HHS Public Access

Author manuscript

Int Public Health J. Author manuscript; available in PMC 2024 February 15.

Published in final edited form as:

Int Public Health J. 2023 ; 15(3): 297–306.

The more you know: Insights from integrated pre-visit surveys in a pediatric environmental health center

Shalini H Shah, DO[1,2,3,4,*], **Alan D Woolf, MD, MPH**[1,2,3,4], **Kimberly Manning, MA, CHES**[2], **Faye Holder-Niles, MD, MPH**[3,4], **Bridget Tully, BS**[1,2,3,4], **Shelby Flanagan, MPH**[2,3,4], **Matthew C Spence, MPH**[2], **Marissa Hauptman, MD, MPH**[1,2,3,4]

[1]Pediatric Environmental Health Center, Boston Children's Hospital, Boston, Massachusetts, USA

[2]Region 1 New England Pediatric Environmental Health Specialty Unit, Boston, Massachusetts, USA

[3]Division of General Pediatrics, Boston Children's Hospital, Boston, Massachusetts, USA

[4]Department of Pediatrics, Harvard Medical School, Boston, Massachusetts, USA

Abstract

The Pediatric Environmental Health Center (PEHC) at Boston Children's Hospital is a specialty referral clinic that provides consultation for approximately 250 patients annually. Identifying environmental hazards is key for clinical management. Exposure concerns include lead, mold, pesticides, perfluoroalkyl substances (PFAS), impaired air quality, and more. Our goal was to identify concerns and visit priorities of our patient population to guide visits. A 47-question pre-visit survey was created exploring potential environmental hazards and administered prior to visits using a platform integrated into the electronic medical record (EMR). The study group was a convenience sample of patients from June 2021 to June 2022. Of 204 total visits, 101 surveys were submitted, yielding a response rate of 49.5%. 66/101 (65.3%) were surveys from initial consultations used for descriptive analysis. The majority of patients were seen for a chief complaint of lead exposure (90.1%). Most respondents had concerns about peeling paint (40.0%), and those reporting peeling paint were more likely to report additional concerns [75.0%, $p < 0.001$]. Other concerns highlighted were mold (15.2%), pests (15.2%), asbestos (10.6%), air pollution (9.1%), temperature regulation (7.6%), pesticides (6.1%), PFAS (4.5%), and formaldehyde (4.5%). A knowledge gap was identified; 45.5% (30/66) respondents responded "no" to the question asking if the Poison Control Center phone number was stored in their phone. This study illustrates how the implementation of a pre-visit EMR integrated survey engages families, informs clinical care, and serves as a point-of-care education tool for specific knowledge gaps. Findings will guide development of future environmental health screeners.

Keywords

Environmental health; clinical screening tools; lead exposure; health disparities; environmental justice; United States

[*]***Correspondence:*** Shalini H Shah, DO, Boston Children's Hospital, Department of Pediatrics, 300 Longwood Avenue, Boston, MA 02115, United States. shalini.shah@childrens.harvard.edu.

Introduction

Social determinants of health (SDOH) are defined as the conditions in which individuals are born, grow, live, work and play, which significantly impact health outcomes and are widely recognized in the healthcare community. SDOH include many factors such as poverty, housing and food insecurity, access to education and healthcare, immigration status, and systemic racism (1). The central tenet of the SDOH construct requires the medical and scientific community to understand and examine the conditions in which children are living, in the hopes that detecting and addressing these components can serve as an opportunity to reduce health disparities and improve long-term health outcomes. Despite this goal of understanding the livelihoods of our patients and life conditions affecting their communities, the environmental aspects of SDOH are often overlooked in clinical practice.

Environmental pollution is widespread and continues to contaminate our air, water, and soil, and the public health community's understanding of the health risks posed by these exposures is sound, robust, and evolving. Lifetime exposure to environmental pollutants has been linked to low birth weight, asthma, cancer, and neurodevelopmental disorders (2). Exposure to air pollution has a variety of short and long-term health effects, which may be experienced as symptoms of cough, wheezing, shortness of breath with high rates of hospitalization. Cumulative impacts on respiratory diseases can be lifelong, such as the development of chronic asthma, chronic obstructive pulmonary disease, pulmonary insufficiency, and cardiovascular disorders in adulthood (2). Water contamination exposes vulnerable children to toxic heavy metals such as lead, arsenic, mercury, and cadmium; with an increased risk of health consequences including developmental/ neuro-cognitive/ behavioral disorders, respiratory illness, cardiovascular disease, and cancer (3). Of these heavy metals, lead is the most common and most studied neurotoxin with a large body of evidence that links exposure to negative impacts on brain function and child development, causing learning and behavior impairment (4). The most common exposure source is via ingestion of lead dust from deteriorating lead-based paint, which is more prevalent in older housing, and housing in poor condition (5). Resultant lead exposure and the related neurodevelopmental health concerns are key examples of the health consequences of environmental injustice and systemic inequity (6). While these are well-studied examples interlinking the presence of environmental hazards and health outcomes, there are innumerable emerging exposures in our environments that likely contribute to health outcomes, though the specific impacts may not yet be understood.

Children are an especially vulnerable subset of the population to environmental threats due in part to their unique physiological, social, and environmental factors; they have higher respiratory rates, have impaired thermoregulatory conditioning, and carry greater exposure risk through demographics affecting their housing, school, and outdoor play and are reliant on caregivers (7). Children of low income and minority communities experience a disproportionately high burden given their increased exposure with limited resources available for adaptation. This can be amplified by barriers to access to solutions because of poverty, environmental racism, and systemic inequity (6, 8). The compounding effects of social and economic disadvantage, amplified by systemic racism and environmental injustice

have been described as a cycle of child health disparities (see Figure 1) and contribute to poor health outcomes for disadvantaged children (9).

Despite the robust evidence showing how environmental hazards impact child health and long-term outcomes, most pediatric healthcare providers do not integrate environmental health assessments into their clinical practice. There are multiple barriers to integrating environmental health into practice, including the time constraints of visits, lack of provider knowledge or confidence in discussing and addressing environmental health concerns with families, and limited resources available for positive findings such as community-based partnerships, educational handouts, referral programs for addressing housing or environmental concerns directly. The lack of recognizing and incorporating environmental considerations into clinical practice can be paralleled to the early phases of integrating the role of SDOH in medical care. Integration of SDOH into practice is often achieved using screening tools prior to or as a part of the clinical encounter. Though several SDOH screeners exist, a systematic review of 11 SDOH screeners in pediatrics revealed the environmental questions are limited to housing stability and neighborhood crime (10). To our knowledge, a well-integrated or validated environmental health screening tool does not currently exist for routine use in pediatric practice.

The Pediatric Environmental Health Center (PEHC) at Boston Children's Hospital is an urban specialty clinic that sees, on average, two hundred fifty patients annually, the majority of whom present with elevated blood lead levels or lead poisoning. Other clinical concerns prompting evaluation include mold or pesticide exposure, potential hazards from air and water quality concerns, and heavy metal exposures such as lead, arsenic, or mercury. Further, there is an emerging level of medical concern regarding exposure to perflouroalkyl and polyflouroalkyl substances (PFAS) such as its role as an endocrine disruptor, altering immune and thyroid function, contributing to liver and renal disease, negative reproductive and developmental outcomes, as well as being linked to renal and testicular cancers (12). Providers are typically allotted thirty to sixty minutes to conduct their consultation visits, although the reality of face-to-face time with patients and families is often much less, due to inconsistent start times with delayed patient arrival, time required for check-in, registration, and preceding clinical assistant assessments such as vital signs +/− connecting with an interpreter if needed. These barriers limit the depth to which environmental health histories can explore additional hazards that may be present but not directly linked or recognized as relevant to the chief complaint. Lack of standardization of electronic medical records and approach to an environmental health history can lead to gaps in care. Relying on retrospective chart review where pertinent historical information may be present in different areas (including but not limited to the demographics section, provider clinical notes, non-EMR integrated intake documentation led by schedulers) can lead to providers missing key environmental needs or hazards identified by families on an individual case level. This also makes large-scale analysis for population management more challenging than if this information was collated in a database.

The aim of this project was to develop a pre-visit survey to improve clinical care provided at the PEHC, increase environmental health literacy, and identify other environmental hazards within a population seen primarily for lead poisoning to provide more comprehensive care

and inform center initiatives. In consideration of the cycle of health disparities outlined by the Break the Cycle of Children's Environmental Health Disparities Program, lead exposure and lead poisoning can be viewed within the cycle framework in that limited social and economic capital leads to inadequate residential options that are more likely to contain lead hazards; this environmental exposure directly impacts the health and growth of the developing child (see Figure 1). This initiative aims to break this intergenerational cycle by detecting residential, community, and environmental hazards that contribute to negative health outcomes and providing clinical intervention(s) to ultimately decrease the burden of adverse childhood health outcomes (see Figure 2). It serves as a foundation upon which to develop future environmental health screening tools for use more broadly in pediatrics.

Methods

This project was conducted in multiple phases. The initial steps included a review of the literature to develop a broad understanding of current screening tools utilized in pediatric care such as screening for domestic or intimate partner violence, depression, and other SDOH (10). This information provided a foundation and knowledge base to inform the development of the environmental survey used in this study. The primary environmental medicine team, consisting of pediatric environmental health clinical faculty and health educators, then developed a questionnaire by using the electronic medical record integrated pre-visit survey platform, Tonic for Health. This platform allows for questionnaires to be sent electronically to patients and families via email prior to their scheduled clinical consultation. This questionnaire was pretested and modified after focus group review. The finalized version included a total of 47 questions spanning a wide range of environmental health topics. It was administered to a convenience sample of patients prior to their scheduled visits in the PEHC from June 18, 2021 through June 18, 2022 (one calendar year). Surveys were administered to all scheduled patients irrespective of initial consultation versus follow-up visits. Families received the intake survey by email five days prior to their appointment with automated reminders three days and again 24 hours prior to the visit. Individual survey responses were automatically uploaded into the electronic medical record to allow provider review prior to or during clinical encounters to address needs during the visit as appropriate. Aggregate data was extracted at the end of the study period through the Tonic for Health database and reviewed using descriptive statistical analysis. Duplicate surveys from follow-up visits were excluded from analysis.

Results

In the one-year study period, there were a total of 204 clinical encounters in the PEHC. Clinic demographics show that nearly 25% of families seen in the center reside in high-risk areas for lead exposure or poisoning as defined by the 2020 Annual Childhood Lead Poisoning Surveillance Report for Massachusetts (11). Approximately 20% of patients seen in the center identify as non-white, 13% report English is not their primary language and most patients (53%) are on public insurance. Of the 204 visits in the study period, 101 surveys were completed, yielding a response rate of 49.5%. Of the 101 surveys completed, 66 were unique patients or initial visits (65.3%) and the remainder of submitted surveys were follow-up visits (34.7%, 35/101). Chart review of these 66 encounters revealed that

90.9% (60/66) of these patients had a chief complaint of lead exposure. The following results and analysis are based upon review of the survey data collected from these unique patient encounters (n = 66).

There was a geographic distribution of a total of 37 towns in Massachusetts and two in Rhode Island (see Figure 3). As seen in Table 1, housing ownership distribution indicated the majority of patients owned their home at 51.5% (34/66) as primary owners (owner-occupied), and 6.1% (4/66) owned by extended family. The remainder 37.9% (25/66) rent their residence; 4.4% refused to answer this question (4/66). A total of 44/66 respondents (66.7%) reported lead inspection had been performed in their home, 25.0% (11/44) of this subgroup reported multiple forms of inspection (Department of Public Health, private inspector and/or lead test kits). Of those who reported inspections, 93.2% (41/44) reported that hazards were identified (options: lead in paint, dust/soil, air, water, disposal of lead wastes, other with free text option). Respondents identified an array of concerns as illustrated in Figure 4. These concerns identified, in descending order, were peeling paint (40.0%, 24/66), mold (15.2%, 10/66), pests (15.2%, 10/66), asbestos (10.6%, 7/66), air pollution (9.1%, 6/66), temperature regulation (7.6%, 5/66), pesticides (6.1%, 4/66), PFAS (4.5%, 3/66), and formaldehyde (4.5%, 3/66). 75.0% (18/24) of those with peeling paint (a lead-related concern) identified additional environmental concerns ($p < 0.001$). For the educational question inquiring if the Poison Control Center telephone number was stored in the respondent's phone, 45.5% (30/66) answered no.

Discussion

This pre-visit environmental survey was created by our center to better understand the scope of environmental hazards our patients and families are exposed to. Results from our survey illustrated a broad range of priorities and key environmental concerns within our patient population (see Figure 4). Although the Pediatric Environmental Health Center primarily sees patients for lead exposure and poisoning, findings from our pre-visit survey demonstrate that families with peeling paint/lead-related concerns (75.0%) are more likely to have additional environmental concerns ($p < 0.001$) compared to those without concerns about peeling paint (see Table 1). This is significant because although these patients may be referred for their lead exposure, there is potential that other environmental hazards are present in their home that could be impacting their health. An unexpected finding was that those who did not report peeling paint concerns were in fact more likely to have a chief complaint related to lead exposure ($p < 0.012$, Table 1). We hypothesize this may be because families who do not have visible peeling paint may be less aware of the presence of lead in their home environment, thus unable to address it and this may lead to elevated lead levels prompting referral to our clinic. This information offers an opportunity for providers to better identify families at risk for other environmental hazards and provide more comprehensive care through anticipatory guidance. The survey also demonstrated a large percentage of PEHC families rent their primary residence vs owner-occupied (37.9% vs 51.5% respectively). An understanding of the ownership status is critical in the field of environmental health as management strategies are often impacted by who is primarily responsible for the remediation of the residence and the financial burden that may accompany these needs. Being able to track this data in our patient population aids its ability

to inform initiatives within our center to help support patients and families in navigating these complexities as well as influence environmental health and housing advocacy on a broader level for environmental justice.

One of our survey questions specifically asked if the Poison Control Center number was stored in the respondent's device. If they stated no, it automatically provided this information within the survey platform using "branching logic" (see Figure 5). The number was provided along with instructions to save it in their device so that it would be readily available in the future in case of emergency". A large portion of respondents reported they did not have this information (45.5%) and were thus directed to this point-of-care education. To our knowledge, this is a unique feature of our screening tool, as other surveys may elucidate needs or concerns but addressing these findings is typically deferred to the provider at the clinical encounter instead of within the survey itself.

Notably, PFAS was one of the least reported concerns by the study population at 4.5% despite growing evidence and national concern about health impacts of chronic PFAS exposure (12).

Environmental exposures to potentially toxic chemicals like PFAS that are reported less frequently may be due to a lack of awareness on the population to the risks they may pose to human health. Analysis of lesser reported concerns and using this model of "branching logic" education in future surveys may be an opportunity to increase environmental health literacy by increasing awareness of children's exposure to potential environmental hazards. Given that improved environmental health literacy has a role in illness prevention "by raising awareness of risks from environmental factors and by providing approaches that individuals and communities can take to avoid, mitigate, or reduce such exposures," the use of an environmental health screener to increase awareness and literacy is significant (13). Further, identifying gaps in our patient population's understanding of different environmental hazards, such as PFAS and other contaminants, is useful to inform future educational outreach initiatives of our center, in hopes of increasing awareness and adaptation to different environmental health threats.

Conclusion

Results from this study show that pre-visit integrated electronic survey implementation helps engage families prior to visits and better direct anticipatory guidance to self-identified concerns. This tool demonstrated its ability to serve as a unique point-of-care platform for immediate education tailored to specific knowledge gaps. Findings from this survey aid can serve as a foundation for the development of further environmental health screening practices and inform a targeted screening approach that can incorporate the needs identified by families, paired with educational materials and provider resources to address identified limitations.

Generalizability of this work is limited by the convenience population in a single subspecialty environmental health clinic in a large academic center. Response rate and percentage of patients identifying environmental concerns may be influenced by this

being a specialty clinic and thus families being more prepared and willing to respond to environmental screening and more sensitive questions about their home environment. This survey was only administered in English and thus may not capture the needs of our non-English speaking families and the diverse patient population seen at the Pediatric Environmental Health Center. Follow-up visit surveys were excluded from our analysis, which could lead t o underestimation of hazards if patients/families reported new concerns at follow-up visits. Denial of certain environmental health hazards may be confounded by limitations of environmental health literacy and population understanding/awareness of these topics. Limitations in implementation for broader clinical practice include length of survey serving as an obstacle both for family completion but also provider review, provider/patient understanding of environmental exposures, the role they play in child health and disease management, and limited resources available if needs are identified.

Despite these limitations, this study illustrates how the implementation of a pre-visit EMR-integrated survey engages families before visits, informs clinical care, and can serve as a point-of-care education for specific knowledge gaps. It confirmed a family's willingness to complete a pre-visit survey regarding details of the child's home environment prior to their scheduled specialty clinic visit. Our findings documented that, while the child was usually referred for a single environmental health hazard, a written pre-visit survey often revealed other health concerns that could (and should) also be addressed during the office visit. And though this tool was used in a specialty center, a pre-visit questionnaire similar to this may also be helpful to community pediatricians and community health centers, who serve larger numbers of vulnerable patients at risk of environmental exposures but may not have access to subspecialty care as readily available. A tool like this could be a source of education for both providers and patients in that asking about potential environmental exposures they may not otherwise consider can raise awareness that these factors may be influencing their health. It could also assist in directing patients to community resources for trigger mitigation. Findings from this effort will guide development of future environmental health screeners.

Acknowledgments

Disclosure statements:

The authors have no financial relationships relevant to this article to disclose. The authors have no conflicts of interest to disclose.

The preparation for this project and manuscript review was supported by the Break the Cycle of Health Disparities Program of the Southeast PEHSU at Emory University and Break the Cycle of Health Disparities, Inc. Dr. Shah's work is supported (in part) by contract # 21W201300122 from the Massachusetts Department of Public Health associated with the Appletree Grant (Component 2) sponsored by the Centers for Disease Control and Prevention, Atlanta GA. Drs. Shah, Woolf, Hauptman, Ms. Manning, Tully, Flanagan and Mr. Spence are also supported (in part) by the cooperative agreement award number FAIN: NU61TS000296 with the Centers for Disease Control and Prevention/Agency for Toxic Substances and Disease Registry (CDC/ATSDR). The US Environmental Protection Agency (EPA) supports the PEHSUs by providing partial funding to CDC/ATSDR through an Inter-Agency Agreement. The findings and conclusions presented have not been formally disseminated by CDC/ATSDR or EPA and should not be construed to represent any agency determination or policy. Use of trade names that may be mentioned is for identification only and does not imply endorsement by the CDC/ATSDR or EPA. Dr. Hauptman is also supported by grants from the National Institutes of Health/National Institute of Environmental Health Sciences K23 ES031663 during the conduct of the study.

Abbreviations

PEHC	Pediatric Environmental Health Center
EMR	electronic medical record
SDOH	social determinants of health
PFAS	perflouroalkyl and polyflouroalkyl substances

References

[1]. Ragavan MI, Marcil LE, Garg A. Climate change as a social determinant of health. Pediatrics 2020;145(5): e20193169.

[2]. Landrigan PJ, Fuller R, Fisher S, Suk WA, Sly P, Chiles TC, et al. Pollution and children's health. Sci Total Environ 2019;650(Pt 2):2389–94. [PubMed: 30292994]

[3]. Eze IC, Schaffner E, Fischer E, Schikowski T, Adam M, Imboden M, et al. Long- term air pollution exposure and diabetes in a population-based Swiss cohort. Environ Int 2014; 70:95–105. doi: 10.1016/j.envint.2014.05.014. [PubMed: 24912113]

[4]. Sanders T, Liu Y, Buchner V, Tchounwou PB. Neurotoxic effects and biomarkers of lead exposure: A review. Rev Environ Health 2009;24(1):15–46. [PubMed: 19476290]

[5]. Osman MA, Yang F, Massey IY. Exposure routes and health effects of heavy metals on children. Biometals 2019;32(4):563–73. [PubMed: 30941546]

[6]. Whitehead LS, Buchanan SD. Childhood lead poisoning: A perpetual environmental justice issue? J Public Health Man 2019;25(1):S115–20.

[7]. Chance GW, Harmsen E. Children are different: Environmental contaminants and children's health. C J Public Health 1998;89(Suppl 1):S10–5.

[8]. Dignam T, Kaufmann RB, LeStourgeon L, Brown MJ. Control of lead sources in the United States, 1970–2017: Public health progress and current challenges to eliminating lead exposure. J Public Health Man 2019;25 (1):S13–22.

[9]. Break the Cycle of Health Disparities: Atlanta, GA: Break the cycle program. URL: https://www.breakthecycleprogram.org/.

[10]. Sokol R, Austin A, Chandler C, Byrum E, Bousquette J, Lancaster C, et al. Screening Children for social determinants of health: A systematic review. Pediatrics 2019;144(4):e20191622.

[11]. Annual screening and blood lead level reports and high-risk community lists, 2021. URL: https://www.mass.gov/lists/annual-screening-and-blood-lead-level-reports-and-high-risk-community-lists.

[12]. Fenton SE, Ducatman A, Boobis A, DeWitt JC, Lau C, Ng C, et al. Per- and polyfluoroalkyl substance toxicity and human health review: Current state of knowledge and strategies for informing future research. Environ Toxicol Chem 2021;40(3):606–30. [PubMed: 33017053]

[13]. Finn S, O'Fallon L. The emergence of environmental health literacy—From its roots to its future potential. Environ Health Persp 2017;125(4):495–501.

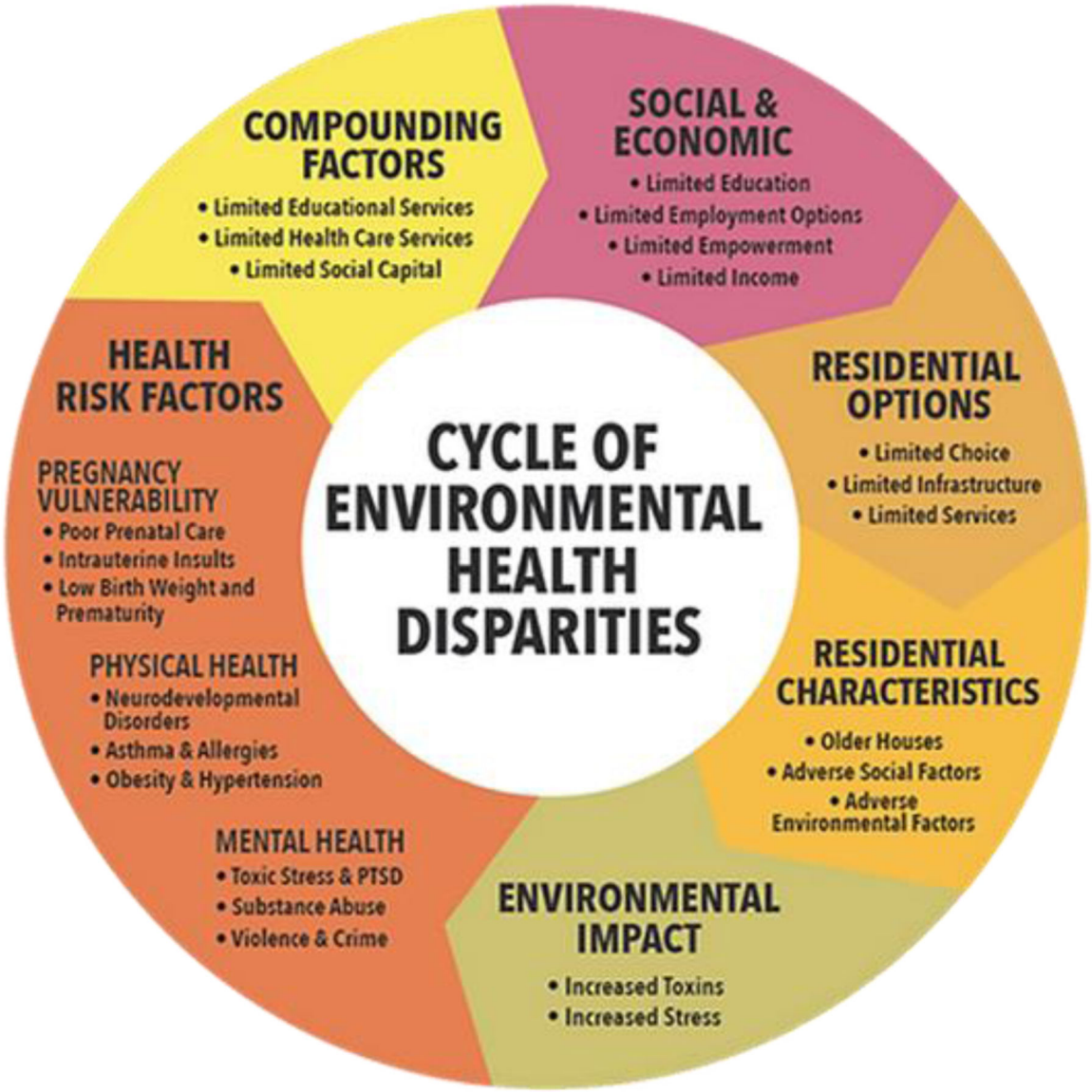

Figure 1.
The cycle of environmental health disparities (9).

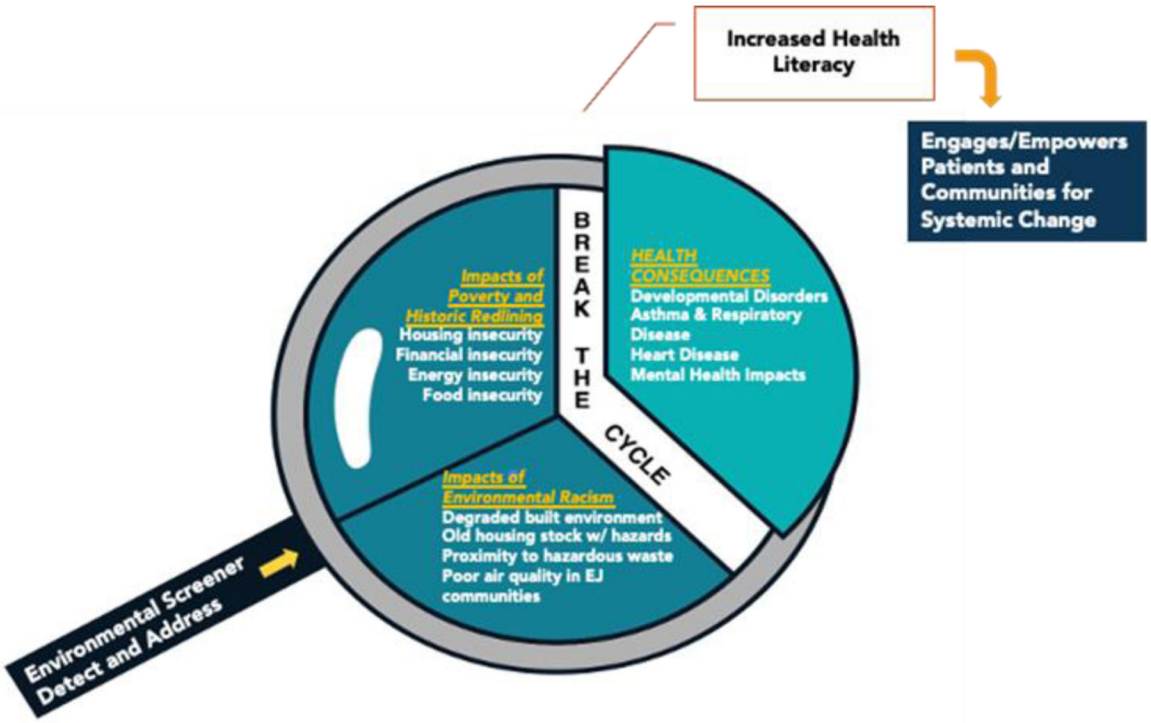

Figure 2.
Environmental health screening as a tool to break the cycle of health disparities.

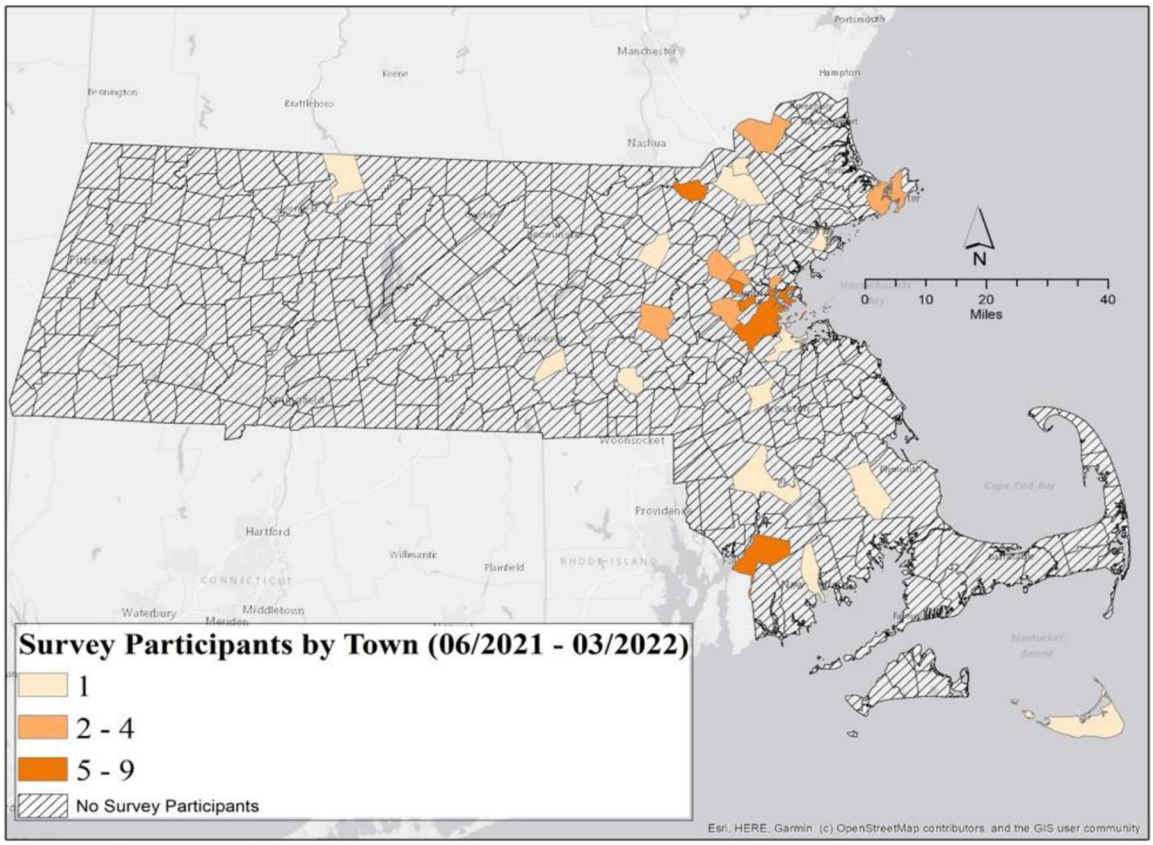

Figure 3.
Geographic distribution of survey respondents.

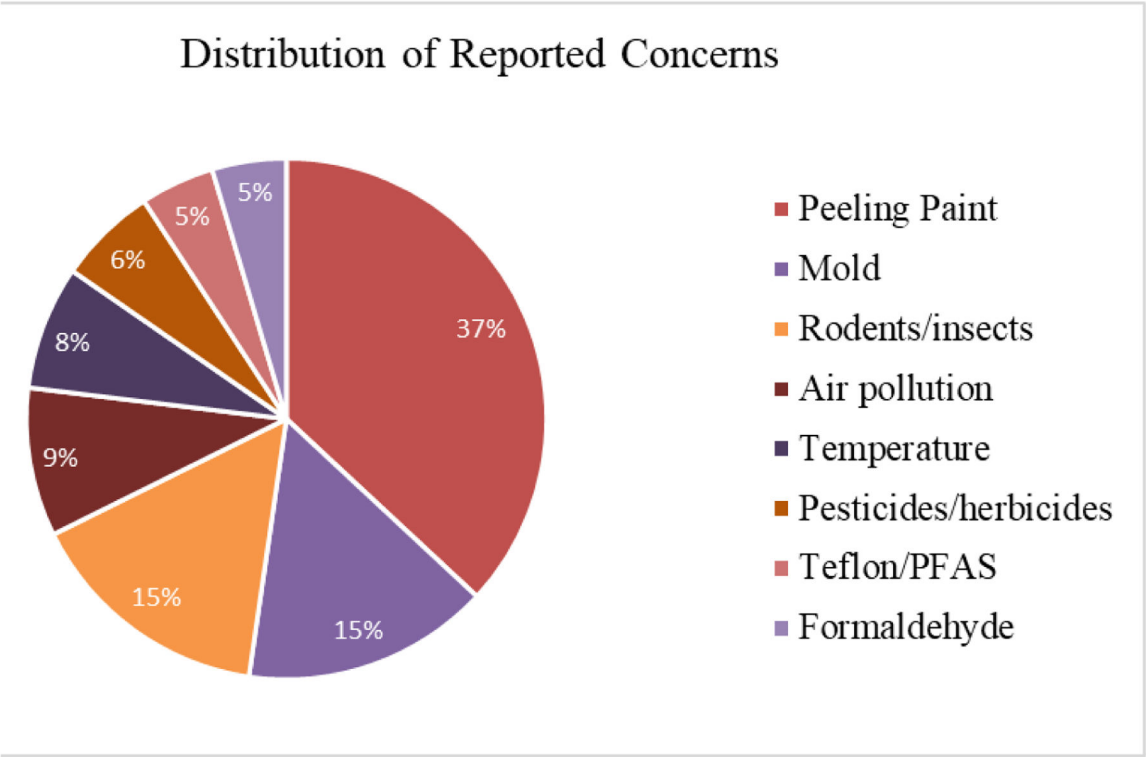

Figure 4.
Distribution of reported concerns.

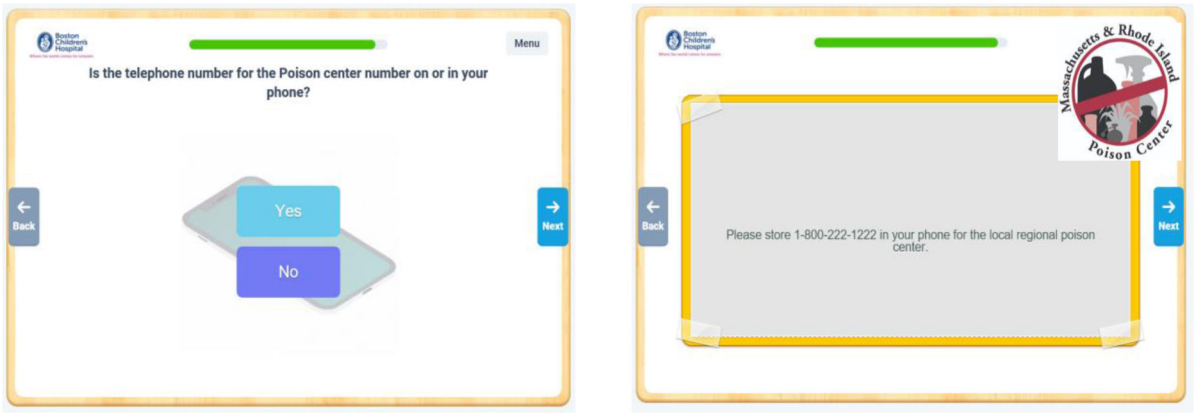

Figure 5.
Tonic for health platform question sample with paired education.

Table 1.

Patient demographics by reported peeling paint concerns

	Totals	No Peeling Paint Concerns	Peeling Paint Concerns	P value
	N = 66 surveys	N = 42 surveys	N = 24 surveys	
Visit Chief Complaint				<0.012
Non-Lead Exposure Concerns	6 (9.1%)	1 (2.4%)	5 (20.8%)	
Lead Exposure Concerns	60 (90.9%)	41 (97.6%)	19 (79.2%)	
Housing Type				0.54
Apartment	20 (30.3%)	12 (28.6%)	8 (33.3%)	
Multi-Family	12 (18.2%)	9 (21.4%)	3 (12.5%)	
Single Family	32 (48.5%)	19 (45.2%)	13 (54.2%)	
Unknown, Refuse to Answer, Skipped	2 (3.0%)	2 (4.8%)	0 (0.0%)	
Housing Ownership				0.26
Owner-Occupied	34 (51.5%)	23 (54.8%)	11 (45.8%)	
Owned by Extended Family	4 (6.1%)	4 (9.5%)	0 (0.0%)	
Rental	25 (37.9%)	13 (31.0%)	12 (50.0%)	
Unknown, Refuse to Answer, Skipped	3 (4.6%)	2 (4.8%)	1 (4.2%)	
Year Built				0.42
Pre 1900	14 (21.2%)	8 (19.1%)	6 (25.0%)	
1900–1950	20 (30.3%)	11 (26.2%)	9 (37.5%)	
1950–1978	9 (13.6%)	5 (11.9%)	4 (16.7%)	
1978–2000	5 (7.6%)	5 (11.9%)	0 (0.0%)	
Post 2000s	1 (1.5%)	1 (2.4%)	0 (0.0%)	
Unknown, Refuse to Answer, Skipped	17 (25.8%)	12 (28.6%)	5 (11.9%)	
Lead Inspection Performed				0.62
No	7 (10.6%)	5 (11.9%)	2 (8.3%)	
Yes	44 (66.7%)	29 (69.1%)	15 (62.5%)	
Unknown	15 (22.7%)	8 (19.1%)	7 (29.2%)	
Additional Environmental Concerns Reported				<0.001
No	42 (63.6%)	36 (85.7%)	6 (14.3%)	

	Totals	No Peeling Paint Concerns	Peeling Paint Concerns	P value
	N = 66 surveys	**N = 42 surveys**	**N = 24 surveys**	
Yes	24 (36.4%)	6 (25.0%)	18 (75.0%)	