Lead, Allergen, and Pesticide Levels in Licensed Child Care Centers in the United States

Authors: S.M. Viet,[1] J. Rogers,[1] D. Marker,[1] A. Fraser,[1] W. Friedman,[2] D. Jacobs,[3] J. Zhou,[4] N.S. Tulve[5]

Affiliations: [1]Westat, [2]HUD, [3]National Center for Healthy Housing, [4]DOE, [5]EPA

Abstract

The First National Environmental Health Survey of Child Care Centers was conducted to provide information about lead, allergens, and pesticide levels in licensed U.S. child care centers. Lead levels were measured in settled dust, paint, and play area soil; indoor allergen levels in settled dust; and pesticide residues on indoor surfaces and in play area soil. Fourteen percent of centers had significant lead hazards, suggesting that an estimated 470,000 children under age 6 years (approximately 10% of all children in licensed centers) attend centers with significant lead hazards. Approximately 5% of centers had levels of allergens associated with asthma and allergic conditions. Three-quarters of centers had pesticides applied (either indoors or outdoors) during the previous year. Although most centers did not appear to present risks from lead and allergens, some centers did have unsafe levels of these contaminants. These conclusions cannot be generalized to unlicensed child care arrangements.

Introduction

The Consumer Product Safety Commission (CPSC) estimates that 13 million children are placed in non-parental child care during some portion of the day (CPSC, 1999). Often children spend a full work day (8-10 hours) in child care. As a result, a significant portion of a child's potential exposure to hazardous contaminants may occur at a child care location. Three types of contaminants present in child care centers have received particular attention in recent years - lead, allergens, and pesticides.

Lead is a toxin that damages the developing nervous system of young children and fetuses (President's Task Force on Environmental Health Risks and Safety Risks to Children, 2000). The effects of lead toxicity are well established, with clear evidence of harm found in children whose blood lead levels are above 10 μg/dL and substantial evidence that harm occurs at lower levels; no threshold has yet been identified below which adverse health effects are not found. The Centers for Disease Control and Prevention (CDC) estimated that in the 2009 reporting period, 163,000 U.S. children aged 1-5 years had blood lead levels above 10 μg/dL (CDC, 2012). Dust and soil are the most common pathways for lead exposure. Lead-based paint (LBP) is an important source of household dust lead, especially in buildings built prior to 1978 (Bornschein, Hammond, Dietrich, Succop, Krafft, Clark, et al., 1985; Lanphear, Matte, Rogers, Clickner, Dietz, Bornschein, et al., 1998; President's Task Force on Environmental Health Risks and Safety Risks to Children, 2000).

Allergens, such as cockroach and dust mite allergens, cause a variety of allergic reactions, including those that trigger asthma symptoms. Asthma is one of the most common chronic

diseases of childhood, afflicting more than 6 million children nationwide (NHLBI, 2007). The association between asthma and allergy is well documented (NHLBI, 2007).

The human health impacts of pesticides have been a concern for many years, and children may be at greater risk from pesticide exposure compared to adults (EPA, 1998). Per pound of body weight, children eat and breathe more, and have a more rapid metabolism than adults. Children have immature immune and metabolic systems, potentially reducing their natural protection against pesticides. Children also play on the floor and ground where pesticides are commonly applied. Pesticides have been linked to many childhood cancers and neurological disease (Le Couteur, McLean, Taylor, Woodham & Board, 1999).

Little is known about levels of lead, allergens, and pesticides in child care centers nationwide. As a result, the U.S. Department of Housing and Urban Development (HUD), CPSC, and the U.S. Environmental Protection Agency (EPA) collaborated on addressing this data gap by conducting the First National Environmental Health Survey of Child Care Centers. The objective of the survey was to assess children's potential exposures to these contaminants in licensed child care centers that serve children less than 6 years in the continental United States. As the first nationally representative survey, the data provide valuable information about child care centers that is not available from any other source. This article summarizes the most significant lead and allergen results and pesticide application patterns in the nation's child care centers.

Methods

The methods used to conduct this study are fully described elsewhere (HUD, 2003c; Tulve, Jones, Nishioka, Fortmann, Croghan, Zhou, et al., 2006). Below are a brief description of how centers and rooms within centers were selected, and the types and methods of data collection.

Selection of Child Care Centers and Rooms

The survey population included all state-licensed child care centers (generally institutional, but included some home-based centers) that served children under age 6 years in the 48 contiguous United States. Unlicensed child care centers were excluded for practical reasons.

Child care centers were selected in two steps:

1. A random sample of 30 clusters, called primary sampling units (PSUs, a metropolitan statistical area, county, or cluster of counties), with probability proportional to the population, was selected from 1,389 PSUs across the continental United States (Figure 1).
2. A list of licensed child care centers within each selected PSU was obtained from state licensing agencies. From these lists, roughly 11 centers were randomly selected in each PSU. Of 334 sampled centers, 68 were not eligible for the survey (out of business, not licensed, or outside of PSU boundaries). Of the remaining 266 centers, a total of 168 eligible centers agreed to participate and completed the survey, for a completion rate of 63%.

Only classrooms and "multipurpose" rooms (e.g., cafeterias, libraries, and gymnasiums) where children under age 6 years regularly spent time were included in the study. All classrooms and multipurpose rooms were enumerated and two classrooms and one multipurpose room, if

present, were randomly sampled from each list. If there were more than 6 classrooms or multipurpose rooms, an additional room of that room type was sampled.

Data Collection

Each center director completed a questionnaire, which asked about building construction date, number of attending children, demographics of the children's families, cleaning routines, type of heat and air conditioning, and use of pesticides at the center. Approximately 27% of directors did not know the building construction year; where possible, the ages of these buildings were determined from housing or tax authorities. For pesticides applied by a professional applicator, the applicator was contacted, with director permission, to determine more specific information.

Trained field staff recorded information about the center (number of rooms, sample room dimensions, and building condition), collected environmental samples, and made measurements in sampled rooms and outside the building. Painted surfaces of floors, walls, trim, doors, and one randomly selected window in each sampled room were tested for lead using a non-destructive x-ray fluorescence (XRF) analyzer. Paint was also tested on accessible exterior walls, wall trim, windows, the most-used exterior door (major entrance), and painted non-building components such as sheds, fences, and play equipment in play areas.

Dust wipe samples for lead were collected on the floor and from the sill of each randomly selected window. Floor dust wipe samples were collected from the center of the largest open floor area. One square foot templates were used for floor samples. The entire interior sill area

was measured and wiped for window sill samples. Preference was given to wiping sills in windows that could be opened.

Dust vacuum samples collected for allergen analysis were analyzed for two dust mite allergens, *Dermatophagoides pteronyssinus* allergen 1 (Der p 1) and *Dermatophagoides farinae* allergen 1 (Der f 1), and cockroach allergen *Blattella germanica* allergen 1 (Bla g 1).

Soil samples for lead analysis were collected in the outdoor play area from bare soil (not covered with grass, concrete, asphalt, or other permanent covering), where present. If no soil was bare, soil samples were collected from covered (grass, mulch) surfaces, if possible. The top one-half inch of soil (that portion most accessible) was included in the sample.

Wipe samples from the floor and a play or work surface in each selected room, and a composite soil sample from each play area, were collected for pesticide analysis (Tulve et al., 2006).

Data collection occurred between July and October, 2001 and was staged such that sampling occurred in all Census regions simultaneously. All samples (including field quality control blank, duplicate, and spike samples) were analyzed by accredited laboratories.

Data Weighting and Statistical Analysis

Jackknife replicate survey weights were calculated to provide national estimates and appropriate confidence intervals for the number and proportion of licensed child care centers and children, overall and within subsets. Initial weights equal to the inverse of the probability of selecting each

center were adjusted for non-response associated with building age, census region, and metropolitan status to minimize possible bias due to differential non-response.

The data were analyzed using chi-square tests of association (www.westat.com/Westat/expertise/information_systems/WesVar/index.cfm). Confidence intervals for percentages were calculated using the Wilson method. Confidence intervals for means and totals were calculated from standard errors using a normal distribution assumption.

Results

Based on the survey data (Table 1), there were an estimated 100,000 licensed child care centers (87,600 to 112,300) with an estimated enrollment of 4.6 million children (3.7 to 5.5 million) under age 6 years in the continental United States. Thirty four percent (28% to 41%) of centers were located in buildings built since 1978, 23% (17% to 30%) between 1960 and 1977, and 29% (25% to 34%) before 1960. Building age was not obtained for the remaining 14% of buildings.

About half the centers were located in central cities. The majority race was white in about half of centers and African American in one quarter of centers. Nine percent of centers had Head Start programs and 80% were privately-owned as opposed to government-owned. Most centers had never been tested for lead and did not require blood tests for children before enrollment.

The following sections present summary results for the lead, allergen, and pesticide measurements in the centers. Detailed results of these analyses are fully described in the study reports (HUD, 2003a; HUD, 2003b; Tulve et al., 2006).

Prevalence of Lead-Based Paint in Centers

Lead-based paint (LBP) is defined as any paint containing 1.0 mg lead/cm^2 or greater, regardless of the amount of damage to the paint. Twenty eight percent (22% to 35%) of centers had LBP on either interior or exterior painted surfaces, or both.

Significantly deteriorated LBP is defined for interior painted surfaces, as more than 2 square feet of damaged LBP on large surface area components (walls, doors) or damage to more than 10% of total surface area of small surface area components (windowsills, baseboards, trim). For exterior painted surfaces, significantly deteriorated LBP is defined as a surface with more than 20 square feet of damaged LBP. Eleven percent (6% to 20%) of centers had significantly deteriorated LBP.

Figure 2 (solid bars) displays the percent of centers with LBP, by paint damage category and building construction year, showing the downward trend in prevalence of LBP in centers as building age decreases. Differences among construction year categories were statistically significant ($p<0.001$).

An estimated 11.8 million square feet of painted interior surfaces were covered with LBP. This represented only 3% of the area of painted interior surfaces in all centers. Almost two-thirds (62%) of this paint was found on walls, floors, and ceilings, and another 25% on trim. An estimated 18.1 million square feet of painted exterior surfaces were covered with LBP. This represented 13% of the area of painted exterior surfaces in all centers. Exterior walls accounted

for 90% of exterior LBP. Of centers with LBP, most had relatively small areas of LBP. On average, centers with LBP had 421 square feet of interior LBP and 645 square feet of exterior LBP. (For comparison, a room 10' x 12' with an 8' ceiling has a combined wall, ceiling, and floor area of 592 square feet.) Only 2% of centers had lead-based paint on exterior non-building painted components.

Prevalence of Significant Lead-based Paint (LBP) Hazards in Centers

The presence of LBP in a building does not mean that a hazard is present. Federal law defines levels of lead in paint, dust, and soil that are considered to be hazards. This study focused on significant LBP hazards, defined in accordance with the HUD Lead Safe Housing Rule (1996), as follows:

- Presence of significantly deteriorated LBP (defined above); or
- Presence of dust lead hazard – defined as dust on floors with greater than or equal to 40 $\mu g/ft^2$ lead, or dust on window sills with greater than or equal to 250 $\mu g/ft^2$ lead; or
- Soil lead hazard – defined as any amount of bare soil with a lead content of 400 ppm or more in a play area.

An estimated 14% (9% to 22%) of centers had significant LBP hazards. The relative proportion of child care centers with the different types of lead hazards is shown in Figure 3. The majority of centers with hazards (11%) had significantly deteriorated LBP. Of the 3% of centers with dust lead hazards, all dust lead hazards were found on window sills - no floor dust lead hazards were identified. Only 2% of centers had a soil lead hazard.

An estimated 470,000 children under age 6 years (170,000 to 760,000) attended licensed child care centers with significant LBP hazards. This represented 10% (4% to 17%) of all children under age 6 years who attended these centers.

Figure 2 (striped bars) display the percent of centers with significant LBP hazards, due to paint, dust, or soil. The prevalence of significant LBP hazards parallels the downward trend in prevalence of LBP in centers as building age decreases. As with LBP prevalence, the percentage of centers with any significant LBP hazard varied significantly among construction year categories ($p<0.05$). Differences in LBP and significant LBP hazard prevalence by other center characteristics (geographic region, center ownership, urbanization, presence of government subsidies, or whether the building was ever tested for lead) were not significant and are not presented.

Allergen Levels in Centers

Figure 4 presents the estimated percent of centers for which the maximum allergen measurement fell within a given allergen concentration range for dust mite allergens *Der p 1* and *Der f 1* (and sum of *Der p* 1 and *Der f* 1), and cockroach allergen *Bla g 1*. Measurements above 8 units/mg for *Bla g 1* (2% of centers) and 10 μg/mg for *Der p* 1 and *Der f* 1 (1 and 2% of centers, respectively) are associated with asthma and allergic conditions (Arbes, Cohn, Yin, Muilenberg, Burge, Friedman, et al., 2003; Arbes, Sever, Archer, Long, Gore, Schal, et al., 2003). It should be noted that 26% of centers did not have enough dust for analysis. Of samples with sufficient dust, 86% of measurements were less than the lower limit of detection.

Pesticide Usage and Levels in Centers

A detailed analysis of the usage and concentration of pesticide residues is available (Tulve et al., 2006). A summary of the pesticide usage findings is presented here.

An estimated 75% (69% to 82%) of centers reported at least one pesticide application, 18% (12% to 23%) reported no applications, and 7% (3% to 11%) were unsure of an application in the last year.

Table 2 presents the percent of the 168 centers applying pesticides and, among those that applied pesticides, the percent that applied specific types of pesticides based on the director's or professional applicator's questionnaire responses. Thirty-one percent of centers applied pesticides in both inside and outside locations, whereas 55% had more limited pesticide applications, applying pesticides only inside, only outside, or not at all.

A total of 375 different pesticide products were reported used across all centers during the year immediately preceding sample collection, and included fungicides, rodenticides, insecticides, herbicides, acaricides, and non-toxic mouse traps and glue boards. The lower part of Table 2 summarizes this data at the center level. For example, 14% of centers applying pesticides reported using pyrethroid products inside the center. Many child care centers that were using pesticides did not know what was being applied (reported as unknown in Table 2).

Comparison of questionnaire responses on pesticide use and measured pesticide levels in floor wipes showed that for all 115 pesticides detected, the pesticide detected matched the reported

product applied 48% of the time (35% for organophosphates, 43% for pyrethroids) (Tulve et al., 2006). This suggested that questionnaire responses are not adequate for predicting potential exposure in child care centers.

Discussion

This study found that 14% of licensed centers had significant lead-based paint hazards; approximately 5% had levels of allergens associated with allergy and asthma, and 75% had applied pesticides in the year before the study.

LBP was banned for residential use in 1978. Because it was not banned for commercial use, it was unknown whether lead-based paint would be present in newer buildings occupied by child care centers. LBP was found in only 7% of centers built after 1978. This was somewhat lower than the national estimate of 13% for residential units built after 1978 (Jacobs, Clickner, Zhou, Viet, Marker, Rogers, et al., 2002), and could not be attributed to centers being in newer buildings.

It is pointed out that more than half of centers had lead-based paint, which while in good condition at the time, poses a potential risk if the paint deteriorates or is disturbed. Because windows had high levels of lead dust and lead paint hazards, centers should consider replacement of old windows, which provides substantial benefits from lead poisoning prevention, energy conservation, and improved market value (Nevin, Jacobs, Berg, & Cohen, 2008).

The small quantities of floor dust found in vacuum samples collected in centers, as indicated by allergen laboratory reports, probably contribute in part to the low levels of lead and allergens found. Many states include as part of their licensing regulations cleaning requirements, such as wet cleaning floors and vacuuming carpets daily, which may account for the low dust levels. Thus, these findings might not be generalizable to unlicensed centers.

Seventy five percent of centers reported at least one pesticide application in the year prior to the study. While the most common product reported being used was pyrethroid pesticides, many centers were unsure of types of pesticides being applied. Because the all others category (reported in 41% of centers) is a listing of all non-specific products reported, including such products as mouse traps, weed killers, rodent killers, etc., the most common pesticide used is not clear. The phase-out of many organophosphates could be reflected in the data given the low reported use.

Conclusions

This survey provided the first data about lead, allergens, and pesticides in child care centers nationwide. Although most centers did not appear to present risks from lead and allergens, some centers did have unsafe levels of these contaminants. With some attention to damaged paint, especially on windows in older buildings, the prevalence of LBP hazards could be markedly reduced. While three-quarters of centers had pesticides applied (either indoors or outdoors) during the previous year, good building hygiene practices (routine cleaning, garbage removal, screening of windows) may reduce the need to use pesticides, thereby reducing potential

exposures. Conclusions cannot be generalized to unlicensed centers and other types of child care locations and further research should be conducted in these types of locations.

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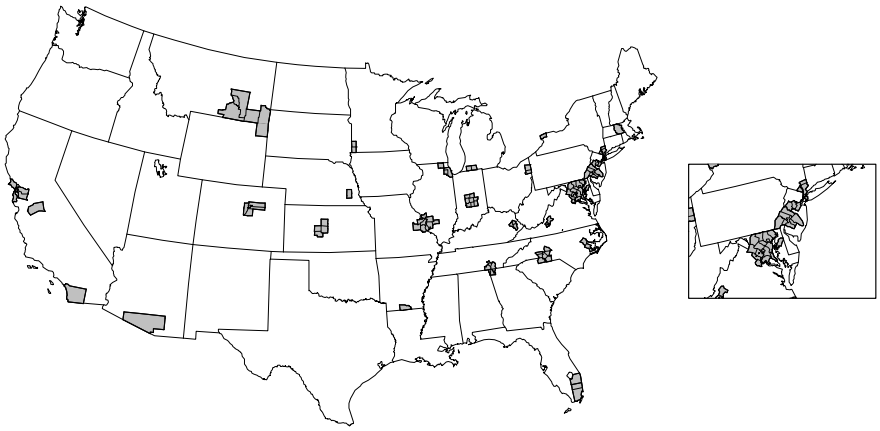
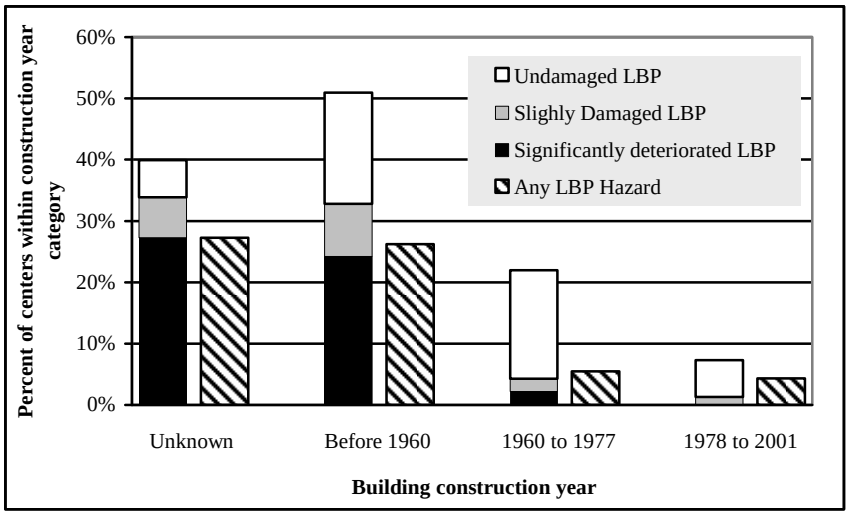
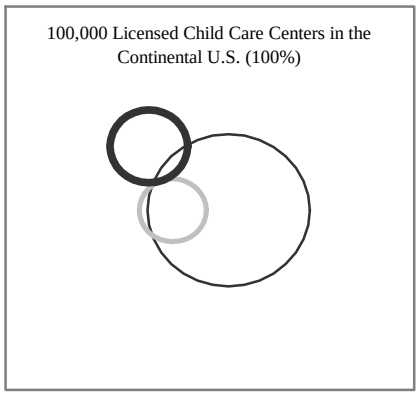



Percent of centers within construction year category
60%
50%
40%
30%
20%
10%
0%
Undamaged LBP
Slighly Damaged LBP
Significantly deteriorated LBP
Any LBP Hazard
Unknown
Before 1960
1960 to 1977
1978 to 2001
Building construction year



11,400 Centers with Significantly Deteriorated LBP (11% (6% to 20%))

2,100 Centers with Soil Lead Hazards (2% (1% to 6%))

2,800 Centers with Dust Lead Hazard (3% (1% to 7%))

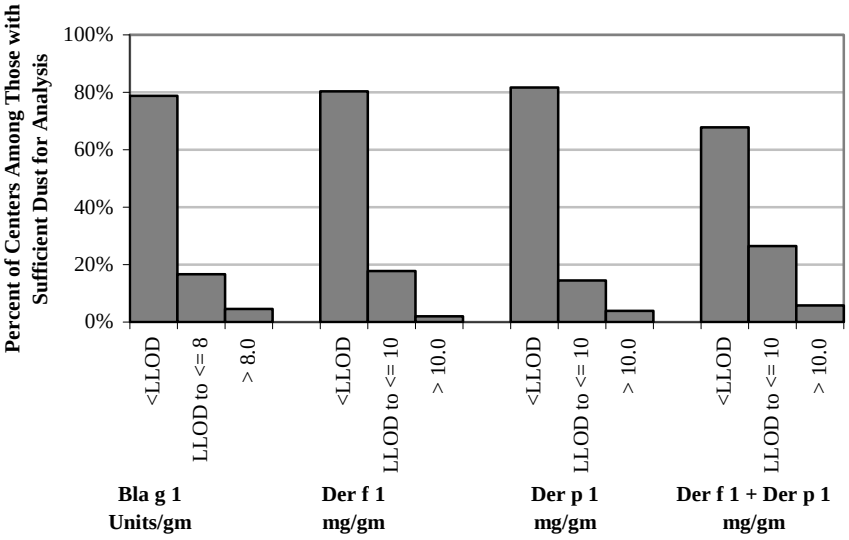

Percent of Centers Among Those with Sufficient Dust for Analysis
100%
80%
60%
40%
20%
0%
<LLOD
LLOD to <= 8
> 8.0
<LLOD
LLOD to <= 10
> 10.0
<LLOD
LLOD to <= 10
> 10.0
<LLOD
LLOD to <= 10
> 10.0
Bla g 1 Units/gm
Der f 1 mg/gm
Der p 1 mg/gm
Der f 1 + Der p 1 mg/gm

Table 1. Selected characteristics of licensed child care centers

Child Care Center Characteristic	Number and Percent of Centers				Centers in Sample
	Estimate	Estimate (%)	Lower 95% CI	Upper 95% CI	
All Centers	100,000	100%			168
Construction year					
1978-2001	33,800	34%	28%	41%	57
1960-1977	22,900	23%	17%	30%	45
Before 1960	29,200	29%	25%	34%	53
Unknown	14,11	14%	9%	20%	13
Region					
Northeast/Midwest	45,200	45%	39%	52%	79
South/West	54,800	55%	48%	61%	89
Urbanization					
MSA Central City	51,200	51%	36%	66%	83
Other MSA	26,600	27%	16%	40%	42
Rural	22,200	22%	10%	43%	43
Majority race at the center					
White	51,300	51%	41%	62%	96
African American	26,800	27%	17%	40%	37
Other	19,200	19%	11%	30%	31
Refusal/Don't Know	2,700	3%	1%	8%	4
Center has Headstart program					
Yes	9,000	9%	5%	17%	14
No	89,400	89%	83%	94%	152
Refusal/Don't Know	1,500	2%	0%	6%	2
Center ownership					
Private	78,900	79%	69%	86%	134
Government	19,200	19%	12%	29%	31
Refusal/Don't Know	1,800	2%	1%	6%	3
Center ever tested for lead					
Yes	19,500	19%	14%	27%	34
No	65,800	66%	57%	73%	111
Refusal/Don't Know	14,600	15%	10%	21%	23
Children required to have blood test for lead					
Yes	19,400	19%	11%	32%	31
No	73,800	74%	60%	84%	127
Refusal/Don't Know	6,800	7%	4%	12%	10

CI = Confidence limit for a 95% confidence interval for the estimated percent
Values may not add to the total due to rounding
MSA = Metropolitan Statistical Area, the "MSA Central City" includes the county in which the MSA central city is located

Table 2. Percent of Centers Applying Pesticides and, for Centers Applying Pesticides, Percent of Centers Applying Specific Types of Pesticides[a]

	Location		
	Inside	**Outside**	**Both Inside and Outside**
Did Center apply pesticides in the last 12 months?[b]			
Yes	63%	44%	31%
No	34%	43%	55%
Don't know	3%	13%	14%
If yes, pesticide class in product[c]			
Pyrethroids	14%	9%	13%
Organophosphates	0%	4%	1%
Carbamates	1%	2%	0%
Pesticide Mix	9%	5%	4%
Unknown	41%	9%	35%
All Others	41%	6%	12%

[a] multiple applications at a center are reported only once

[b] weighted data

[c] unweighted data; centers reported product names and registration numbers, EPA determined type of pesticide in product