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Environmental risks and children's health: What can PRAMS tell us?

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Abstract

Objectives—Environmental exposures during pregnancy have a lasting impact on children's health. We combined environmental and maternal risk factor survey data to inform efforts to protect children's health. We made recommendations for future use of such data.

Methods—A modified version of the Pregnancy Risk Assessment Monitoring System (PRAMS) mail survey was conducted based on weighted sampling design with low-income and non-low income women in Monroe County, NY (1022 respondents). A series of environmental questions were included in the questionnaire. Data were analyzed using chi-square tests and Poisson loglinear regression model to identify patterns in environmental health risk and sociodemographic characteristics.

Results—We identified women who rented their homes, had lower incomes, and lived in inner city zip codes as “high environmental health risk” (HEHR). HEHR respondents were more likely to report that a health care provider talked with them about lead and on average reported more behaviors to protect their children from lead poisoning.

Conclusions—Combining environmental and perinatal risk factor data could yield important recommendations for medical practice, health education, and policy development. However, at present PRAMS gathers only limited and inconsistent environmental data. We found that existing PRAMS environmental questions are insufficient. Further work is needed to develop updated and more comprehensive environmental health survey questions and implement them consistently across the country.

Introduction

Pre- and peri-natal exposures to environmental chemicals can have significant impacts on fetal development, child health, and lifelong susceptibility to disease. For example, lifelong

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effects of early exposure to heavy metals including lead, mercury, and arsenic are well established (1-6). Exposures to other chemicals, including PCBs and phthalates, are also known or strongly suspected to affect human development (7). Research continues to reveal significant health effects at lower exposure levels than previously thought (8, 9). Further, many toxins travel through the placenta to the fetus and through breastmilk to the infant (10). Low income and minority populations may be disproportionately exposed to environmental toxins, contributing to observed health disparities (11-14). Knowledge about developmental vulnerabilities to combined environmental exposures, genetic factors, and stress continues to grow.

Increased appreciation of *in utero* and early life environmental exposures has focused researchers' attention on the timing, nature, and extent of pregnant and breastfeeding women's environmental exposures. Some risks result from the mother's lifelong exposure to environmental chemicals; others may be modified by behavior (e.g. diet, consumer products, etc.) during pregnancy (10). For this reason, women's pre-pregnancy environmental health literacy together with the information provided by health care professionals to pregnant women may reduce environmental health risks (15-18). Therefore, knowing pregnant women's exposure to, understanding of, and behaviors related to environmental health risks is important. This paper argues that PRAMS' potential to inform our understanding of women's environmental health risks – and that of their children - is currently underutilized.

The Centers for Disease Control's (CDC) Pregnancy Risk Assessment Monitoring System (PRAMS) is a survey sent to new mothers to measure perinatal health (19, 20). PRAMS provides data to inform, improve, and evaluate efforts to reduce infant mortality and promote child health. PRAMS collects self-reported maternal behaviors and experiences that occur before, during and immediately after pregnancy including prenatal care, alcohol and tobacco use, physical abuse, family planning, maternal stress, and early infant health status. All states that participate in PRAMS ask a series of core questions. In addition to these questions, states may choose to implement additional questions approved as part of PRAMS about specific topics of local interest, including environmental health (21). Survey response data are linked to specific data fields collected as part of the infant's birth certificate.

Potential uses of environmental information collected in the context of pregnancy are numerous. First, health care providers could help reduce fetal and infant exposure to toxins by better communication about environmental health risks and protective behaviors during pregnancy (18). Understanding how current environmental counseling compares to other pregnancy counseling and how it varies across different populations could inform improved counseling practices. Second, information about pregnant women's environmental health-related knowledge and behaviors (e.g. lead-safe cleaning, fish consumption habits, or drinking water source) may reveal needs for public health, media, and outreach programs. Coupling environmental data with demographic information could identify women with the greatest need for such information and resources. Third, understanding the distribution of environmental risks could help efficiently target policy and public resource allocation decisions to women with the greatest needs.

In its current form, environmental health data collected via PRAMS cannot be used to achieve the above goals. Only six of the 40 states that use PRAMS include any environmental health questions(22, 23). Each of these six states uses a different subset of environmental questions, so comparative analyses are not possible. Additionally, use of these questions has varied over time, making longitudinal analysis difficult. One notable exception is physician counseling questions about risks of mercury from fish consumption: Washington, Maine, and Oregon included these questions in their PRAMS from 2004-2011. However, we found no peer-reviewed publications reporting results of these questions or other PRAMS environmental health data.

This study explored the potential for PRAMS to address three questions about how environmental risks relate to women's demographic characteristics, geographic location, and personal situations (e.g. housing type, drinking water source, etc.):

1. How are environmental health risks distributed?
2. What is the nature and impact of health care providers' counseling practices?
3. How do women's knowledge of and behavior related to environment risks vary?

We analyzed responses to environmental health questions collected through a modified PRAMS survey of women in one upstate New York county who gave birth between May 2009 and May 2011. These analyses considered potential indicators of maternal risk, including income, race, age, education, and location of residence. Our analysis suggests that PRAMS could be expanded to better document environmental health risks, related behaviors, and education needs. This paper provides a glimpse of PRAMS's potential to contribute to better understanding of perinatal environmental risks and is an important first step to developing improved systems to monitor and reduce pregnant women's exposures to environmental health risks.

Methods

In collaboration with the Monroe County Department of Public Health (MCDPH), we surveyed 1032 randomly selected Monroe County, NY women using a modified version of the CDC's PRAMS survey (version 6) called "Monroe County Mothers and Babies Health Survey" (MBHS) (24). The sampling frame included all live births to mothers residing in Monroe County. Each month, a stratified randomized sampling procedure identified mothers to receive the survey. Sampling procedures oversampled low income mothers (LIM) defined as either having a Medicaid-funded delivery or receiving WIC prenatally. This study was reviewed by the University of Rochester Research Subjects Review Board (RSRB00019220).

The survey was mailed to the mothers at approximately 4 months post-partum, followed, as needed, by a second mailing and then phone call over a 4-5 week follow-up (24). The 1022 usable surveys, after merging with birth certificate data, were weighted to reflect the true distribution of high-and low-income births in Monroe County. The mothers giving birth in this county, while not representing the full range of diversity in the United States, are heterogeneous across key characteristics relevant to environmental health issues including

urban, suburban and rural, socioeconomic status, and race and ethnicity. The strategy of sampling in a smaller geographic area than the typical state-wide implementation of PRAMS allowed MBHS to explore the potential of this method to support finer-scale geographic, demographic, and time-series analysis and the resources (logistical, analytical, and financial) required by this approach.

The MBHS incorporated several environmental health questions previously included in other states' PRAMS surveys (22, 23). These questions addressed key local concerns about environmental risks (e.g. lead in housing, mercury in fish, and drinking water contamination). Because prior research has associated rental housing and higher lead hazards, we added a non-PRAMS question about housing tenure (owner-occupied or rented) (25).

Of the environmental questions in the MBHS (Figure 1), two questions probed whether pregnant women recalled receiving counseling about exposure to environmental toxins ("how eating fish containing high levels of mercury could affect my baby" and "how lead could affect my baby"). These two items were included in the multi-answer question: "During any of your prenatal care visits, did a doctor, nurse, or other health care worker talk with you about any of the things listed below?" The other 15 responses asked about counseling topics such as signs of labor, maternal depression, and smoking during pregnancy.

Lead poisoning risk questions included "Was the house or apartment you live in now built after 1977?" and "Do you rent the house or apartment you live in now?" These questions were included because pre-1978 (the year of implementation of the federal ban on lead in residential paint in the U.S.) rental housing (particularly that occupied by low income families) has an elevated risk of containing lead hazards (25). Six actions were listed related to the question, "What are you currently doing to protect your family (your children, your partner, and yourself) from lead poisoning?" An additional question addressed water supply source (public water supply versus private wells). Private drinking water wells are generally tested less frequently and for fewer contaminants, than are public water supplies. Therefore, in general, private wells are more likely to be a source of harmful water contaminants, such as bacteria, pesticides and heavy metals (26).

In order to investigate the potential of MBHS to identify environmental health disparities, we divided respondents based on their likelihood of exposure. "High environmental health risk" (HEHR) included those women identified as low income (as defined as above), lived in an inner city zip code, and rented their home. Housing tenure and income were included because low income women who rent their homes are more likely to live in hazardous home environments and to have fewer resources (e.g. access to information, ability to relocate, financial resources to make repairs) to mitigate any risks in their physical environment (25). We did not include women's report of living in pre-1978 housing as a HEHR characteristic because of the extent of "do not know" responses to this question. All non-HEHR respondents were classified as Low Environmental Health Risk (LEHR), even if they had one or two of the high risk characteristics.

We performed bivariate analyses using SAS 9.2 accounting for the complex sampling methodology, including stratification and weighting. Chi squared analyses identified 1) differences in health care provider counseling between HEHR and LEHR mothers and 2) comparison of reported lead- protective actions across different sub-groups (including age, race, education, Hispanic ethnicity, parity, income level, zip code, environmental risk status) and environmental risk factors (renter versus owner-occupant, age of housing, source of water). We created a lead behavior index based on number of lead-protective behaviors reported. The lead behavior index was then modeled against HEHR status using a Poisson loglinear regression model, and the adjusted lead behavior indices from the two populations were reported. Additionally, using the provider counseling list, we created a counseling index from 1 to 17 based on the number of counseling topics each woman reported receiving.

Results

Table 1 includes demographic characteristics of the MBHS respondents (N=1022) for categories relevant to the environmental analysis. All data presented are based on the weighted response data from the MHBS to estimate the county-wide population characteristics.

Environmental health risk status

HEHR respondents differed significantly from the LEHR respondents with respect to many demographic characteristics. Nearly all respondents (91.7%) were 19-39 years old; however, more women under age 19 were in the high risk (10.3%) versus low risk (3.3%) group. Low educational attainment (not high school graduate) was more common among HEHR respondents (32.4% HEHR versus 4.8% LEHR). The HEHR group also differed by race and ethnicity from the LEHR mothers (59.2% HEHR were black race versus 12.1% LEHR; 13.1% HEHR were Hispanic versus 5.6% LEHR). HEHR women were less likely to be first time mothers (35.3% versus 45.5%).

Unexpectedly, fewer HEHR women reported living in pre-1978 housing (19.9% HEHR versus 54.8% LEHR). However, 62.8% HEHR reported not knowing when their home was built (versus 16.0% LEHR). 95% of HEHR and 97.5% of LEHR women reported that their home was on a public water supply system, rather than a private well. This difference may be due to the larger proportion of HEHR women who did not know their drinking water source (HEHR: 5.0% missing or did not know versus 1.2% LEHR).

Table 2 depicts demographic differences in mothers' recall of health care provider communications about environmental health. Response patterns between the lead and mercury questions were very different. Respondents who were HEHR, black race, lower education, rented their home, had low income, or lived in an inner-city zip code were more likely to report that their provider talked with them about how lead could affect her baby. Surprisingly, women who reported living in pre-1978 housing were not more likely to recall that a health care provider talked with them about lead than were those women who reported they did not live in older housing. Again, this finding may be due to the high percentage of HEHR women who did not know the age of their housing. Women who did not know their

housing age reported more provider education related to lead. In contrast, we found no significant differences by demographics or environmental risk factors in whether women reported that their provider talked with them about how eating fish containing high levels of mercury could affect their baby.

Environmental risk counseling by health care providers

We created a “counseling index” for each respondent by summing the number of issues on which she reported being counseled. In analyzing all 17 of the provider counseling questions, HEHR women reported receiving counseling about more issues than LEHR respondents (mean 13.74 versus 11.79 for LEHR ($p < .0001$)). Similarly, a previous study found that “high need” population groups (defined by the researchers as reported cigarette smoking, alcohol use, not breast feeding, partner violence, or prior pre-term labor) are more likely than others to receive prenatal counseling about alcohol consumption and smoking (27).

Because other studies have found that some populations, including racial minorities, may be more likely to give acquiescent survey responses, we explored the effect of removing respondents who answered “yes” to all options (28). HEHR respondents were more likely (28.4%) than LEHR women (20.5%) to give positive answers to *all* of the counseling questions. After removing these “all yes” responders HEHR women still had significantly higher counseling index scores (mean 11.69 versus 9.80, $p < .0001$).

We analyzed the difference between counseling on environmental risks compared to other topics (Table 3). Being counseled on “how eating fish high in mercury could affect my baby” was reported by more respondents (68.5%) than was lead counseling (52.8%). Lead was one of the least frequently reported counseling topics overall (lead counseling ranked 14th for HEHR; 16th for LEHR). We also compared HEHR and LEHR women's reports of counseling on each topic. Significantly more HEHR than LEHR women (68.5% versus 48.7%) reported hearing from a health care provider about lead. This disparity was one of the largest differences in counseling topics between HEHR and LEHR, along with alcohol, smoking, illegal drugs and partner abuse. In contrast, counseling on the risks of eating fish did not differ significantly between HEHR and LEHR women (71.7% versus 67.7% respectively).

Lead protective behaviors

Responses to the six lead risk reduction behavior questions demonstrated that, excluding respondents who reported living in post-1977 housing, HEHR women were more likely than LEHR women to report running cold water for a minute before using it (Table 4). This behavior was also reported more frequently by women who were under 30, black race, Hispanic, non-high school graduates, renters, inner-city residents, low income, and those women who did not know the age of their housing. Washing windows, doorways, floors, and dusty areas was reported more frequently by women who had a prior birth. White and Black women were more likely than women whose race was categorized as mixed or other to report eating food rich in iron and calcium, washing hands frequently and storing food in clean plastic or glass containers to reduce lead risks.

We compared the number of lead protective behaviors (lead behavior index) by HEHR versus LEHR women, again excluding women who reported living in post-1977 housing. The mean lead protective behaviors index (from 1 to 6) for HEHR women was 4.8, significantly higher than for LEHR women (4.3; $p<.0001$). For reasons explained above, we explored acquiescent response patterns. More HEHR respondents (30.0%) than LEHR respondents (13.5%) reported “yes” to all lead protective behaviors. After removing the “all-yes” respondents (index = 6), the difference became non-significant (HEHR mean index = 3.47; LEHR = 3.35 $p=0.09$).

Discussion

The relevance of PRAMS data to our three main questions relating environmental health to other risk factors, behaviors, and demographics of new mothers is discussed below.

How are environmental health risks distributed?

Combining environmental risk questions with socioeconomic data may identify sub-populations at elevated risk for environmental exposures. However, as this analysis shows, the usefulness of self-reported environmental risks may vary by topic. For example, reported knowledge of water supply source was more common than knowledge of age of housing (2.1% vs. 26.1% missing/do not know).

Disparities in respondent groups' knowledge about their physical environment may also exist. For example, we found that HEHR women were much less likely than LEHR women to report knowing the age of their housing. Furthermore, these reports may not be accurate. 54.2% of the HEHR women who knew the age of their housing reported it was pre-1978; however, 87% of the housing in Rochester was built before 1978 (29). The proportion of pre-1978 housing is even higher in the inner city zip codes in which HEHR women reside. Women's knowledge of their water supply sources may well be accurate; health department data confirms that a very small percentage of Monroe County residents rely on non-public supplies.

Our findings shed light on PRAMS' potential to collect information on new mothers' exposure to environmental risks. Additional risks could be assessed, such as whether they live near areas with heavy truck traffic, hazardous waste sites, or industrial facilities. Although accuracy of women's knowledge about neighborhood or regional environmental risks may vary, they are likely to be able to answer questions reliably about chemicals they use in the home (e.g. cleaners, pesticides, etc.), indoor air quality (e.g. presence of asthma triggers like pets, pests and mold), and actions they currently take to reduce risks (e.g. testing for radon, use of a carbon monoxide detector, changing air filters). Coupled with demographic information, these data could inform targeted educational and policy interventions.

What is the nature and impact of health care providers' counseling practices?

PRAMS environmental questions could monitor and provide guidance to health care providers about counseling practices. Our results indicate that health care providers' communication about environmental risks varies (i.e. HEHR women were more likely to

report hearing about lead). Because HEHR women in Rochester are more likely than are LEHR women to live in high lead-risk housing, health care providers appropriately emphasize the risks of lead poisoning more with this group. Medical education on environmental health is often limited; however, there have been strong provider and community outreach efforts in this community. Therefore, local health care providers may be particularly likely to educate women living in older housing in poor condition.

Differences in counseling about ingesting mercury from fish were not found. This pattern is also expected for Monroe County, where rates of fish consumption are not clearly related to any of the measured demographic variables. However, in other areas where certain subpopulations are known to eat large amounts of fish (for example, Asians, recent immigrants, or anglers) health care providers may counsel women from these groups more extensively about mercury.

PRAMS could also provide information about changes in counseling practices over time. Counseling practices might change as a result of greater emphasis in medical or continuing education on environmental health, time available in pre-natal visits, community awareness or media reports about certain risks, outreach to health care providers, or resources (such as support staff, referral programs, or educational materials) on environmental health. For example, data from Oregon showed that the percentage of respondents answering “yes” regarding counseling on mercury increased steadily from 2004 (42.2%) to 2008 (62.7%) (30). Longitudinal data about counseling practices could evaluate whether HEHR women are appropriately targeted, or a comparison regarding counseling practices could be made between states. Such analyses would require consistent implementation, reporting, and analysis of PRAMS environmental counseling questions.

Caution must be used in interpreting PRAMS environmental health counseling data, however. For example, it may be tempting to infer a causal relationship between reports of more lead counseling and higher frequency of lead-protective behaviors by HEHR in Rochester. However, for many years Rochester has had an active community outreach program on lead poisoning prevention targeting low income mothers in the City (31, 32). Thus, these women may have learned about lead elsewhere. Alternately, they may engage in the “lead protective” behaviors for other reasons. The current PRAMS questions do not make this distinction. Thus, adding questions about sources of environmental health information (media, internet, etc.) would be valuable for designing or evaluating educational campaigns.

How do mothers' knowledge of and behavior related to environment risks vary?

While our results reveal differences among subpopulations and between different types of lead-protective behaviors, the pattern of responses was difficult to interpret. We cannot infer from these data whether women are undertaking “lead protective behaviors” specifically to reduce lead risk, or because of other reasons. “Washing windows, doorways, floors and dusty areas with a wet cloth,” “eating foods rich in iron and calcium,” and “washing hands frequently” are healthy habits for a variety of reasons unconnected to lead. Several questions are relevant only to women living in high-lead environments (e.g. “Blocking chipped or peeling paint”). In addition, women with resources to repair paint (e.g. owner occupants who

can afford to buy paint or hire painters) are unlikely to employ this approach. Similarly, “running water for a minute before cooking or drinking” is only a good strategy if the house contains leaded pipes and the household cannot afford pipe replacement or a filter.

Thus, the questions currently available through PRAMS may not accurately capture the most relevant lead risk reduction behaviors. Some questions are outdated or simply confusing. For example, “Storing food in clean plastic and glass” is a lead-protective behavior only if taken as an alternative to storing food in cans or pottery that may contain lead – which is now banned in cans in the U.S (33). Given the recent media attention to the risks of BPA and phthalates in plastic containers some women who reported not storing food “in clean plastic or glass” may be trying to minimize exposure to chemicals in plastics, rather than to reduce lead exposure. Thus, responses to this behavioral question may have nothing to do with lead education, perceived lead risk, or actual protection of children from lead.

Improved or expanded questions based on updated lead education messages may be more effective in documenting relevant behaviors. Additional questions could be developed that address behaviors related to other important environmental risks, including asthma-related cleaning practices, household air ventilation, or pest management. Further questions might explore neighborhood-level risks, such as traffic, hazardous waste sites, or industrial facilities. Alternately, respondent addresses could be geocoded to measure proximity to known environmental hazards.

Limitations and contributions

This study has several limitations. Issues with the available PRAMS environmental questions described above limited the conclusions we could draw about women's risk reduction behaviors. Only a small number of environmental questions were asked in the MBHS. The MBHS was only implemented in one county; environmental risks, counseling, and behaviors vary widely from place to place. For example, although medical and nursing education does not generally emphasize environmental health, health care providers in this county may be particularly sensitized to lead poisoning prevention because of strong local community outreach efforts on lead. Lastly, the environmental questions are self-report and rely on recall.

Conclusions

Environmental factors significantly affect human health. In particular, exposures to toxins during the perinatal period may influence lifelong health and susceptibility to disease. Environmental health risks are a function of both the physical (what chemicals exist in the local environment) and behavioral (actions that modify their exposure to these chemicals). Therefore, to inform policies, practices, and educational messages, we need to understand not only the geographic and demographic distribution of environmental risks, but also women's knowledge about and behaviors that modify these risks.

Our analyses show both the potential and current limitations of PRAMS for collecting information on exposure of mothers and babies to environmental risks. As an established, consistent method of collecting demographic and health information from new mothers, the

PRAMS survey has unrealized potential to provide additional information about their environmental risks.

To realize PRAMS' full potential to improve environmental health, several modifications are warranted. Environmental questions could be added to ongoing PRAMS survey efforts at minimal incremental cost. First, a comprehensive effort to identify the key environmental health risks facing pregnant women in different areas is needed. Second, questions should be developed based on the best available environmental health research to measure these risks. Close collaboration between experts in maternal/child health and environmental health experts will be needed to accomplish these goals.

Particular attention should be given to collecting data that can be compared over time and between regions, at a geographic scale that is relevant to informing local decisions. This effort should account for changes over time in understanding, distribution, and priority of diverse environmental risks. When linked with existing PRAMS data on demographics, such information could inform targeting resources, surveillance, and evaluation of programs to reduce environmental health risks.

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1. During any of your prenatal care visits, did a doctor, nurse, or other health care worker talk with you about any of the things listed below? <i>Please count</i>	a. How smoking during pregnancy could affect my baby
	b. Breastfeeding my baby
	c. How drinking alcohol during pregnancy could affect my baby
	d. Using a seat belt during my pregnancy
	e. Medicines that are safe to take during my pregnancy
	f. How illegal drugs could affect my baby
<i>discussions</i> , not reading materials or videos. For each item, check Yes if someone talked with you about it or check No if no one talked with you about it.	g. Doing tests to screen for birth defects or diseases that run in my family
	h. The signs and symptoms of preterm labor (labor more than 3 weeks before the baby is due)
	i. What to do if labor starts early
	j. Getting tested for HIV (the virus that causes AIDS)
	k. What to do if I feel depressed during my pregnancy or after my baby is born
	l. Physical abuse to women by their husbands or partners
	m. How lead could affect my baby
	n. How eating fish containing high levels of mercury could affect my baby
	o. Getting your blood tested for the disease called toxoplasmosis
2. Was the house or apartment you live in now built after 1977?	No
	Yes
	I don't Know
3. Do you rent the house or apartment you live in now? (Developed for MBHS survey)	No
	Yes
	I don't Know
4. Do you get the water you use in your house, apartment, or trailer from a city or county water supply or from a private well?	City or county water supply
	Private well
5. What are you currently doing to protect your family (your children, your partner, and yourself) from lead poisoning? For each one, please check Yes if you are doing it or No if you are not doing it.	a. Washing windows, doorways, floors, and dusty areas with a wet mop or cloth.
	b. Blocking chipped or peeling paint with furniture, or covering it with duct tape.
	c. Eating foods that are rich in iron and calcium.
	d. Washing hands frequently.
	e. Running cold water for 1 minute before using for cooking or drinking.
	f. Storing food in clean plastic or glass containers, not in crystal, pottery, or ceramic dishes.

States Using These Environmental Prams Questions						
	FL	ME	MI	OR	RI	WA
Phase 3	#2					
Phase 4					#1m	
Phase 5		#1n ^b		#1n?	#5 ^a , #2 ^a	#1n ^a , #4 ^a
Phase 6	#1m ^b , #2 ^b , #1n ^a	#1n ^b	#1n ^a	#1n?	#1n ^a	#1n ^a
^a Same question ^b Different question, same topic						

Figure 1. List of environmental questions included in MBHS

Table 1

Comparison of Environmental Health Risk Status High Environmental Health Risk (HEHR) compared to Low Environmental Health Risk (LEHR)

	Raw Data n=1022 n(%)	Total Weighted Data n=7902 n(%)	Weighted High Environmental Health Risk (HEHR) n=1628 ^a n(%, CI)	Weighted Low Environmental Health Risk (LEHR) n=6253 ^a n(%, CI)	p-value
Maternal age					<.0001
18 and under	42(4.1)	373(4.7)	168(10.3, 3.6-14.5)	205(3.3, 1.7-4.8)	
19-29	519(50.7)	3881(49.1)	1110(68.2, 61.9-74.4)	2764(44.2, 40.5-47.9)	
30-39	427(41.8)	3363(42.5)	323(18.6, 13.5-23.7)	3046(48.7, 44.9-52.4)	
40-49	34(3.3)	286(3.6)	47(2.9, 0.6-5.2)	239(3.8, 2.4-5.3)	
Race					<.0001
White	734(71.8)	5272(66.7)	469(28.8, 23.1-34.4)	4797(76.7, 73.2-80.2)	
Black	196(19.2)	1718(21.7)	964(59.2, 52.8-65.6)	75(12.1, 9.3-14.8)	
Other	66(6.5)	662(8.4)	133(8.1, 4.4-11.9)	515(8.2, 5.8-10.6)	
Mixed	26(2.5)	251(3.2)	63(3.9, 1.2-6.6)	188(3.0, 1.5-4.5)	
Hispanic					0.0004
Yes	70(6.8)	562(7.1)	21(13.1, 8.7-17.5)	349(5.6, 3.7-7.5)	
Education					<.0001
<High School & age >18	99(9.7)	837(10.6)	528(32.4, 26.1-38.8)	309(4.8, 3.0-6.6)	
High School or more & age>18	881(86.2)	6692(84.7)	932(57.3, 50.6-63.9)	5760(91.9, 89.6-94.3)	
Age 18	42(4.1)	373(4.7)	168(10.3, 6.1-14.5)	205(3.3, 1.7-4.8)	
Prior birth¹					0.0008
Yes	564(55.2)	4385(56.7)	1029(64.7, 58.3-71.1)	3336(54.5, 50.8-58.2)	
House or apartment built after 1977					<.0001
No	486(47.6)	3749(47.4)	325(19.9, 14.7-25.2)	3425(54.8, 51.0-58.4)	
Yes	267(26.1)	2087(26.4)	275(16.9, 12.0-21.7)	1807(29.0, 25.5-32.3)	
I don't know	262(25.6)	2022(25.6)	1023(62.8, 56.5-69.2)	994(16.0, 13.0-18.8)	
Missing	7(0.7)	44(0.6)	6(0.2, 0.0-1.1)	29(0.7, 0.04-0.9)	
How I get water in my house					N/A
City/county water	994(97.3)	7656(96.9)	1547(95.0, 92.0-98.1)	6097(97.5, 97.1-98.9)	
Private well	8(0.8)	83(1.0)	0(0.0)	83(1.3, 0.3-2.4)	

	Raw Data n=1022 n(%)	Total Weighted Data n=7902 n(%)	Weighted High Environmental Health Risk (HEHR) n=1628 ^a n(%, CI)	Weighted Low Environmental Health Risk (LEHR) n=6253 ^a n(%, CI)	p-value
DK/Missing	20(2.0)	163(2.1)	8(5.0, 1.9-8.0)	74(1.2, 0.3-2.1)	N/A
Lives in rented house/apartment					
Yes	463 (45.3)	3491 (44.2)	1628(100.0)	1864(29.8, 26.3-33.3)	
No	553 (54.1)	4369(55.3)	0(0.0)	4369(69.9, 66.4-73.4)	
DK/Missing	6(0.6)	42(0.5)	0(0.0)	3(0.3, 0.0-0.7)	
Inner-City Resident					
Yes	356(34.8)	2806(35.5)	1628(100.0)	1157(18.5,15.3-21.7)	N/A
Income level					
Low	501(49.0)	3194(40.4)	1628(100.0)	1545(24.7, 21.9-27.6)	N/A

^a Of the 1022 survey respondents, 3 could not be classified due to missing data so were excluded from HEHR/LEHR comparison

¹ 19 respondents were missing 'Previous birth' information

'N/A' indicates unable to calculate p-value due to cells with missing numbers

Table 2

Provider education related to environmental health

	Provider talked about how lead could affect my baby=Yes						Provider talked about how eating fish containing high levels of mercury could affect my baby =Yes					
	N=1004 ^e						N=1007 ^e					
	n	Weighted n	Weighted %	CI Lower	CI Upper	p-Value	n	Weighted n	Weighted %	CI Lower	CI Upper	p-Value
Maternal age						0.007						0.80
18 and under	27	247	66.1	50.7	81.5		31	281	75.1	61.0	89.3	
19-29	293	2179	57.3	52.7	61.8		355	2628	68.8	64.5	73.1	
30-39	195	1551	47.0	42.0	52.0		281	2237	67.7	63.0	72.3	
40-49	14	115	42.6	24.8	60.4		22	178	66.2	48.7	83.7	
Race						0.001						0.60
White	352	2517	48.4	44.6	52.2		489	3507	67.3	63.8	70.9	
Black	132	1119	66.8	59.5	74.1		141	1217	72.3	65.5	79.1	
Other	33	330	52.8	39.5	66.1		43	442	70.8	58.9	82.6	
Mixed	12	127	50.4	29.7	71.1		16	158	63.0	43.5	82.6	
Hispanic						0.02						0.89
Yes	44	377	67.0	55.6	78.5		48	390	69.3	57.6	81.0	
No	485	3715	51.7	48.3	55.1		641	4934	68.5	65.3	71.6	
Education						0.002						0.66
<High School & age>18	64	547	68.3	58.6	78.0		66	538	67.2	57.1	77.4	
High School or more & age>18	438	3299	50.2	46.7	53.7		592	4505	68.3	65.1	71.6	
Age 18	27	247	66.1	50.7	81.5		31	281	75.1	61.0	89.3	
Prior birth^f						0.013						0.44
Yes	311	2418	56.6	52.2	61.0		371	2885	67.4	63.2	71.5	
No	209	1595	48.2	43.3	53.2		304	2314	69.8	65.3	74.3	
House or apartment built after 1977^g						0.04						0.56
Yes	131	1027	50.0	43.5	56.4		187	1468	71.2	65.5	76.9	
No	234	1839	50.4	45.7	55.1		319	2479	67.8	63.4	72.2	
Don't know	161	1204	60.1	53.6	66.5		178	1347	66.9	60.7	73.1	

Provider talked about how lead could affect my baby=Yes						Provider talked about how eating fish containing high levels of mercury could affect my baby =Yes						
N=1004 ^a						N=1007 ^a						
Weighted N=7746						Weighted N=7767						
	n	Weighted n	Weighted %	CI Lower	CI Upper	p-Value	n	Weighted n	Weighted %	CI Lower	CI Upper	p-Value
How I get water in my house ³						0.24						0.52
City/county water	51 3	3930	52.2	48.9	55.5		671	5158	68.3	65.3	71.4	
Private well	4	56	73.6	42.4	100.0		5	60	79.1	50.6	100.0	
Lives in rented house or apartment ⁴ #						<.0001						0.32
Yes	283	2114	61.9	57.1	66.8		320	2412	70.2	65.7	74.7	
No	244	1963	45.6	41.3	50.0		365	2885	67.1	63.0	71.2	
Inner-City Resident*						0.0004						0.71
Yes	217	1676	60.9	55.4	66.4		245	1917	69.3	64.1	74.5	
No	312	2416	48.4	44.3	52.4		444	3406	68.1	64.4	71.8	
Income*						<.0001						0.32
Low income	296	1927	61.9	57.5	66.4		344	2202	70.3	66.2	74.5	
Not Low income	233	2164	46.7	42.2	51.2		345	3121	67.3	63.1	71.6	
Environmental Health Risk ⁵ #						<.0001						0.27
HEHR*	15 4	1088	68.5	62.3	74.8		162	1149	71.7	65.7	77.7	
LEHR*	37 3	2989	48.7	45.0	52.4		525	4160	67.7	64.2	71.2	

^a Respondent's answering 'Yes' to provider questions; 7 mothers did not receive Prenatal Care so followed skip pattern, skipping these questions, additionally 9 did not answer lead question; 6 did not answer mercury question

¹18 were missing 'Previous birth' information

26 did not respond to 'Built after 1977' question

3 19 did not respond to 'Water Supply' question

45 did not respond to 'Rental' question

53 could not be classified for Environmental Health Risk Status due to missing information

Environmental Health Risk classification based on 'Lives in rented house or apartment', 'Inner-city resident', and 'Low income'; 'Yes' to ALL 3 questions=High Environmental Health Risk (HEHR); Answer 'No' to ANY of the questions=Low Environmental Health Risk(LEHR)

Table 3
Ranking provider education by environmental health risk status

During my prenatal care visit someone talked to me about:	Total Weighted Population	Weighted High Environmental Health Risk (HEHR)	Weighted Low Environmental Health Risk (LEHR)	Relative Risk ^d (Confidence Interval)
Response to provider question = Yes	n (%)	n (%)	n (%)	
Medicines that are safe to take	6919 (88.6)	#1 1478 (91.8)	#4 5441 (87.7)	#2 1.05 (1.00-1.10)
Getting tested for HIV ¹	6831 (88.5)	#2 1541 (96.7)	#1 5289 (86.4)	#3 1.12 (1.08-1.16)
Doing test to screen for birth defects ²	6831 (88.1)	#3 1380 (86.5)	#8 5451 (88.5)	#1 0.98 (0.92-1.04)
Breastfeeding my baby	6639 (85.0)	#4 1535 (95.3)	#2 5104 (82.3)	#5 1.16 (1.11-1.21)
What to do if my labor starts early ³	6521 (84.2)	#5 1394 (87.03)	#7 5127 (83.5)	#4 1.04 (0.98-1.11)
The signs and symptoms of preterm labor ⁴	6243 (80.4)	#6 1371 (85.2)	#10 4871 (79.2)	#6 1.08 (1.01-1.15)
How drinking alcohol could affect my baby ⁵	5913 (76.1)	#7 1461 (90.7)	#5 4452 (72.3)	#8 1.26 (1.18-1.34)
The baby blues ³	5893 (76.0)	#8 1317 (82.2)	#11 4575 (74.3)	#7 1.11 (1.03-1.20)
How smoking could affect my baby ⁵	5898 (75.8)	#9 1493 (92.7)	#3 4405 (71.4)	#9 1.30 (1.22-1.38)
What to do if I feel depressed ²	5636 (72.7)	#10 1371 (85.6)	#9 4265 (69.4)	#10 1.23 (1.15-1.33)
How eating fish could affect my baby ³	5309 (68.5)	#11 1149 (71.7)	#12 4160 (67.7)	#11 1.06 (0.96-1.17)
How illegal drugs could affect my baby ⁶	5203 (67.2)	#12 1397 (87.04)	#6 3806 (62.0)	#12 1.40 (1.30-1.51)
Using a seat belt ⁷	4511 (58.0)	#13 1043 (64.8)	#15 3467 (56.2)	#13 1.15 (1.02-1.30)
Getting my blood tested for toxoplasmosis ⁸	4255 (55.3)	#14 992 (62.2)	#16 3264 (53.4)	#14 1.16 (1.03-1.32)
Physical abuse to women by partners ³	4143 (53.5)	#15 1152 (71.6)	#13 2991 (48.73)	#15 1.47 (1.31-1.64)
How lead could affect my baby ⁹	4077 (52.8)	#16 1088 (68.5)	#14 2989 (48.70)	#16 1.41 (1.25-1.58)
How long to wait before having another baby ¹⁰	3720 (48.1)	#17 876 (54.7)	#17 2844 (46.3)	#17 1.18 (1.02-1.36)

^aOf the 1022 survey respondents, 12 are missing from Table 3 (7 mothers skipped all questions, 2 mother did not receive PNC so skipped these questions, 3 missing risk status information)

^bOf the 12 missing from Table 3, 2 are missing from the High Environmental Risk (HEHR) category (3 were unclassifiable so were missing from HEHR & LEHR)

^cOf the 12 missing from Table 3, 7 are missing from the Low Environmental Risk (LEHR) category (3 were unclassifiable so were missing from HEHR & LEHR)

^dBolded 'Relative Risk (Confidence Interval)' indicates there was a statistical significant difference noted regarding provider education for specific education topic

6 did not answer if labor start early, how eating fish could affect my baby, baby blues & physical abuse to women questions

5 did not answer birth defect screening & depression questions

10 did not answer HIV question

4 did not answer signs/symptoms of preterm labor question

3 did not answer how drinking alcohol and smoking could affect my baby questions

8 did not answer how using illegal drugs could affect my baby question

2 did not answer using seat belt question

13 did not answer toxoplasmosis question

9 did not answer how lead could affect my baby question

7 did not answer how long to wait before having another baby question

Table 4
Lead protective behaviors: Includes responses for mothers who said they lived in pre 1978 housing, didn't know the age of housing or didn't answer the question

Response to protective behavior =Yes Weighted n=5771 ^f	A. Washes window, doorways, floors and dusty areas with wet mop or cloth ²		B. Blocks chipped or peeling paint with furniture or covers with duct tape ³		C. Eats food rich in iron and calcium ⁴		D. Washes hands frequently ⁵		E. Runs cold water 1 min before cooking/ drinking ⁶		F. Stores food in clean plastic or glass ⁷	
	Raw-Weighted(%)	Confidence interval	Raw-Weighted (%)	Confidence interval	Raw-Weighted (%)	Confidence interval	Raw-Weighted(%)	Confidence interval	Raw-Weighted(%)	Confidence interval	Raw-Weighted(%)	Confidence interval
Maternal age												
18 and under	24-212(87.8)		15-143(61.1) ^a		23-205(85.0)		27-235(97.4)		18-152(63.2) ^b		22-192(79.6)	
	76.1-99.4		42.1-80.1		72.3-97.7		92.2-100.0		43.6-82.8		64.6-94.7	
19-29	284-2126(83.3)		141-1073(43.5)		286-2139(84.9)		323-2405(95.3)		190-1414(56.1)		309-2276(90.2)	
	79.2-87.4		37.9-49.1		81.0-88.8		93.1-97.6		50.6-61.7		86.6-93.8	
30-39	206-1615(77.8)		93-699(34.4)		228-1782(85.8)		256-2004(96.5)		107-832(40.1)		243-1898(91.4)	
	72.6-83.0		28.4-40.4		81.5-90.2		94.3-98.7		33.9-46.2		87.9-95.0	
40-49	13-121(81.4)		8-73(53.5)		17-149(100.0)		15-127(100.0)		8-71(47.6)		16-141(94.7)	
	63.8-98.9		28.1-79.0		100.0-100.0		100.0-100.0		22.7-72.5		84.6-100.0	
Race												
White	373-2697(80.6)		174-1237(38.3)		398-2887(86.6) ^b		447-3225(96.9) ^b		199-1395(41.9) ^c		428-3094(92.8) ^b	
	76.9-84.3		33.6-42.9		83.5-89.8		95.3-98.5		37.2-46.6		90.4-95.3	
Black	110-951(83.5)		60-507(46.0)		118-1005(89.5)		127-1080(97.2)		97-803(71.1)		117-994(88.5)	
	77.3-89.8		37.1-55.0		84.2-94.8		94.4-99.9		62.8-79.4		82.9-94.1	
Other	29-288(77.1)		16-179(47.9)		27-282(76.8)		323-335(89.6)		18-183(50.8)		30-284(76.0)	
	63.1-91.1		30.1-65.1		63.2-90.3		80.3-98.8		33.6-67.4		60.1-91.9	
Mixed	15-138(85.6)		7-65(40.2)		11-100(62.1)		14-130(84.8)		9-88(54.6)		15-136(84.1)	
	70.1-100.0		16.8-63.6		39.3-85.0		68.5-100.0		31.2-78.0		67.4-100.0	
Hispanic												
Yes	44- 370(91.4)		15-135(33.6)		38- 325(81.7)		47-390(96.3)		36- 300(74.1) ^b		41-339(83.7)	
	83.5-99.3		18.3-48.9		70.6-92.8		91.2-100.0		61.2-87.0		71.6-95.8	
No	483- 36704(80.3)		242-1852(41.5)		516- 3949(86.1)		574- 43780(96.0)		287- 2169(47.4)		549-4168(90.9)	
	77.0-83.6		37.4-45.7		83.3-88.9		94.4-97.6		43.2-51.5		88.4-93.4	
Education												

Response to protective behavior =Yes Weighted n=5771 ¹	A. Washes window, doorways, floors and dusty areas with wet mop or cloth ²		B. Blocks chipped or peeling paint with furniture or covers with duct tape ³		C. Eats food rich in iron and calcium ⁴		D. Washes hands frequently ⁵		E. Runs cold water 1 min before cooking/drinking ⁶		F. Stores food in clean plastic or glass ⁷	
	Raw-Weighted(%)	Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted(%)	Confidence interval	Raw-Weighted(%)	Confidence interval	Raw-Weighted(%)	Confidence interval
<High School & age>18	66-567(92.4)	^a	35-300(51.6)	^a	63-543(89.8)		69-590(98.9)		58-493(82.7)	^c	63-517(86.4)	
	86.4-98.4		39.0-64.2		82.9-96.7		96.8-100.0		73.0-92.3		76.2-96.6	
	437-3296(79.2)		207-1543(38.2)		468-3527(85.2)		525-3945(95.6)		247-1824(44.0)		505-3798(91.5)	
High School or more &												
	75.6-82.7		33.8-42.4		82.1-88.2		93.8-97.3		39.6-48.3		89.1-94.0	
	24-212(87.8)		15-143(61.1)		23-205(85.0)		27-235(97.4)		18-152(63.2)		22-192(79.6)	
Age 18	76.1-99.4		42.1-80.1		72.3-97.7		92.2-100.0		43.6-82.8		64.6-94.7	
Prior birth												
Yes	298-22303(84.6)	⁸	142-1088(40.5)	⁹	310- 2376(88.0)	⁸	338-2596(96.7)	⁹	188-1447(53.7)	^{8, a}	323-2472(91.5)	⁹
			35.5-46.6		84.5-91.5		94.8-98.5		48.2-59.2		88.4-94.7	
	80.7-88.4											
No	216-1652(76.2)		111- 867(40.5)		232- 1784(82.6)		270- 2056(95.0)		128- 962(44.4)		256-1933(89.0)	
			34.5-46.6		78.2-87.1		92.4-97.6		38.4-50.5		85.0-93.1	
	71.1-81.3											
House or apartment built after 1977												
No	346-2666 (79.4)		165-1271(39.1)		370- 2845(85.0)		416-3181(95.7)		171-1336 (40.0)	^c	399-3055(91.5)	
			34.3-44.0		81.6-88.4		93.8-97.7		35.1-44.8		88.7-94.2	
	75.5-83.3											
I don't know/Missing	181-1407 (84.8)		92-716(44.2)		184-1429(87.2)		205-1589(96.7)		152-1132 (68.9)		191-1451(88.0)	
			37.0-51.4		82.7-91.8		94.4-99.0		62.31-75.8		82.9-93.0	
	79.9-89.7											
Lives in rented house or apartment [#]												
Yes	255-1944 (83.3)	⁹	132-1036(45.4)	^{9, a}	256-1957(84.5)	⁹	288-2183(94.4)	^{9, a}	205-1557(67.1)	^{9, c}	272- 2025(87.2)	^{9, a}
			39.6-51.4		80.4-88.6		91.8-97.0		61.4-72.5		83.0-91.5	
	79.0-87.6											
No	271- 2121(79.3)		124-943(36.6)		297- 2310(86.8)		332- 2579(97.5)		118- 911(34.4)		317- 2473(93.0)	
			31.2-41.9		83.1-90.5		95.8-99.1		29.1 -39.6		90.2-95.8	
	74.9-83.7											
Inner-City Resident [#]												
Yes	207-1659(84.2)		114- 918(47.5)	^b	206-1644(84.1)		237- 1875(96.4)		158-1232(63.1)	^c	221-1726(88.6)	
			40.8-54.1		79.4-88.7		94.1-98.8		56.7-69.5		84.1-93.2	
	79.6-88.8											

Response to protective behavior =Yes Weighted n=5771 ¹	A. Washes window, doorways, floors and dusty areas with wet mop or cloth ²		B. Blocks chipped or peeling paint with furniture or covers with duct tape ³		C. Eats food rich in iron and calcium ⁴		D. Washes hands frequently ⁵		E. Runs cold water 1 min before cooking/drinking ⁶		F. Stores food in clean plastic or glass ⁷	
	Raw-Weighted(%)	Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted (%) Confidence interval	Raw-Weighted(%)	Confidence interval	Raw-Weighted(%)	Confidence interval	Raw-Weighted(%)	Confidence interval
No	320-2414(79.2)	143-1069(36.5)			348- 26230(86.8)		384- 2894(95.8)	165-1236(40.8)	369-2780(91.4)			
	75.1-83.3	31.5-41.4			83.4-90.2		93.8-97.8	35.8-45.8	88.5-94.3			
Income [#]												
Low	279-1835(84.8) ^a	140- 934(44.2)			274-1766(82.2) ^a		311- 2014(94.3)	214-1432(66.7) ^c	295-1908(88.6)			
	80.8-88.7	38.6-49.8			77.9-86.5		91.7-96.9	61.5-72.9	85.0-92.2			
Not Low income	248-2238(78.5)	117-1053 (38.3)			280- 2508(88.4)		310- 2756(97.4)	109-1036(36.5)	295-2598(91.6)			
	73.9-83.0	32.6-43.9			84.9-91.9		95.6-99.1	30.9-42.1	88.2-95.0			
Environmental Risk Status [#]												
HEHR	141-1028(86.0)	75- 544(46.1)			141-1021(86.1)		156-1125(96.2)	124-909(76.5) ^c	145-1041(88.1)			
	80.6-91.3	38.3-53.9			80.7-91.5		93.2-99.2	70.0-83.1	82.9-93.3			
LEHR	386- 3046(79.7)	182- 1443(39.1)			413- 32453(85.6)		465-3644(96.0)	199-1560(41.1)	445-3466(91.0)			
	76.0-83.4	34.5-43.8			82.4-88.8		94.3-97.7	36.4-45.7	88.2-93.8			

¹ 94 mothers who were eligible to answer behavior questions did not answer any so are not included in Table 4

² An additional 8 did not respond to behavior question A

³ An additional 26 did not respond to behavior question B

⁴ An additional 12 did not respond to behavior question C

⁵ An additional 13 did not respond to behavior question D

⁶ An additional 12 did not respond to behavior question E

⁷ An additional 11 did not respond to behavior question F

⁸ 14 did not respond to 'prior birth' question

⁹ 1 did not respond to rental question

¹⁰ 13 did not respond to prior birth question

[#] Environmental Health Risk classification based on 'Lives in rented house or apartment', 'Inner-city resident', and Low income'; 'Yes' to ALL 3 questions=High Environmental Health Risk (HEHR); 'No' to ANY =Low Environmental Health Risk (LEHR)

1000> >0.0001
c global p-value
10> >0.05
q global p-value