, exposure to contaminated soil, and water contamination (from lead-containing home pipes or on a municipal level) (ACCLPP, 2012). The American Healthy Homes Survey in 2005-2006 determined that 37.1 million (35%) of the homes in the US contain lead-based paint, including three million homes with children under the age of six (Dewalt et al., 2015). The manner in which lead-based paint poisons young children may include ingestion of paint chips

and exposure to the dust created by friction to lead-painted surfaces (such as windows being opened and closed), which can be inhaled or ingested as it accumulates on surfaces (such as carpets) which come into contact with objects or extremities that children put in their mouths (Environmental Protection Agency [EPA], 2017).

Imported items common in immigrant communities can also contain lead, with frequent examples including toys, cosmetics, candies, teas, herbal medicines, and spices (ACCLPP, 2012). In Hispanic communities, two lead-containing folk remedies that may be encountered are Greta (lead oxide) and Azarcon (lead tetroxide), which are taken for *empacho*, or gastrointestinal discomfort; alarmingly, these are sometimes given to infants who are teething (Baer & Ackerman, 1988; Centers for Disease Control and Prevention [CDC], 2013b). Leaded gasoline was a major source of contamination before the 1970s, and lingering effects are still seen in areas that had heavy vehicular traffic during this era (Davis et al., 2016; Mielke, Gonzales, & Mielke, 2011). Ambient air levels have shown a correlation to elevated BLLs even when controlling for age of housing, race, and rural or urban residence (Brink et al., 2013). Poor nutrition worsens the damage done by lead exposure (Mason, Harp, & Han, 2014). Air quality may also have an impact on lead burden, as ambient nitrogen dioxide and ozone can increase the liberation of lead from lead-based paint through their interaction with binders in the paint (Edwards, Lam, Zhang, Johnson, & Kleinman, 2009).

Abatement of lead paint and home renovations can increase the risk of lead exposure if performed by inexperienced workers who are untrained in lead-safe practices (EPA, 2017). Some families may have difficulty locating and affording the services of experienced professionals authorized to carry out lead testing and safe abatement, which should be considered when

making recommendations about risk reduction to caregivers. It should also be noted that home testing kits available at hardware stores are not federally approved due to their overwhelming false positive rate of nearly 100% (Buehler & Rhoda, 2012).

Disparities

In the U.S., disparities in environmental lead exposure and toxicity exist for racial minorities (Jain, 2016; White, Bonilha, & Ellis, 2016), immigrants (Cleveland, Minter, Cobb, Scott, & German, 2008a), and low-income subpopulations (Aelion, Davis, Lawson, Cai, & McDermott, 2013). Hispanic children are at an increased risk compared to their white counterparts (Brown & Longoria, 2010; Perla, Rue, Cheadle, Krieger, & Karr, 2015), which is of particular concern in the heavily populated Hispanic communities of Southern Arizona.

Reasons for these disparities vary widely among groups and may include old, poorly maintained, rental, and substandard housing (Jacobs, 2011; Weitzman et al., 2013); proximity to sources of environmental contaminants related to industry and mining (Wiener & Jurevic, 2016); historic exposure to high levels of traffic and thus leaded gasoline (Davis et al., 2016; Mielke, Gonzales, & Mielke, 2011); use of lead-tainted products, foods, and remedies obtained from other countries; nutritional deficits that exacerbate lead toxicity; exposure to secondhand smoke (Jain, 2016); reduced access to health care; higher rates of pica, the practice of ingesting non-foodstuffs (Thihalolipavan, Candalla, & Ehrlich, 2013); and cultural and language barriers to information and screening (Taylor & Holtrop, 2007).

Problems Caused by Lead Toxicity

The neurotoxic effects of lead are wide-ranging, affecting such varied functions as overall intelligence, memory, language, motor and visuospatial skills, and executive functioning

(Mason, Harp, & Han, 2014). There is compelling evidence linking lead exposure in early childhood with intellectual disability and low academic achievement (Nevin, 2009). Potential connections also exist between elevated BLLs and attention-deficit hyperactivity disorder (ADHD) (He, Ning, & Huang, 2017), conduct problems (Marcus, Fulton, & Clarke, 2010), and lower reading readiness for children entering school (McLaine et al., 2013). Higher BLLs correspond with greater risk and more extreme physical effects. Epigenetic mechanisms are proposed for some neurodevelopmental changes (Senut et al., 2012), although lead can also directly interfere with neuronal differentiation, neurotransmitter action, metabolic pathways, and other core functions of the central nervous system (Mason et al., 2014). Additionally, lead acts pharmacologically by displacing cations such as calcium in vital intracellular and intercellular processes (Mason et al., 2014). Other health issues that show associations with increased lead levels in children are encephalopathy, kidney damage, thyroid dysfunction, and dental caries (Mason et al., 2014; Wiener, Long, & Jurevic, 2015).

Importantly, many of these health effects are initially asymptomatic, only showing clinical signs and symptoms later in life. This can be a problem if parents interpret the lack of symptoms to mean that blood lead screening is unnecessary (Haboush-Deloye, Marquez, & Gerstenberger, 2017).

Prevention and Treatment

The disparities in lead poisoning seen in low-income neighborhoods suggest that primary prevention through abatement of heavy metal contamination can lead to improved outcomes. There is accumulating evidence concerning the positive effects of lead paint risk reduction and laws enforcing it (Shao, Zhang, & Zhen, 2017). Primary prevention is the focus of

recommendations from Healthy People 2020 (HealthyPeople.gov, 2018) and a policy statement from the American Academy of Pediatrics' Council on Environmental Health (2016).

Primary Prevention

Media campaigns (Greene, Tehranifar, DeMartini, Faciano, & Nagin, 2015; McLaughlin, Humphries Jr, Nguyen, Maljanian, & McCormack, 2004) and local policy initiatives (Korfmacher & Hanley, 2013) are being undertaken by citizens, public health departments, and lawmakers concerned about the lead burden in their communities. In one case, a group of nursing students worked with their local community to provide education on lead safety standards to paint retailers (Gordon, Datema, Slager, Martin, & Vander Werf, 2009). Another project recruited lay health advisors from eight American Indian tribes in Oklahoma to convey lead poisoning prevention messages to community members (Kegler, Stern, Whitecrow-Ollis, & Malcoe, 2003). One barrier to lead-based paint risk reduction efforts is low risk perception from residents (Haclerode, Lal, Vedwan, Wolde, & Miller, 2016). Those seeking to educate members of the public on lead poisoning prevention should take care to select written materials at an appropriate reading level, since one study found that just 40% of the brochures on prevention of lead toxicity were written at the suggested 4th to 6th grade reading level (Endres, Montgomery, & Welch, 2002).

Household interventions to reduce lead hazards include dust removal, increased child supervision, and the safe removal of lead-based paint and contaminated soil. Home-based visits (Brown, McLaine, Dixon, & Simon, 2006) and videos (Kersten et al., 2004) focused on educating families on household lead risk reduction have shown success in individual studies,

but a Cochrane systematic review determined that, overall, household educational interventions and dust control are ineffective at reducing lead risk (Nussbaumer-Streit et al., 2016).

Treatment

The CDC (2017) offers specific recommendations depending on the results of blood lead testing. Along with follow-up testing and reporting requirements, treatment guidelines are offered. Children at all levels of lead exposure should be assessed regularly for nutritional status and developmental milestones, and caregivers should be given information regarding lead hazards. Beginning at 5 µg/dL, investigations into the source of lead exposure should be initiated and specific counseling regarding nutritional deficits should be offered. Lab work for nutritional deficits may be ordered with lead levels between 10 µg/dL and 19 µg/dL. From 20 µg/dL to 44 µg/dL, more detailed assessments, lab work, and imaging are required, and from 45 µg/dL to 69 µg/dL oral chelation therapy may be considered. At the most extreme lead levels (above 70 µg/dL), hospitalization and chelation therapy under the observation of specialists are essential.

The perception that there are limited evidence-based treatment options for low levels of lead toxicity has been identified as a barrier to screening for both clinicians and families (Boreland & Lyle, 2008). At the very least, however, discovering that a child has an elevated BLL can prompt the family to seek out sources of lead contamination and, if possible, eliminate them or remove the child from the environment.

Screening

The threshold of concern used by the CDC to refer to elevated BLLs was lowered from 10 µg/dL to 5 µg/dL in 2012 upon the recommendation of the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP, 2012). In the following years the group that

replaced the committee, the Lead Poisoning Prevention Subcommittee to the Board of Scientific Counselors, recommended that the reference level should be further lowered to 3.5 µg/dL, with the caveat that current testing technology needs to be improved to more reliably measure BLLs below 5 µg/dL (Board of Scientific Counselors [BSC], 2017). Despite classifying elevated BLLs by these reference levels, CDC publications acknowledge that the scientific consensus is there is no safe level of lead exposure (Raymond & Brown, 2017).

Complicating the picture is the lack of a recommendation for screening from the U.S. Preventive Services Task Force (USPSTF), which currently claims there is insufficient evidence to recommend for or against routine screening for asymptomatic children at increased risk, also recommending against screening for children and pregnant women at average risk (U.S. Preventive Services Task Force [USPSTF], 2006). The list of risk factors considered in this guideline is quite broad, encompassing minorities, urban residents, those with low income and low educational levels, standard lead exposure risk factors such as older housing, and many others. This guideline is in the process of being updated, which may lend clarity to a muddied picture for clinicians seeking guidance for lead screening who encounter contradictory messages from the CDC and USPSTF.

Methods of Testing

Capillary and venous blood testing are the standard methods of measuring lead levels. Either capillary or venous blood may be used for initial testing, although elevated capillary results must be confirmed with venous blood. One study showed that in-office capillary blood testing, especially when conducted in synchrony with the immunization schedule, has been shown to increase parental compliance compared to referring them to an offsite laboratory

(Boreland, Lyle, Brown, & Perkins, 2015), and another study found that clinicians with in-office blood collection capability were more likely to screen patients (Kemper & Clark, 2005). Underscoring the burden that traveling to a laboratory may present to families, a past public health effort also demonstrated the benefit of home phlebotomy visits to reach vulnerable members of the community (Dowling, Miranda, & Galaviz, 2008).

While venous blood testing is generally considered to be more accurate, the only reliable way to obtain these results is by drawing and/or processing the blood sample at an offsite laboratory. In 2017, two in-office venous blood lead testing devices were recalled due to falsely low readings, meaning that children who were tested using the machines needed to be retested (Food and Drug Administration [FDA], 2017). An alternative to blood testing using oral samples has shown promise experimentally but is not presently an available option for clinicians (Gardner, Geller, Hannigan, Sun, & Mangla, 2016).

Costs and Benefits

An analysis of the costs of childhood lead poisoning estimated the total at $5.9 million for health care expenses and an additional $50.9 billion in lost productivity stemming from reduced cognitive potential (Trasande & Liu, 2011). The benefits of lead hazard reduction efforts such as lead-based paint abatement have been shown to greatly outweigh the costs, with a 2009 estimate showing that for each dollar spent on reducing lead paint hazards, as much as $221 can be saved for an overall net savings per cohort of $181-269 billion (Gould, 2009). The costs and benefits of universal childhood lead screening were analyzed and published by the CDC in 1997, an analysis that has been cited by states developing targeted screening programs ever since (Briss, Matte, Schwartz, Rosenblum, & Binder, 1997). In the years since that analysis was

completed, much more has been discovered about the consequences of lead exposure and there are a multitude of new treatment options for attributable developmental and behavior problems that were not taken into consideration at that time.

Targeted Screening

States that opt for targeted screening, including Arizona, take into account factors including the percentage of pre-1950s housing and the prevalence of known lead toxicity, based on the CDC's 1997 recommendations that suggest universal screening if ≥27% of housing is pre-1950s and/or there is a ≥12% prevalence of elevated BLLs above 10μg/dL among children between 12 and 36 months (ACCLPP, 2012). This is problematic since the reference level of interest has since decreased, and moreover an accurate prevalence is difficult to estimate since screening levels are often low even among children that are required to be screened by state and federal rules.

Alternative methods of targeting lead screening and primary prevention to those most at risk have been suggested, among them geographic information systems (GIS) (Akkus & Ozdenerol, 2014) and soil mapping (Mielke, Gonzales, Powell, & Mielke, 2014).

Risk Assessment Questionnaires

The use of pre-screening questionnaires is widespread and requires parents and caregivers to answer questions regarding the age of their home, exposure to known lead-containing products, and other common factors that may expose their child to risk for lead exposure. Numerous studies have evaluated the effectiveness of these tools in identifying children with elevated BLLs, showing that in many cases they offer no better odds than chance at predicting risk (Ossiander, 2013). Asking parents about the age of their home is problematic for

many reasons: children often spend time in more than one home and parents may not know the ages of the houses of their friends and relatives; families living in rental housing typically do not have access to information about the age of the building; and perhaps most crucially, parents' inaccurate estimates of their home's age gave this question a sensitivity of 52% in one study (Schwab, Roberts, & Reigart, 2003). Targeted screening programs that rely on questionnaires to identify children at risk may lead to vulnerable children going untested. The questionnaires can, however, serve as conversational guides for family education on reducing environmental hazards.

FRAMEWORK

Theory of Planned Behavior

Icek Ajzen's Theory of Planned Behavior (Ajzen, 1985) has been used to guide inquiries into wide-ranging phenomena in the realm of health care quality improvement. While it has frequently been applied to studies of patient behavior, researchers also use elements of the theory in crafting survey instruments to identify factors influencing the behavior of health care workers. Examples of such studies include inquiries into health care workers' intent to provide or perform evidence-based care services, including: oral hygiene after stroke (Ab Malik, Yatim, Lam, Jin, & McGrath, 2018), correct blood pressure monitoring technique (Nelson, Cook, & Ingram, 2014), sexual counseling for patients with epilepsy (Lin, Fung, Nikoobakht, Burri, & Pakpour, 2017), adherence to antibiotic guidelines (Cortoos, Schreurs, Peetermans, De Witte, & Laekeman, 2012), and discussion of sexual risk behavior with HIV-positive patients (De Munnik, Vervoort, Ammerlaan, Kok, & Den Daas, 2017).

The Theory of Planned Behavior extended the Theory of Reasoned Action (Fishbein & Ajzen, 1975), which presented the idea that intention determines whether an action will be performed, and this intention is influenced by personal (attitude) and social (subjective norm) determinants. In turn, attitude is influenced by personal beliefs about how the behavior will lead to certain desired or undesired outcomes; such beliefs are termed *behavioral beliefs* (Ajzen, 1985). Subjective norms are also affected by beliefs, known as *normative beliefs*, about whether influential people think the behavior should be performed, causing a perception of social pressure to perform or not to perform the action (Ajzen, 1985).

Ajzen expanded on these ideas in his Theory of Planned Behavior by introducing the elements of volition and unanticipated impediments to performing intended actions, pointing out that the likelihood of changing one's actions based on new information or changing circumstances (stability of intention) depends on a number of variables, such as time, initial confidence in your intent, and whether one ranks low or high on the self-monitoring scale (i.e., whether behavior is more rigidly guided by fixed principles or malleable and pragmatic) (Ajzen, 1985). Additional identified factors that could influence success in performing an action are: belief in an internal or external locus of control (and the accuracy of that belief), possession of the necessary skills or attributes, will power, emotion, and external circumstances out of the individual's control (Ajzen, 1985).

Recognizing the circuitous path that may lead from intention to action, Ajzen (1985) re-envisions the action as a goal and the intention as an action plan for achieving it. He states that intention can predict an attempt at an action but not its successful completion, and moreover, that if intent adequately predicts attempt but the action is not completed, that may indicate elements

partially or totally out of the person's volitional control (Ajzen, 1985). Ajzen (1985) goes on to advise that, in any situation where circumstances are not entirely volitional, meaning that failure is an option and not everything is in the person's control, then the Theory of Planned Behavior, rather than the Theory of Reasoned Action, is a better choice for analyzing the situation. Here, the decision of whether to attempt an action must be made while taking into account the probability, meanings, and consequences of success versus failure; since success is not guaranteed, the person must weigh the likelihood of success with the relative risks and benefits, both personally and in the eyes of others, to decide whether a behavior is worth performing (Ajzen, 1985).

Relevant Constructs

To identify the barriers and facilitators of adherence to childhood lead screening guidelines, it is necessary to define the elements of the phenomena under investigation. The individual under consideration is a health care provider offering primary care to children under six. The behavior or goal will be defined as following Arizona lead screening guidelines (CLPPP, 2017b), which could be further described as (a) performing blood lead testing on every child who fits the aforementioned qualifications for lead screening in Arizona, (b) reporting the results in accordance with ADHS requirements, and (c) conducting follow-up testing and treatment in accordance with CDC guidelines. For simplicity, however, the action could be limited to conducting initial testing on the targeted children at 12 and 24 months. The intent to perform this behavior would be elicited by self-report. Behavioral and normative beliefs about lead screening would be gauged by questions about whether the individual primary care provider believes that lead screening is important and effective, and whether their coworkers and

organization encourage lead screening. Barriers will be defined as impediments to performing the intended action of consistently screening, including non-volitional factors and deficient knowledge. Barriers will be identified through additional questions assessing knowledge of current state and federal guidelines and (reflecting the non-volitional nature of the path from intent to action) external factors such as limited budget and time, staff shortages, and lack of cooperation from parents. The definition of lead toxicity will follow that currently used by the CDC, which is a BLL greater than 5 μg/dL (CDC, 2016b).

LITERATURE REVIEW

Current Topics in Research

In April 2014, the city of Flint, Michigan switched its water source to Flint River water treated at the Flint Water Service Center with the goal of saving $2 million per year, but inadequate processing led to leaching of lead from pipes and consequent BLL elevations in the city's children (Zahran, McElmurry, & Sadler, 2017). This water source change was associated with an average BLL increase of 0.5 μg/dL, or an additional 561 children with BLLs over 5 μg/dL, which is associated with an estimated long-term cost of $65 million from lost productivity (Zahran et al., 2017). This water crisis and the national attention it received had the effect of renewing interest in lead poisoning prevention and the consequences of lead exposure. References to Flint, Michigan were made in a 2016 document on federal programs to reduce lead poisoning from the President's Task Force on Environmental Health Risks and Safety Risks to Children (2016). This report also cited recent research demonstrating negative effects of BLLs below 5 μg/dL on intelligence, academic achievement, and attention-related behaviors (President's Task Force on Environmental Health Risks and Safety Risks to Children, 2016).

More recently, a study in *The Lancet Public Health* estimated the number of deaths per year that are attributable to lead exposure at around 400,000, which is 10 times higher than previous estimates and is similar to the number of deaths from tobacco smoke (Lanphear et al., 2018). While this research was focused on adult mortality, it has implications for public health efforts to reduce lead exposure in all age groups.

Much of the recent research on lead toxicity has focused on prevention, including the use of geospatial analyses to identify populations at increased risk (Akkus & Ozdenerol, 2014; Mielke et al., 2014; Miranda, Anthopolos, & Hastings, 2011; Morrison et al., 2013), home-based primary prevention (Campbell et al., 2011; Nussbaumer-Streit et al., 2016), and racial disparities in environmental lead risk (Aelion et al., 2013; Davis et al., 2016; White et al., 2016). Research is also ongoing on the causes and effects of lead exposure among pregnant and breastfeeding women (Allen, 2015; Baranowska-Bosiacka et al., 2016; Koyashiki, Paoliello, & Tchounwou, 2010).

Search Strategy

A search of the literature was conducted to gain a better understanding of poor adherence to childhood lead screening guidelines. Inclusion criteria included articles published since 1990 (to capture the CDC's 1991 recommendations that lowered the BLL of concern), English language, and human species. The search engines PubMed and CINAHL were utilized with search terms including "lead poisoning," "lead toxicity," "childhood lead," and "blood lead level"; these terms were combined alternately with "screening," "testing," "barriers," "guidelines," "compliance," and "adherence" to obtain more specific results. Bibliographies were also reviewed to identify additional relevant articles. The initial search yielded 9923 results.

The search was further refined to results focused upon surveys or focus groups that questioned physicians or other primary care providers about childhood lead screening, and quality improvement projects or studies that sought to increase lead screening either directly or through related systems improvements. This exclusion, and the elimination of duplicate search results, yielded 23 pertinent articles to review.

Relevant Search Results

The most relevant results of the literature search (Table 1) can be roughly divided into two groups, according to the previously mentioned search criteria. The first group more closely resembles this project, in that the authors directly questioned health care providers about their knowledge, attitudes, and barriers to testing children for lead. The second group represents a wide range of approaches to the question of how to increase the number of children screened for lead toxicity, but all are helpful in designing a survey instrument to identify the particular barriers that may exist at any particular clinic or organization.

Studies of Primary Care Provider Compliance and Barriers

Nine articles comprise the first group and range in publication date from 1996 to 2017. All but one of the studies utilized surveys and targeted physicians; the remaining article utilized chart review and questioned physicians on missed lead tests (Feinberg & Cummings, 2005). Participants varied in their screening rates, with those who said they never screened children ranging from 4% (Schaffer, Campbell, Szilagyi, & Weitzman, 1998) to 12% (Goldman et al., 1998). Sample sizes ranged from 72 (Keeshan et al., 2010) to 734 (Campbell et al., 1996). Campbell et al. (1996) surveyed a national sample of primary care pediatric physicians in response to the CDC's 1991 recommendations that lowered the BLL of concern to 10 μg/dL and

championed universal lead screening. In this survey, 16% of participants disagreed with the new BLL of concern, and 34% believed that the costs of screening outweigh the benefits (Campbell et al., 1996). Health care providers that were female, recent medical school graduates (within 10 years), and working in urban settings were more likely to universally screen (Campbell et al., 1996). Meanwhile, providers who did not screen cited reasons including the belief that lead poisoning prevalence was low among their patients, that screening is too expensive, that collecting blood is difficult, that there are more important things to do, and that little help is available for those identified with lead poisoning (Campbell et al., 1996). Only 68% of the doctors who screened children reported that they provided any information about lead toxicity to parents (Campbell et al., 1996).

A study in California the following year used a short survey to determine physician knowledge, attitudes, and practices related to lead screening (Ferguson & Lieu, 1997). Knowledge of CDC guidelines was assessed, with just 46% correctly answering three questions about screening recommendations, and it was noted that those who answered correctly were much more likely to universally screen (Ferguson & Lieu, 1997). Universal screening was also seen more frequently in more recently trained physicians, those with diverse patient populations, and those in academic or community clinic settings (Ferguson & Lieu, 1997).

TABLE 1. *Evidence table.*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
Binns, H. J., LeBailly, S. A., Fingar, A. R., & Saunders, S. (1999). Evaluation of risk assessment questions used to target blood lead screening in Illinois. *Pediatrics, 103*(1), 100-106. Retrieved from http://pediatrics.aappublications.org/content/103/1/100.full	To assess the sensitivity and specificity of risk assessment questions used in Illinois' targeted lead screening program	Cross-sectional survey and blood draw (Level 6)	**Sample:** Convenience sample of parents of nine-, 10-, -12- and 24-month-old children attending health supervision visits at 13 pediatric clinics (N=460 children); and parents of six- to 25-month-old children who needed lead tests, receiving care at five health departments (N=285 children) **Setting:** Illinois (excluding Chicago due to the city's high-risk status)	**Data Collection:** The eight-question risk assessment questionnaire was completed by parents, and no-cost blood lead testing was offered. **Data Analysis:** Chi-square tests, positive and negative predictive values, sensitivity and specificity	-7% of the children tested (3.5% of the children in low-risk areas and 12.1% of the children in high-risk areas) had BLLs above 10 µg/dL. -The state's risk assessment questions had a sensitivity of 0.75 and a specificity of 0.39 for BLLs above 10 µg/dL. -Questions that most predicted risk were about peeling/chipping paint, older home age, and home rental.
Bordley, W. C., Margolis, P. A., Stuart, J., Lannon, C., & Keyes, L. (2001). Improving preventive service delivery through office systems. *Pediatrics, 108*(3), E41. Retrieved from http://pediatrics.aappublications.org/content/108/3/e41.long	To improve delivery of pediatric preventive care services through redesigning office systems	Quality improvement project (Level 6)	**Sample:** Pediatric and family practices that enrolled ≥ 5 neonates per month (N=8) **Setting:** Durham, North Carolina	**Data Collection:** Project staff members met with clinical staff members 10-15 times over one year to assess and find solutions for barriers to vaccination and screening for lead, anemia, and TB. Solutions included reminder systems, patient education, pre-screening	-All practices showed increases in lead and anemia screening -The mean proportion of children tested for lead across all practices significantly increased from 12 at baseline to 48% post-intervention (p=.001) -Changes in preventive service delivery varied

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
				forms, reassigning responsibilities, and pre-screening of charts. **Data Analysis:** Mantel-Hazel and Wald Chi-square tests, logistic models, probability models	by practice in the areas of immunization and TB screening, with some practices showing negative changes -Increases in the proportion of children vaccinated and screened for anemia were related in a linear fashion to increased exposure to the intervention
Boreland, F., & Lyle, D. (2008). Screening children for elevated blood lead - Learnings from the literature. *The Science of the Total Environment, 390*(1), 13-22. https://doi.org/10.1016/j.scitotenv.2007.09.041	To understand the influences on parents'/caregivers' decisions on whether to screen their children for lead poisoning	Literature review of qualitative studies (Level 5)	**Sample:** Seven studies on parents' attitudes to blood lead screening **Setting:** N/A	**Data Collection:** An electronic search of Medline, CINAHL, EMBASE, and Psychinfo was conducted, followed by reference list review and general internet search. 34 papers on lead screening were identified, seven of which were relevant. **Data Analysis:** Results discussed; no formal data analysis	-Barriers included lack of knowledge, educational materials at too high a reading level or in non-user-friendly forms, perception that little help is available for children with elevated BLLs, concern about the pain of testing, fear of causing trouble with landlords or employers if toxicity is found, embarrassment or stigma, and transportation. -Barriers are consistent with those identified in studies of other types of health screening.

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
Boreland, F., Lyle, D., Brown, A., & Perkins, D. (2015). Effectiveness of introducing point of care capillary testing and linking screening with routine appointments for increasing blood lead screening rates of young children: A before-after study. *Archives of Public Health, 73*, 60. https://doi.org/10.1186/s13690-015-0111-y	To increase blood lead screening of young children through introduction of in-house capillary blood testing and linking lead testing to routine preventive services	Before-after study (Level 4)	**Sample:** Children from seven to 59 months who had a blood lead test at the main and Indigenous Broken Hill clinics over the seven-year study period (N=2287) **Setting:** Broken Hill, New South Wales, Australia	**Data Collection:** LeadCare II point of care testing device introduced to lead screening clinics, then lead testing bundled with immunizations and SMS reminders initiated. Outcomes were determined from reviews of lead program database and census data. **Data Analysis:** Cross-sectional and cohort analyses	-The proportion of children screened by one year of age increased from 0.39 to 0.60 after in-office capillary testing was introduced, but the proportion of children screened by 24 months decreased from 0.69 to 0.63. -Overall participation in screening by 12-59-month-olds increased from (proportion) 0.39 to 0.44 after capillary testing was introduced. When lead screening was linked with immunization and SMS reminders, attendance further increased to 0.75. -There was no mean change in the population blood lead level seen with increased screening.
Burns, M. S., Shah, L. H., Marquez, E. R., Denton, S. L., Neyland, B. A., Vereschzagin, D., ... Gerstenberger, S. L. (2012). Efforts to identify	To increase screening rates of high-risk children in Southern Nevada, and to test a questionnaire with	Cross-sectional survey and blood test (Level 6)	**Sample:** Convenience sample of children aged one to six who attended (or whose siblings attended) the Lied Pediatric Center or	**Data Collection:** A brief (five-question) questionnaire was filled out by parents/caregivers, and a blood sample was drawn. 1048 families	-6.2% of participants had detectable BLLs, all below 10µg/dL. 77.1% of these were in males. -Children with elevated BLLs were significantly

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
at-risk children for blood lead screening in pediatric clinics-- Clark County, Nevada. *Clinical Pediatrics, 51*(11), 1048-1055. https://doi.org/10.1177/0009922812458352	the goal of identifying high-risk children and increasing lead screening compliance		Kid's HealthCare and who had never been tested for lead (N=564), 55.5% male **Setting:** Clark County, Nevada	were approached and 564 completed the study (53.8% participation). **Data Analysis:** Response frequencies, Fisher's exact test, and tests of 2 proportions used to analyze responses	more likely to have an affirmative response to a question about pica (eating, chewing, or sucking on nonfood items), and a negative response to a question about a household member working with lead.
Campbell, J. R., Schaffer, S. J., Szilagyi, P. G., O'Connor, K. G., Briss, P., & Weitzman, M. (1996). Blood lead screening practices among US pediatricians. *Pediatrics, 98*(3), 372-377. Retrieved from http://pediatrics.aappublications.org/content/98/3/372	To study the attitudes of pediatric primary care providers toward universal lead screening	Cross-sectional survey (Level 6)	**Sample:** Random sample of primary care pediatric physicians who are members of the American Academy of Pediatrics (AAP) (N=734), 52.3% male **Setting:** United States (mail survey)	**Data Collection:** An eight-page survey was mailed to 1610 AAP members (response rate 64.3%) assessing demographics, practice characteristics, screening and family education practices, and attitudes. **Data Analysis:** Bivariate analysis and multivariate logistic regression were used to compare demographics and practice characteristics to screening habits and attitudes.	-53% screened all patients (nine-36 months), 39% selectively screened, 8% never screened. -Commonly cited risk factors for selective screening were pica, older home with peeling paint, affected sibling, home renovations, and Medicaid status -Leading reasons for not screening were belief that prevalence in patient population is low, more important issues to discuss, cost, little help for elevated BLLs, and difficulty of drawing blood -30% did not know if

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					their local health department provides services for children with elevated BLLs -16% disagreed with 10 μg/dL as BLL of concern. -34% believed that costs of screening outweigh benefits. -Universal screening was more likely among females, recent graduates, and those practicing in urban areas. -68% of respondents reported providing education to families on lead toxicity.
Feinberg, A. N., & Cummings, C. K. (2005). Blood lead screening. *Clinical Pediatrics, 44*(7), 569-574. https://doi.org/10.1177/000992280504400703	To determine barriers to lead testing of Medicaid-enrolled young children	Retrospective chart review and survey (Level 6)	**Sample:** Patient charts (N=675) from seven practices serving children aged 12-36 months enrolled in Medicaid, and physicians (N=38) working at the practices **Setting:** Kalamazoo, Michigan	**Data Collection:** Charts and laboratory test results were reviewed from seven practices for ordered lead tests and test results. 43 physicians were given surveys (88.4% response rate) on reasons lead tests were not ordered.	-27.6% of charts included a documented lead level. 17.7% were ≥ 5 μg/dL, and 2.2% were ≥ 10 μg/dL. -The 38 physicians surveyed estimated that an average of 47.6% of their patients had received lead tests, but the percentage of this subgroup's patients that

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
				Data Analysis: Chi-square tests, means and standard deviations	actually had lead tests was 24.4%. -When addressing reasons for not ordering tests, 13 of the physicians cited exclusion based on written risk assessment questionnaires and 17 cited oral questionnaires. 10 cited forgetting to order the test. -37% of missed lead tests were attributed to physicians forgetting to order the test. 10.6% of failures occurred due to patients presenting for office visits but no well child exams between one and three years of age. Other reasons for failure included lack of patient follow-up and receiving all care in the ED/HHS.
Ferguson, S. C., & Lieu, T. A. (1997). Blood lead testing by pediatricians: Practice, attitudes, and demographics. *American Journal of Public Health, 87*, 1349-1351. Retrieved /	To evaluate adherence to lead testing guidelines and attitudes toward lead testing among pediatricians	Cross-sectional survey (Level 6)	**Sample:** Primary care pediatricians belonging to the American Academy of Pediatrics (N=224)	**Data Collection:** 14-item survey mailed to 180 pediatricians (response rate 86%), assessing adherence to CDC guidelines, knowledge, attitudes, and	-27% of respondents routinely ordered lead tests for asymptomatic children under six. 10% ordered no tests, and the rest screened selectively. -46% correctly answered

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1381099/			**Setting:** San Francisco and Alameda counties, California	demographics/practice characteristics **Data Analysis:** Chi-square test, Wilcoxon rank-sum test, logistic regression	all three questions on CDC guidelines, and those who answered correctly were nearly four times more likely to universally screen. -Universal screening was more common among physicians with more recent training, working in academic or public/community settings, and with more minority or Medicaid patients. -Physicians practicing in HMOs were less likely to screen universally. -Attitudes alone did not significantly predict testing.
Goldman, K. D., Demissie, K., DiStefano, D., Ty, A., McNally, K., & Rhoads, G. G. (1998). Childhood lead screening knowledge and practice: Results of a New Jersey physician survey. *American Journal of Preventive Medicine, 15*(3), 228-234.	To assess screening practices and guideline adherence of New Jersey physicians caring for young children	Cross-sectional survey (Level 6)	**Sample:** Pediatricians and family practitioners (N=333), gender not specified **Setting:** New Jersey	**Data Collection:** Two-page, 17-item survey sent to 541 randomly chosen pediatricians and family practitioners (chosen from a mailing list from a maternal and child health nonprofit) in New Jersey (69.4% response rate)	-11.8% of physicians never screened children for lead. 35.8% said they screened 76%-100% of patients by age 2. -Out of four questions gauging knowledge of and adherence to CDC guidelines, 1.7% of respondents correctly answered all four, 31.8%

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
https://doi.org/10.1016/S0749-3797(98)00072-5				**Data Analysis:** Wilcoxon rank sums test, Kruskal-Wallis test, Chi-square test	got zero, 45% one, 18% two, and 3.5% got three correct. One third did not know the BLL that is a medical emergency. -20% never asked questions about lead exposure, and 48.7% said they ask more than 50% of their patients/families. -23.6% never provided education about lead poisoning, and 36.6% educated more than 50% of children/families. Those who educated were more likely to assess lead risk and to screen patients consistently. -The top barrier was parental refusal.
Haboush-Deloye, A., Marquez, E. R., & Gerstenberger, S. L. (2017). Determining childhood blood lead level screening compliance among physicians. *Journal of Community Health, 42*(4), 779-784.	To identify barriers to childhood lead screening among physicians	Survey and in-person interviews (Level 6)	**Sample:** Pediatricians, family practitioners, and general practice physicians serving patients under age six (N=77 for survey, N=12 for interviews)	**Data Collection:** Telephone/fax survey delivered to 516 providers targeted through state medical licensing board and internet search (139 responses for 27% response rate, but 62 excluded due to not	-52% of respondents screened according to CDC guidelines, 18% selectively screened, and 30% did not follow guidelines. -Estimates of parental follow-through ranged from 5% to 100%.

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
https://doi.org/10.1007/s10900-017-0317-8			**Setting:** Clark County, Nevada	working with children). County lead poisoning prevention data reviewed to find 12 physicians who tested at least 100 children, with whom in-person interviews were conducted. **Data Analysis:** Responses discussed; no formal data analysis	-Barriers were cost/insurance concerns, lack of understanding of lead poisoning and risks, and parents unwilling to allow venous draw due to low risk perception. -Ideas to increase screening were including lead screening with other routine services, discounted rates, educating families, and on-site testing.
Keeshan, B., Avener, C., Abramson, A., Brennan, J., Hill, E., MacLean, J., ... Sumner, A. (2010). Barriers to pediatric lead screening: Implications from a web-based survey of Vermont pediatricians. *Clinical Pediatrics, 49*(7), 656-663. https://doi.org/10.1177/0009922809360926	To identify barriers to lead screening among primary care pediatricians in Vermont	Cross-sectional survey (Level 6)	**Sample:** Pediatricians (N=72), 40.3% male **Setting:** Vermont	**Data Collection:** Web-based survey emailed (or offered by phone) to 98 pediatricians (74% response rate). Respondents entered in raffle for gift card. **Data Analysis:** Chi-square tests, continuous variables, *T*-tests, univariate analysis, logistic regression, odds ratios, model coefficients	-Top barriers to lead screening cited by respondents were parent refusal, perception of low patient risk or no exposure to lead sources, and trouble obtaining a sample. Higher-screening physicians cited more barriers. -Characteristics more common among high screeners were female gender and having a higher proportion of Medicaid patients. -Low screeners were more likely to believe

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					that health risks start at BLLs over 10 µg/dL, work in the most populous county, disagree with screening recommendations, and work in non-academic settings.
Kemper, A. R., & Clark, S. J. (2005). Physician barriers to lead testing of Medicaid-enrolled children. *Ambulatory Pediatrics, 5*(5), 290-293. https://doi.org/10.1367/A05-008R.1	To determine barriers to lead screening of Medicaid-enrolled children	Cross-sectional survey (Level 6)	**Sample:** Primary care pediatricians serving Medicaid patients (N=257), gender not specified **Setting:** Michigan	**Data Collection:** Mail survey sent to random sample of 520 physicians, 396 of which were eligible (65% response rate) with cash incentive. **Data Analysis:** Pearson Chi-square test, nonparametric median test	-68% of survey respondents routinely lead tested one-year-old Medicaid patients, 30% selectively screened based on risk factors, and 2% did not test. -42% of respondents routinely tested two-year-old Medicaid patients, 53% selectively screened based on risk factors, and 5% did not test at all. -52% said they would test three- to five-year-olds who had not been tested. -Likelihood of testing increased with proportion of Medicaid patients and number of previously identified patients with elevated

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					BLLs. -Onsite sample collection was associated with increased routine testing of one-year-olds. -76% of those who did not routinely screen were aware of Medicaid requirements, and 70% of them believed their practice area was low-risk, but 35% of these actually practiced in high-risk areas.
Margolis, P. A., Lannon, C. M., Stuart, J. M., Fried, B. J., Keyes-Elstein, L., & Moore Jr, D. E. (2004). Practice based education to improve delivery systems for prevention in primary care: Randomised trial. BMJ, 328(7436), 388. https://doi.org/10.1136/bmj.38009.706319.47	To evaluate whether process improvement plus continuing medical education would increase delivery of pediatric preventive care services	Randomized trial (Level 2)	**Sample:** Random sample of pediatric primary care practices not publicly funded or associated with academic institutions (N=44) **Setting:** North Carolina	**Data Collection:** Delivery of preventive services (immunizations and testing for lead, anemia, and TB) was assessed for children from 24-30 months of age every six months from baseline to 18 months after implementation (30 months total). Randomly selected practices were allocated to intervention and control groups, with control group receiving feedback and intervention group receiving	-Practices in the intervention group saw an increase in the proportion of children receiving all four preventive services from 0.07 (at the conclusion of implementation) to 0.34 (at the conclusion of follow-up). The control group increased from 0.09 to 0.10 during this time. -The proportion of children screened for lead at the end of the follow-up period was

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
				continuing medical education (CME) and monthly visits for a year (with follow-up every two to three months over another year). System improvements were implemented with PDSA cycles and included customized tools (e.g. flow sheets), tracking systems, and visit flow changes. Data were collected from random samples of medical records and through surveys of clinic staff. **<u>Data Analysis:</u>** Logistic random regression model	significantly higher in the intervention group (0.68) than control (0.30). -The increase in the proportion of age-appropriate lead testing within the intervention group was from 11% to 34%, while the increase in the control group was from 15% to 19%.
McGrath, K., Foster, K., Doggett, P., Altshuler, M., Osborne-Wu, J., Castellan, C., ... Parra, Y. (2016). EMR-based intervention improves lead screening at an urban family medicine practice. *Family Medicine, 48*(10), 801-804. Retrieved from http://www.stfm.org/	To evaluate whether a reminder system within the electronic health record (EHR) would increase the number of blood lead tests ordered by providers	Retrospective chart review (pre- and post-intervention) (Level 4)	**<u>Sample:</u>** Children from nine to 72 months who attended the Jefferson Family Medical Associates clinic for well or sick visits (N=210 pre-intervention, 46% male; N=166 post-intervention, 54%	**<u>Data Collection:</u>** An addition to the pediatric EHR template was added to the system and providers informed of the change. A retrospective chart review was conducted for all pediatric visits over 2.5-month periods before and after the intervention,	-Pre-intervention, 48% of patients had already been lead tested and 21% had tests ordered. After the intervention, 49% of the patients had already been tested and 49% had tests ordered. The increase in new tests ordered was significant ($p<.0001$).

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
FamilyMedicine/Vol48Issue10/McGrath801			male) **Setting:** Large academic medical practice in Philadelphia, Pennsylvania	looking for lead tests ordered for children who had not already received them. **Data Analysis:** Fisher's exact test	-The test completion rate decreased during the study period from 78% to 36.5%. -It was discovered that another unrelated study was conducted at the clinic during the pre-intervention period, wherein every participating child having their blood drawn also had their BLL checked. This may have inflated the pre-intervention completion rate.
Meropol, S. B., Schiltz, N. K., Sattar, A., Stange, K. C., Nevar, A. H., Davey, C., ... Cuttler, L. (2014). Practice-tailored facilitation to improve pediatric preventive care delivery: A randomized trial. *Pediatrics, 133*(6), e1664-e1675. https://doi.org/10.1542/peds.2013-1578	To test a Practice-Tailored Facilitation Intervention focused on delivery of pediatric preventive care services	Cluster-randomized trial (Level 2)	**Sample:** Well-child visits (N=16419) at 30 medical practices serving children (≥ 15% of patients 10 or younger, ≥ 20% of pediatric patients receiving Medicaid) **S** **etting:** Cleveland, Ohio and surrounding counties	**Data Collection:** A practice-tailored, rapid-cycle feedback and change intervention called CHEC-UPPP (Child Health Excellence Center: a University Practice-Public Partnership) was used to identify and eliminate barriers to providing lead screening at 12 and 24 months, obesity screening and counseling from two to 18 years, and the	- Significant increases in lead screening were seen in both the early-phase (from 62.2% at baseline to 87.5% at six months) and late-phase groups (from 70.9% at four months to 94.5% at 10 months). -Obesity screening and counseling increased significantly in both early-phase (3.5% at baseline to 86.5% at six months) and late-phase

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
				application of dental fluoride varnish from 12-35 months. Clinic staff received six-month interventions involving two education sessions followed by weekly one-hour visits reviewing run charts, assessing for solutions, and planning next steps (i.e. training). Chart reviews were used to evaluate outcomes at baseline and at two-month intervals for eight to 12 months depending on group (early or late intervention). **Data Analysis:** Student's *t* test, Fisher's exact test, Chi-square test	groups (12.5% at four months to 88.9% at 10 months). -Fluoride varnish application increased significantly in both early-phase (0.01% at baseline to 78.9% at six months) and late-phase groups (4.4% at four months to 81.9% at 10 months). -Two months after the intervention, lead screening rates decreased slightly in the early-phase groups (from 87.5% to 86.5%), but increased in the late-phase groups (from 94.5% to 97%).
Ossiander, E. M. (2013). A systematic review of screening questionnaires for childhood lead poisoning. *Journal of Public Health Management and Practice, 19*(1), E21-E29. http://dx.doi.org/10.1097/PHH.0b013e3182249523	To evaluate the effectiveness of lead screening questionnaires in identifying children at risk for lead poisoning.	Systematic review of descriptive studies (Level 5)	**Sample:** 20 articles evaluating 28 questionnaires **Setting:** N/A	**Data Collection:** An electronic search of Medline, followed by a review of reference lists, was conducted. **Data Analysis:** True and false positives/negatives extracted from articles	-The 1991 CDC screening tool was evaluated in 17 cases, with a mean sensitivity of 0.61 (95% CI 0.53-0.68, range 0.25-0.87), mean specificity of 0.52 (95% CI 0.45-0.60, range 0.31-0.80), and mean accuracy of 1.12

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
				and used to calculate sensitivity, specificity, and accuracy (sum of sensitivity and specificity ranging from 0 to 2, with 1 being the same as chance).	(95% CI 1.06-1.18, range 0.74-1.39). -The 11 other questionnaires evaluated had a mean sensitivity of 0.76 (95% CI 0.68-0.85, range 0.43-0.90), mean specificity of 0.41 (95% CI 0.33-0.49, range 0.17-0.66), and mean accuracy of 1.13 (95% CI 1.06-1.20, range 0.94-1.27). -A limitation was that no studies of the revised 1997 CDC questionnaire were located.
Polivka, B. J. (2006). Needs assessment and intervention strategies to reduce lead-poisoning risk among low-income Ohio toddlers. *Public Health Nursing, 23*(1), 52-58. https://doi.org/10.1111/j.0737-1209.2006.230108.x	To determine the ways parents of young children prefer to receive information about lead poisoning prevention	Cross-sectional survey (Level 6)	**Sample:** Parents with 12-35-month-old children enrolled in Medicaid (N=532), 3% male **Setting:** Ohio	**Data Collection:** Five to 10-minute Blood Lead Education and Screening Tool developed for the study, mailed to random sample of 1656 parents (39% response rate) on the Ohio Medicaid program list, with free bookmark included in the mailing and prepaid phone card sent to respondents. **Data Analysis:**	-60% of parents had seen information on lead poisoning, 34% had not, 6% were unsure. -Parents were significantly more likely to receive information if they were over 25, unmarried, and had more than a high school education. -Minority respondents were more likely to have spoken to somebody about lead poisoning,

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
				Descriptive analysis, Pearson Chi-square test, odds ratios, multivariate logistic regression applied to survey responses	and those in high-risk zip codes spoke to more people (typically family or friends). -Most respondents preferred information in pamphlets and from doctors/nurses. Minority participants and those with high school or less education preferred videos.
Polivka, B. J., & Gottesman, M. M. (2005). Parental perceptions of barriers to blood lead testing. *Journal of Pediatric Health Care, 19*(5), 276-284. https://doi.org/10.1016/j.pedhc.2005.02.007	To identify barriers to lead testing from the point of view of parents of Medicaid-enrolled children	Focus groups (Level 6)	**Sample:** Attendees at WIC and Help Me Grow offices who were parents/caregivers of children six or younger who were eligible for Medicaid (N=30 in three focus groups), gender only specified for two out of three studies at 0.08% male **Setting:** Rural and urban Ohio counties, randomly selected	**Data Collection:** Three one-hour focus groups with open-ended questions on lead testing (knowledge of lead poisoning and how you learned about it, has child been lead tested and describe experience or explain why not, what would make lead testing easier, and how would you like to receive lead information?) **Data Analysis:** Responses discussed; no formal data analysis	-Parents were often unaware if their child had been tested for lead -They wanted to be able to do all medical services in the same place (i.e. WIC clinic) and for clinics to be open on the weekends -They wanted testing to be free -They wanted better communication from health care providers about what services were given to their children -They lamented inexperienced phlebotomists who needed multiple

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					needlesticks to get a blood sample -Parents wanted lead information presented in pamphlets, conversations with providers, videos, and billboards
Samaan, Z. M., Brown, C. M., Morehous, J., Perkins, A. A., Kahn, R. S., & Mansour, M. E. (2016). Implementation of a preventive services bundle in academic pediatric primary care centers. *Pediatrics, 137*(3), e20143136. https://doi.org/10.1542/peds.2014-3136	To increase delivery of a bundle of pediatric preventive care services	Quality improvement project (Level 6)	**Sample:** Academic clinics providing pediatric primary care (N=3) **Setting:** Cincinnati, Ohio	**Data Collection:** A bundle of preventive services (lead screening, immunizations, developmental screening, bio-psychosocial risk factor assessment) was implemented using the Model for Improvement and tested with Plan, Do, Study, Act (PDSA) cycles. Improvements were made to patient visit flow and staff responsibility redistribution. Charts were reviewed for percentage of visits where all bundle elements were delivered to children aged zero to 14 months. **Data Analysis:** Data reported on run charts	-Bundle delivery increased for children aged zero-14 months from 58% at baseline to 92% post-intervention, a rate which was sustained over one year.

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
Schaffer, S. J., Campbell, J. R., Szilagyi, P. G., & Weitzman, M. (1998). Lead screening practices of pediatric residents. *Archives of Pediatrics & Adolescent Medicine, 152*(2), 185-189. https://doi.org/10.1001/archpedi.152.2.185	To assess lead screening guideline adherence among pediatric residents and compare it to demographics/practice characteristics and attitudes	Cross-sectional survey (Level 6)	**Sample:** Pediatric residents who are members of the American Academy of Physicians (AAP) (N=143), 38% male **Setting:** United States (national sample)	**Data Collection:** Eight-page survey included in AAP 28th Periodic Survey of Fellows, sent to random sample of 1610 members of the AAP, of which 281 were pediatric residents (51% response rate). **Data Analysis:** Bivariate analysis, Mann-Whitney test, multivariate logistic regression	-75% of respondents reported universally screening children under six for lead, 21% selectively screened, and 4% did not screen. Factors increasing screening likelihood were living in the Northeastern U.S., being further along in their residency, working in an urban setting, and higher estimated local prevalence of lead poisoning. -About half of those who screened selectively used a questionnaire. -88% of those who screened also provided information to families. 61% provided it before screening, and 39% only provided it if the child had an elevated BLL. -54% overall (67% of universal screeners versus 17% of selective screeners) believed the

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					benefits of screening outweigh costs. -70% agreed with the BLL of concern being 10 µg/dL, but there was concern that parents may become anxious about elevated BLLs in the lower range and most believe more epidemiological studies need to be done to identify high-risk areas.
Taylor, D. K., Lepisto, B. L., Lecea, N., Ghamrawi, R., Bachuwa, G., LaChance, J., & Hanna-Attisha, M. (2017). Surveying resident and faculty physician knowledge, attitudes, and experiences in response to public lead contamination. Academic Medicine, 92(3), 308-311. https://doi.org/10.1097/ACM.0000000000001562	To determine physicians' knowledge, attitudes, and experiences regarding lead contamination	Informal survey (Level 6)	**Sample:** Residents and faculty physicians (N=75), gender not specified **Setting:** Hurley Medical Center, a public teaching hospital in Flint, Michigan	**Data Collection:** A survey assessing knowledge, attitudes, and experiences surrounding lead health risks was distributed (medium not specified) to 149 physicians (50% response rate). **Data Analysis:** Responses discussed; no formal data analysis	-91% of respondents desired continuing medical education (CME) on lead contamination. -Only 13% had strong ratings for comfort answering patient questions about lead, and less than 9% felt strongly confident providing accurate information. -34% of respondents reported having been trained to diagnose and treat lead toxicity. -Knowledge scores were not reported,

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					although it is noted that the lowest scores were for questions about CDC guidelines (particularly the BLL at which action should be taken by clinicians) and the role of nutrition in prevention of lead poisoning.
Thomas, S. L., Boreland, F., & Lyle, D. M. (2013). Improving participation by Aboriginal children in blood lead screening services in Broken Hill, NSW. *New South Wales Public Health Bulletin, 23*(11-12), 234-238. https://doi.org/10.1071/NB11056	To identify ways to increase lead screening of young Aboriginal children	Focus groups and semi-structured interviews (Level 6)	**Sample:** Aboriginal parents/caregivers of children aged one to four, and clinic service providers/public health staff (N=18 for interviews, N=14 for two focus groups), with community members only participating in interviews; gender not specified **Setting:** Broken Hills, New South Wales, Australia (a mining town with historically high lead poisoning)	**Data Collection:** Data review of lead management program (phase 1), followed by 40-60-minute focus groups and 10-minute semi-structured interviews **Data Analysis:** Focus group findings grouped into recurring themes and categorized as barriers, enablers, and strategies	-Blood lead screening rate decreased from 55% in 2000 to 39% in 2010 (highest rate was 80% in 2004, lowest was 27% in 2009) -Barriers cited were poor communication from health care providers to patients, and perception that no help is available for children with elevated BLLs or necessary home improvements -Suggestions included capillary testing, transportation assistance, culturally aware practices and education materials, flexible clinic

TABLE 1 – *Continued*

Reference	Purpose	Study Design	Sample and Setting	Methods for Data Collection and Data Analysis	Findings
					hours/special screening days, bundling lead screening with other services, and face-to-face communication of lead information
Trepka, M. J. (2005). Using surveillance data to develop and disseminate local childhood lead poisoning screening recommendations: Miami-Dade County's experience. *American Journal of Public Health, 95*(4), 556-558. https://doi.org/10.2105/AJPH.2004.039602	To improve childhood lead screening rates through development of screening recommendations and disseminating resources to primary care providers	Public health project report (Level 6)	**Sample:** Pediatric primary care providers (number not specified) **Setting:** Miami-Dade County, Florida	**Data Collection:** Clinician tool and guidelines were disseminated by mail to pediatric primary care providers. Packet included a laminated pocket-sized screening tool, a laminated paper-sized tool, information on lead poisoning, resources, and a Rolodex card with program contact information. **Data Analysis:** Surveillance data reviewed annually	-Screening rate for children six and younger increased from 4.1% in 1998 to 20.3% in 2003 (after program implementation). -55% of a random sample of providers remembered the recommendations four months after dissemination

A national survey of pediatric residents (Schaffer, Campbell, Szilagyi, & Weitzman, 1998) showed that factors increasing the likelihood of screening included an urban clinic setting, practicing in the Northeastern U.S., perception of increased local prevalence of lead poisoning, and belief that the benefits outweigh the cost (Schaffer et al., 1998). Among those who screened, 88% provided parent education on lead risks, but 39% of these only provided the education if the child was found to have an elevated BLL (Schaffer et al., 1998).

The same year, a survey of New Jersey physicians showed a troubling lack of knowledge among participants, with only 1.7% correctly answering four questions about CDC guidelines (Goldman et al., 1998). Fewer than half of the physicians reported consistently asking parents about lead risks or providing education, although those behaviors, when performed, were positively correlated and related to consistency of screening (Goldman et al., 1998). Out of 10 preselected barriers, participants chose parental refusal of testing as number one, also selecting parents' failure to request testing as an important barrier (Goldman et al., 1998).

A study evaluating barriers to lead testing of Medicaid patients in Michigan (Feinberg & Cummings, 2005) used a chart review and questioned the physicians on their failure to order lead tests. The physicians overestimated the number of their patients that were screened, estimating an average of 47.6% whereas the average was actually 24.4% (Feinberg & Cummings, 2005). Out of those patients who were not screened, 37% were attributed to the physician forgetting to order the test, while 20% were deemed the fault of the patient's family and 10.6% were blamed on both the family and the doctor since the child had office visits but no well-child visits between one and three years old (Feinberg & Cummings, 2005). A

different study that year also examined the low rates of lead testing of Medicaid-enrolled pediatric patients in Michigan (Kemper & Clark, 2005). Of the primary care providers who did not consistently screen Medicaid children, 76% stated that they knew they were supposed to (Kemper & Clark, 2005). The most frequently cited reason for not testing was belief that the practice area was at low risk, although the authors reveal that 35% of those individuals actually practiced in an area known to be at high risk (Kemper & Clark, 2005). It was noted that practices where on-site lead testing was available had significantly higher levels of routine testing of 12-month-olds (Kemper & Clark, 2005).

A survey of pediatricians in Vermont by Keeshan et al. (2010) found that those who infrequently screened did not agree with current screening recommendations, believed that negative health effects of lead begin at BLLs above 10 μg/dL, worked in the most populous county, and were less likely to practice in academic settings. High screening physicians were more likely to be female and have higher proportions of Medicaid patients (Keeshan et al., 2010). The top barriers selected by participants were parental refusal, patients perceived to be at low risk, and the difficulty of obtaining a blood sample, with high screeners citing more barriers overall (Keeshan et al., 2010).

More recently, physicians in Clark County, Nevada, gave reasons for failing to comply with CDC guidelines that included lack of mandate and belief that testing is not required for all children (Haboush-Deloye et al., 2017). Perceived barriers identified through follow-up interviews with 77 high-screening physicians included cost, insurance concerns, parents' refusal due to concerns about the blood draw, and parents' limited knowledge of lead poisoning, such as the fact that it may be outwardly asymptomatic (Haboush-Deloye et al.,

2017). Suggestions were to treat lead screening as a routine part of preventive care, help families with costs, provide family education, and allow on-site testing to increase follow-through (Haboush-Deloye et al., 2017).

Another recent survey was conducted in response to the Flint, Michigan water contamination crisis, after which physicians at the Hurley Medical Center expressed a need for training on environmental health risks to be able to properly respond to the influx of questions from patients and families (Taylor et al., 2017). 91% of participants desired additional education on the topic, less than 15% felt comfortable answering patient questions, and only 34% said they had been trained to diagnose and treat lead toxicity (Taylor et al., 2017).

Additional Barriers and Facilitators of Lead Screening

An additional 14 articles were identified that offer different perspectives on improving the delivery of lead screening services at pediatric office visits. Six of these concerned preventive service bundles and office system redesigns (Bordley, Margolis, Stuart, Lannon, & Keyes, 2001; Boreland et al., 2015; Margolis et al., 2004; McGrath et al., 2016; Meropol et al., 2014; Samaan et al., 2016), three focused on identification of at-risk patients through pre-screening questionnaires (Binns, LeBailly, Fingar, & Saunders, 1999; Burns et al., 2012; Ossiander, 2013), four analyze barriers to screening from the perspectives of families and communities (Boreland & Lyle, 2008; Polivka & Gottesman, 2005; Polivka, 2006; Thomas, Boreland, & Lyle, 2013), and one studied whether disseminating surveillance data and screening guidelines would improve physician adherence (Trepka, 2005).

Improvements to office systems generally involved redesign of visit flow to eliminate barriers to delivery of preventive care services. Bordley et al. (2001) looked at whether improvements to office systems could increase performance of pediatric preventive services, including lead testing, vaccinations, and screening for anemia and tuberculosis. Practice improvements in the participating clinics ranged from new well child visit forms and flow sheets to redistribution of responsibilities and development of patient tracking systems (Bordley et al., 2001). Overall, the mean proportion of children receiving lead screening increased significantly from 12% to 48% (Bordley et al., 2001). A randomized trial (Margolis et al., 2004) utilized office system improvements along with continuing education to increase delivery of preventive care services at pediatric primary care practices. Delivery of the four-service bundle increased from 7% at baseline to 34% post-intervention in the intervention group, with a significant positive difference between intervention and control groups still seen 30-months after the trial (Margolis et al., 2004). Similarly, a cluster-randomized trial (Meropol et al., 2014) used a practice-tailored facilitation intervention known as CHEC-UPPP (Child Health Excellence Center: A University Practice-Public Partnership) that focused on increasing lead testing, counseling of obese children, and fluoride varnishing. Through coaching, feedback, and system redesign in rapid change cycles, significant increases in lead screening were achieved (Meropol et al., 2014). Thirdly, a bundle measure was developed (Brown et al., 2015) and tested (Samaan et al., 2016) to assess for delivery of multiple preventive care services including lead testing. It included a visit-level measure that would provide immediate feedback to office staff, providing them with a checklist of which services the child is eligible for during his or her visit (Brown et al., 2015). Following a series of office

system redesigns to implement the measure, delivery of all bundled preventive care services increased from 58% to 92% of visits over one year among children under 14 months (Samaan et al., 2016).

Studies have also assessed the effects of implementing new technology to increase lead screening. One Australian study attempted to increase lead screening adherence through use of in-house capillary blood testing for lead and bundling lead testing with other routine preventive services (Boreland et al., 2015). After the introduction of capillary testing, the proportion of children aged 12 to 59 months participating in blood lead screening increased from 0.39 to 0.44, and when capillary lead testing was bundled with immunizations and short message service (SMS) reminders, the proportion further increased to 0.75 (Boreland et al., 2015). Also in the realm of new technology, McGrath et al. (2016) studied whether a reminder system added to the electronic medical record (EMR) would increase lead screening. Just 21% of the children eligible for lead screening had tests ordered before the intervention, a rate which increased to 49% post-intervention (McGrath et al., 2016). However, the percentage of children with completed tests increased much more modestly, from 17% (78% of tests ordered) to 18% (36.5% of tests ordered), over the study period (McGrath et al., 2016). It is noted that the office lacked in-house blood sample collection capabilities, which may have presented a barrier to test completion (McGrath et al., 2016).

While the use of risk assessment questionnaires may not be a barrier to lead screening itself, it may be a barrier to identification of children with elevated BLLs since health care providers have cited low risk scores from questionnaires as a reason to avoid screening large numbers of patients (Feinberg & Cummings, 2005). In one study, risk assessment scores from

a questionnaire were compared to BLLs, showing that the questionnaire had a sensitivity of 0.75 and a specificity of 0.39 for BLLs greater than or equal to 10 μg/dL, with sensitivity increasing at higher BLLs and specificity decreasing when the questionnaire was applied to children in high-risk areas (Binns et al., 1999). In another study, only two risk assessment answers were shown to have statistically significant correlations to elevated BLLs: an affirmative response to a question about pica, and, unexpectedly, a negative response to a question about a household member working with lead (Burns et al., 2012). A broader look at the efficacy of questionnaires used in targeted lead screening was offered by Ossiander (2013) in his systematic review evaluating 28 different studies. A 1991 CDC questionnaire was evaluated by 17 of the included studies, with a mean sensitivity of 0.61 and a mean specificity of 0.52 (Ossiander, 2013). Notably, only five of these 17 studies showed the CDC questionnaire performing better than pure chance (Ossiander, 2013). An additional 11 studies evaluated concerned a variety of different questionnaires with sensitivities ranging from 0.43 to 0.90 and specificities ranging from 0.17 to 0.66; in only four of these 11 studies did the questionnaire perform better than chance (Ossiander, 2013). Ossiander (2013) also notes that positive and negative predictive value is not an appropriate measure for judging these questionnaires, since local prevalence biases these statistics.

Considering the importance of parental participation in successfully screening children for lead toxicity, it is also important to look at parental attitudes and beliefs regarding lead screening. One article (Polivka, 2006) examined parents' preferences for education about lead poisoning prevention, finding that most parents preferred conversations with their primary care provider, as well as informational brochures. Participants who were from minority groups

or had a high school education or less preferred videos as their first choices, while those with greater than a high school education favored television and radio advertisements (Polivka, 2006). A focus group study by Polivka and Gottesman (2005) questioned families about various aspects of lead poisoning prevention, and in regard to lead screening it showed that parents were sometimes unaware whether their child had been tested for lead. Suggestions for making it easier to screen children included making it mandatory, making it easy to get all services done in one location, eliminating costs, having weekend hours at clinics, and help with transportation (Polivka & Gottesman, 2005). It was also suggested that primary care providers include blood tests on the checklist of immunizations kept by the parent so they can keep track of the services their child has received (Polivka & Gottesman, 2005).

Another study utilized interviews and focus groups to gauge the perceptions on lead screening of Aboriginal community members of Broken Hill, Australia, which are useful despite their specificity to the community (Thomas et al., 2013). Barriers cited by community members included poor communication of the importance of lead screening and risks of toxicity, perception that few services exist for children with elevated BLLs, and lack of support for making home improvements for lead abatement (Thomas et al., 2013). Facilitators identified by the group were (a) use of capillary testing, (b) special screening days where families could come in for services, (c) transportation assistance, (d) culturally respectful care models and education materials, (e) face-to-face communication and home visits as opposed to telephone and mail reminders, and (f) flexible clinic hours (Thomas et al., 2013). One of the main points of agreement was that bundling lead screening with other preventive services,

such as immunization and well checks, was an important screening enabler (Thomas et al., 2013).

A literature review by Boreland and Lyle (2008) looked at barriers to screening for lead and other diseases that have been frequently identified in the literature. Among them was (a) the failure to present information at an appropriate reading level and in user-friendly forms, (b) the perception that little can be done about elevated BLLs, (c) concern about the pain of testing, (d) fear of repercussions from landlords or employers, (e) embarrassment or perceived stigma of lead poisoning, and (f) problems with accessing testing, such as transportation difficulties (Boreland & Lyle, 2008). The authors found these barriers to be in keeping with theories of health beliefs as predictors of health behaviors.

Lastly, an effort by the Miami-Dade County Health Department to increase lead screening has implications for health care provider education (Trepka, 2005). After developing targeted screening recommendations for the locality, the health department created a clinician-oriented tool that included geographic information system data (Trepka, 2005). The department also sent out a guideline packet that included laminated pocket-sized screening tools as well as reporting forms and other resources (Trepka, 2005). The screening rate for children aged six and younger increased from 4.1% to 20.3% during the study period (Trepka, 2005).

Summary of Findings

Common themes were identified in the literature review. Demographic factors that made health care providers more likely to screen were: (a) recent education, (b) practicing in an academic medical organization, (c) working in an urban setting, (d) female gender, and (e)

having higher populations of Medicaid-enrolled and minority patients (Campbell et al., 1996; Keeshan et al., 2010; Schaffer et al., 1998). Knowledge of lead screening guidelines was found to be lacking (Goldman et al., 1998), particularly among those who do not screen their patients (Ferguson & Lieu, 1997). Providers were also found to be inconsistent in educating parents about lead risks and the reasons for testing (Campbell et al., 1996; Schaffer et al., 1998), with one study finding a correlation between this failure to educate and low screening compliance (Goldman et al., 1998). Attitudes were also influential, with providers' perceptions of the local prevalence of lead poisoning correlated with their likelihood to consistently screen (Campbell et al., 1996; Kemper & Clark, 2005; Schaffer et al., 1998). Barriers to screening that were commonly identified were parents' refusal of testing, difficulty of obtaining blood samples, and lack of on-site testing (Campbell et al., 1996; Goldman et al., 1998; Haboush-Deloye et al., 2017; Keeshan et al., 2010; Kemper & Clark, 2005).

Promising ideas for facilitators of lead testing that were reported in the literature include linking lead screening with routine immunization appointments (Boreland et al., 2015; Thomas et al., 2013), providing in-house capillary blood testing (Boreland et al., 2015; Haboush-Deloye et al., 2017), making sure that testing is accessible through flexible office hours and transportation assistance (Polivka & Gottesman, 2005; Thomas et al., 2013), providing family education in a way that is user-friendly (Polivka & Gottesman, 2005; Polivka, 2006), and bundling preventive care measures for auditing and as a visit 'to do' list (Bordley et al., 2001; Meropol et al., 2014; Samaan et al., 2016). Redesigning visit flow and reallocating staff responsibilities led to increased consistency of preventive service delivery (Bordley et al., 2001; Margolis et al., 2004; Meropol et al., 2014; Samaan et al., 2016). While

EMR-based prompts show promise, more studies are needed to demonstrate their ability to increase lead screening compliance among health care providers (McGrath et al., 2016). Finally, clinicians should be selective when choosing a risk assessment questionnaire, due to the highly variable sensitivity and specificity of the available screening tools (Binns et al., 1999; Burns et al., 2012; Ossiander, 2013).

Strengths, Weaknesses and Gaps

This review of the literature reveals that, while progress has been made in investigating the reasons that so many children at risk for lead poisoning go unscreened, there is still a great deal of work to be done. While strong work has been done in the area of identifying primary care provider knowledge gaps and perceived barriers to lead screening, most of this research is more than 10 years old, which is problematic due to changing screening recommendations and BLLs of concern that may affect provider attitudes and practices.

The level of evidence of the studies identified was generally low, with most of the evidence (17 articles) consisting of Level 6 evidence such as surveys, descriptive or qualitative studies, and quality improvement project reports. Two articles were Level 5: one literature review of qualitative studies and one systematic review of descriptive studies. Two pre- and post-intervention studies were Level 4, and two randomized trials were Level 2.

A notable gap in the literature is studies on technology-based solutions, with only one study approaching the subject of EMR prompts. Similarly, only one study tested the implementation of in-office capillary blood testing, although this would appear to be a simple and easy-to-study intervention. Another problem that became apparent in reviewing the

literature is that the studies included in this literature review that focused on screening questionnaires raise troubling questions but offer little in the way of remediation. Since many states, including Arizona, rely at least partly on the use of risk assessment questionnaires for their targeted screening programs, this creates a quandary for clinicians who are rightly concerned about missing a diagnosis of lead poisoning because a faulty questionnaire said that a child did not need to be screened.

Another noticeable gap in the literature is the absence of nurse practitioners and physician assistants, who increasingly provide primary care services in the United States. All of the surveys regarding health care providers' perspectives on lead screening were focused on physicians, and it is possible that attitudes, knowledge, and perceived barriers would differ between physicians and advanced practice nurses or physician assistants.

METHODS

Project Design

The goal of my DNP Project was to increase the number of children appropriately screened for lead toxicity in Tucson, Arizona, and I planned to assess for perceived barriers to screening among primary care providers. Therefore, my project used an exploratory design that was observational, rather than experimental (Rouen, 2017). However, elements of quality improvement (QI) were utilized in presenting the results of my clinical inquiry and information on current lead screening guidelines in the form of a PowerPoint presentation to the survey participants.

Setting

The setting of my project was a family practice clinic located in Green Valley, Arizona, a rural retirement community located approximately 30 miles south of Tucson. The practice employs four primary care providers and serves patients across the lifespan, including privately insured and Medicaid/Medicare patients. Pediatric patients make up a minority of the patients seen at the clinic, which mostly serves an adult and geriatric population, but all of the clinic's providers are family practitioners who work with patients of all ages.

Participants

Two of the providers at the family practice clinic are physicians (one MD and one DO) and two are Masters-educated Family Nurse Practitioners (FNP). Online surveys were emailed to all four providers, with exclusion criteria defined as providers who do not provide primary care to children under the age of six.

Data Collection

Data collection was via a self-report online or paper survey (Appendix A), which is a practical and well-accepted method for use with adult professionals such as health care providers (Rouen, 2017). Elements of the Theory of Planned Behavior (Ajzen, 1985) were used to assess attitudes and barriers to achieving intended screening behaviors, while knowledge of guidelines was assessed using multiple choice questions. The content of these questions was drawn from the published guidelines of the Arizona Department of Health Services (ADHS, 2018) and the CDC (2017).

Demographic data gathered on the surveyed primary care providers included gender, years of practice experience, provider profession, education level (for nurse practitioners),

proportion of patients who receive Medicaid, proportion of Spanish-speaking patients, and ability to speak Spanish. The purpose of gathering these demographic data was to offer additional insights into factors influencing lead testing habits. The questionnaire also addressed specific barriers that were identified in the literature review, such as presence or lack of onsite capillary testing and EHR reminder systems. Additionally, a free-text question allowed providers to cite any other barriers that they have observed in their practice.

Since this original survey questionnaire was not a previously validated instrument, it was evaluated by two content experts: A Pediatric Nurse Practitioner with a PhD in Nursing and Healthcare Innovation, and a Family Nurse Practitioner primarily serving a rural and underserved patient population. It is also important to pilot test an original survey for clarity and to determine how long it takes to complete (Rouen, 2017). In recognition of this need, four fellow students and faculty members were asked to complete the online survey and provide feedback on the length of the survey and any aspects that were unclear.

After survey collection and initial data analysis were complete, all of the clinic's providers received a follow-up email that included a short educational PowerPoint presentation reviewing lead screening guidelines and addressing the learning needs identified in the initial survey (Appendix B). All participants were asked to complete a post-survey evaluating the PowerPoint presentation's effectiveness (Appendix C).

Budget and Timeline

The survey was created using Google Forms, a cloud-based software product that ensures results are stored on secure servers and password protected. The only cost involved in the project, therefore, was in the form of $5 electronic gift cards that were offered as

incentives for survey completion. The clinic providers were sent a series of three weekly emails with links to the survey, which closed four weeks after the final email was sent. If potential participants preferred, an optional paper survey was available. No identifying data were collected.

Ethical Considerations

My population of study was primary care providers, a non-vulnerable group. I demonstrated respect for the participants by ensuring that their survey responses were voluntary and anonymous, while making the survey as brief and easy to complete as possible. A statement at the beginning of the survey explained how long it would take to complete and advised the participants that voluntary participation indicated consent and employment was not affected by participation. Beneficence was demonstrated immediately with the offer of a $5 Amazon gift card to thank the participants for their time, and later by sending them the informational PowerPoint that was created using the survey responses. Participants may also have gained satisfaction from the knowledge that their participation may contribute to future efforts aimed at increasing lead screening. Finally, justice was demonstrated by the inclusion of all types of primary health care providers (physicians and nurse practitioners) in the study without specifying any further demographic limitations. Additionally, this project's ultimate goal of increasing lead screening promotes environmental justice for children from historically underserved subpopulations.

RESULTS

Demographics

Three out of four health care providers at the project site submitted responses to the email survey, for a response rate of 75%. Demographics are presented in Table 2. Two of the respondents were female, and one was male. Two were masters-educated nurse practitioners, and one was a MD. Years in practice ranged from less than five to more than 30. Two were fluently bilingual. Two providers estimated the percentage of primarily Spanish-speaking patients at 26-50% (the other was unsure), while one provider estimated the percentage of Medicaid patients at 26-50% (the other two were unsure).

TABLE 2. *Demographics.*

	# of Responses	Percentage
Total Responses (N)		
Profession		
M.D.	1	33.3%
D.O.	0	0.0%
N.P. (Masters)	2	66.7%
N.P. (DNP)	0	0.0%
P.A.	0	0.0%
Other	0	0.0%
# Years Practicing		
0-5	1	33.3%
6-10	0	0.0%
11-20	1	33.3%
21-30	0	0.0%
31+	1	33.3%
Gender		
Female	2	66.7%
Male	1	33.3%
Prefer Not to Say	0	0.0%
Other	0	0.0%
% Medicaid Patients		
0-25%	0	0.0%
26-50%	1	33.3%
51-75%	0	0.0%
76-100%	0	0.0%
Don't Know	2	66.7%
% Spanish Speaking Patients		
0-25%	0	0.0%
26-50%	2	66.7%

TABLE 2 – *Continued*

	# of Responses	Percentage
51-75%	0	0.0%
76-100%	0	0.0%
Don't Know	1	33.3%
Bilingual (English/Spanish)		
Yes	2	66.7%
No	1	33.3%

Knowledge

Knowledge assessment scores are presented in Table 3, and participants' responses to knowledge assessment are listed in Table 4. None of the surveyed providers correctly identified 12 and 24 months as the ages at which lead screening is required for either Medicaid patients or those living in at-risk zip codes. All respondents also failed the questions about when to retest patients with BLLs at or above 45 µg/dL and the follow-up tests that are recommended against by the CDC. The only question that was answered correctly by all three providers regarded the BLL at which chelation should be initiated. Scores for individual providers were 3/10, 3/10, and 5/10 correct, for a mean score of 3.7/10 or 37%.

TABLE 3. *Knowledge assessment.*

Questions	**Respondent 1**	**Respondent 2**	**Respondent 3**	**Correct No. (%)**	**Incorrect No. (%)**
1	I	I	I	0 (0.0%)	3 (100.0%)
2	I	I	I	0 (0.0%)	3 (100.0%)
3	I	C	C	2 (66.7%)	1 (33.3%)
4	I	I	C	1 (33.3%)	2 (66.7%)
5	C	I	C	2 (66.7%)	1 (33.3%)
6	C	C	C	3 (100.0%)	0 (0.0%)
7	C	I	I	1 (33.3%)	2 (66.7%)
8	I	C	C	2 (66.7%)	1 (33.3%)
9	I	I	I	0 (0.0%)	3 (100.0%)
10	I	I	I	0 (0.0%)	3 (100.0%)

TABLE 4. *Respondents' answers to knowledge assessment questions.*

Questions	Respondent 1	Respondent 2	Respondent 3	Correct Response
1	12 months	18 months & 3 years	12 months	12 months & 24 months
2	12 months	3 years	2 years	12 months & 24 months
3	7 days	5 days*	5 days*	5 days
4	3 days	3 days	1 day*	1 day
5	True*	False	True*	True
6	45 µg/dL*	45 µg/dL*	45 µg/dL*	45 µg/dL
7	20 µg/dL*	10 µg/dL	45 µg/dL	20 µg/dL
8	20 µg/dL	70 µg/dL*	70 µg/dL*	70 µg/dL
9	Emergently	Within 24 hours	Emergently	Within 48 hours
10	All of the above	All of the above	Renal testing	None of the above

Note: Asterisks indicate correct answers.

Attitudes

The mean and median ratings for questions regarding attitudes towards lead screening were four and above for all questions. This indicates a generally positive attitude towards lead screening. The highest scores were recorded for questions about intent to perform lead screening during the next year and about the respondent being expected to perform lead screening. Additional attitude responses are presented in Table 5.

TABLE 5. *Attitudes.*

Question	Respondent 1	Respondent 2	Respondent 3	Mean Score	Median Score
I consistently screen	5	3	5	4.3	5
I intend to screen	5	4	5	4.7	5
Following AZ guidelines is…					
Harmful-Beneficial	5	3	5	4.3	5
Difficult-Easy	5	3	4	4	4
Unimportant-Important	5	3	5	4.3	5
Incompatible-Compatible	5	3	4	4	4
Benefits outweigh risks	5	3	5	4.3	5
Important people (to me) follow guidelines	5	3	4	4	4
Important people (to me) want me to follow guidelines	5	3	4	4	4
I'm expected to follow guidelines	5	4	5	4.7	5
It is within my control to follow guidelines	5	3	5	4.3	5

Note: Score represents a value from 1 to 5 (Appendix A for each question's corresponding scale).

Barriers

The lowest mean scores on questions about potential barriers to lead screening, with lower scores representing greater impediments to guideline adherence, were for questions about knowing where and how to locate ADHS lead screening guidelines and how easy the CDC guidelines are to follow. Higher mean scores were recorded for questions about the organization's policies supporting lead screening and parents permitting lead screening. Interestingly, providers disagreed about whether or not the clinic used a preventive care service bundle for pediatric visits, and one respondent did not know whether the organization had in-house point-of-care capillary or venous testing, or whether the EHR included a lead screening reminder system. Responses to questions about barriers to lead screening are presented in Table 6. Individual and mean score comparisons for all categories are illustrated in Figures 1 and 2.

TABLE 6. *Barriers.*

Question	Respondent 1	Respondent 2	Respondent 3	Mean Score	Median Score
Org. makes it easy to follow guidelines	5	3	4	4	4
Org.'s policies support following guidelines	5	4	4	4.3	4
Org. has necessary technology	5	3	4	4	4
Org. has necessary Electronic Health Record	5	3	4	4	4
Know where to find AZ guidelines	5	1	4	3.3	4
AZ guidelines make it easy to identify at-risk patients	5	3	4	4	4
CDC recommendations are easy to follow	5	3	3	3.7	3

TABLE 6 – *Continued*

Question	Respondent 1	Respondent 2	Respondent 3	Mean Score	Median Score	
Feel comfortable educating patients and families	5	4	3	4	4	
Parents refuse testing (Always=1 to Never=5)	5	4	5	4.7	5	
				Yes (%)	**No (%)**	**Don't Know (%)**
Org. uses point-of-care capillary testing	N	D	N	0 (0.0%)	2 (66.7%)	1 (33.3%)
Org. uses in-house venous blood draws	N	D	N	0 (0.0%)	2 (66.7%)	1 (33.3%)
Org. uses pediatric preventive services bundle	Y	D	N	1 (33.3%)	1 (33.3%)	1 (33.3%)
Org. uses electronic reminder system	Y	D	Y	2 (66.7%)	0 (0.0%)	1 (33.3%)

Note: Score represents a value from 1 to 5 (Appendix A for each question's corresponding scale).

One respondent contributed a free text response for additional barriers, citing lack of provider education as a perceived barrier to lead screening.

Educational Intervention and Follow-Up Survey

Despite the small sample size, numerous learning needs were identified through the provider survey. One notable finding was that none of the providers was able to correctly identify the two ages at which lead screening is required to be conducted by ADHS and Medicaid guidelines. The fact that none of the providers knew that interventions such as renal testing, long bone radiographic imaging, and testing of hair and nails are no longer recommended by the CDC was also troubling since unnecessary testing can be costly and have the potential for unwanted side effects (exposing children to needless radiation, for example). Survey answers also suggested that providers were unsure of where to locate

Arizona's current lead screening guidelines, in addition to finding CDC guidelines somewhat difficult to follow.

A brief, 12-slide PowerPoint presentation was created with these educational needs in mind, highlighting the causes and effects of lead poisoning, current ADHS guidelines, the CDC's follow-up recommendations for rescreening and treatment, and online resources for further reading and reference. The presentation was emailed to survey respondents along with a four-question post-survey on the acceptability of the PowerPoint presentation.

Acceptability

Two responses to the post-survey were returned, both with entirely positive appraisals of the effectiveness and feasibility of the educational tool, rating it highly on: helpfulness, likelihood to change their future practice, accurately reflecting the barriers at their particular practice, and whether they would recommend the tool to others.

DISCUSSION

Results Versus Expectations

While the limited scope of this quality improvement project makes it challenging to observe any clear trends in the results (Figures 1 through 3), the results of the provider survey are unsurprising when compared with findings in the literature. The low percentage of correct responses to the knowledge questions (ranging from 30% to 50%) and the type of questions missed are in keeping with the results of other lead screening knowledge assessments (Ferguson & Lieu, 1997; Goldman et al., 1998; Taylor et al., 2017). The perceived barriers, such as difficulty locating current state guidelines and following the complex CDC recommendations for management of patients with elevated BLLs, are also understandable in

light of the low screening and follow-up rates in Pima County and the state as a whole, which may be attributable in part to a similar unfamiliarity with current guidelines.

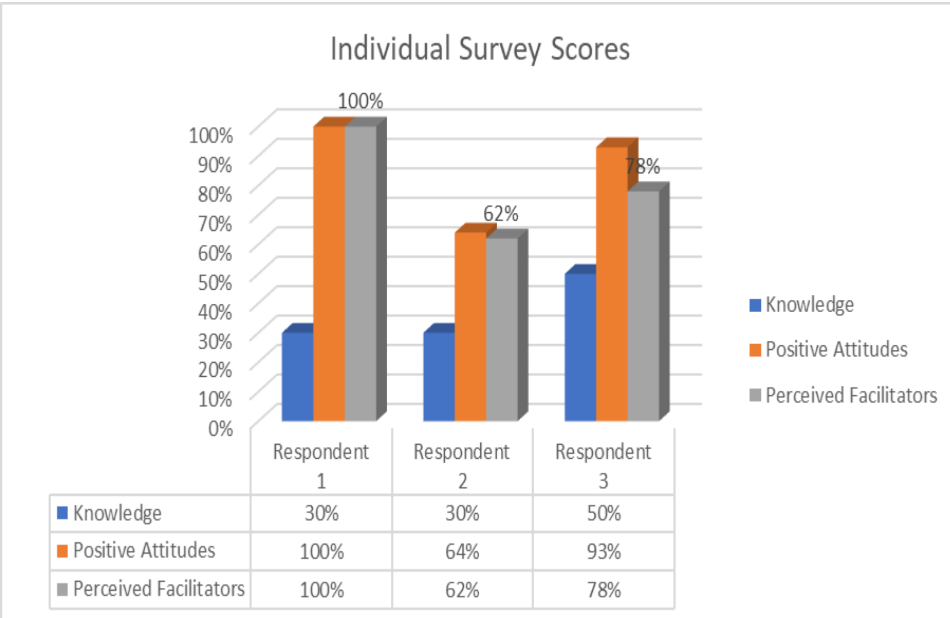

FIGURE 1. Individual survey scores. (Comparison of individual percent scores for: knowledge, indicating correct responses with a maximum score of 10; positive attitudes, with a maximum score of 55; and perceived facilitators of lead screening, with a higher score reflecting fewer barriers as measured by the first nine barrier questions, with a maximum score of 45.)

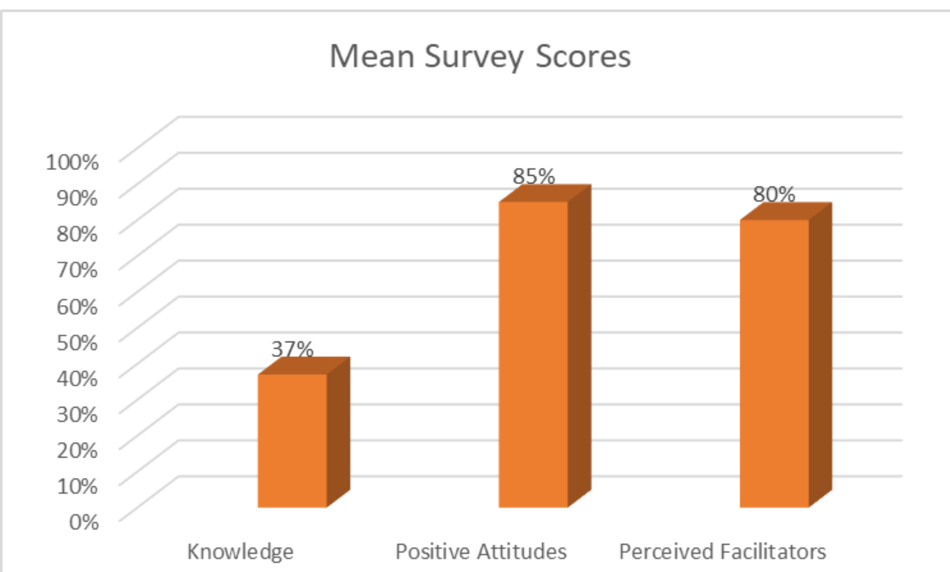

FIGURE 2. Mean survey scores. (Comparison of mean scores for knowledge, positive attitudes, and perceived facilitators of lead screening.)

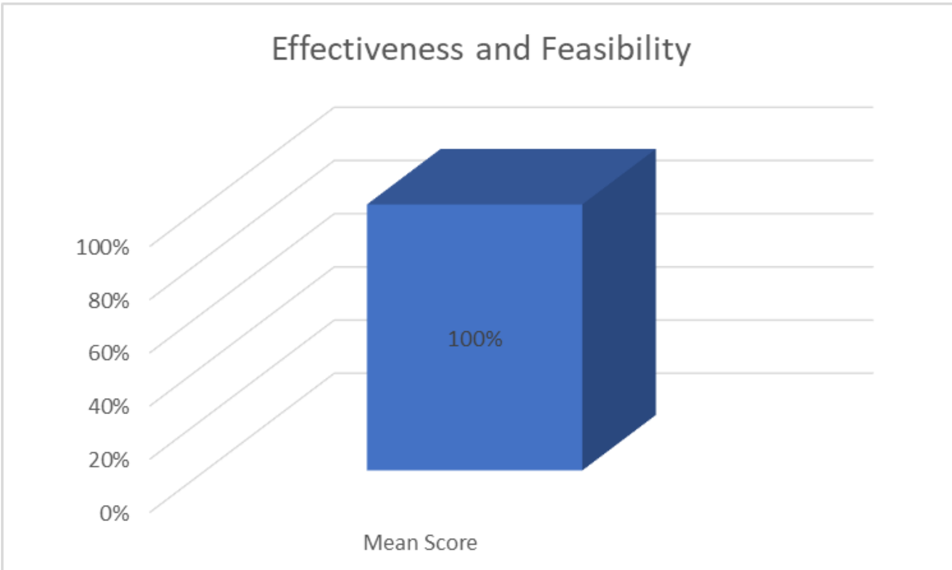

FIGURE 3. Effectiveness and feasibility. (Mean score for post-survey evaluating acceptability of the provider education provided.)

Although not generalizable and pertinent only to this target clinical practice, it was interesting to observe that the NP with the least work experience reported the least barriers and had the most positive attitude, while the physician who had the most work experience of the team had the lowest attitude score and perceived the most barriers to consistent screening. The most experienced NP had the highest knowledge score and an attitude score above 90%, with an intermediate score for perceived barriers. More positive attitudes were associated with NPs versus physicians in this group, as well as bilingualism, female gender, fewer years practicing, and fewer perceived barriers. The findings on female gender and years in practice are in keeping with the literature (Campbell et al., 1996; Keeshan et al., 2010; Schaffer et al., 1998). It would be interesting to see if the finding regarding NPs versus physicians having generally higher attitudes and lower perceived barriers would be observed in a larger sample,

and whether a clear trend on knowledge differences between NPs and physicians would become apparent with a larger sample.

Challenges and Limitations

The main limitation to this quality improvement project is the small sample size, which makes it difficult to draw conclusions about the top knowledge gaps and barriers identified through the survey. The sample size also precludes drawing any connections between demographic characteristics (such as type of provider and gender) and survey responses. The small sample is not intended to be representative of Green Valley nor Pima County, but it offers a serviceable picture of the learning needs of this particular clinic's providers and a feasible targeted education intervention.

Another limitation is the lack of an identical post-survey instrument that would allow for measurement of an improvement in knowledge or attitude following the educational intervention. This type of pre-post design was intentionally deferred since the focus of this initial inquiry was to establish acceptability of the educational intervention, and to determine whether the survey instrument was appropriate for capturing differences among providers in this area. If this project were repeated, the use of a post-survey that more closely mimicked the pre-survey would help to validate the questionnaire as a useful tool for larger samples of providers. Even better, chart review or auditing for appropriate ordering of lead tests before and after the educational intervention could be utilized for an objective measurement of change.

One important challenge that was encountered in the data collection phase was that the original project site, a large health care organization with two Tucson-area family medicine

clinics, withdrew its initial approval following an administrative personnel change and a proposed future change in the process for approving quality improvement and research projects that would be conducted in the clinics. This was despite the initial organizational support for the project and permission to proceed with data collection, obtained prior to review by The University of Arizona's Institutional Review Board (IRB) (Appendix D). Often encountered in successful research efforts is the need to remain flexible, thus a change of site was required, and organizational support from the Green Valley clinic was subsequently obtained.

An additional challenge that was encountered involved the staff of the clinic being unaccustomed to checking their work emails, which became apparent in conversations with the providers after the initial survey email had been sent. All but one of the providers followed through with checking their emails following a verbal reminder to do so. In the future, a paper-only survey may be a more effective, even if tedious, means of obtaining responses from providers at small clinics such as this one, some of whom may be less comfortable with email and web survey technology. Future considerations should include assessing the most effective communication channels of targeted participants.

Finally, the clinic at which this project was conducted sees a limited number of pediatric patients (approximately 10-20% of the patient population), and therefore the clinic's providers may be less knowledgeable about the lead screening guidelines than providers who regularly provide preventive health care to children. It is even more vital, then, that the providers at clinics with similarly low numbers of pediatric well visits are provided with

educational support for compliant pediatric preventive care practices, since they may be less likely to be up to date on current practices than those who routinely provide such care.

Implications

The knowledge gaps identified in the project survey are of importance to insurers and management who have an interest in maintaining compliance with Medicaid requirements for quality indicators and reducing waste from unnecessary testing. Since none of the providers surveyed were able to correctly select the ages at which screening is required, nor were they aware of diagnostic tests that are recommended against by the CDC, it is in the interest of those responsible for their continuing education to utilize an accessible, easy-to-understand tool such as the PowerPoint tested in this project to support their practice.

Ideally, the responsibility for educating providers on requirements and expectations for best practice should be shared between employers, state and federal health authorities, academic institutions, and the professional groups that publish recommendations and practice updates. However, it may be argued that, in a time when providers are often overwhelmed by the ever-accumulating multitude of guidelines and changing recommendations, it ultimately falls to organizational leadership to simplify and clarify policies in order to ensure consistent quality of care.

Future Directions

A logical next step would be to repeat this project with a larger sample of providers, using a longer post-survey that assesses for changes in providers' knowledge and attitude following delivery of the asynchronous focused educational PowerPoint presentation. However, there are other interventions that were identified in the literature review as holding

promise for increasing adherence to lead screening guidelines. Some of these interventions that could be tested locally include office system improvements such as preventive care bundles, as well as EHR prompts for follow-up testing and treatment that could be triggered if an elevated BLL result were received. A preventive services bundle could be particularly appropriate for the clinic site surveyed in this project, since the providers' responses indicated they were uncertain if such a bundle existed.

In-house capillary testing machines would also be a potentially effective intervention for larger clinics that could afford the initial and ongoing investment associated with the machines, especially if grant money could help to cover these costs. Clinics that encounter the problem of families failing to follow up on ordered venous blood draws may find this intervention particularly beneficial.

Additional interesting avenues to explore if a larger sample were surveyed would be to compare the responses of nurse practitioners to physicians, and to compare masters-educated to doctorate-educated nurse practitioners.

Dissemination

The findings of this DNP Project were shared with the management and providers of the project site and a sister clinic in Tucson, Arizona. As a follow-up, the educational PowerPoint was provided to the medical group's management, who subsequently distributed it to the providers at the sister site.

This project was also shared in its proposal stage at two peer-reviewed poster presentations: the 2018 Western Institute of Nursing Communicating Nursing Research

Conference, and the 2018 3rd Annual El Rio/Wright Center for GME Virtual Health Fair. Future plans include presenting the completed project at poster presentations in 2019.

Conclusion

Screening for lead exposure in young children benefits the health of the community through early identification of, and timely intervention for, lead toxicity. This project examined the potential causes of poor adherence to lead screening guidelines among health care providers in Pima County, Arizona, and tested a potential solution for health care organizations and educators interested in promoting provider knowledge of current lead screening guidelines. This was accomplished through: 1) Assessing primary care providers' knowledge of and adherence to childhood lead screening guidelines; and 2) Based on survey results, developing an educational tool addressing primary care providers' barriers to lead screening. The results pointed to a need among health care providers for clear and easy-to-find instructions when it comes to screening and reporting requirements. The providers surveyed were unclear on the current state and federal guidelines for testing children for lead exposure, and they endorsed a range of unnecessary follow-up testing procedures that are wasteful and unnecessarily invasive. Future inquiries into provider lead testing practices are warranted, since events like the water crisis in Flint, Michigan demonstrate that the issue of lead poisoning is not just relegated to the history books.

APPENDIX A:

ONLINE SURVEY QUESTIONNAIRE

Online Survey Questionnaire

<u>Inclusion Criteria Verification</u>

Are you a physician, nurse practitioner, or physician assistant who currently provides primary care to children under 6 in Tucson, Arizona?

- Yes
- No

<u>Demographics</u>

Profession

- MD
- DO
- Nurse Practitioner with a Masters Degree
- Nurse Practitioner with a Doctoral Degree
- Physician Assistant
- Other

Number of Years Practicing as a Health Care Provider

- 0-5
- 6-10
- 11-20
- 21-30
- 30+

Gender

- Female
- Male
- Prefer Not to Say
- Other

Estimated percentage of your patients on AHCCCS/Medicaid

- 0-25%
- 26-50%
- 51-75%
- 76-100%
- Don’t Know

Estimated percentage of families served by your practice that are primarily Spanish speaking

- 0-25%
- 26-50%
- 51-75%
- 76-100%
- Don't Know

Are you fluently bilingual (English/Spanish)?

- Yes
- No

<u>Knowledge Assessment</u>

At what ages does the Arizona Department of Health Services (ADHS) require blood lead screening in high-risk pediatric patients? (select all that apply)

- 3 months
- 6 months
- 12 months (correct)
- 18 months
- 2 years (correct)
- 3 years
- 4 years

At what ages does CMS require blood lead screening for all Medicaid patients? (select all that apply)

- 3 months
- 6 months
- 12 months (correct)
- 18 months
- 2 years (correct)
- 3 years
- 4 years

Blood lead levels of 10-45 µg/dL must be reported to ADHS within how many business days?

- 1
- 3
- 5 (correct)
- 7
- 9
- 11
- 13

Blood lead levels over 45 µg/dL must be reported to ADHS within how many business days?

- 1 (correct)
- 3
- 5
- 7
- 9
- 11
- 13

True or false: Normal blood lead levels must be reported to ADHS when the patient's previous results were elevated.

- True (correct)
- False

Chelation therapy should be initiated when patients have a blood lead level greater than or equal to . . .

- 5 µg/dL
- 10 µg/dL
- 20 µg/dL
- 45 µg/dL (correct)
- 70 µg/dL

Abdominal x-rays and blood labs for iron and hemoglobin/hematocrit should be ordered when patients have a blood lead level greater than or equal to . . .

- 5 µg/dL
- 10 µg/dL
- 20 µg/dL (correct)
- 45 µg/dL
- 70 µg/dL

Patients should be hospitalized when they have a blood lead level greater than or equal to . . .

- 5 µg/dL
- 10 µg/dL
- 20 µg/dL
- 45 µg/dL
- 70 µg/dL (correct)

If a patient has a blood lead level at or above 45 µg/dL, how soon should a confirmatory venous test be conducted?

- Emergently
- Within 24 hours
- Within 48 hours (correct)
- Within 1-4 weeks
- Within 1-3 months

Which of these follow-up tests does the CDC currently recommend for patients with blood lead levels of 10-20 µg/dL?

- Testing of hair for lead
- Long bone radiographic imaging
- Long bone x-ray fluorescence
- Assessing for gingival lead lines
- Renal function testing
- All of the above
- None of the above (correct)

<u>**Attitudes**</u>

I consistently perform lead screening on children under 6 years of age in accordance with Arizona's lead screening guidelines.

Strongly Disagree Strongly Agree
1 2 3 4 5

During the next year, I intend to follow Arizona's lead screening guidelines.

Strongly Disagree Strongly Agree
1 2 3 4 5

Following Arizona's lead screening guidelines is…

Extremely Harmful Extremely Beneficial
1 2 3 4 5

Following Arizona's lead screening guidelines is…

Extremely Difficult Extremely Easy
1 2 3 4 5

Following Arizona's lead screening guidelines is…

Extremely Unimportant to Me Extremely Important to Me
1 2 3 4 5

Following Arizona's lead screening guidelines is…

Extremely Incompatible with my Current Practice Extremely Compatible with my Current Practice
1 2 3 4 5

The benefits of following Arizona's lead screening guidelines outweigh the risks.

Strongly Disagree Strongly Agree
1 2 3 4 5

People who are important to me follow Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

People who are important to me want me to follow Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

It is expected of me that I follow Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

The decision to follow Arizona's lead screening guidelines is within my control.
Strongly Disagree Strongly Agree
1 2 3 4 5

Barriers

My organization makes it easy for me to follow Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

My organization's policies/protocols support following Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

My organization has the technology necessary for me to follow Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

My organization's electronic health record makes it easy for me to follow Arizona's lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

I know where/how to locate the Arizona Department of Health Services childhood lead screening guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

It is easy to identify high-risk children who need to receive lead screening according to the Arizona Department of Health Services guidelines.
Strongly Disagree Strongly Agree
1 2 3 4 5

The CDC recommendations for treatment and follow-up of elevated BLLs are easy to follow.
Strongly Disagree Strongly Agree
1 2 3 4 5

I feel comfortable educating parents/families about lead poisoning prevention and screening.
Strongly Disagree Strongly Agree
1 2 3 4 5

Parents at my clinic refuse to allow their child to be tested for blood lead levels…

- Always
- More than Half the Time
- About Half the Time
- Less than Half the Time
- Never

My organization uses point-of-care capillary testing for blood lead levels.

- Yes
- No
- Don't Know

My organization uses in-house venous blood draws for blood lead levels.

- Yes
- No
- Don't Know

My organization uses a preventive care service bundle for pediatric well child visits.

- Yes
- No
- Don't Know

My organization uses a reminder system in the electronic health record to ensure that routine screenings and vaccinations are ordered.

- Yes
- No
- Don't Know

Identify any additional barriers to consistent lead screening at your practice. (optional) [Free text]

APPENDIX B:

EDUCATIONAL POWERPOINT

GET THE LEAD OUT!
LEAD SCREENING TIPS FOR HEALTH CARE PROVIDERS

Laura Kennicutt, MS-RN
Patricia Daly, PhD, FNP
Audrey Russell-Kibble, DNP, FNP-C, FAANP
Deborah Williams, PhD, MPH, RN

THE UNIVERSITY OF ARIZONA
College of Nursing

LEARNING OBJECTIVES

Following this learning activity participants will be able to:

1. Describe physical and developmental consequences of lead toxicity on children
2. Explain rationale for Arizona's policy on childhood lead screening
3. Identify which patients require lead screening
4. Locate current CDC recommendations for follow-up testing
5. Locate current CDC recommendations for treatment of elevated blood lead levels

WHY IS LEAD SCREENING IMPORTANT?

- Elevated blood lead levels (BLLs) are associated with:
  - Lower intelligence
  - Developmental disorders
  - Anemia
  - Seizures
  - Effects on growth
  - Coma and death
- 500,000 U.S. children between 1 and 5 are estimated to have elevated BLLs, with low-income and minority families particularly affected

(ACCLPP, 2012)

SOURCES OF LEAD

Lead-based paint

Painted pottery

Soil (pica)

Water

Makeup

Toys

Candies and spices

Herbal medicines and teas

(ADHS, 2018)

WHAT IS ARIZONA'S LEAD SCREENING POLICY?

- The Arizona Department of Health Services (ADHS) requires screening at **12 and 24 months** (or between 36 and 72 months for those not yet tested) for:
  - Medicaid recipients
  - Children in high-risk zip codes
  - Children with at least one risk factor for lead exposure per the ADHS questionnaire
- At-risk zip codes in Pima County:

85321, 85629, 85633, 85634, 85639, 85658, 85701, 85702, 85703, 85705, 85706, 85710, 85711, 85712, 85713, 85714, 85715, 85716, 85717, 85719, 85721, 85724, 85725, 85726, 85730, 85731, 85732, 85733, 85734, 85735, 85736, 85745, 85746, 85751, 85754, 85756, 85757

WHAT DO I DO WITH THE RESULTS?

- All results between 10-44 µg/dL must be reported to ADHS within **FIVE business days**
- All results ≥45 µg/dL must be reported within **ONE business day**
- Children who previously had elevated levels should report all subsequent results (even if normal)!
- Recommended actions based on lead levels ≥5 µg/dL (including treatments, screenings, and follow-up test intervals) can be found at https://www.cdc.gov/nceh/lead/acclpp/actions_blls.html

FOLLOW-UP TESTING SCHEDULE

Recommendation Schedule for Follow up Blood Lead Testing

Venous blood lead level (µg/dL)	Early follow-up (first 2-4 tests after identification)	Late follow-up (after blood lead level begins to decline)
≥ 5-9	3 months	6-9 months
10-19	3 months*	3-6 months
20-24	1 month	1-3 months
25-44	2 weeks-1 month	1 month
≥ 45	As soon as possible	As soon as possible

Some health care providers may choose to repeat blood lead tests on all new patients within a month to ensure that their blood lead level is not rising more quickly than anticipated.

(ADHS, 2018)

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WHAT ARE THE RECOMMENDED TREATMENTS?

<5 µg/dL: Assess nutrition and development, education about lead exposure, follow-up tests

5-9 µg/dL: All interventions for <5 µg/dL PLUS detailed environmental assessment (no home visit required) for source of lead, nutritional counseling on iron and calcium intake

10-19 µg/dL: All interventions for 5-9 µg/dL PLUS home visit to evaluate sources of lead, possible lab work (iron level)

(CDC, 2018)

20-44 µg/dL: Complete H&P, neurodevelopmental assessment, environmental home assessment with lead hazard reduction, labs (iron, H&H), abdominal x-ray (with bowel decontamination as indicated), follow-up tests

45-69 µg/dL: All interventions for 20-44 µg/dL PLUS complete neuro exam, oral chelation therapy, consider hospitalization if lead-free home not guaranteed

≥70 µg/dL: All interventions for 45-69 µg/dL PLUS hospitalization, chelation therapy in consultation with medical toxicologist or pediatric environmental health unit

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WHAT FOLLOW-UPS ARE NOT RECOMMENDED?

- Testing hair
- Long bone x-rays and x-ray fluorescence
- Assessing for gingival lead lines
- Testing of neurophysiological function
- Renal function testing (except during chelation)

(CDC, 2018)

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WHERE TO FIND RESOURCES

- Arizona Department of Health Services (ADHS) lead poisoning health care provider portal:

https://www.azdhs.gov/preparedness/epidemiology-disease-control/lead-poisoning/index.php#health-care-provider

Contains questionnaires in English and Spanish, flyers, waiting room posters, refugee-specific recommendations, and instructions for reporting test results

- CDC page on Lead (contains updated guidelines): https://www.cdc.gov/nceh/lead/default.htm

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SUMMARY

1. Describe physical and developmental consequences of lead toxicity on children
2. Explain rationale for Arizona's policy on childhood lead screening
3. Identify which patients require lead screening
4. Locate current CDC recommendations for follow-up testing
5. Locate current CDC recommendations for treatment of elevated blood lead levels

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APPENDIX C:

POST-SURVEY QUESTIONNAIRE

Post-Survey for "Barriers to Childhood Lead Screening in Tucson, Arizona"

1. Was this PowerPoint presentation helpful?
    - Yes
    - No
    - Maybe
2. Will you change your day-to-day practice based on what you learned in this PowerPoint presentation?
    - Yes
    - No
    - Maybe
3. Does this PowerPoint presentation accurately reflect the barriers to lead screening at your organization?
    - Yes
    - No
    - Maybe
4. Would you recommend this PowerPoint presentation to other health care providers?
    - Yes
    - No
    - Maybe

APPENDIX D:

THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD (IRB) APPROVAL LETTER

THE UNIVERSITY OF ARIZONA
Research, Discovery & Innovation

Human Subjects Protection Program

1618 E. Helen St.
P.O.Box 245137
Tucson, AZ 85724-5137
Tel: (520) 626-6721
http://rgw.arizona.edu/compliance/home

Date:	June 19, 2018
Principal Investigator:	Laura Joanna Kennicutt
Protocol Number:	1806688370
Protocol Title:	Barriers to Childhood Lead Screening in Tucson, Arizona: A Quality Improvement Project
Determination:	Human Subjects Review not Required

Documents Reviewed Concurrently:

Data Collection Tools: *Lead Screening Survey (Text Version).docx*
Data Collection Tools: *Post-survey (text version).docx*
HSPP Forms/Correspondence: *Advisor Confirmation email.pdf*
HSPP Forms/Correspondence: *Kennicutt IRB determination of research.pdf*
Informed Consent/PHI Forms: *Disclosure form - Kennicutt.docx*
Other: *LOS for DNP Project Laura Kennicutt 2018.05.25.docx*
Other: *NRDUC supplemental questionnaire - Kennicutt.docx*
Recruitment Material: *Recruitment email.docx*

Regulatory Determinations/Comments:

- Not Human Subjects Research as defined by 45 CFR 46.102(f): as presented, the activities described above do not meet the definition of research involving human subjects as cited in the regulations issued by the U.S. Department of Health and Human Services which state that "human subject means a living individual about whom an investigator (whether professional or student) conducting research obtains data through intervention or interaction with the individual, or identifiable private information."

The project listed above does not require oversight by the University of Arizona.

If the nature of the project changes, submit a new determination form to the Human Subjects Protection Program (HSPP) for reassessment. Changes include addition of research with children, specimen collection, participant observation, prospective collection of data when the study was previously retrospective in nature, and broadening the scope or nature of the study activity. Please contact the HSPP to consult on whether the proposed changes need further review.

The University of Arizona maintains a Federalwide Assurance with the Office for Human Research Protections (FWA #00004218).

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