PESTICIDE LEVELS IN 48-HOUR PERSONAL AIR SAMPLES DURING PREGNANCY AND IN BLOOD SAMLES AT DELIVERY FROM URBAN MINORITY MOTHERS AND NEWBORNS

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ABSTRACT
Residential pesticide use is widespread in the U.S. However, little is known about pesticide exposures among minority women during pregnancy. We have measured levels of 9 contemporary-use pesticides in 48-hour personal air samples collected during the 3rd trimester and blood samples (maternal and umbilical cord) collected at delivery from 194 African American and Dominican mothers and newborns in New York City. Our prior data show widespread prenatal pesticide use among this minority cohort. The organophosphates diazinon and chlorpyrifos and the carbamate propoxur were detected in 100% of the air samples (range 0.7-6010 ng/m^3) and 57%-97% of blood samples (range 0.3-63 pg/g). Blood and air levels were not correlated. Maternal and newborn blood levels were similar and significantly correlated. The remaining pesticides were detected less frequently in air and blood. Results show that prenatal exposure is widespread and that the pesticides are readily transferred from mother to the fetus during pregnancy.

INDEX TERMS
Pesticides, Prenatal, Residential, Minority, Personal air monitoring

INTRODUCTION
Approximately 80-90% of American households use pesticides (Landrigan et al., 1999). The less persistent pesticides (organophosphates, carbamates and pyrethroids) have replaced the older organochlorines for residential use. However, little is known about residential pesticide exposures among minority populations. The lack of data regarding exposures during pregnancy is of particular concern as experimental studies have shown a link between exposures to several organophosphates during gestation, or the early postnatal period, and adverse neurodevelopmental sequelae in the offspring (reviewed in (Eskenazi et al., 1999). The current study extends our on-going research of pesticide exposures among African American and Dominican women in New York City (Whyatt et al., in press). Our prior data show widespread use of pest control during pregnancy among this minority cohort (Whyatt et al., in press). Specifically, 266/314 (85%) of the women report that some form of pest control was used; 35% report using an exterminator (Whyatt et al., in press).

METHODS
The women in this report are part of an ongoing prospective cohort study of minority mothers and their newborns being conducted by the Columbia Center of Children's Environmental Health. Study protocols have been described in detail previously (Whyatt et al., in press).

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Briefly, recruitment is restricted to non-smoking African American and Dominican women ages 18-35 who have resided in Northern Manhattan (Central Harlem or Washington Heights/Inwood) or the South Bronx for ≥ one year prior to pregnancy. Women are recruited through the prenatal clinics at New York Presbyterian and Harlem Hospitals.

During the 3rd trimester of pregnancy, the women are administered a questionnaire in the home by a trained research worker. Information on pesticide use includes whether or not pests were sighted in the home during pregnancy, whether any pest control measures were used by an exterminator or by others (the woman, other household members or the building superintendent) and which types of methods were used. During the 3rd trimester, the women are also asked to wear a small backpack holding a personal ambient air monitor during the daytime hours for two consecutive days and to place the monitor near the bed at night. The personal air sampling pumps operate continuously at 4 liters per minute (LPM) over this 48-hour period, collecting particles of $\leq$2.5 microns in diameter on a precleaned quartz microfiber filter and semivolatile vapors and aerosols on a polyurethane foam (PUF) plug back-up. The personal ambient air monitoring for the women that are included in this report was undertaken during September, 1998 through March, 2000. At delivery, a sample of umbilical cord blood is collected from the newborn and a maternal blood sample is collected within one-two days postpartum. Analyses of pesticides in the personal air samples have been conducted by GC/MS at Southwest Research Institute (Whyatt et al., in press) and in blood samples by isotope dilution GC-high resolution MS at the Centers for Disease Control (Barr et al., in press).The study was approved by the Institutional Review Board of Columbia Presbyterian Medical Center and informed consent was obtained from all study subjects. The current report includes 194 mothers and newborns from the cohort with data available on pesticide levels in personal air and/or blood samples.

Prior to statistical analyses, the range in pesticide concentrations in personal air and blood samples, and the percent of samples with levels above the detection limit, were calculated for all 9 pesticides. Means and standard deviations (SD) were additionally calculated for the 3 pesticides detected in > half of the air and blood samples (chlorpyrifos, diazinon and propoxur). Statistical analyses are restricted to these 3 pesticides; levels were log-transformed to normalize positively skewed distributions. Pearson's correlation coefficient was used to examine associations between pesticide levels. Multiple linear regression was used to examine associations between pesticide levels and ethnicity and neighborhood of residence. Multiple regression was also used to examine associations between pesticide levels and other demographic variables (marital status, education, income levels and proportion receiving Medicaid), after controlling for ethnicity and neighborhood of residence. Independent t-tests were used to assess differences in pesticide levels between women not using pest control methods compared to women using (1) non-spray methods of pest control only (sticky traps, bait traps, boric acid and gels); (2) can sprays and pest bombs (with or without non-spray methods); and (3) exterminators (with or without the other methods). Results were considered statistically significant at $p < 0.05$.

RESULTS

Table 1 presents demographics for the 194 study subjects and shows the proportion of the study populations reporting use of pest control measures during pregnancy. Consistent with our prior results (Whyatt et al., in press), 86% of the women reported using some form of pest control during pregnancy and 35% reported using an exterminator.

Table 2 presents results for the 9 pesticides measured in personal air and maternal and cord blood samples. Three pesticides were detected frequently in both air and blood. These were the organophosphates diazinon and chlorpyrifos (detected in 100% of air samples and 54%-97% of blood samples) and the carbamate propoxur (detected in 100% of air samples and 68% of blood samples). Blood and air levels of these pesticides were not correlated (all r- values < 0.2, all p-values > 0.1, data not shown). Maternal and newborn blood pesticide

Table 1. Demographics and the number of women using pest control during pregnancy N=194

Age	24.5±5.0		
Ethnicity		**Education**	
African American	85 (44%)	< High School	61 (32%)[a]
Dominican	109 (56%)	**Annual Household Income**	
Community		< $10,000	80 (43%)[a]
Harlem	75 (39%)	**Medicaid Recipient**	169 (87%)
Washington Heights	71 (37%)	**Total using pest control**	158 (86%)[a]
South Bronx	48 (25%)	By an exterminator only	11 (6%)
		By exterminator plus others[b]	53 (29%)
Marital Status			
Never married	132 (68%)[a]	By others[b] only	94 (51%)

Age is reported as mean±S.D.; the rest of the table presents number of subjects (%) in each category. [a] Missing values: marital status and education (n=1); income (n=6); pest control (10). [b]The woman herself, other household member or the apartment superintendent.

Table 2. Pesticide levels in 48-hours personal air samples during pregnancy and blood samples at delivery

	Air (ng/m^3) N=166		Maternal blood (pg/g) n=142		Cord blood (pg/g) n=155	
	%[1]	Mean±SD[2] (range)	%[1]	Mean±SD[2] (range)	%[1]	Mean±SD (range)
Chlorpyrifos	100	18.9±29.4 (0.7-193)	97	6.9±5.4 (ND-35)	95	6.8±7.0 (ND-63)
Diazinon	100	139±654 (2.0-6010)	54	1.1±2.3 (ND-25)	57	1.1±1.8 (ND-13)
Propoxur[2]	100	89.4±180 (3.4-1420)	68	3.8±2.5 (ND-16)	68	3.7±2.4 (ND-16)
Trans-permethrin	40	NC (ND-523)	6	NC (ND-9)	6	NC (ND-5)
cis-permethrin	29	NC (ND-324)	8	NC (ND-5)	8	NC (ND-4)
Carbofuran	8	NC (ND-5)	21	NC (ND-21)	20	NC (ND-19)
Malathion	7	NC (ND-11)	1	NC (ND-24)	2	NC (ND-47)
Methyl parathion	4	NC (ND-0.9)	1	NC (ND-5)	3	NC (ND-16)
Carbaryl[3]	1	NC (ND-0.7)	28	NC (ND-97)	24	NC (ND-120)

[1]percent (%) of samples with levels above the detection limit; air concentration could not be calculated for some samples due to interference peaks. [2]Mean±SD were calculated for the pesticides detected in > 50% of air and blood samples. ND = not detected; NC = not calculated. Metabolites measured in blood were: [2]2-isopropoxyphenol (metabolite of propoxur) and [3]1-naphthol (metabolite of carbaryl and naphthalene).

Levels were similar (Table 2) and were significantly correlated: chlorpyrifos r=0.5, p<0.001; diazinon r=0.5, p<0.001 and 2-isopropoxyphenol (metabolite of propoxur) r=0.3, p=0.001. The pyrethroid *trans*-permethrin was detected in 40% of air samples but in only 6% of blood

samples. The remaining 5 pesticides were detected less frequently in either personal air or blood samples.

Controlling for neighborhood of residence, African Americans had significantly higher levels than Dominicans of: (1) propoxur in personal air samples (beta = 0.07, p = 0.003; (2) chlorpyrifos in maternal blood (beta=0.4, p=0.03) and cord blood (beta=0.5, p=0.009); and (3) diazinon in maternal blood (beta=0.6, p=0.004) and cord blood (beta=0.5, p=0.009). There was no significant difference between African Americans and Dominicans in levels of chlorpyrifos and diazinon in personal air nor propoxur in blood. Controlling for ethnicity, residents of Washington Heights had significantly higher levels than residents of Harlem of: (1) chlorpyrifos in maternal blood (beta=0.6, p=0.002) and cord blood (beta=0.4, p=0.04) and (2) diazinon in maternal blood (beta=0.6, p=0.005) and cord blood (beta=0.4,p=0.04). There were no other significant differences in pesticide levels in air or blood by neighborhood of residence.

After controlling for ethnicity and neighborhood of residence, pesticide levels in air and blood did not vary significantly as a function of most of the other maternal demographic variables assessed (marital status, education level, income and medicaid recipient). However, levels of diazinon in personal air were significantly higher among women reporting an annual income of < $10,000 compared to women reporting an annual income of $10,000 or greater (beta = -0.7, p = 0.001). Further, levels of 2-isopropoxyphenol (metabolite of propoxur) in cord blood were somewhat lower in newborns of women reporting that they were never married compared to women reporting that they were ever married (beta = 0.2, p = 0.03).

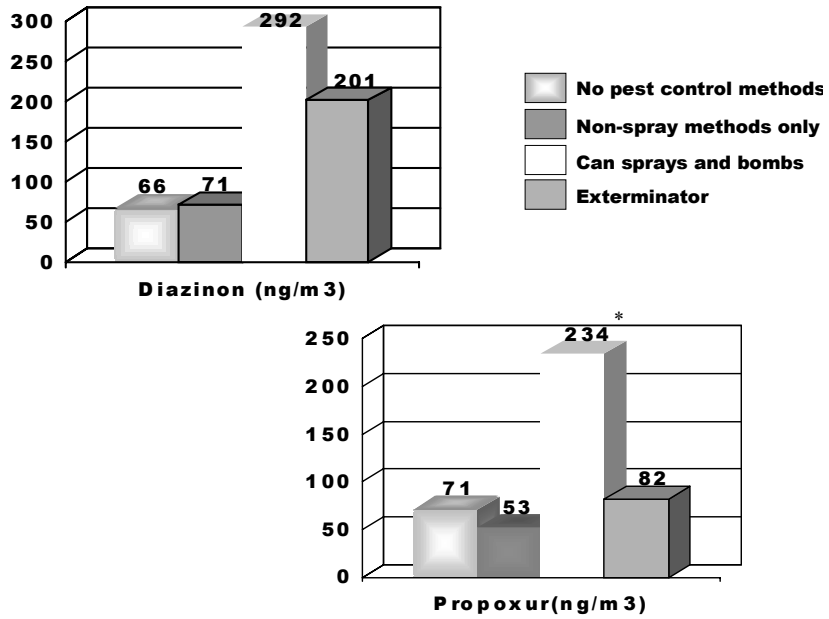

Figure 1. Personal air pesticide levels stratified by whether or not pest control methods were used during pregnancy. * P = 0.02 compared to levels among users of non-spray methods.

Figure 1 shows mean air concentrations of diazinon and propoxur among women who reported that pest control measures were not used during pregnancy compared to women reporting use of : (1) non-spray pest control methods only; (2) can sprays and pest bombs; (3) spraying by an exterminator. Levels were generally higher among women reporting use of pesticides (can sprays, pest bombs or an exterminator) compared to women reporting that only non-spray methods were used or that no pest control was used. However, except for the

difference in propoxur levels between women using can sprays compared to women using non-spray methods, the differences were not statistically significant. Air levels of chlorpyrifos did not vary as a function of whether or not the woman reported using pest control methods during pregnancy. Similarly, pesticide levels in maternal blood samples did not vary significantly by whether or not the woman reported that pest control methods were used. However, diazinon levels in cord blood were somewhat higher among newborns whose mother reported using can sprays and pest bombs compared to newborns of mothers who reported using non-spray methods only ($p=0.06$). Levels of 2-isopropoxyphenol in cord blood were significantly lower in newborns whose mothers reported using non-spray methods only compared both to newborns whose mothers reported that no pest control measures were used ($p=0.02$) and newborns whose mothers reported that can sprays and pest bombs were used ($p=0.045$).

DISCUSSION AND IMPLICATIONS

These results show widespread pesticide exposures during pregnancy among a cohort of African American and Dominican women from minority communities of New York City. The pesticides detected with the greatest frequency in personal air were the organophosphates diazinon and chlorpyrifos, and the carbamate propoxur. All three have been used for residential pest control. Prior to the recent regulatory action to phase out residential uses of chlorpyrifos and diazinon, EPA estimated that approximately 75% of U.S. diazinon use and 50% of U.S. chlorpyrifos use were for residential pest control (U. S. EPA, 2000a; U. S. EPA , 2001). Propoxur is registered for indoor uses to control cockroaches and other pests, as well as for uses in pet sprays and pet collars (U.S. EPA, 1997).

Personal air concentrations of these three pesticides were generally low but highly variable and it is possible that inhalation exposures of women at the highest diazinon concentrations exceeded the health-based levels recommended by the U. S. Environmental Protection Agency (EPA) (U.S. EPA, 2000b). Specifically, the U.S. EPA has set a reference dose (RfD) of 0.00009 mg/kg/day for inhalation exposures to diazinon (of any duration) (U.S. EPA, 2000b.). Based on the Agency's assumptions regarding absorption and using EPA's default inhalation volumes (15.2 m^3/day) and body weight (70 kg) for adults, inhalation exposures at air concentrations measured for five (3%) of the women would exceed the RfD. Exposures at the 95^{th} percentile concentration would be 79% of the RfD. Further, it is possible that the aggregate exposures associated with the air concentrations seen here are greater than exposures from inhalation alone, as prior data indicate that exposure from residential pesticide use may also come from dermal absorption and non-intentional ingestion, although uncertainty remains over the extent of exposure from these sources (Whitmore et al., 1994; Gurunathan et al., 1998; Lu and Fenske, 1999).

To our knowledge, this is the first report of pesticide levels in paired maternal and newborn blood levels. Maternal and cord blood pesticide levels were similar and significantly correlated. Consistent with experimental data (Richardson, 1995.), these results indicate that the pesticides are readily transferred from the mother to fetus during pregnancy. The pesticides that were detected with the greatest frequencies in blood samples were also detected frequently in air samples. However, blood levels were not correlated with air levels nor were they generally associated with maternal self-reported pesticide use during pregnancy. This may reflect the fact that the pesticides are rapidly excreted (half-life on the order of a few days and blood levels provide a short-term dosimeter only. Additionally, blood levels can reflect exposures from all routes (including dermal absorption and ingestion, as well as inhalation).

No prior studies have assessed effects of prenatal exposure to the pesticides on the developing human fetus and it is not known whether the exposures at the pesticide concentrations seen in the current study are associated with any adverse sequelae. However, experimental evidence in laboratory rodents has linked organophosphate exposure at higher concentrations during gestation or the early postnatal period to adverse neurodevelopmental sequelae in the offspring (Brimijoin and Koenigsberger, 1999.; Eskenazi et al., 1999.). The newborns in this cohort are being followed and the association between prenatal exposure and their postnatal neurocognitive development will be assessed.

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