US EPA STAR GRANT #R827446

Improving Human Risk Assessment for Tetrachloroethylene by Using Biomarkers and Neurobehavioral Testing

Final Technical Report

March 25, 2005

EXECUTIVE SUMMARY – US EPA STAR GRANT #R827446

Funding provided to the New York State Department of Health (NYSDOH) through U.S. EPA STAR Grant #R827446 supported three research projects related to assessing perchloroethylene (perc) exposures and the occurrence of possible associated health effects. These include the New York City Perc Project, the Pumpkin Patch Day Care Center Follow-up Evaluation, and a compilation and review of historic perc levels in dry cleaner buildings available through files and databases maintained by the New York State Department of Environmental Conservation (NYSDEC) and the New York City Departments of Health and Mental Hygiene (NYCDOHMH) and Environmental Protection (NYCDEP).

The New York City Perc Project (NYC Perc Project)

Objectives of the NYC Perc Project were to:
- assess perc exposures among residents of buildings with co-located dry cleaners;
- evaluate whether living in a building with a dry cleaner is associated with vision effects;
- evaluate relationships between measures of perc exposure and vision effects; and,
- assess whether children are disproportionately exposed to or affected by perc exposure compared to adults.

Health outcome and perc exposure data were obtained over the 2001-2003 period of the study. Sixty-five households in 24 residential buildings with dry cleaners using perc on-site and 61 households in 36 buildings without dry cleaners located in the study area in Manhattan, New York City participated.

Study participants included children and adults residing in the same household (i.e., child-adult pairs) in buildings with or without a co-located dry cleaner using perc on-site. Visual contrast sensitivity (VCS) and color discrimination ability were the health outcomes evaluated as these endpoints appear to be most sensitive to perc exposure. Indoor air, exhaled alveolar breath, and blood perc levels were the measures of perc exposure evaluated.

Indoor Air Perc Levels. Indoor air perc levels in dry cleaner buildings ranged up to 5,000 ug/m^3 and averaged 34 ug/m^3. Indoor air perc levels in buildings without dry cleaners averaged ranged up to 92 ug/m^3 and averaged 3 ug/m^3. Overall, levels of perc in dry cleaner buildings were decreased from levels documented in the study area of New York City prior to 1997 when state and city dry cleaner regulations addressing fugitive perc emissions from co-located dry cleaners were adopted. Prior to 1997, indoor air perc levels in residential dry cleaner buildings ranged up to 25,000 ug/m^3 and averaged 340-1,300 ug/m^3. However, 12 of the 24 residential dry cleaner **buildings** sampled had at least one apartment with indoor air perc levels above the NYSDOH air guideline of 100 ug/m^3. Four buildings had at least one **apartment** with indoor air levels above 1000 ug/m^3. Seventeen of the 65 apartments sampled had perc levels above 100 ug/m^3.

Levels of perc in dry cleaner buildings were not uniform across the study area. Buildings with the highest perc levels were located in minority and/or low income neighborhoods. Perc levels averaged 72 ug/m^3 in **buildings** located in minority neighborhoods and 18 ug/m^3 in **buildings** located in non-minority neighborhoods. Perc levels averaged 230 ug/m^3 in **buildings** located in low income neighborhoods and 23 ug/m^3 in higher income neighborhoods. Indoor air perc levels were also significantly higher in minority and low income **households** (as opposed to neighborhoods). Indoor air perc levels averaged 82.3 ug/m^3 in minority **households** and 16.4 ug/m^3 in non-minority **households**. Indoor air perc levels averaged 105.6 ug/m^3 in low income **households** and 17.6 ug/m^3 in higher income **households**.

Thus, for people living in buildings with dry cleaners using perc, minority and low-income residents of New York City have greater exposure to perc than non-minority and higher income residents. Reasons for this are being explored by state and city agencies.

Breath and Blood Perc Levels. Both breath and blood perc levels were significantly correlated with indoor air perc levels for adult (R^2=0.55-0.68) and child (R^2=0.56-0.66) residents of dry cleaner buildings.

For residents of dry cleaner buildings, mean blood perc levels were significantly higher in minority adults (1.96 ng/mL) and children (1.07 ng/mL) compared to non-minority adults and children (0.54 ng/mL for both). At home, mean breath perc levels in minority adults (28.2 ug/m^3) and children (22.0 ug/m^3) exceeded levels in non-minority adults (15.3 ug/m^3) and children (15.2 ug/m^3), but differences were not statistically significant. Immediately after vision testing at the research clinic, mean perc breath levels in minority adults (22.9 ug/m^3) and children (12.3 ug/m^3) exceeded levels in non-minority adults (9.6 ug/m^3) and children (8.5 ug/m^3), respectively, but only the difference between minority and non-minority adult breath samples reached statistical significance (p=0.04).

Mean blood perc levels were significantly higher in low income residents of dry cleaner buildings (annual income <$30,000) than in higher income (annual income > $60,000) residents of dry cleaner buildings. Blood perc levels averaged 2.16 and 1.17 ng/mL in low income adults and children, respectively, compared to 0.50 and 0.51 ng/mL in higher income adults and children, respectively. At home, mean breath perc levels in low income adults (34.1 ug/m^3) and children (27.7 ug/m^3) exceeded levels in higher income adults (15.2 ug/m^3) and children (16.1 ug/m^3), but differences were not statistically significant. At the clinic, mean perc breath levels in low income adults (27.7 ug/m3) and children (15.2 ug/m^3) exceeded levels in higher income adults (8.3 ug/m^3) and children (8.2 ug/m^3), respectively, but only the difference between low income and higher income adult breath samples reached statistical significance (p=0.04).

Neither blood nor breath perc levels differed significantly between children and adults residing in the same household within race/ethnicity or income categories. This suggests that, given the same residential exposure environment, children do not experience greater internal exposures to perc than adults.

Visual Contrast Sensitivity (VCS). For all participants (residents of reference and dry cleaner buildings) VCS functions exhibited a marked ceiling effect especially at the lowest three spatial frequencies (1.5, 3, 6 cycles per degree (cpd)); i.e., high numbers of participants achieved the maximum possible VCS score. Additionally, children tended to perform better than adults at every spatial frequency. Both of these findings were unexpected. A ceiling effect on VCS performance has been only recently recognized and the enhanced performance of children compared to adults on VCS has not been previously reported.

For statistical analyses, participants were categorized into one of the following three categories: residence in a reference building (46 adults, 53 children); residence in a dry cleaner building and apartment perc < 100 ug/m^3 (42 adults, 39 children); or, residence in a dry cleaner building and apartment perc > 100 ug/m^3 (12 adults, 11 children). Indoor air perc levels associated with these exposure categories averaged 3, 12, and 340 (children) - 480 (adults) ug/m^3, respectively.

Across exposure categories, a significant decreasing trend in the proportion of adults achieving the maximum VCS score was observed at 6 cpd (Cochran-Armitage Exact Trend Test). Stratified analysis suggested that neither race/ethnicity nor income were important confounders. For children, significant decreasing trends were observed at 6 and 12 cpd. Stratified analysis suggested this effect was especially pronounced among minority and low income children. Too few non-minority and higher income children had elevated perc exposures to reliably estimate whether they would exhibit a similar effect.

To evaluate whether VCS among children exposed to perc was more affected compared to adults, paired analyses were performed. VCS data were available for 45 reference child-adult pairs, 38 child-adult pairs with apartment perc < 100 ug/m^3, and 10 child-adult pairs with apartment perc > 100 ug/m^3. Differences in VCS scores between children and adults residing in the same household did not differ significantly across exposure categories (Kruskal-Wallis chi-square). At 12 cpd mean child-adult differences across exposure categories for the worst eye approached significance (p=0.06). A comparatively smaller difference between child and adult scores at this frequency in the dry cleaner > 100 ug/m^3 perc exposure category suggested that the advantage of children over adults was markedly reduced.

Logistic regression indicated that adult VCS at 6 or 12 cpd was not significantly influenced by any measure of perc exposure (indoor air, breath, or blood perc level). Among children, logistic regression indicated that VCS performance at 12 cpd was significantly associated with increased perc levels in indoor air (p=0.05) and in blood (0.04) (but not in breath) after controlling for age and gender. Socioeconomic (race/ethnicity, income) and personal (e.g., years of education, smoking habits, alcohol use, etc.) characteristics (other than age and gender in child models) were not included in regression models as they were significantly correlated with perc exposure.

These analyses together suggest that VCS at 6 and 12 cpd may be decreased among minority and/or low income children with the highest exposure to perc (>100 ug/m^3). Too few non-minority and/or higher income children with elevated exposures to perc were enrolled to evaluate whether alterations in their VCS might also be associated with elevated perc exposure. VCS also appears to have been altered at 6 cpd among adults with the highest exposures to perc.

<u>Color Vision</u>. Most participants achieved perfect scores on both the Farnsworth and Lanthony color vision tests, i.e., they made no errors on either test. Consequently, group Color Confusion Indices (CCI's) for both tests exhibited marked floor effects. This finding was unexpected and has not been addressed in the scientific literature.

For statistical analyses, participants meeting all inclusion criteria and completing the color vision tests were categorized into the three exposure categories noted above, i.e., reference, <100 ug/m^3 perc, and >100 ug/m^3 perc. Indoor air perc levels associated with these three exposure categories averaged 3, 11, and 480 ug/m^3, respectively, for adults; and 3, 12, and 330 ug/m^3, respectively, for children.

Proportions of adults and children making no major errors on the Farnsworth color vision test did not decrease significantly across exposure categories (Cochran Armitage Exact Trend test). Also, mean CCI scores did not differ across exposure categories for either adults or children, and significant differences between children and adults residing in the same household were not observed (Kruskal-Wallis chi-square test).

Proportions of adults and children making no major errors on the Lanthony color vision test did not decrease significantly across exposure categories (Cochran Armitage Exact Trend test). CCI scores did not differ across exposure categories for adults. However, children in the highest exposure category (> 100 ug/m^3) had significantly higher CCI's than children in the other two exposure categories. Also, the difference in CCI between children and adults residing in the same household in the > 100 ug/m^3 exposure category was significantly greater than in either of the other two exposure categories.

Logistic regression indicated that adult performance on the Lanthony test was not significantly influenced by any measure of perc exposure. Among children, logistic regression indicated that Lanthony test performance was significantly associated with perc levels in breath samples obtained at the time of vision testing (p=0.05) in a model including age and gender as co-variates. No other measure of perc exposure (indoor air, home breath, or blood perc levels) was significantly associated with child performance on the Lanthony test. As for VCS, socioeconomic (race/ethnicity, income) and personal (e.g., years of education, smoking habits, alcohol use, etc.) characteristics (other than age and gender for children) were not included in the regression model as they were significantly correlated with perc exposure.

Considered together these analyses suggest that Lanthony color vision test performance was altered among children with the highest exposure to perc.

Conclusions. Elevated levels of perc in indoor air (> 100 ug/m^3) were found in about 25% of apartments in dry cleaner buildings sampled as part of the NYC Perc Project. Most of these apartments were located in buildings in minority and/or low income neighborhoods. Perc levels in breath and blood were directly related to levels of perc in indoor air; and, there was no indication, based on breath and blood perc levels, that children had greater exposures to perc than adults residing in the same household.

All groups of participants scored very well on VCS and color vision tests and examining clinicians did not identify any participant as having abnormal VCS or color vision. For statistical analyses, participants were categorized by residence in a reference building, in a dry cleaner building and apartment perc < 100 ug/m^3, or in a dry cleaner building and apartment perc > 100 ug/m^3. The proportion of adults achieving the maximum VCS score at 6 cpd and the proportion of children achieving the maximum VCS score at 6 and 12 cpd decreased significantly as perc exposure increased. Decreased VCS at 12 cpd was also associated with increased blood perc levels among children. Paired analyses suggested no difference in VCS between children and adults residing in the same household. The proportion of adults and children scoring perfectly on the color vision tests was not affected by perc exposure. However, CCI's were significantly higher among children residing in households with > 100 ug/m^3 perc. Paired analyses suggested that CCI's were significantly greater among children with > 100 ug/m^3 than adults residing in the same household.

These results together suggest that detectable changes in VCS and color vision may be associated with residential exposure to perc. The association of increased perc exposure with decreased VCS and color vision test performance is consistent with other studies lending credence to the conclusion that residential perc exposure may be associated with alterations in vision. However, sample size of the highest exposed group was small ($n \leq 13$) which limits confidence in the differences observed. Additionally, ceiling and floor effects, which characterized performance on VCS and color vision tests, respectively, limit usefulness of these tests to evaluate differences in these endpoints among groups. Finally, most participants in the highest exposure category were also minority and/or low income, and these socioeconomic characteristics may have influenced performance on the VCS and color vision tests. Additional research on methods for measuring VCS and color vision, on the influence of socioeconomic factors on these outcomes, and on interpreting subtle alterations in VCS and color vision is warranted.

The Pumpkin Patch Day Care Center (PPDCC) Follow-up Investigation

In August 1998, elevated perc levels (1,800 to 2,400 ug/m^3) were detected at the PPDCC which was operating adjacent to a dry cleaner using perc. Also in August 1998 NYS DOH and Albany County Health Department, with the support of the U.S. Centers for Disease Control and Prevention and the U.S. EPA, evaluated VCS and color vision among nine PPDCC employees and neuropsychological function among 18 PPDCC attendees. (Vision was not assessed in children because they were too young to perform reliably on the tests available, and neuropsychological function was not assessed in adults because the tests available were appropriate for children only.) Small decreases in VCS were observed among the employees although VCS was still within normal limits. No deficits in neuropsychological function were detected in the children. Also, at the time of this original investigation all employees and attendees of the PPDCC were invited to enroll in the NYSDOH Volatile Organic Compound (VOC) Exposure Registry.

Follow-up evaluations of vision among employees and of vision and neuropsychological function among children possibly exposed to perc at the PPDCC were conducted to assess whether they exhibited long term effects possibly associated with perc exposure. These evaluations were completed in 2003 by NYSDOH in association with local clinicians.

Five employees participated and completed a comprehensive ophthalmologic exam which included visual contrast sensitivity (VCS) and color vision testing. Color vision was normal in all employees. VCS was normal in four of the five employees evaluated when they were properly refracted. One adult had VCS in one eye that was slightly lower than normal and also had a common eye condition known to lower VCS which may have contributed to this effect. Because the number of employees evaluated was small, strong conclusions cannot be drawn from these observations and applied to others who may have been similarly exposed to perc. However, for those evaluated, neither color vision nor VCS appears to have been altered by prior perc exposure.

The PPDCC follow-up evaluation also included a subset of children enrolled in the NYS VOC Exposure Registry who had the greatest possible exposures to perc (i.e., had spent the most hours at the PPDCC prior to and during 1998). They averaged about nine to ten years old at the time of the follow-up and had been exposed to perc for an average of about three years while attending preschool at the PPDCC. Seventeen PPDCC children completed a comprehensive ophthalmologic exam which included VCS and color vision testing. Thirteen PPDCC children completed a comprehensive neuropsychological evaluation. Vision and neuropsychological function was also evaluated in 13 comparison children that were matched by age, gender, and daycare experience to the PPDCC children.

VCS was clinically normal in all PPDCC and comparison children. Analysis of mean VCS scores for matched groups indicated that PPDCC children actually performed significantly better than comparison children at a single VCS frequency. Color vision was clinically abnormal in some PPDCC and some comparison children. There were no significant differences in color vision between matched pairs of PPDCC and comparison children. Analysis of the correlation between hours spent at the PPDCC (i.e., exposed to perc) and color vision showed that color vision test performance was not related to this measure of perc exposure. Neuropsychological function of the PPDCC children was in the average to superior range and did not differ significantly from neuropsychological function of the comparison children.

These findings together indicate that effects on vision or neuropsychological function were not detected among these most highly exposed children.

NYSDOH/NYSDEC Review of Perc Levels in Buildings with Co-Located Dry Cleaners

To support further evaluation of perc levels in buildings housing dry cleaners, NYSDOH compiled perc levels measured in residences and businesses co-located with perc dry cleaners as well as information provided by NYSDEC, NYCDEP and NYCDOHMH on dry cleaner operating characteristics and dry cleaner regulation compliance. The data summarized were obtained before, during and after implementation of the NYS DEC dry cleaner regulations (i.e., 6NYCRR Part 232) which were associated with gradually more restrictive controls over fugitive perc emissions from 1997 to 2003. The data summarized may be of some use in evaluating overall trends in residential perc levels within New York State with respect to dry cleaner regulation implementation and/or dry cleaner operating characteristics.

Overall, the information compiled demonstrates a general decline in indoor air perc levels from before the new regulations (1993-1997) to the present, with many fewer very elevated perc levels (>1000 ug/m^3) being measured in buildings with co-located dry cleaners after 2001.

INTRODUCTION/ BACKGROUND

To evaluate residential exposures to perchloroethylene (perc) and possible associated central nervous system (CNS) effects, especially among children, the New York State Department of Health (NYSDOH) conducted the New York City Perc Project (NYC Perc Project), under funding provided through U.S. Environmental Protection Agency (EPA) STAR Grant # R827446010 and other sources. Objectives of the NYC Perc Project were: to document perc exposures in buildings where dry cleaners were present; to evaluate whether living in a building with a dry cleaner was associated with CNS effects; to evaluate the relationship(s) between measures of perc exposure and CNS effects; and, to assess whether children were disproportionately exposed to and/or affected by perc compared to adults. Study participants were adults and children in the same household residing in a building with an operating dry cleaner using perc (dry cleaner buildings/dry cleaner adult-child pairs) or residing in a building with no dry cleaner or other potential source of volatile organic compounds (VOCs) (reference buildings/reference adult-child pairs). Measures of perc exposure were environmental (indoor air perc levels) and biological (alveolar breath and blood perc levels). CNS function was measured through evaluation of visual contrast sensitivity (VCS) and color vision ability, which had previously been shown to be affected by perc and/or solvent exposure.

Evaluations of CNS function using a computer-based neurobehavioral testing battery (the Neurological Evaluation System-2 (NES-2)) were included in plans for the NYC Perc Project. However, administration of the NES-2 proved infeasible during the initial phase of the study. Dedicated and knowledgeable staff to ensure adequate testing and a quiet location for testing could not be assured at the research clinic providing visual function evaluations and collecting some biological samples. Additionally, unexpectedly low levels of indoor perc present in most apartments sampled early in the study suggested that detecting any NES-2 performance deficits was unlikely. Hence evaluation of NES-2 performance was not assessed among participants of the NYC Perc Project. However, because of persistent interest in evaluating whether perc exposures might influence NES-2 performance, funding provided through U.S. EPA STAR Grant # R827446010 was used to evaluate NES-2 performance among children previously exposed to perc while attending a day care center in Guilderland NY. The findings of this study, termed the Pumpkin Patch Day Care Center Follow-up Evaluation, are also summarized here.

These U.S. EPA STAR Grant funded studies are consistent with a recommendation by the Children's Health Protection Advisory Committee to U.S. EPA Administrator Carol Browner that the National Emission Standard governing emissions of perc be re-evaluated to determine if it is protective of children's health.

Finally, funding available through U.S. EPA STAR Grant #R827446010 supplemented efforts of the New York State Departments of Health (NYS DOH) and Environmental Conservation (NYS DEC) to compile information on indoor perc levels measured in residences and businesses co-located with perc dry cleaners and dry cleaner facility characteristics. These data were provided to the U.S.EPA Office of Air Quality Planning and Standards to support the residual risk assessment for perc required under the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Source Categories: Perchloroethylene Dry Cleaning Facilities.

THE NEW YORK CITY PERC PROJECT

1.0 Methods

1.1 Institutional Review Board(s)

Study design and all protocols were under continuous approval by Institutional Review Boards at the NYSDOH and other collaborating institutions (Mt. Sinai Medical Center; U.S. Centers for Disease Control and Prevention).

1.2 Study Area and Building Selection

Eleven Zip Code areas surrounding Central Park in the borough of Manhattan in New York City (xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx and xxxxx) comprised the study area. (One dry cleaner building in Zip Code Area xxxxx was also sampled.) This area was selected based on the high number of residential buildings with dry cleaners; the presence of some buildings where residential perc levels up to 5,500 ug/m^3 had been previously documented (NYSDOH Unpublished data); and, proximity of the area to the ophthalmology clinic at the Mt. Sinai School of Medicine where VCS and color vision evaluations were scheduled.

As illustrated in **Figure 1.2-1a,b**, these ZIP Code areas are geographically contiguous with one another, but differ in demographic and socioeconomic characteristics. Based on U.S. Census 2000 data, ZIP Code areas xxxxx, xxxxx and xxxxx are considered to be minority (mostly Hispanic and/or African-American) (**Figure 1.2-1a**) and low-income (**Figure 1.2-1b**) (NYSDEC 2003). Minority areas are those with a population greater than or equal to 51.1% Hispanic, African-American or Black, Asian and Pacific Islander or American Indian (or less than 51.5% non-Hispanic White) (NYSDEC 2003). Low-income areas are those where greater than or equal to 23.59% of the population fell below the poverty threshold (NYSDEC 2003). All other ZIP Code areas included in the study area are primarily non-Hispanic White (i.e., non-minority) with fewer households below the poverty threshold (i.e., non low-income) (U.S. Census Bureau 2001 and 2002). As discussed below, these differing socioeconomic characteristics required different strategies for recruitment.

Most dry cleaners in residential buildings included in this study were identified from registration certificates submitted to New York State Department of Environmental Conservation (NYSDEC) as required by NYS dry cleaner regulations (NYS 1997). Some others were identified from NYSDEC National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Perchloroethylene Dry Cleaners records and from internet based yellow pages (ReferenceUSA^{SM}, InfoSpace^{R}). In most ZIP Code Areas (xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx) internet based yellow page directories were cross-referenced against NYSDEC records to identify all dry cleaners, even those possibly not in compliance with NYS dry cleaner regulations. Dry cleaners identified were contacted by telephone to ascertain whether they were still in business, and whether they identified themselves as using perc on-site or as a drop-off facilities (i.e., locations where items to be dry cleaned are dropped off and picked up; no dry cleaning occurs on-site).

Initially, all residential buildings with on-site dry cleaners were included in the recruitment effort. By July 2002 however, preliminary analytical results indicated that perc levels in most apartments sampled in ZIP Code Areas xxxxx, xxxxx (the first ZIP Code areas investigated) were at, or only slightly above, the NYSDOH health-based residential air guideline of 100 ug/m^3. Additionally, the highest levels appeared to exist in buildings located in low-income, minority neighborhoods (i.e., ZIP Code Areas xxxxx). As a result of this observation, the recruitment strategy was altered slightly. To increase the likelihood that as many apartments as possible with elevated perc levels would be identified, buildings located in minority and/or low income ZIP code areas were prioritized for possible sampling. Additionally, reasoning that buildings that had been the subject of a resident complaint to the New York City Department of Health and Mental Hygiene (NYCDOHMH) might be likely to have higher perc levels, so-called “complaint” buildings were also prioritized for sampling.

In all ZIP Code Areas, NYSDOH staff visited and characterized identified dry cleaner buildings to verify that the dry cleaner in the building was still operating and that occupied residences were present in the same building. Study inclusion criteria required that participants have no exposure to volatile organic compounds (VOCs) other than perc that might influence CNS function, so staff also verified that no other businesses using VOCs (e.g., nail salons, shoe repair stores, photography developing, etc.) were present in the same building. At least three other residential buildings with no dry cleaner or other business possibly using VOCs, and located at least one city block away from each dry cleaner building meeting inclusion criteria were selected as reference buildings for each dry cleaner building identified.

Several residential buildings with dry cleaning drop-off facilities were included early in the study before phone calls were initiated to affirm that perc was being used on-site. Although not meeting study criteria for inclusion in the NYC Perc Project, indoor air perc levels associated with drop-off facilities are of interest and are reported here.

1.3 Recruitment

As noted above, objectives of the NYC Perc Project were to document perc exposures and possible effects among residents of dry cleaner buildings, and to assess whether children were at greater risk for exposure and/or effect. To assess whether residential perc exposure would disproportionately affect children, adult-child pairs residing in the same household were required as study participants. Eligible households therefore included at least one adult (20-55 years old) and one child (5-14 years old) residing in their building for at least one year. (Original age inclusion criteria were 20-50 years for adults and 7-12 years for children. These age ranges were expanded over the course of the study due to the difficulty in finding sufficient numbers of adult/child pairs meeting these criteria, and in order to be responsive to some individuals outside these age ranges who were eager to participate in the study.) Eligible participants were required to have resided full-time at their current address for at least one year. Households determined to be eligible had at least one eligible adult-child pair, but may have had more.

Adult-child pairs meeting the above inclusion criteria and willing to participate were further screened to exclude those with known current or previous exposures to VOCs and/or medical conditions that could possibly interfere with CNS or visual function evaluation (i.e. substance abuse, diabetes, cataracts, glaucoma, etc.). During screening, participants were also asked to categorize their household race/ethnicity into one or more (up to four) of the following categories: White, African American, American Indian, Chinese, Japanese, Korean, Native Hawaiian, Somoan, Hispanic, or Other. Adult participants were also asked to categorize their annual household income into one of the following ranges: <$15,000, $15,000-$30,000, $30,000-$45,000, $45,000-$60,000, or >$60,000.

Determination of sample sizes required to demonstrate a significant, disproportionate effect of perc exposure on children was based on the ability to detect a 20% difference in VCS between adults and children at a single visual contrast frequency (i.e. 12 cycles per degree (CPD)). This endpoint was chosen based on previous findings suggesting VCS at this frequency was more likely to be affected by perc exposure than VCS at other frequencies. Measures of variability associated with this measure presented in ATSDR (1995) and ATSDR (1996) were used for these calculations. Sample size required to demonstrate this difference in VCS in children compared to adults residing in the same household were estimated to be 61 reference adult-child pairs and 61 dry cleaner adult-child pairs, setting the probability for a Type I error (α) = 0.05 and the probability of a Type II error (β) = 0.20.

Enrollment of adult-child pairs residing in targeted buildings located within the defined study area posed several challenges for recruitment. Not only was the desired study sample limited by specific residential address, but also by the presence of children. Additionally, the study sample was to be drawn from demographically and socioeconomically diverse communities requiring different recruitment strategies.

Another important challenge was unanticipated and became apparent only after analyses of early indoor air samples became available. As noted above, few residences in dry cleaner buildings had elevated indoor air levels of perc (i.e., perc > 100 ug/m^3). When this was determined, results of indoor air sampling were monitored and recruitment efforts attempted to maximize the likelihood of enrolling households in dry cleaner buildings with elevated perc. Since early analyses indicated that residences in dry cleaner buildings located in minority, low-income ZIP Code areas tended to have higher perc levels than residences in dry cleaner buildings located in other ZIP Code areas, recruitment effort after the initial phase of the study tended to emphasize identification and enrollment of dry cleaner households in minority, low-income ZIP Code areas.

NYC Perc Project staff conducted recruitment for buildings located in ZIP Code areas xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, and xxxxx using mail/telephone contact. The Northern Manhattan Perinatal Partnership, Inc. (NMPP), a community based organization employing bilingual (Spanish/English) community health workers, was contracted to conduct recruitment in ZIP Code areas xxxxx, xxxxx and xxxxx using door-to-door contact. All NYSDOH and NMPP staff received training regarding the protection of human participants in research by the NYSDOH and/or Mt. Sinai Medical School Institutional Review Boards.

To facilitate recruitment and continuing communication with all potentially eligible and eligible households, a toll-free telephone line was established – the NYC Perc Project Hotline. All contacted households were informed of this number and encouraged to call at anytime to volunteer for, or inquire about, the NYC Perc Project. The toll-free telephone line was answered by staff during regular business hours and by a Spanish and English voice mailbox system after regular business hours. Records of all calls to the Hotline and all responses to calls were kept on a NYC Perc Project Hotline phone log.

1.3.1 Mail/Telephone Recruitment in ZIP Code Areas xxxxx, xxxxx, xxxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx, xxxxx

Beginning in July 2001, written material describing the NYC Perc Project was mailed to apartments in identified dry cleaner and reference buildings using addresses obtained during building characterization or through the U.S. Postal Service NYS Zip+4 Directory (U.S. Postal Service 2000). Mailed material included a one-page flyer, a letter of introduction, a four-page fact sheet describing the study, and a response card with a pre-paid return envelope. The flyer was intended to capture the attention of the addressee and interest them in reading the enclosed material. The letter of introduction was a more formal request to participate from the Principal Investigator. The fact sheet described project sponsors, study objectives, requirements for eligibility, participant activities, possible risks, and compensation offered in greater detail. The response card asked recipients to indicate their interest in participating in the study, to provide telephone numbers for contact, and to return the card in the pre-paid return envelope. All material was in English and included the toll-free NYC Perc Project Hotline telephone number. A statement in Spanish on the bottom of the flyer and letter of introduction asked Spanish speakers to call the NYC Perc Project Hotline for more information or for written translated material.

Listed telephone numbers associated with buildings meeting inclusion criteria were obtained through reverse address queries from Internet based residential telephone directories (ReferenceUSA^{SM}, InfoSpace^{R}). Beginning one week after information was mailed, up to five calls to every residential telephone number (not associated with a returned response card) were made at different times of day and on different days of the week. Unlisted telephone numbers were not obtained. When a telephone call was answered, an attempt was made to determine whether an adult-child pair was present and, if so, the respondent was asked to complete a short screening questionnaire. Households were considered successfully contacted only after potential eligibility (i.e., whether children were present) was determined. Telephone call outcomes included: no answer; no children present - did not complete screening questionnaire; children present - completed screening questionnaire – eligible; children present - completed screening questionnaire – ineligible; children present – did not complete screening questionaire; answering machine/left message; hung up, busy, non-residential/non-working number or wrong number (i.e. number not associated with targeted building). Households not successfully contacted after three to five calls were deemed unreachable. Messages that briefly described the project and urged the resident to call the toll-free number to enroll or for more information, were left on all answering machines encountered.

Mail/telephone recruitment activities stopped on September 11, 2001 due to the collapse of the World Trade Center buildings in lower Manhattan. Recruitment resumed in mid-October 2001 after participants enrolled prior to September 11th indicated a desire to continue the study. When recruitment resumed, the information mailed included a revised letter of introduction acknowledging the World Trade Center collapse and noting that NYSDOH had been requested to continue the study. Response cards and pre-paid envelopes were not included when mailings resumed as very few addressees had returned the card. Mailed material was again revised after anthrax was found in mail and U.S. Postal Service facilities in October 2001. Because the U.S. government recommended that individuals not open mail from unknown sources, a one-page flyer which was folded, stapled, and mailed without the use of an envelope was created. The flyer provided a brief description of the NYC Perc Project and urged addressees to call the toll-free NYC Perc Project hotline for more information. This single-page flyer was used until the end of mail/telephone recruitment in November 2002.

1.3.2 Door-to-door Recruitment in ZIP Code Areas xxxxx, xxxxx, xxxxx

In October 2002 the Northern Manhattan Perinatal Partnership, Inc. (NMPP) was contracted to conduct bilingual telephone recruitment in ZIP Code area xxxxx, which includes a large Hispanic population. NMPP is a not-for-profit child health advocacy organization working to promote the health and well being of infants, children and families and employs bilingual (Spanish/English) community health workers. Based on their familiarity with communities in ZIP Code area xxxxx, NMPP recommended that door-to-door contact be the primary means of recruiting eligible households in this Zip Code area as well as ZIP Code areas xxxxx and xxxxx which also have large Hispanic and African American populations.

Working in pairs, NMPP staff visited residences in buildings meeting inclusion criteria. Visits occurred during afternoon and evening hours on different days of the week. Adult residents responding to door knocks were given a verbal description of the study and a written fact sheet describing the project in Spanish or English, whichever was appropriate, and were screened for eligibility whenever possible. Written information urging residents to call NMPP to enroll, or for more information, was left on doorsteps or slipped under doors when residents were not at home. Date, time and outcome of every visit was recorded for each residence visited. Outcomes recorded included: no answer; did not complete screening questionnaire; completed screening questionnaire – eligible; completed screening questionnaire – ineligible; or, vacant household. Households were deemed unreachable after contact could not be established after two to three visits.

1.4 Participant Activities

All adult and child participants volunteered and signed consent or child assent forms approved by the NYSDOH and MSSM (and U.S. CDC) Institutional Review Boards, respectively.

Participant activities are generally illustrated in **Figure 1.4-1**. Participating households were asked to allow NYC Perc Project staff to collect 24-hour indoor air samples (using passive monitoring badges (PSDs)) in their residences to determine indoor air levels of perc and a suite of other VOCs routinely measured with PSDs. During home visits, adult participants completed a residential/occupational/medical history questionnaire for themselves and for their child(ren) and both adults and child(ren) provided exhaled alveolar breath samples for determination of alveolar breath and carbon dioxide (CO_2) perc level.

During the first or second home visit or by phone, participants were scheduled at the Mount Sinai School of Medicine (MSSM) Department of Ophthalmology research clinic where they completed comprehensive eye examinations and VCS and color vision assessments, and provided blood samples for the determination of levels of perc, other VOCs, lead and mercury and another alveolar breath sample for determination of perc.

Participants received $50 for completion of home visit activities and $50 for completion of MSSM visit activities to compensate for the inconvenience associated with participation. Screening for glaucoma, other eye diseases and a prescription for corrective lenses were also provided if warranted, at no cost.

1.5 Analytical Methods

Table 1.5-1 summarizes analytes evaluated in environmental and biological samples.

1.5.1 PSDs/Indoor Air

Indoor air samples were collected using 3M (Minnesota Mining and Manufacturing Co., Minneapolis, MN) organic vapor monitors deployed in duplicate in the main living areas. Monitors were placed approximately six feet high and away from any direct sources of ventilation such as windows, air conditioners, fans or heating/cooling vents. Air sampling occurred for 21 to 27 hours during weekdays beginning between 3 and 9 PM. A hard plastic, impermeable lid provided by the manufacturer was affixed to each monitor at the end of the collection period.

Monitors were analyzed for perc and ten other VOCs by the NYSDOH Wadsworth Center for Laboratories and Research in Albany, NY as described by Amin et al. (1998). Analytical results were reviewed at the laboratory in accordance with approved Quality Assurance/Quality Control procedures and entered into the NYSDOH Environmental Laboratory Data Accessioning and Reporting System (ELDARS). Sample results at or below the detection limit of 5 ug/m^3 are reported as “present but less than (PL) 5 ug/m^3”. Both the participating household and the New York City Department of Health and Mental Hygiene (NYCDOHMH) were notified as soon as possible when apartment perc levels were above background (described below) and follow-up activities were initiated by NYCDOHMH.

1.5.2 Alveolar Breath

Breath samples were analyzed for perc and carbon dioxide as described by Stein et al. (1996). Volumes (0.1-1 ml) of breath samples were withdrawn from breath tubes using a gas tight syringe (0.5 or 1.0 mL) and injected into a gas chromatograph (Hewlett-Packard 5890). The gas chromatograph was fitted with a Rt_x-volatiles fused silica capillary column (60 m, 0.53 mm ID, Restek Corp.) and a Carboxen-1000 stainless steel packed column (15 ft., 1/8” id) connected to an electron capture detector for determination of perc, and to a separate pulsed discharge detector for determination of carbon dioxide. Standards were generated using a Dynacalibrator for volatiles (perc) and a 5% commercially prepared standard of permanent gases for carbon dioxide.

CO_2 levels were normally distributed. Breath samples outside of 1.5 interquartile ranges of the mean (for the samples being analyzed) were excluded from analysis in accordance with recommendations for excluding outliers (Rosner 1995). As recommended by Guillemin and Gubéran (1982), alveolar breath perc levels were corrected by a proportional adjustment assuming that perc levels varied directly with CO_2 levels, and that average alveolar breath CO_2 partial pressure was that observed at sea-level: 40.0 mm Hg or 5.3% (Guyton and Hall 1996).

1.5.3 Blood

Blood samples were collected and forwarded to the U.S. Centers for Disease Control and Prevention for analysis as previously described for perc and other VOCs (Ashley et al. 1992). Briefly, two whole human blood samples were collected by venipuncture into vacutainers (Becton Dickinson, Franklin Lakes, NJ) specially prepared for VOC analysis (Cardinali et al. 1995). These samples were shipped chilled to the U.S. Centers for Disease Control and Prevention and stored at 4° C until analysis. Analysis of perc and other VOCs involved analysis of a 3 mL aliquot from each vacutainer using solid phase microextraction/gas chromatography/mass spectrometry (SPME/GC/MS) as previously described (Cardinali et al. 2000). Isotope dilution mass spectrometry was used for calculation of analyte levels based on relative response compared with an internal standard (perc-^{13}C1, Cambridge Isotope Labs, Andover, MA). This method had a limit of detection of 0.048 ng perc/ml blood, and was able to measure perc in most of the blood samples tested. This analysis involved rigorous QC procedures including evaluation for: contamination, absolute sensitivity, confirmation ion ratios, accuracy and precision. Blind QC samples were evaluated by an independent QC officer according to Westgard QC rules (Westgard et al. 1981). If a QC sample exceeded QC limits for an analyte, then all results for that analyte on that day were rejected.

Lead was measured by graphite furnace atomic absorption spectrometry (GFAAS) using a modification of the method of Miller et. al. (1987). The GFAAS utilized Zeeman background correction with a resulting blood lead limit of detection of 0.3 µg/dL. The reported lead result was the average of two measurements. The blood lead instrument used an aqueous calibration using calibrators.

Whole blood specimens 0.2 mL, were analyzed for total mercury by an automated cold vapor atomic absorption spectrophotometry system (Flow Injection Mercury System 400 Perkin-Elmer, Shelton, CT) with an AS-91 autosampler and a Maxidigest MX 350, (Prolabo, Fontenay-sous-Bois, Cedex, France) in-line microwave digester connected to the FIMS-400 system. Matrix matched calibration methods were used (Chen et al. 1998). The method has a detection limit of 0.14 µg/L for total mercury. National Institute of Standards Technology Standard Reference Material (NIST SRM 966) was used as a bench quality control material as well as 3 levels of in-house blood pools traceable to NIST SRM 966 for daily quality control.

1.6 Visual Function

To ensure that all potential optical and medical factors known to influence VCS and/or color vision (e.g., glaucoma, diabetes, cataracts and astigmatism) were appropriately considered, evaluations of visual function were conducted in a controlled clinical setting under standardized testing conditions at the MSSM Department of Ophthalmology Research Clinic. All clinicians conducting the evaluations were unaware of whether participants resided in buildings with dry cleaners or not.

1.6.1 Ophthalmologic Examination

Each participant was given a thorough ophthalmologic examination which included determination of past ocular and medical history, measurement of visual acuity, pupil size, extraocular motility, and intraocular pressure; and anterior (slit-lamp) and posterior (fundus) segment exams. For participants whose uncorrected acuity was worse than 20/25, manifest refraction was performed. If best corrected visual acuity was not better than or equal to 20/25 or if VCS was abnormal, a dilated fundus exam and automated visual field test of the central 30 degrees was performed to document foveolar sensitivity and retinal function. Participating ophthalmologists discussed individual findings with each case. Participants with abnormalities or taking medications that could influence VCS and/or color vision were excluded from further consideration.

1.6.2 Visual Contrast Sensitivity

Visual contrast sensitivity was determined using the Functional Acuity Contrast Test (F.A.C.T.) distance chart (Stereo Optical Co., Inc. Chicago IL) placed 10 feet from the participant under light conditions specified by the manufacturer (i.e., 68-240 cd/m^2). This chart (37" x 27") consists of five rows of nine different patches filled with sinusoidal gratings (parallel dark and light bars within a circle) oriented at +15°, 0°, or –15°. Spatial frequency (number of bars per patch; referred to as cycles per degree of visual arc (cpd)) is constant within rows but increases from the top to bottom row. Contrast of bars against background decreases within rows from left to right. At different spatial frequencies, different degrees of contrast are required to reach threshold visibility. Visual contrast sensitivity is reflected in a function which reflects the threshold stimulus for spatial vision in terms of spatial frequency and contrast.

For each eye, each participant was asked to indicate the orientation of bars in each patch as the test administrator called out each patch from left to right, row by row, beginning at the top row, left patch. If orientation was misidentified, the participant was instructed to view each succeeding patch to the left until a correct response was again obtained. Testing then proceeded to the right and the last patch correctly identified was taken as the contrast sensitivity score for that spatial frequency. This procedure was repeated for each row in descending order. Scores for each eye were recorded on a graph showing a normal range (90% confidence interval) provided by the F.A.C.T. manufacturer and typically used for clinical interpretation of VCS. For each participant, the examining ophthalmologist made a judgement as to whether or not VCS was normal or abnormal based on these graphs. Specific contrast values for each frequency, contrast sensitivity combination provided with the F.A.C.T. were used in quantitative analyses of VCS results.

1.6.3 Color Vision

Color vision was assessed biocularly using both the Farnsworth D15 and Lanthony's Desaturated 15 Hue Test according to Farnsworth Munsell (D-15d) (Luneau Ophthalmology, Paris France) under light conditions specified by the manufacturer. For both tests, participants were shown a rectangular box containing 16 colored caps (about the size of a bottle cap) arranged in chromatic order. The test administrator removed 15 caps, leaving the first as a standard, and randomized them in front of the participant. Participants were asked to place the cap which most closely matched the standard in hue (i.e., color) in the box next to the standard, and to continue the process until all colored caps were in the box. When the participant was done, the order of cap placement was recorded and diagrammed on templates provided with the tests. Based on review of these charts, the examining ophthalmologist made a judgement as to whether or not color vision was normal or abnormal.

The number of errors for each eye was recorded by noting instances of inversions involving a single cap (a minor error) and instances of inversions involving two or more caps (major errors). Perceptual color distances between colored caps were obtained using the recorded order of color cap placement and published tables of perceptual color distances between caps (Bowman 1982; Geller 2001). Total Color Distance Scores (TCDS) were determined and a Color Confusion Index (CCI) was calculated for each participant according to Geller (2001) and Bowman (1982). CCI is the ratio of participant's TCDS and the TCDS associated with errorless performance, which is 116.9 for the Farnsworth and 56.4 for the Lanthony D15-d. A perfect score would have a CCI=1.0.

1.7 Socioeconomic Characterization of Sampled Dry Cleaner Buildings

Sampled buildings were geocoded according to street address using Mapinfo© (Professional Version 7.0) and were assigned Census 2000 block group characteristics for the census block groups where they were located. Census block groups were categorized as minority and low income according to definitions outlined in the NYSDEC Environmental Justice and Permitting Policy (NYSDEC 2003). Census block groups with a population greater than or equal to 51.1% Hispanic, African American or Black, Asian and Pacific Islander or American Indian (or less then 51.1% non-Hispanic White) were classified as minority. Census block groups in which greater than or equal to 23.59% of the population fell below the poverty threshold (as determined by the U.S. Census Bureau) were classified as low income. In some analyses, sampled apartments were assigned census block group characteristics for the building in which they were located.

2.0 Analyses

2.1 Recruitment

Non-working and non-residential telephone numbers identified during mail/telephone recruitment and vacant households identified during door-to-door recruitment were eliminated to provide the total number of households in the sampling frame. Remaining households were categorized into contacted (presence of adult-child pair determined) and not contacted (presence of adult-child pair not determined) groups. Contacted households were further categorized as not eligible (households without an age-eligible adult-child pair); potentially eligible (households with an age-eligible adult-child pair); or, eligible (households meeting all inclusion criteria (i.e., no other VOC exposures, residence > 1 year, no excluding medical conditions) based on the screening questionnaire. All eligible adult-child pairs were asked to participate.

Identification and enrollment of at least 122 participating households (61 dry cleaner; 61 reference) for the NYC Perc Project required an unexpectedly large amount of staff time. This not only slowed down our ability to gather data but also markedly influenced project funds expended on the recruitment phase of the study. Consequently, we sought to evaluate the time and cost associated with the recruitment and enrollment phase of the study. This information should prove useful for planning additional studies similar to the NYC Perc Project in design.

Time (in hours) associated with mail/telephone recruitment was determined by summing staff hours associated with preparing mailed material; making outgoing recruitment calls; and, responding to calls to the NYC Perc Project Hotline. Hours spent preparing mailed materials was calculated by multiplying the time required to complete one information packet (about 30 seconds) or one flyer (about 15 seconds) by the total number of packets (4,152) and flyers (6,359) mailed. Hours spent placing outgoing phone calls or responding to incoming phone calls was calculated by multiplying a weighted call time average by the total number of telephone calls made (12,856). A weighted call time average (1.6 minutes) was used to account for variable average call times associated with different outgoing call outcomes and with responding to calls to the NYC Perc Project Hotline. For example, telephone calls during which screening questionnaires were administered took more time (about 10 minutes) but were encountered less frequently than telephone calls that were not answered (about 1 minute) or where a message was left on an answering machine (about 3 minutes). Calls received by staff answering the NYC Perc Project Hotline averaged about 3 minutes per call.

Total staff time (in hours) associated with door-to-door recruitment was determined by multiplying recruitment time for one recruiter by 2.5 to account for activities conducted simultaneously by two or more staff. (Door-to-door recruiters always traveled in one or more pairs). Total recruitment time for one door-to-door recruiter was determined by summing hours associated with travel to and from targeted buildings; hours spent going door-to-door; and, hours spent completing screening questionnaires. Travel time was calculated by multiplying estimated travel time to and from targeted buildings (60 minutes) by total number of recruitment trips (10) conducted. Based on times recorded for some recruitment trips, overall time spent visiting targeted buildings, and discussions with recruiters, the average time spent going door-to-door was 10 minutes per household. Hours associated with making door-to-door contact with potentially eligible households was calculated by multiplying the estimate of ten minutes per visit by total household visits (753).

Total time associated with each recruitment method was divided by the number of households reached to estimate the time required to determine eligibility for each contacted household. Total staff time was also divided by the number of households that enrolled and participated to estimate the time required to successfully recruit a single household.

Total cost (in dollars) associated with mail/telephone recruitment was estimated by summing costs associated with staff salaries, telephone calls, and materials included in mailed information packets and flyers. Staff salary costs were calculated by multiplying total staff hours associated with recruitment activities by staff salary, including fringe and indirect costs, expressed as an hourly rate. Cost for each outgoing ($.03) and incoming ($.05) telephone call and mailed material, including postage costs, were obtained from telephone and print shop bills.

Total cost associated with door-to-door recruitment was estimated by summing door-to-door recruiter indirect ($6,505), salary and fringe ($5,950) costs. Indirect costs were contractual and included supplies, office rental space, travel and telephone usage. Staff salary and fringe solely contributing to recruitment activities were determined by multiplying the average hourly rate for one door-to-door recruiter ($17.55) by the estimated level of effort (339 hours).

Total cost associated with recruitment was divided by the number of households contacted to estimate the cost per household for which eligibility was determined. The total cost was also divided by the number of households that enrolled and participated to estimate the cost required to successfully enroll a single adult-child pair.

2.2 Environmental and Health Outcome Data

Spearman's correlations were used to assess associations between socioeconomic factors, other individual characteristics, perc exposures, VCS and color vision.

2.2.1 Household/Individual Questionnaires/Characteristics

Categorical household and participant characteristics were summarized by percent and compared between exposure groups using the chi-square test. Continuous variables were summarized by mean ± std.dev. and compared between exposure groups using the two-sample students-*t* test. All analyses were performed using SAS software (Release 8.02, SAS Institute, Cary, NC).

2.2.2 Perc Exposures

Duplicate indoor air samples obtained from main living areas in each household were averaged to determine apartment perc level. In some analyses, quantities of perc in indoor air present but below the detection limit of 5 ug/m^3 were assigned half the detection limit; in other analyses the actual perc level reported was used.

Apartment perc levels were evaluated qualitatively against background levels of perc and against the NYSDOH residential air guideline of 100 ug/m^3. Background was considered to be less than or equal to 11 ug/m^3, the 75th percentile of indoor air perc levels detected in homes and offices sampled throughout the United States (Shah and Heyerdahl 1988). Perc levels were also qualitatively compared to perc levels measured in residential dry cleaner buildings prior to 1997 before adoption of state and city dry cleaner regulations which applied to dry cleaners operating in residential buildings.

Spearman's correlation coefficients were used to estimate the association between resident self-reported race/ethnicity (minority (i.e., non-Hispanic White), non-minority (i.e., not non-Hispanic

White)) and annual income range (<$30,000/yr, >$30,000/yr) and census block group assignment of residents' building. Logistic regression using generalized estimating equations (GEE) appropriate for clustered observations and SAS software (SAS Release 9.1, SAS Institute, Cary NC) was used to evaluate associations between the occurrence of indoor air perc level greater than the NYSDOH residential air guideline of 100 ug/m^3 (perc > 100 ug/m^3) and building census block group income or minority category.

Elevated perc levels were detected more often in dry cleaner buildings located in low income and/or minority neighborhoods and significant Spearman's correlation coefficients indicated that race/ethnicity and annual income range were significantly associated with increases in indoor air levels of perc. Thus, analytical results for adults and children were stratified by race/ethnicity and annual income for statistical analyses. To increase sample sizes for statistical comparisons across race/ethnicity groups, participants were categorized as non-minority, minority, or other. The non-minority category included participants identifying themselves as non-Hispanic White only. The minority category included participants identifying themselves as African American only, Hispanic only, or as African American or Hispanic in combination with any other category. The Other category included participants not falling into either of these defined categories; these participants were not included in race/ethnicity analyses. To increase sample sizes for statistical comparisons across income categories, participants were categorized as having annual incomes of <$30,000, $30,000 to $60,000, or >$60,000. Participants who chose not to provide this information were categorized as "non-responders" and were not included in analyses. Relationships between measures of perc exposure and race/ethnicity and annual household income were assessed using Students t-test (race/ethnicity) or Analysis of Variance (ANOVA) followed by Tukey-Kramer post-hoc pairwise comparisons (annual income range) using SAS software (SAS Release 8.02, SAS Institute, Cary NC).

Dependence of blood and breath perc levels on indoor air perc levels was assessed using linear and nonlinear regression and SYSTAT 9.0 computer software. The influence of gender, age, hours spent at home prior to providing the home breath sample, and the time spent in transit from home to the research clinic on perc levels in alveolar breath and blood samples obtained at the clinic were assessed using multiple regression models. Hours spent at home was included in the models because perc levels in both breath and blood increase to steady state over a period of several hours (IARC 1995; ACGIH 2001). Transit time was included in the models since longer transit times may have allowed greater elimination of perc, thereby influencing biological levels of perc determined in samples obtained at the clinic (IARC 1995; ACGIH 2001).

To evaluate whether children might experience greater individual exposures than adults residing in the same household, child-adult differences in perc breath and blood levels were evaluated using Wilcoxon signed-rank test.

2.2.3 Visual Function and Perc Exposures

Each individual participant and each adult-child pair was categorized into one of the following three exposure categories: reference, dry cleaner building with indoor air perc < 100 ug/m3; dry cleaner building with indoor air perc > 100 ug/m3. (As described below, mean indoor air perc levels in these 3 exposure categories differed by roughly a factor of 10.) Within exposure categories, participants were also grouped according to race/ethnicity and income since correlations had shown that most of those in the highest exposure category were minority and/or low income.

Group VCS functions exhibited a marked ceiling effect, especially at mid- and high frequencies. Therefore for each participant VCS at each frequency was categorized as being either the maximum or less then maximum score possible. The proportion of participants in each exposure category scoring the maximum VCS score was evaluated at each spatial frequency using the Cochran-Armitage exact trend test. Separate analyses were done for all adults and children and also for adults and children stratified by race/ethnicity and by income. Quantitative differences in VCS scores were also assessed using the Kruskal-Wallis chi-square test. Logistic regression was used to assess associations between measures of perc exposure and achievement of maximum score at each spatial frequency.

To assess the possible vulnerability of children, child-adult differences in VCS performance, using actual VCS scores for either the worst or averaged eyes, between children and adults residing in the same household (i.e. adult-child pairs) were evaluated using the Kruskall Wallis chi-square test.

A very high proportion of both adult and child participants scored perfectly on both the Farnsworth and Lanthony color vision tests and group color confusion indices (CCI) for both the Farnsworth and Lanthony color vision tests exhibited marked floor effects. Therefore for each participant the number of major errors (in which cap inversions spanned at least 2 cap locations) was noted and participants were categorized according to whether they made no major errors or whether they made one or more major errors. The proportion of participants in each exposure category making no errors was evaluated for both the Farnsworth and Lanthony tests using the Cochran-Armitage exact trend test. Separate analyses were done for all adults and children and also for adults and children stratified by race/ethnicity and by income. Quantitative differences in CCI were also assessed using the Kruskal-Wallis chi-square test. Logistic regression was used to assess associations between measures of perc exposure and the occurrence of any major errors.

To assess the possible vulnerability of children, differences in color confusion indices (CCI) (and number of major errors) between children and adults residing in the same household (i.e., adult-child pairs) were evaluated using Kruskall-Wallis chi square test.

3.0 Results

3.1 Recruitment Summary

3.1.1 Buildings

Buildings identified, surveyed and sampled are summarized in **Table 3.1-1**. ZIP Code areas where a strategy of evaluating every dry cleaner was followed are designated under “initial” strategy on **Table 3.1-1**. ZIP Code areas where emphasis was placed on characterizing only buildings that had been the subject of a complaint to NYCDOHMH are designated under “modified” strategy on **Table 3.1-1**. **Figure 3.1-1a,b** illustrates locations of buildings where recruitment of households was attempted and where at least one apartment was sampled.

In ZIP Code areas addressed early in the study (e.g., xxxxx; “initial strategy”), a concerted effort was made to sample as many identified dry cleaner buildings as possible. Later, effort was focused on identifying and sampling buildings that had been the subject of a complaint (e.g., xxxxx). Also, mid-way through the recruitment effort, indoor air results indicated that households in dry cleaner buildings in ZIP Code area xxxxx, a low income, minority area, were more likely to have elevated levels of perc than dry cleaner buildings located in other ZIP Code areas. Therefore recruitment effort in ZIP Code areas xxxxx and other ZIP Code areas with large low income, minority populations (ZIP Code areas, xxxxx and xxxxx) was increased.

Overall, recruitment activities was attempted in 68 residential buildings with a dry cleaner using perc on-site. Of these, one or more adult-child pairs (or households) participated (fully or in part) from 24 dry cleaner buildings. At least one apartment in 36 reference buildings and in five buildings with drop-off facilities were also sampled.

3.1.2 Household/Apartments and Individuals

The total sampling frame and final yield for dry cleaner and reference households are summarized in **Table 3.1-2**. In total, attempts were made to contact 2780 dry cleaner and 3215 reference households. Contact was made and eligibility was determined for 1261 dry cleaner and 1252 reference households. A small percentage of households contacted included age-eligible adult-child pairs (n=132, 10.5% of dry cleaner households; n=175, 13.9% of reference households) and a total of 89 dry cleaner and 82 reference households with adult-child pairs were eligible after completing the screening questionnaire. Reasons for ineligibility are summarized in **Table 3.1-3** (*Pending)***.**

Table 3.1-2 also summarizes household recruitment separately for areas where recruitment was by mail/telephone and where recruitment was door-to-door. Door-to-door recruitment in the minority, low income ZIP Code areas successfully established contact and determined household eligibility in 102 dry cleaner and 273 reference households. Mail/telephone recruitment in non-minority, non low-income Zip Code areas established contact and determined eligibility for 1159 dry cleaner and 979 reference households.

A higher proportion of households in ZIP Code areas contacted door-to-door included age eligible adult-child pairs compared to households in ZIP Code areas contacted by mail/telephone. Thirty-one dry cleaner (30.4% of those contacted) and 63 reference (23% of those contacted) households reached door-to-door included an adult-child pair compared to 101 dry cleaner (9.5% of those contacted) and 112 (12.9% of those contacted) households reached by mail/telephone. Dry cleaner households meeting eligibility criteria and recruited door-to-door were more likely to participate (n=22, 96% of those eligible) than exposed households meeting eligibility criteria and recruited by mail/telephone contact (n=43, 65% of those eligible). This however was not the case for reference households. Equal proportions of non-exposed households meeting eligibility criteria participated.

3.1.3 Level of Effort and Costs Associated with Recruitment

Table 3.1-4a summarizes the estimated level of effort and cost associated with contacting households to determine eligibility. **Table 3.1-4b** summarizes the level of effort and cost required to identify and enroll each participating household. Total staff time required for recruitment was estimated to be 742 hours for the study as whole; 403 hours by mail/telephone recruitment; and, 339 hours by door-to-door recruitment. The total cost associated with recruitment was estimated to be $41,311 for the study as whole; $28,858 by mail/telephone recruitment; and, $12,453 by door-to-door recruitment.

For the study as a whole about 0.3 hrs and $16 were required to successfully contact a household to determine whether an adult-child pair was present **(Table 3.1-4a).** A slightly greater proportion of households in the minority, low-income ZIP Code areas were contacted door-to-door (57% of households contacted) than in the non-minority, non low-income ZIP Code areas using mail/telephone contact (40% of households contacted). However, this required nearly five times the staff time per household contacted (0.9 hrs/contacted household vs. 0.2 hrs/contacted household) and was associated with more then twice the cost ($33/contacted household vs. $13/contacted household).

For the study as a whole about 6 hours and $328 were required to successfully enroll one eligible household **(Table 3.1-4b).** Where door-to-door recruitment occurred, 8 hours of staff time and $283 were required to enroll an eligible household. Where mail/telephone recruitment occurred, 5 hours of staff time and $352 was required to enroll an eligible household. Thus, although the time required to enroll one eligible household in minority, low-income Zip Code areas by door-to-door contact was more than in non-minority, non low-income Zip Code areas by mail/telephone contact, the cost per household enrolled was less.

3.1.4 Characteristics of Study Population (Sampled Households)

Demographic and socioeconomic characteristics of dry cleaner and reference households and individual adult and child participants enrolled in the study are presented in **Table 3.1-5a.** (This summary reflects all households/individuals participating wholly or in part. Characteristics of subsets of individuals included in various analyses are presented along with those analyses.) Race/ethnicity or language spoken in the home did not differ between groups. Reported annual income appeared to be significantly different between dry cleaner and reference groups but was likely influenced by the larger proportion of households not providing income information in the dry cleaner group (n= 18, 27.7 %) compared to the non-exposed group (n=7, 11.5%). No difference between exposure groups for reported annual income was observed when non-responders were removed.

Dry cleaner and reference adults enrolled in the study did not differ with respect to age, employment status, length of residency or years of education when participants enrolled through both mail/telephone and door-to-door contact are considered together. Slightly more adult females participated in the reference group (n=54, 88.5%) than in the dry cleaner group (n=50, 74.6%). Dry cleaner and reference children enrolled in the study did not differ in age, gender, length of residency or years of education.

Demographic and socioeconomic characteristics of dry cleaner and reference participants within each recruitment method are presented in **Table 3.1-5b**. No differences between exposure groups were observed for household or individual level characteristics among participants recruited using the mail/telephone method. Language and adult age differed significantly between exposed and non-exposed groups within participants recruited door-to-door. More English speaking households participated in the non-exposed group (n=18, 81.8%) than in the exposed group (n=11, 50%) and non-exposed adults were slightly older than exposed adults. The distributions of the remaining characteristics for participating households, adults and children recruited using the door-to door method were not significantly different between exposure groups.

Significant correlations between socioeconomic and other characteristics of the study population are summarized in **Table 3.1-6**. Annual income, race/ethnicity, and language spoken at home are highly correlated for all groups of participants. Among adults, education level is also correlated with these characteristics.

3.2 Perc Exposure

3.2.1 Perc in Indoor Air in Minority and/or Low Income Buildings

Table 3.2-1 details minority and income census block group assignment for each dry cleaner building sampled as well as whether it had ever been the subject of a complaint, number of floors in each building, and perc levels for each household sampled. **Figure 3.2-1** illustrates the location of sampled buildings within census block group categories and also shows the maximum indoor air perc level detected in each dry cleaner building sampled. **Table 3.2-1** and **Figure 3.2-1** together convey the following: First, the buildings sampled are widely dispersed throughout the study area and thus provide information for buildings in socioeconomically diverse areas. Second, the six highest perc levels detected, ranging between 695 - 5000 ug/m^3, are in six different dry cleaner buildings located in census block groups characterized as minority or as both minority and low income. These buildings are also among the smallest buildings sampled, only one having more than four floors. Third, perc levels in "complaint" buildings, ranging from 5(PL) - 372 ug/m^3, were not among the highest in the study area although they were among the highest in non-minority, higher income census block groups. None of the nine "complaint" buildings sampled were in minority or low income areas. Fourth, all residences with perc > 100 ug/m^3, with one exception (building e47), occurred on floors 1 – 4 of sampled buildings. Finally, 12 of the 24 sampled dry cleaner buildings had at least one apartment where perc > 100 ug/m^3, with four of them also having at least one apartment where perc > 1,000 ug/m^3.

Of the 65 individual apartments sampled, 17 had perc > 100 ug/m^3, and 11 of these were in buildings in census block groups categorized as minority or as both minority and low income. Four apartments sampled had perc levels exceeding 1,000 ug/m^3 all of which were in census block groups categorized as minority or as both minority and low income. Indoor air perc levels in 21 apartments in "complaint" buildings ranged up to 372 ug/m^3 and accounted for three of the four highest levels observed in non-minority, higher income census block groups. All nine apartments in buildings with drop-off facilities except one had perc levels at or below background, and all except one of the 61 apartments in the 36 buildings without dry cleaners sampled had perc levels similar to background (data not shown).

Given these observations, associations between indoor air perc level > 100 ug/m^3 (on floors 1-4) and building census block group minority and income assignment were assessed. (Too few samples on floors > 4 were obtained in buildings in minority or low income census block groups to include them in this analysis.) Logistic regression appropriate for clustered data indicated that indoor air perc > 100 ug/m^3 was significantly more likely in dry cleaner buildings located in minority census block groups than in non-minority census block groups (OR = 6.7; 95% CI = 1.5-30.5). Too few samples were obtained in low-income neighborhoods to evaluate the likelihood that perc levels there were higher than elsewhere.

These analyses, although based on building census block group category rather than individual household socioeconomic characteristics, suggested that residents of dry cleaner buildings in minority or low income census block groups represent a subpopulation with disproportionately elevated exposures to perc. Indeed building census block group assignment and self-reported household minority and income categories were significantly correlated. For building and household minority category, $r=0.55$ ($p<0.0001$); for building and household low income category, $r=0.48$ ($p=0.005$).

Apartment indoor air perc levels by building type for this study and for studies completed prior to adoption of New York State and New York City dry cleaner regulations in 1997 are summarized in **Table 3.2-2**. Mean (geometric) indoor air perc level in residential dry cleaner buildings in New York City decreased from about 340-360 ug/m^3 during the 1994-1997 period to 35 ug/m^3 during the 2001-2003 period. Maximum indoor air perc values decreased from 25,000 to 5,000 ug/m^3 over the same period. Mean perc levels in buildings without dry cleaners appears to have remained constant at 3 ug/m^3 and mean perc level in buildings that had only drop-off facilities was only slightly higher at 6 ug/m^3.

Importantly, when only buildings located in minority and/or low income neighborhoods are considered, mean (geometric) perc levels are close to or exceed the NYSDOH residential air guideline of 100 ug/m^3. **Table 3.2-2** shows that indoor air perc level in 29 apartments in 10 dry cleaner buildings located in a minority census block group averaged 75 ug/m^3 compared to 19 ug/m^3 in 36 apartments in 14 buildings located in non-minority census block groups. Mean perc level in 11 apartments in five dry cleaner buildings located in a low income census block group was 256 ug/m^3 compared to 23 ug/m^3 in 54 apartments in 19 buildings located in non low-income census block groups. Thus, residents of dry cleaner buildings in minority, low income areas appear to have disproportionately elevated exposures to perc even though, overall, perc levels have decreased since adoption of the 1997 dry cleaner regulations.

3.2.2 Indoor Air Perc Levels and Biologic Indices of Perc Exposure

Significant correlations between socioeconomic characteristics and measures of perc exposure are summarized in **Table 3.2-3**. Indoor air perc level is significantly correlated with household income for both adult and child dry cleaner building residents, with lower income households associated with higher perc levels. Blood perc level in children is also significantly correlated with household income, with lower income children associated with higher blood perc levels.

Figure 3.2-2a,b shows that both biologic indices of perc exposure are significantly correlated with perc levels in indoor air for both adults (R^2=0.55-0.68) (**Figure 3.2-2a**) and children (R^2=0.56-0.66) (**Figure 3.2-2b**). Computed *p*-values for regression models and their component terms were highly significant. The strongest linear relationship was observed between perc levels in indoor air and in blood for both adults and children. Stepwise linear regression identified two additional factors -- transit time and race/ethnicity -- that were significant predictors of perc levels in blood. However, these factors were unimportant compared to indoor air perc levels and their addition to the simple model increased R^2 by less than 5%.

All four measures of perc exposure were highly correlated with one another (p<0.001)
Table 3.2-4 summarizes indoor air, breath, and blood perc levels for adults and children by household race/ethnicity category, i.e., minority/non-minority. Indoor air perc levels were statistically significantly higher in minority households compared to non-minority households (Students t=2.84, df=55, p=0.006). Blood perc levels were statistically significantly higher in minority adults and children compared to non-minority adults (Students t=3.03, df=27.7, p=0.005) and children (Students t=2.21, df=37, p=0.033), respectively. Mean alveolar breath perc levels in minority adults and children exceeded alveolar breath perc levels in non-minority adults and children at home and at the research clinic, although only the difference between minority and non-minority adult breath samples obtained at the clinic reached statistical significance (Student t=2.13, df=35.5, p=0.04).

Table 3.2-5 summarizes indoor air, breath, and blood perc levels for adults and children by annual income range category. Indoor air perc levels were significantly different across annual income range categories (ANOVA F=4.49, df=2,54, p=0.016). Posthoc pairwise comparisons indicated that indoor air perc levels between households in the lowest (<$30,000/year) and highest (>$60,000/year) income ranges differed significantly (p<0.05). There was a significant difference in blood perc levels across income ranges for both adults (F=6.10, df=2,46, p=0.0045) and children (F=4.16, df=2,38, p=0.0231). Posthoc pairwise comparisons indicated that blood perc levels between both adults and children in the lowest (<$30,000/year) and highest (>$60,000/year) income ranges differed significantly (p<0.05). Mean alveolar breath perc levels of adults and children obtained at home or at the clinic did not differ across income range categories with the exception of adult breath obtained at the clinic (ANOVA F=4.09, df=2,47, p=0.02). Posthoc pairwise comparison indicated that perc levels in breath from low income adults differed significantly from that of higher income adults (p=0.02).

Neither blood nor breath perc levels differed significantly between children and adults residing in the same household within race/ethnicity or income categories. For the entire group of dry cleaner residents, adults had significantly higher levels of perc in their blood and breath obtained at Mt. Sinai and nearly significantly higher levels in their breath at home (p<0.09) compared to children.

3.3 Visual Contrast Sensitivity and Perc Exposures

Numbers of individual adults and children meeting all inclusion criteria and for whom measures of VCS were obtained are summarized in **Figure 3.3-1ab**. Indoor air of all participating households was sampled for perc, but some adults and children did not complete the visual function assessment portion of the study. Other adults and children completed visual function assessments but their test results were excluded from analyses due to the presence of medical or eye conditions known to influence the measures evaluated, indication of past or present exposure to perc or other VOC's outside the home, or a residence time of less than one year. Visual function tests for some children were excluded from analyses because of their young age (less than 6 years old) or because they were noted by their parents as learning disabled or having attention deficit hyperactivity disorder.

Demographic and socioeconomic characteristics of households and individuals completing VCS assessment are summarized in **Table 3.3-1ab.** Race/ethnicity and annual income ranges were dichotomized as shown to support statistical analyses. Differences between adult residents of reference buildings or buildings with dry cleaners in socioeconomic characteristics, residence duration, education level, age, smoking or alcohol use are not apparent/present. Differences between child residents in gender or residence duration are not apparent, but the highest exposure group is about a year younger and has about one less year of education.

Table 3.3-2a summarizes perc exposures for this group of participants and **Table 3.3-2b** summarizes perc exposures for child-adult pairs. Adult and child residents of dry cleaner buildings for whom VCS data are available had significantly elevated indoor air levels of perc and significantly greater exhaled alveolar air or blood perc levels, than residents of buildings without dry cleaners. No other differences in exposure to other VOCs are apparent (cf., VOC indices).

VCS functions for adult and child residents of reference and dry cleaner buildings are illustrated in **Figure 3.3-2abcd** which shows the marked ceiling effect observed especially at the lowest three spatial frequencies (1.5, 3, 6 cpd). Additionally, these figures show that children tend to perform better on the F.A.C.T. than adults; the proportions of children at each frequency scoring the maximum is clearly higher than adults. Both of these findings were unexpected. Neither a ceiling effect nor the enhanced performance of children compared to adults on the F.A.C.T. had been previously reported.

Among adults no VCS scores were significantly correlated with any socioeconomic factor (e.g., race/ethnicity, income, language spoke at home) or personal characteristic (e.g., smoking, alcohol use, level of education, duration of residence). Among children poorer VCS at the lowest three spatial frequencies (1.5, 3, 6 cpd) was significantly correlated with speaking primarily Spanish at home. No other consistently significant correlations were observed.

Using performance of each participants' worst eye, Cochran-Armitage exact trend tests for all adults and children categorized by residence in a reference building, residence in a dry cleaner building with perc < 100 ug/m^3, and residence in a dry cleaner building with perc > 100 ug/m^3

are summarized in **Table 3.3-3a**. Trend tests at 6 and 12 cpd (the frequencies at which perc exposure is associated with a significant decreasing trend in the proportion of participants scoring the maximum (**Table 3.3-3a**)), stratified by race/ethnicity and by income level are summarized in **Table 3.3-3b** and **Table 3.3-3c**, for adults and children respectively.

Together, these analyses suggest that increased perc exposure is significantly associated with decreased adult VCS performance at 6 cpd. Stratification of adult VCS performance at 6 cpd by race/ethnicity or by income suggests similar proportions and trends in minority compared to non-minority adults and in low income compared to higher income adults, although sample sizes, especially in the highest exposed group, are very small (**Table 3.3-3b**). Thus, neither race/ethnicity nor income appear to be important confounders.

For children, the unstratified analyses suggest that VCS performance at both 6 and 12 cpd is significantly influenced by perc exposure (**Table 3.3-3a**). Stratification of child VCS performance by race/ethnicity or by income suggests that this effect is significant only among minority and low income children (**Table 3.3-3c**). However, the number of children in the highest exposure category (i.e., the >100 ug/m^3 group) is very small, especially in the non-minority and higher income group, limiting reliability of this conclusion.

Together, these analyses suggest that decreased child VCS performance at 6 and 12 cpd is significantly associated with increased perc exposure. Stratification of child VCS performance at 6 and 12 cpd by race/ethnicity or by income suggests that this effect is significant only among minority and low-income children. However, sample sizes, especially in the highest exposed group, are very small (**Table 3.3-3c**) so the conclusion that non-minority and higher income children are less affected than minority and low income children may be unreliable.

Table 3.3-4 summarizes mean differences in VCS scores between children and adults residing in the same household (child-adult pairs) and the results of paired tests. The mean differences are consistent with the observation that children tend to perform better than adults; most of the mean differences are positive. This effect appears quantitatively smaller at the lowest frequencies (1.5, 3 cpd), but this may be a consequence of the high proportion of both adults and children scoring the maximum at these frequencies making actual differences in contrast sensitivity difficult to quantify (**Table 3.3-3a**).

No significant differences in contrast sensitivity scores were observed among exposure groups in the difference between child and adult performance on VCS based on the worst eye for each participant or scores averaged across eyes although differences between children and adults at 12 cpd for the worst eye approaches significance. The mean child-adult differences suggest that at 12 cpd, the advantage of children over adults may be much smaller in the highest exposed group (> 100 ug/m^3) compared to the other two exposure groups. However, as with other analyses, the relatively small sample size in this exposure category (n=10 child-adult pairs) limits reliability of this conclusion.

Logistic regression was used to further evaluate the influence of perc exposure on achievement of maximum score at 6 and 12 cpd. Socioeconomic (e.g., annual income, race/ethnicity) and personal (e.g., years of education, smoking, alcohol use, age (children only), gender (children only)) characteristics were not included as independent variables as they were significantly correlated with one another as well as with perc exposure, and not with VCS performance. Adult VCS at 6 or 12 cpd was not significantly influenced by any measure of perc exposure (indoor air, breath or blood perc levels). Among children, VCS performance at 12 cpd was significantly influenced by perc levels in indoor air (p=0.05) and in blood, and nearly significantly influenced by perc levels in breath while at the clinic (p=0.06).

3.4 Color Vision

Numbers of individual adults and children meeting all inclusion criteria and for whom measures of color vision were obtained are summarized in **Figure 3.3-1ab**.

Demographic and socioeconomic characteristics of households and individuals completing color vision assessment are summarized in **Table 3.4-1ab** and **Table 3.4-1c** summarizes this information for child-adult pairs**.** Differences among adult residents of buildings with or without dry cleaners in socioeconomic characteristics, duration of building residence, education level, age, smoking or alcohol use are not apparent/present. Differences among child residents are not significant although children in the highest exposure group appear to be about one year younger and have one less year of education than children in the other exposure groups.

Table 3.4-2abc illustrates that adult and child residents of dry cleaner buildings for whom color vision data are available had significantly elevated indoor air levels of perc and significantly greater breath and blood levels of perc than residents of buildings without dry cleaners. Differences in exposures to other VOCs are not apparent (cf., see VOC indices).

CCI's for adult and child residents of reference and dry cleaner buildings are illustrated in **Figure 3.4-1** and **Figure 3.4-2** which show that CCI's for both the Farnsworth and Lanthony color vision tests were associated with a marked floor effect. For both tests a very high proportion of tested participants performed perfectly.

As shown in **Table 3.4-3**, among both adults and children, lower annual household income, being a member of a minority group (i.e., not non-Hispanic White), speaking primarily Spanish at home, and fewer years of education were all significantly associated with increased CCI on both color vision tests. Correlations of these factors with making one or more major errors on the Farnsworth were not significant for adults, but generally were significant for the Farnsworth for children and for both adults and children on the more sensitive Lanthony test. Adult and child age was most often negatively associated with CCI and making major errors. For adults, significant correlations between CCI and smoking or alcohol use were not observed. Correlations of color vision test performance and socioeconomic factors have not been previously demonstrated. Meaningful significant correlations between measures of perc exposure and measures of color vision test performance were not observed with the exception of positive correlations between home alveolar breath perc level and Lanthony CCI (n=36; correlation coefficient=0.35, p=0.03) and the occurrence of one or more major errors (n=36; correlation coefficient=0.32, p=0.05) among children.

Cochran-Armitage trend tests for all adults and children categorized by residence in a reference building, residence in a dry cleaner building with perc < 100 ug/m^3, and residence in a dry cleaner building with perc > 100 ug/m^3 are summarized in **Table 3.4-4a.** Trend tests for adults and children stratified by race/ethnicity and by income level are summarized in **Table 3.4-4b** and **Table 3.4-4c**. Together these tables suggest no differences in performance on either the Farnsworth or Lanthony color vision tests among exposure groups for either adults or children. However, the very high proportion of participants making no errors in all groups and the small sample size in the highest exposed group in particular limits reliability of this finding.

Table 3.4-5 summarizes CCI's for adults and children by exposure category. Perc exposure was unrelated to either Farnsworth and Lanthony CCI among adults, and Farnsworth CCI among children. However, perc exposure significantly influenced Lanthony CCI among children. Mean CCI's suggest that children in the highest exposure category (mean CCI=1.30) performed worse than reference children (mean CCI=1.20) and children in the low exposure category (mean CCI=1.09). However, children in this category are also slightly younger (mean age of 9.7 years compared to 11.0 and 10.7 years in the <100 ug/m3 and reference groups, respectively) and age is negatively correlated with CCI.

Table 3.4-6 summarizes mean differences in color confusion indices (CCI) between children and adults residing in the same household (child-adult pairs) and the results of paired tests. A significant difference was not observed among groups in the difference between child and adult performance on the Farnsworth color vision test. However, on the more sensitive Lanthony test, a significant effect of perc exposure was observed on the difference in CCI with children apparently scoring comparatively higher compared to adults. Post-hoc Dunnett's t-test indicated a significantly greater mean difference between child and adult performance in the highest exposed group. This suggests that children in this exposure category may have been affected by perc exposure to a greater extent than adults residing in the same household and is consistent with effects noted above for un-paired children. However, it should be recognized that the children in the >100 ug/m^3 matched child-adult pairs are slightly younger (average age 9.8 years) than children in the <100 ug/m^3 (average age 10.9 years) and reference (average age 10.7 years) child-adult pairs. Spearman correlations between CCI's and age were statistically significant.

Logistic regression indicated that adult performance on the Lanthony test was not significantly influenced by any measure of perc exposure. Among children, Lanthony color vision test performance (dichotomized as making no or one or more major errors) was significantly associated with elevated perc levels in breath samples obtained at the time of vision testing at the clinic (p=0.05) when controlling for age and gender.

4.0 Discussion

4.1 Indoor Air Perc Levels in Dry Cleaner Buildings

Perc levels documented during this study suggest that mean indoor air perc levels in residential dry cleaner buildings in the study area have decreased by about ten-fold overall since adoption of state and city dry cleaner regulations and related enforcement activities (e.g., the New York City government complaint response process) in 1997. Maximum indoor air perc values have decreased about five fold over the same period.

Thus, state and city dry cleaner regulations which include specific components to address control of fugitive perc emissions from dry cleaners operating in residential buildings have apparently contributed to a decrease in indoor air perc levels in those buildings. NYSDOHMH responds to residential complaints of perc odors; activities associated with their response often results in changes at the dry cleaner or in the building that reduce indoor air perc levels. It is not clear how large a role, if any, the complaint response process played in this decrease. Data were not obtained in this study that would support analysis of this. Moreover, despite the overall decrease in perc levels, mean levels in dry cleaner **buildings** remain elevated above levels in **buildings** with only drop-off facilities or without a dry cleaner. Additionally, half the residential dry cleaner **buildings** sampled still had at least one apartment where indoor air perc levels exceeded the NYSDOH residential air guideline of 100 ug/m^3; and four of them had at least one apartment where perc levels exceeded ten times the NYSDOH residential air guideline. And, of the 65 individual **apartments** sampled, 17 had perc levels above 100 ug/m^3; four had a perc level above 1,000 ug/m^3. Thus, despite the evident success of additional state and city dry cleaner regulations adopted in 1997 in reducing residential exposures to perc, involuntary residential perc exposures continued in the study area through 2003, when sampling for the NYC Perc Project was completed.

Perc levels were higher in residential dry cleaner buildings located in minority, low-income neighborhoods compared to non-minority, higher income neighborhoods. All four apartments with > 1,000 ug/m^3 perc were located in four different dry cleaner buildings in minority neighborhoods (three of which are also low-income), while none of 36 apartments in 14 dry cleaner buildings in non-minority, higher income neighborhoods had perc levels > 1,000 ug/m^3. Further, mean perc levels in dry cleaner buildings in low income or minority neighborhoods were about ten and four times higher than mean levels in higher income and non-minority neighborhoods, respectively. Finally, logistic regression indicated a significantly increased likelihood that apartments on floors 1-4 in residential dry cleaner buildings located in minority or low income neighborhoods would have perc > 100 ug/m^3 compared to apartments in residential dry cleaner buildings located in non-minority or higher income neighborhoods. Individual household race/ethnicity and annual income were significantly correlated with residents' building census block group minority and income assignment providing corroborative evidence that minority, low income residents of dry cleaner buildings have disproportionately elevated exposures to perc compared to non-minority, higher income residents.

Information provided by dry cleaners in the buildings sampled, as required by the dry cleaner regulations, indicated that dry cleaners in 22 of the 24 sampled buildings were using equipment that was in compliance with the regulations at the time of sampling. Thus, failure to utilize approved dry cleaner equipment does not appear to account for disproportionately high perc levels in some buildings. Prior complaints associated with some of the dry cleaner buildings sampled, even though equipment met regulatory requirements, suggests that poor work practices may have contributed to some of the elevated perc levels observed. Another possible contributing factor to higher perc levels in some buildings is the existence of undesirable air flow and ventilation characteristics. Indoor air quality investigations in residences co-located with dry cleaners completed by state and city staff frequently note higher perc levels where there are structural conditions (e.g., poorly sealed pipe chases, cracks in walls or ceilings, etc.) providing pathways for perc migration.

Finally, residents of buildings in minority, low income neighborhoods may be less likely to complain to the city about fugitive perc emissions in their building. (The complaint response process is a tool the New York City health department uses to help identify instances where residential perc levels are elevated and consequently where dry cleaners may not be operating in compliance with regulations.) The observation that none of the sampled dry cleaner buildings in minority, low income areas had ever been the subject of a prior complaint whereas nine of the 16 sampled dry cleaner buildings in the remainder of the study had been, is consistent with this notion. On the other hand some "complaint" buildings had some of the highest perc levels in non-minority, higher income areas. Thus it is not clear to what extent the complaint response process contributed to reductions of perc to 100 ug/m^3 or less.

Bias in the selection of households sampled could have influenced the results in the observed direction if recruitment methods reduced the likelihood of including apartments with elevated perc levels in non-minority, higher income neighborhoods. However, it appears unlikely this occurred to a major extent. Although not all residential dry cleaner buildings were targeted for recruitment in non-minority, higher income areas, many of those that were targeted were "complaint" buildings and were therefore thought most likely to have elevated perc levels. In fact, nine of the 17 buildings sampled in these areas had been the subject of a prior complaint; and, indeed, they were among the four buildings in these areas with the highest perc levels. Bias may also have influenced results in the observed direction if recruitment methods increased the likelihood of including apartments with elevated perc in minority, low income neighborhoods. This also appears unlikely to have significantly influenced results. Although a higher proportion of apartments on floors 1 – 4 in minority and/or low income neighborhoods were sampled compared to non-minority, higher income neighborhoods, similar numbers of samples on floors 1 – 4 were obtained in both areas and the highest absolute levels of perc were consistently observed in minority, low income areas. Further, participation rates were similar for eligible households in both socioeconomic neighborhoods, providing no suggestion that those with comparatively higher or lower levels of perc were more or less likely to participate. Still, the possibility that differences in recruitment strategies or other characteristics differentiating minority, low income households from non-minority, higher income households may have influenced these findings is an acknowledged limitation of this study.

4.2 Indoor Air, Breath and Blood Perc Levels Among Adult and Child Residents of Dry Cleaner Buildings

In residential buildings where a dry cleaner is present, indoor air perc levels were five times higher (mean 82 ug/m^3) in minority households (i.e., those identifying themselves as African-American or Hispanic alone or in combination with any other race) than they were in non-minority households (i.e., those identifying themselves as non-Hispanic White alone) (mean 16 ug/m^3). Indoor air perc levels were six times higher in low income households (i.e., those reporting annual incomes <\$30,000) (mean 106 ug/m^3) than they were in higher income households (i.e., those reporting annual incomes >\$60,000) (mean 18 ug/m^3).

Biologic indices of perc exposure (breath, blood perc level) for both adult and child residents were directly related to indoor air perc level with the strongest relationship being observed between indoor air and blood perc levels. Additionally, all measures of perc exposure were significantly correlated with one another ($p<0.01$). Not surprisingly then, blood perc levels among minority and low-income residents were statistically significantly higher than blood perc levels among non-minority and higher income residents of dry cleaner buildings. Mean blood perc levels in minority adults were about four times higher than in non-minority adults (1.96 ng/mL vs. 0.54 ng/mL) and mean blood perc levels in minority children were about two times higher than in non-minority children (1.07 ng/mL vs. 0.54 ng/mL). When individuals were grouped by annual income, mean blood perc level in adults in the lowest income group (<$30,000) were about four times higher than in the highest income group (>$60,000) (2.16 ng/mL vs. 0.50 ng/mL) and mean blood perc level in the lowest income children was about two times higher than among the highest income children (1.17 ng/mL vs. 0.51 ng/mL).

Breath perc levels were also higher among minority and low-income residents than among non-minority and higher income residents, although differences were not consistently statistically significant. Under steady state exposure conditions, environmental, alveolar breath and blood perc levels are in equilibrium. Thus, at or close to equilibrium differences between groups in breath perc levels would be expected to parallel significant differences between groups in blood perc levels. However, simultaneous collection of breath or blood samples at equilibrium was not attempted. At the clinic, breath and blood samples were collected during late morning or late afternoon hours after participants had been away from home for variable amounts of time ranging from one to eight or more hours. Perc levels in breath and blood at the clinic would have been influenced by the timing of the clinic visit with respect to when participants were last at home, and elimination half lives of perc in breath and blood. Elimination of perc in breath has an initial rapid component with an elimination half life of about 10 minutes and a slower component with an elimination half life of about 2 to 4 hours (Raymer et al. 1991); whereas an elimination half life of perc in blood has been estimated to be slightly longer at about 7 or 8 hours (Dallas et al. 1994). The shorter elimination half life of perc in breath may have contributed to greater variability in estimation of the relationship between breath and indoor air perc levels compared to the relationship between blood and indoor air perc levels.

Additional variability in breath perc levels may have been introduced by an uneven ability to obtain exclusively alveolar air samples. Whether or not a true alveolar sample is obtained depends upon how deeply a participant inhales, how long they hold their breath prior to exhaling, and how thoroughly they exhale before their sample is captured (Opdam and Smolders 1986; Guillemin and Gubéran 1982). Although a consistent alveolar breath collection method was followed, variability in the degree to which captured samples reflected alveolar breath was evident in the variability of CO_2 levels in breath samples; CO_2 and perc levels in alveolar air are presumed to be proportional. Mean percent CO_2 in alveolar breath in New York City (i.e., at sea level) is expected to be 5.3% (Guyton et al. 1996); whereas, mean percent CO_2 in the breath samples captured here was 4.4%. This suggests that variable degrees of hyperventilation or contamination of the alveolar sample with dead space air may have contributed variability to alveolar breath perc measurements as these factors tend to reduce CO_2 as well as volatile organic compound levels in alveolar breath samples (Guillemin and Gubéran 1982).

Indoor air measurements reflect the average perc levels detected over the approximately 24 hour period the passive diffusive monitor was deployed (Amin et al. 1998). Perc levels within the hours prior to blood or breath collection may have been higher or lower than the 24 hour average and thus may have contributed additional variability to the relationships between indoor air and breath and blood perc level. Nevertheless, the correlations (ranging between 0.55 and 0.68) between indoor air and blood or breath perc levels were strong and approached correlations recently observed at much higher occupational exposures (Gobba et al. 2003). Among dry cleaner workers exposed to a mean (TWA) of 44,000 ug/m^3 perc, correlations between alveolar breath and blood samples collected at the end of shift were 0.81 and 0.94, respectively (Gobba et al. 2003). This suggests that with greater control over the timing of indoor air, breath and blood sample collection, the usefulness of blood and breath as biologic indices of perc exposure can be extended to the comparatively low levels existing in households in buildings with dry cleaners using perc on-site. It also suggests that when assessing individual perc exposure, it may be sufficient to rely on indoor air measurements alone which are easier to collect and more economical than blood or alveolar breath samples to analyze.

To our knowledge, with the notable exception of childhood exposures to lead, links between disproportionate environmental exposures (i.e., indoor air perc levels), biologic indices, and socioeconomic status (e.g., race/ethnicity, income) have not been empirically demonstrated (Evans and Kantrowitz 2002; Northridge et al. 2003). Moreover, with the exception of environmental tobacco smoke, little has been published linking disproportionately elevated contaminants in indoor air and elevated biologic indices of exposure to either race/ethnicity or income (Pellizari et al. 1999; Evans and Kantrowitz 2002; Sexton et al. 2004). In a national survey of indoor air levels of nine volatile organic compounds (VOCs) in single family homes, only median benzene levels were significantly higher in minority homes, probably due to an increased prevalence of smoking inside the home, but no biologic indices of exposure were available (Pellizzari et al. 1999; Sexton et al. 1993; Sexton et al. 1994). Indoor air levels of perc and several other VOCs (chloroform, trichloroethylene, 1,1,1-trichloroethane, styrene, toluene, xylenes, p-dichlorobenzene) did not differ between homes classified as minority (Hispanic, Black, 'others') or non-minority. In a subsample (n=982) of the population-based Third National Health and Nutrition Examination Survey (NHANES III), blood perc levels were significantly increased over the 90^{th} percentile (95^{th} percentile = 0.62 ng perc/mL blood (90^{th} percentile not specified)) of the population distribution for those identifying themselves as non-Hispanic Blacks and for those residing in urban areas, but specific indoor air perc levels were not reported (Churchill et al. 2001). Additionally, in the NHANES III sample, low annual income (<$20,000) was actually associated with lower perc blood levels contrary to the findings reported here for dry cleaner residents. Potential exposures to nearby dry cleaners were apparently not considered; the authors speculating that lower levels of perc may have been due to a decreased prevalence of dry cleaned clothing in these homes.

Finally, child-adult differences in perc breath and blood levels were not consistent with the notion that children experience greater exposures than adults in the same residential environment. In fact, adults had significantly higher levels of perc in both breath and blood than children living in the same household. This appears contrary to the idea that children are likely to experience greater individual exposures than adults in the same environment as has been suggested by many (e.g. Needham and Sexton 2000; Stein et al. 2002; Schwenk et al. 2003). One possible explanation for this is that a higher ventilatory rate of children compared to adults contributes to a higher rate of perc elimination via exhalation through the lungs and a concomitant decrease in levels of perc in the blood (Snodgrass 1992). Other factors possibly contributing to this observation are that children with comparatively lower blood perc levels may have been away from home longer than adults prior to blood sampling and/or that exhaled breath samples obtained from children may have been less representative of alveolar air than adults. Also, there may be toxicokinetic factors, as yet unknown, that contribute to higher body burden of perc among adults compared to children.

Additional detailed exploration of the pharmacokinetic relationships between indoor air perc levels and biologic indices of exposures in adults and children enrolled in the NYC Perc Project are ongoing.

4.3 Perc Exposure and Visual Contrast Sensitivity

VCS performance measured with the F.A.C.T. demonstrated a marked ceiling effect for both adults and children. This observation was unexpected and, until recently, unreported in the scientific literature. Recently, however, a similar ceiling effect was reported by investigators evaluating the usefulness of the F.A.C.T. for outcomes research. Pesudovs et al. (2004) reported that 19%, 26%, 11%, 4% and 11% of normal subjects (n=27; mean age=38.8 years) achieved the maximum contrast sensitivity score at 1.5, 3, 6, 12 and 18 cpd, respectively. This pattern of somewhat better performance at 1.5 and 3 cpd than at 6, 12 and 18 cpd is similar to what was observed here among reference adults, although considerably higher proportions of both reference adults and children scored perfectly at every spatial frequency here than reported by Pesudovs et al. (2004).

Differences in administration of the F.A.C.T. by different investigators may influence how well participants respond. In this study, clinicians carefully followed the examination procedure outlined by the F.A.C.T. manufacturer as described in the Methods section above. Determination of contrast sensitivity began with the lowest spatial frequency and proceeded sequentially to the highest spatial frequency. Orders of spatial frequency measurement within each test were randomized by Pesudovs et al. (2004). This difference may have contributed to the differences in proportions achieving the maximum score observed between this study and Pesudovs et al. (2004).

The occurrence of a ceiling effect seriously limits the ability to quantify differences in VCS among exposure groups. It was for this reason that participant responses were categorized as having achieved the maximum score or not at each spatial frequency and statistical techniques suitable for categorical data were applied. Another concern is that such a marked ceiling effect indicates that all groups have good contrast sensitivity, raising questions about whether an effect on proportions would indicate the occurrence of an "adverse" effect. As noted by Pesudovs et al. (2004), "so many cases reaching the ceiling of the chart is a serious problem as the F.A.C.T. chart is missing the most important part of the scale if it were to be used for detecting any subtle loss of CS ……."

Another unexpected observation, not previously reported, was the considerably better performance of children on the F.A.C.T. compared to adults. At all spatial frequencies, a greater proportion of children achieved the maximum score than did adults. This characteristic is pertinent to interpreting mean differences in VCS response between adults and children residing in the same household which was an original objective of the NYC Perc Project. Since VCS apparently tends to be better in children than adults, a **decreased**, rather than an **increased**, child-adult difference could indicate a greater effect in children than in adults. Equivalent child-adult differences could indicate no effect on either children or adults or a quantitatively similar effect on both. However, because of the marked ceiling effect, results from this type of paired analysis may be unreliable.

Using data on proportions of participants achieving the maximum VCS score, the Cochran-Armitage exact trend test indicated that increasing residential perc exposure was associated with statistically significant decreasing trends in the proportion of adults achieving the maximum contrast sensitivity score at 6 cpd and in the proportion of children achieving the maximum contrast sensitivity score at 6 and 12 cpd. Stratified analyses suggested that low income and minority children were more affected than higher income and non-minority children, but very small sample sizes in the highest exposure group, especially in higher income, non-minority groups, limits reliability of this observation.

These findings are generally consistent with Schreiber et al. (2002) who reported an overall decrease in near F.A.C.T. VCS among adult residents of dry cleaner buildings, later found to be not quite statistically significant (Storm and Mazor 2004). Additionally, these findings are the first demonstration that VCS among children, with no other known confounding conditions, such as learning disability or attention deficit hyperactivity disorder, may be influenced by perc exposure. The suggestion that perc exposure may have an effect on VCS, and specifically at spatial frequencies 6 and 12 cpd, is also consistent with other reports of adults occupationally exposed to solvents while working at microelectronics or furniture factories (Mergler et al. 1991; Frenette et al. 1991; Gong et al. 2003) or to styrene while working at reinforced plastics factories (Castillo et al. 2001), although all of these reports used a different visual contrast sensitivity chart (e.g., Vistech) characterized by a less marked ceiling effect (Pesudovs et al. 2004).

Significant differences in VCS scores (for participants' worst eyes or averaged across eyes) between children and adults residing in the same household (i.e., child-adult pairs) were not observed, although a nearly significant greater effect among children was detected at 12 cpd. This is consistent with the notion that VCS of children and adults do not differ significantly in their possible susceptibility to perc exposure. The effect on children at 12 cpd is consistent with results of the trend test, which indicated an effect on children but not adults at this frequency, and with logistic regression which indicated that VCS performance of children at 12 cpd was significantly influenced by perc levels in indoor air and in blood. However, the very high proportions of maximum scores achieved and the small sample size in the highest exposed group (n=10 child-adult pairs) limit reliability in the quantification of differences in VCS between participants and in the statistical test, respectively.

Together these observations suggest that VCS of both adults and children is, at one or two spatial frequencies, respectively, affected by residence in a building with a dry cleaner using perc on-site. Twenty-four hour time-weighted average indoor air perc levels in the highest exposure group averaged about 300-500 ug/m^3.

4.4 Perc Exposure and Color Vision

Most adult and child participants scored perfectly, i.e. had a color confusion index (CCI) of 1.0, on both the Farnsworth and Lanthony color vision tests or made no major errors on either test. The high proportion of perfect scores and associated low mean and median CCI scores is consistent with what has been observed in several other investigations (e.g., Schaper et al. 2004; Castillo et al. 2001; Gong et al. 2003) although it was unexpected here. This limits the ability to detect quantitative differences in CCI among exposure groups.

The possible influence of perc exposure on color vision was also assessed using the Cochran-Armitage exact trend test using the proportions of participants making one or more major errors as the dependent variable. The significance of a decreasing trend in the proportion of participants making no major errors as perc exposure increased was assessed for all adults and children separately as well as for adults and children stratified by race/ethnicity and income. No effect of residential perc exposures was apparent.

Mean CCI's for reference, lower exposure (<100 ug/m3), and higher (>100 ug/m3) exposure adults were 1.10, 1.08, and 1.11, respectively. For children, mean CCI's were 1.12, 1.09, and 1.30, respectively. These mean Lanthony CCI values are within the range of means observed in 15 studies assessing the influence of toluene, styrene or mixed solvents on Lanthony color vision (Paramei et al. 2004). Considering all studies, mean CCI's ranged from 1.07 to 1.34 for exposed adults and 1.05 to 1.32 for unexposed adults. Although most studies summarized by Paramei et al. (2004) reported significant differences between CCI's of exposed and unexposed subjects, a meta-analysis of all studies suggested that solvent exposure may not have consistently affected color vision discrimination. Paramei et al. (2004) suggests that possible reasons for the apparent lack of an effect of solvent exposure on Lanthony CCI are that evaluated exposures have not been high enough, that confounding effects such as age, gender, illumination level, or degree of subjects' chromatic expertise have not been appropriately considered in analyses, and/or that CCI as a measure of color vision loss lacks sensitivity.

Several socioeconomic factors and personal characteristics were also shown to influence Lanthony (as well as Farnsworth) CCI. Among both adults and children, lower annual household income, being a member of a minority group (i.e., not non-Hispanic White), speaking primarily Spanish at home, and fewer years of education were all significantly associated with increased CCI. Both adult and child age was negatively associated with CCI. Significant correlations among adults between CCI and smoking or alcohol use were not observed. Together, these observations indicate that in addition to the factors noted above, socioeconomic status influences performance on the Lanthony color vision test.

Significant correlations between measures of perc exposure and CCI or the occurrence of major errors on either the Farnsworth or Lanthony color vision test were not observed among adult residents of dry cleaner buildings. Among children, perc levels in alveolar breath samples obtained at home were significantly correlated with CCI and making major errors on the Lanthony color vision test.

Kruskal-Wallis chi-square test found no effect of perc exposure on Lanthony CCI among adults, but a significant effect of perc exposure on CCI among children (Chi Square = 6.48, df=2, $p<0.05$). The largest effect appeared to occur in the highest exposed group. Also among children, logistic regression indicated that Lanthony test performance was significantly associated with elevated perc levels in breath samples obtained at the time of vision testing at the clinic when controlling for the influence of age and gender. This is consistent with the notion that CCI among perc exposed children has been adversely affected.

Paired analysis of child-adult color confusion indices, categorized into three exposure groups, suggested a significant association between child-adult differences in performance on the Lanthony color vision test and perc exposures (Chi Square = 9.727, df = , $p<0.01$). Post-hoc Dunnett's t-test indicated that in child-adult pairs with the highest exposures (perc > 100 ug/m^3) the difference between adult and child performance on this test was significantly greater than the difference between children and adults in either of the other two groups. For the variable CCI, a mean difference of or near zero suggests no difference in performance between adults and children. A large negative difference would suggest that children perform better (i.e., have lower CCI) than adults and/or that adults perform worse (i.e., have higher CCI) than children. The comparatively large positive difference in the highest exposed pairs suggests that children perform worse (have higher CCI) and/or that adults perform better (have lower CCI) as perc exposure increases. Mean CCI scores for paired children and adults suggests that in the highest exposed group, adults may have performed slightly better, but that children may have performed considerably worse. It is unlikely that a decrease in adult CCI would be associated with increased perc exposure although it may be associated with younger adult age in this group. Average age was 35.1 years in this group, and ages over 40 have been associated with increased CCI's. It is more likely that an increase in child CCI would be associated with perc exposure. However, it also possible that the slightly younger age of children in the highest exposure group contributed to this observation. The average age of these children was about ten years; whereas the average age in the other two exposure groups was about 11 years.

Together these observations suggest that color vision of children measured with the Lanthony color vision test may be affected by residence in a building with a dry cleaner using perc on-site. Twenty-four hour time-weighted average indoor air perc levels possibly associated with this effect averaged about 300 ug/m^3.

5.0 Conclusions

Indoor air perc levels in residential dry cleaner buildings in New York City (Manhattan) have decreased since 1997 when additional dry cleaner regulations addressing the operation of dry cleaners in residential buildings were adopted.

> Mean (geometric) **apartment** perc level was 34 ug/m^3, ten fold lower than mean apartment levels of 340-360 ug/m^3 prior to 1997.

Maximum detected perc level was 5,000 ug/m^3, five fold lower than the maximum of 25,000 ug/m^3 found prior to 1997.

Despite the overall decrease in indoor air perc levels, many residential dry cleaner **buildings** still have indoor air perc levels above the NYSDOH residential air guideline of 100 ug/m^3; some have levels above 1,000 ug/m^3.

Of 24 dry cleaner buildings sampled, 4 had at least one apartment with indoor air perc levels above 1000 ug/m3; 12 had at least one apartment with indoor air levels above 100 ug/m3

Of 65 apartments in dry cleaner buildings sampled, 4 had indoor air perc level above 1000 ug/m3; 17 had indoor air perc level above 100 ug/m3.

Residential dry cleaner **buildings** located in low income and minority neighborhoods have disproportionately elevated perc levels compared to those located in higher income and non-minority neighborhoods.

Mean apartment perc level in dry cleaner buildings in low income neighborhoods is 256 ug/m^3 compared 23 ug/m^3 in buildings located in higher income neighborhoods.

Mean apartment perc level in dry cleaner buildings located in minority neighborhoods is 75 ug/m^3 compared to 19 ug/m^3 in buildings located in higher non-minority neighborhoods.

For all dry cleaner building residents, perc levels in breath at home and at the clinic and in blood were directly related to levels of perc in indoor air.

Individual dry cleaner building **residents** characterizing themselves as minority (African-American or Hispanic alone or in combination with any other race) or low income (<$30,000 annual income) had significantly higher perc exposures than other residents of dry cleaner buildings.

Indoor air perc levels in households identifying themselves as minority averaged 82.3 ug/m^3 and in households identifying themselves as non-Hispanic White (non-minority) averaged 16.4 ug/m^3.

Indoor air perc levels in households reporting annual income <$30,000 (low income) averaged 105.6 ug/m^3 and in households reporting annual incomes >$60,000 (higher income) averaged 17.6 ug/m^3.

Blood perc levels in minority (1.07-2.16 ng/mL) or low income (0.50-0.54 ng/mL) residents were significantly higher than in residents categorized as non-minority or higher income.

Based on perc levels in blood and breath of children and adults residing in the same household, children did not appear to experience greater internal exposures to perc given exposure to the same residential indoor air perc level. Exploration of possible reasons for this observation are ongoing.

All participants performed very well on the Visual Contrast Sensitivity test. Thus some analyses were based on the proportion of participants achieving maximum scores. Increasing perc exposure was significantly associated with a decreased proportion of adults and children scoring the maximum achievable score at one or two spatial frequencies, respectively.

> Adults categorized as reference, dry cleaner low exposure (indoor air perc < 100 ug/m^3), or dry cleaner high exposure (indoor air > 100 ug/m^3) showed a significantly decreasing trend in proportions achieving the maximum score at 6 cpd. Mean (geometric) indoor air perc levels associated with these exposure categories were 3, 12, and 480 ug/m^3, respectively.
>
> Adult VCS test performance at 6 or 12 cpd was not significantly influenced by any measure of perc exposure (indoor air, breath, blood perc levels).
>
> Children categorized as reference, dry cleaner low exposure (indoor air perc < 100 ug/m^3), or dry cleaner high exposure (indoor air > 100 ug/m^3) showed a significantly decreasing trend in proportions achieving the maximum score at 6 and 12 cpd. Mean (geometric) indoor air perc levels associated with these exposure categories were 3, 12, and 340 ug/m^3, respectively.
>
> Child VCS test performance at 12 cpd was significantly influenced by perc levels in indoor air and blood.

Significant differences in VCS scores between children and adults residing in the same household were not observed among exposure categories, although calculation of differences in VCS scores may be unreliable due to the high proportion of maximum scores.

All participants performed very well on both the Farnsworth and Lanthony color vision tests. Thus some analyses were based on the proportion of participants making no major errors. Increasing perc exposure did not alter the proportion of adults or children making major errors on either test. However, performance of children on the Lanthony color vision test was significantly influenced by perc level in breath samples obtained at the time of vision testing.

No effect of perc exposure on the Farnsworth Color Confusion Index (CCI) was observed among adults or children categorized into reference, dry cleaner low exposure (indoor air perc < 100 ug/m^3), or dry cleaner high exposure (indoor air > 100 ug/m^3) groups.

A significant effect of perc exposure on the Lanthony CCI was observed among children. No effect was observed among adults.

> Children categorized as reference, dry cleaner low exposure (indoor air perc < 100 ug/m^3), or dry cleaner high exposure (indoor air > 100 ug/m^3) had mean CCI's of 1.153, 1.091 and 1.339, respectively. Mean (geometric) indoor air perc levels associated with these exposure categories were 3, 13, and 330 ug/m^3, respectively.

CCI of children in the high exposure group was significantly higher than in the other two groups.

The difference in Lanthony CCI between children and adults residing in the same household was significantly greater than in the other two exposure categories. This suggests that color vision in children may be more vulnerable to perc exposure than color vision in adults.

THE PUMPKIN PATCH DAY CARE CENTER FOLLOW-UP INVESTIGATION

Funding from U.S. EPA STAR Grant R827446010 supported follow-up evaluation of children who may have been exposed to perchloroethylene (perc) while attending the Pumpkin Patch Day Care Center (PPDCC) in Guilderland, NY.

In August 1998 NYS DOH, the Albany County Health Department, and the U.S. Centers for Disease Control (U.S. CDC) conducted an investigation at the PPDCC. In August 1998 a dry cleaner using perc was operating adjacent to the PPDCC and elevated air levels of perc (1,800 – 2,400 ug/m^3) were detected in classrooms. All employees and parents or guardians of children attending the PPDCC were notified, the dry cleaner voluntarily ceased using perc at that location, and perc levels quickly decreased to background levels.

Central nervous system (CNS) function was assessed in 18 four- and five-year-old PPDCC children and 24 age- and gender-matched control children. Visual function was assessed in nine PPDCC employees and in nine adults not exposed to perc using tests of visual contrast sensitivity (VCS) and color vision. Children were not given VCS or color vision tests because they were too young to perform them at the time of the original investigation; adults were not given CNS function tests since the tests available were appropriate for children only.

No deficits in CNS function were detected in the PPDCC children. Employees had a small decrease in VCS compared to the group of adults not exposed to perc, although performance of both groups was within the normal range. A small difference in color vision between PPDCC employees and the adults not exposed to perc was noted, but the difference was not statistically significant. These findings were summarized in draft and final reports (NYSDOH 1999; 2004).

In the final report, NYSDOH noted that follow-up evaluations of PPDCC employees and children would be completed to assess whether there were long term effects on vision among employees and/or long term effects on vision and/or neurobehavioral function among children (NYSDOH 2004). The child follow-up investigation funded in part through this EPA STAR grant is described here. Follow-up evaluation of children who attended the PPDCC included tests of visual function (VCS, color vision), which had not been evaluated in children in the original PPDCC investigation, as well as a comprehensive neurobehavioral assessment.

1.0 Methods

1.1 NYS DOH Volatile Organic Compound (VOC) Exposure Registry

At the time of the original PPDCC investigation in 1998, families of all children who attended the PPDCC prior to August 1998 were offered enrollment in the NYS VOC Exposure Registry. This registry enrolls NYS residents with non-occupational exposures to specific VOCs such as perc, and provides a mechanism for tracking health status of VOC exposed individuals. The registry also provides a means to identify individuals who may be willing to participate in studies pertinent to their exposures. As of October 2001 when planning for these follow-up evaluations began, there were 115 child attendees of the PPDCC enrolled in the NYS VOC Registry.

1.2 Institutional Review Board

All procedures used in follow-up evaluations were under continuous approval by the NYSDOH Institutional Review Board (IRB). Parents/guardians of all participating children provided informed consent, and their children signed an IRB approved child assent form.

1.3 Identification and Recruitment of Participants

Cumulative number of hours spent at the PPDCC was calculated for all children enrolled in the NYS VOC Exposure Registry who had attended the PPDCC within the year prior to discovery of perc contamination. Parents/guardians of 27 children with the highest number of hours spent at the PPDCC were contacted by letter and by phone to determine their interest in having their child (children) participate in the follow-up evaluation. Parents/guardians were asked to allow their children to have a thorough ophthalmological exam at Cornea Consultants of Albany, PPLC, including VCS and color vision testing, and also to complete a neurobehavioral assessment at Albany Psychological Associates, Inc. of Albany. Siblings of these children were also invited to participate if they were at least six years old and had also attended the PPDCC.

Another group of children who attended other daycare centers and who were about the same age as participating PPDCC children were also asked to participate as comparison children. Children were matched on daycare experience to control for possible confounding due to daycare experience resulting in improved socialization, confidence, attention-span and other test-related skills. Selection criteria for comparison children included attendance at a different daycare center for at least 20 hours per week for a minimum of nine months, an age of at least six years, and the absence of any diagnosed learning disabilities. Comparison children were gender and age matched (± 12 months) to PPDCC children.

Parents/guardians of children participating in the follow-up evaluation were asked to complete a comprehensive questionnaire which inquired about family and child medical history as well as the developmental, educational, and psychosocial history of the child participant(s). They were also asked to document the daycare attendance history of their child(ren). Information provided on questionnaires was evaluated for the presence of exposures or medical conditions that might confound vision or neurobehavioral assessment results.

1.4 Ophthalmologic Examination and Vision Testing

All ophthalmologic examinations and visual function testing was performed at the offices of Cornea Consultants of Albany located in Slingerlands, NY under the direction of Robert Schultze, M.D. To ensure that all potential optical and medical confounders known to influence VCS and/or color vision (e.g., glaucoma, diabetes, cataracts and astigmatism) were appropriately considered, evaluations of visual function were conducted in a controlled clinical setting under standardized lighting and testing conditions. Although examiners were not told whether participants worked at or attended the PPDCC, strict “blinding” was not attempted.

Each participant was given a thorough ophthalmologic examination by an ophthalmologist or other eye technician. The exam included determination of past ocular and medical history, measurement of EDTRS visual acuity, pupil size, extraocular motility, and intraocular pressure;

and anterior (slit-lamp) and posterior (fundus) segment exams. For participants with uncorrected acuity worse than 20/25, manifest refraction was performed. If best corrected visual acuity was not better than or equal to 20/25 or if VCS was abnormal, a dilated fundus exam and automated visual field test of the central 30 degrees was performed to document foveolar sensitivity and retinal function.

Visual contrast sensitivity was determined monocularly using the Functional Acuity Contrast Test (F.A.C.T.) distance chart (Stereo Optical Co., Inc. Chicago IL) placed 10 feet from the participant under light conditions specified by the manufacturer. Scores for each eye were recorded on a graph showing a normal range (90% confidence interval) of contrast sensitivities at each spatial frequency which is typically used for clinical interpretation of VCS (Stereo Optical, Inc. 1993). For each participant, the examining ophthalmologist made a judgement as to whether or not VCS was normal or abnormal based on these graphs. Specific contrast values for each frequency, contrast sensitivity combination associated with the F.A.C.T. were used in quantitative analyses of VCS results.

VCS results for all matched pairs of children were analyzed using the Wilcoxon matched-pairs signed-ranks test. For each child VCS scores at each frequency were averaged across eyes and analyses were performed on the average score. Two pairs of PPDCC and comparison children were six years old during vision testing; all other children were seven years old or older. Six-year-old children are sometimes inattentive and perform variably on the VCS test. Therefore exploratory analysis was done excluding pairs which included six-year-olds. VCS results for PPDCC children for whom age- and gender-matched children were not identified (n=4 children) were evaluated qualitatively.

Color vision was assessed using both the Farnsworth D15 and Lanthony's Desaturated 15 Hue Test according to Farnsworth Munsell (D-15d) (Luneau Ophthalmology, Paris France) under light conditions specified by the manufacturer. Both tests were performed monocularly. For both tests, for each eye, participants were shown a rectangular box containing 16 colored caps (about the size of a bottle cap) arranged in chromatic order. The test administrator removed 15 caps, leaving the first as a standard, and randomized them in front of the participant. Participants were asked to place the cap which most closely matched the standard in hue (i.e., color) in the box next to the standard, and to continue the process until all colored caps were in the box. When the participant was done, the order of cap placement was recorded and diagrammed on templates accompanying the tests. Based on review of these charts, the examining ophthalmologist made a judgement as to whether or not color vision was normal or abnormal.

The number of errors for each eye was recorded by noting instances of inversions involving a single cap (a minor error) and instances of inversions involving two or more caps (major errors). Minor errors are common; major errors are less common and are more likely to reflect an acquired color vision deficit (dyschromatopsia). The general type of color vision error was also determined. Color vision defects can be categorized as to whether they reflect deficits in detecting blue-yellow or red-green wavelengths by noting the specific colored caps that an individual inverts or misplaces. The type of color vision deficit most often associated with comparatively high levels of exposure to perc or other solvents is blue-yellow or blue-yellow in combination with red-green. Thus, errors were categorized according to whether they were blue-yellow, red-green, or blue-yellow and red-green.

Perceptual color distances between colored caps were obtained for each eye using the recorded order of color cap placement and published tables of perceptual color distances between caps (Bowman 1982; Geller 2001). A Color Confusion Index (CCI) was also calculated for each eye for each participant according to Geller (2001) and Bowman (1982). CCI is the ratio of participant's TCDS and the TCDS associated with errorless performance, which is 56.4 for Lanthony's desaturated 15 hue test and 116.9 for the Farnsworth D15 test (Bowman 1982; Geller 2001).

Color vision results were evaluated in several ways. Statistical analyses were performed for matched pairs (n=13) only. Proportions of pairs of children with discordant clinical judgements (one abnormal, one normal) and with discordant numbers of major errors (one with no errors, one with at least one error) were assessed using McNemar's Exact Test for Correlated Proportions.

Differences in CCI between matched PPDCC and comparison children were assessed using Wilcoxon matched-pairs signed-rank test. CCI scores averaged across eyes for each child as well as CCI scores for the worst eye of each child were used in analyses since there is evidence that color vision loss can be monocular or asymmetrical. Exploratory analyses excluded six-year-old pairs since children six years and younger sometimes have trouble performing the color vision tests due to inattentiveness associated with their young age.

The general type of color defects noted (e.g., blue-yellow, red-green) for all children, and color vision test results for PPDCC children for whom age- and gender-matched comparison children were not identified (n=4 children) were evaluated qualitatively.

1.5 Neuropsychological Assessment

All neuropsychological evaluations were conducted at the office of Albany Psychological Associates, P.C., in Albany, NY, under the direction of Robert McCaffrey, Ph.D. over the course of two three-hour sessions. Children were administered a battery of standard neuropsychological tests that assess general intellectual functioning, attention/information processing speed, visuospatial ability, reasoning and logical analysis, memory, motor functions, and sensory-perceptual functions. Tests were administered in fixed order on two different days. **Table 1.5-1** summarizes the specific tests administered grouped by the type of CNS function (i.e., the domain) assessed. Children were also administered one symptom validity measure – the Test of Memory Malingering - to assess each child's compliance with testing demands and effort put forth during the testing (Constantinou and McCaffrey 2003). Children also performed portions of the computerized neurobehavioral testing system, Neurobehavioural Evaluation System – 2 (NES-2), which assessed perceptual-motor skills, attention, visual memory, and mood. All children completed the same tests with the exception of the Halstead-Reitan Neuropsychological Batteries. Children age eight or younger were administered the Reitan-Indiana Neuropsychological Test Battery whereas children age nine or older were administered the Halstead-Reitan Neuropsychological Test Battery for Older Children (HRNB-OC).

A parent/guardian for each child completed the Child Behavioral Checklist (CBCL) (Achenbach 2002) a rating scale regarding the child's behavioral and emotional functioning, as well as the background history questionnaire.

The neuropsychological evaluation yielded 204 individual test scores. Only composite scores from the Reitan-Indiana neuropsychological test battery, HRND-OC and WISC III were analyzed. Composite scores are a more reliable basis for statistical comparisons than individual test scores since they are comprised of a number of different scores combined to measure the different areas or domains of cognitive functioning noted in **Table 1.5-2**.

Independent samples t-tests were performed on the scores from the Wechsler Intelligence Scale for Children (WISC-III), Childrens Memory Scale (CMS), HRNB-OC, and Reitan Indiana Neuropsychological Test Battery. (Matched samples t-tests were not completed due to the small number of matched pairs; although 13 children were tested, only eight age- and gender-matched pairs completed at least some portion of the neuropsychological assessment.) Age was significantly correlated with performance on the Purdue Pegboard and the majority of subtests on the NES-2. Therefore, an Analysis of Covariance was completed on each of the subtests from the NES-2 and Purdue Pegboard with age as the covariate. Exploratory analyses excluding two six-year-old PPDCC and comparison children were performed on HRNB-OC and Reitan Indiana composite scores, NES-2 variables, and Purdue Pegboard scores. This was not done for the WISC-III or CMS scores since the scores are age-adjusted.

Each child's performance level on the neuropsychological tests was determined by comparing his/her test score to normative information for the specific test or battery. Normative data for the HRNB-OC and Reitan-Indiana Neuropsychological Test Battery are provided by Reitan and Wolfson (1992a, b). Normative data for the WISC-III and CMS are provided in Wechsler (1991) and Cohen (1997). Normative data for the Purdue Pegboard test are provided for same age and gender children/adolescents by Gardner and Broman (1979). Because there are limited normative data available in the scientific literature for the NES-2, performance of the comparison children was used as the normative base. Scores two standard deviations below the mean of the same age and gender children/adolescents from the normative data were classified as impaired.

The CBLC was scored based upon the normative information provided by the test developer (Achenbach 2002). On this measure, T-scores less than 67 fall within the normal range, T-scores between 67 to 70 fall within the borderline clinical range, and T-scores greater than 70 fall within the clinical range.

2.0 Results

2.1 Recruitment Summary

As illustrated in **Figure 2.1-1a**, 28 children who had attended the PPDCC prior to discovery of perc contamination were considered for participation. Twenty-one children agreed to participate in the follow-up evaluation. One child was ineligible due to health concerns. Twenty children met inclusion criteria and were enrolled. Vision testing occurred in September 2002, November 2002, and March 2003. Seventeen children completed vision testing. Three children were unable to schedule vision appointments. Neurobehavioral testing occurred between August 2002 and July 2003. Thirteen children completed some or all of the neurobehavioral assessment.

As illustrated in **Figure 2.1-1b,** parents/guardians of 45 possible comparison children volunteered their child(ren) for participation. Eleven children were ineligible due to age, medical conditions, or lack of public daycare experience. Thirteen children were not age- or gender-matched to enrolled PPDCC children. Twenty-one children were matched to PPDCC children, but one child refused participation and two were subsequently found to be ineligible. Thus, 18 children were enrolled as comparison children. Five children were unable to schedule vision or neurobehavioral assessment appointments. Thus, 13 matched comparison children completed vision testing and 13 matched comparison children completed some or all neurobehavioral testing.

2.2 Exposure and Questionnaire Analysis

All PPDCC children were offered vision tests and neurobehavioral testing, regardless of whether a matched comparison child was enrolled. All enrolled PPDCC and matched comparison children were encouraged to complete both the vision testing and neurobehavioral assessment portions of the follow-up. Some PPDCC participants completed both portions; some completed only vision testing; and, some completed only neurobehavioral assessment. Thus the total number of matched pairs and total number of child participants completing vision and neurobehavioral assessment is unequal. Thirteen matched pairs completed vision testing; but only eight matched pairs completed neuropsychological testing. Overall, 17 PPDCC and 13 comparison children completed vision testing; and 13 PPDCC and 13 comparison children completed neuropsychological testing.

Characteristics of children completing vision and at least some portion of the neuropsychological assessments are summarized in **Table 2.2-1a** and **2.2-1b**, respectively. Although PPDCC children had generally spent more hours/week and more total hours at daycare than comparison children, these differences were not statistically significant when assessed by Student's t-test. Overall, PPDCC children had spent about 6200-6500 hours (or about three years, assuming 40 hrs/wk, 52 weeks/year) at the PPDCC prior to August 8, 1998 when perc contamination was discovered. About 55-56 months (or about 4 ½ years) had passed since possible perc exposure stopped.

2.3 Visual Function

All children examined were normal upon ophthalmologic exam, with the exception of one comparison child who had slightly increased pressure in the one eye and another with mild blephiritis (inflammation of the eyelid). The examining ophthalmologist concluded these conditions were unlikely to influence VCS or color vision in these subjects.

Ophthalmologic exams indicated VCS for all children in both groups was within the published normal range (Stereo Optical, Inc. 1993) and the examining ophthalmologist considered them all to be clinically normal. Mean VCS scores (± std dev) for matched groups, including and excluding six-year-olds are summarized in **Table –2.3-1**. VCS functions are illustrated in **Figure 2.3-1**.

Table 2.3-1 and **Figure 2.3-1** show that at all frequencies, PPDCC children actually performed better on the VCS test than comparison children. Exclusion of matched pairs including six-year-old children does not alter this overall finding.

VCS of all four unmatched PPDCC children were also within the normal range.

Table 2.3-2 summarizes numbers of discordant and concordant pairs of children based on whether color vision for one or both eyes was judged by the examining ophthalmologist to be abnormal or normal. A discordant pair is one in which one member of the pair is judged to have abnormal color vision and the other one is judged to have normal color vision. A concordant pair is one in which both members of the pair are judged to have either abnormal or normal color vision. There were no significant differences in proportions of children with abnormal color vision between PPDCC and comparison children for either the Farnsworth or Lanthony test as determined by McNemar's Exact Test for correlated proportions.

Table 2.3-3 summarizes numbers of discordant and concordant pairs of children based on the presence or absence of major errors. In this case, a discordant pair is one in which one member of the pair has no errors and the other has one or more major errors. A concordant pair is one in which both members of the pair have no errors or both members of the pair have one or more major errors. There were no significant differences in proportions of children making major errors between PPDCC and comparison children for either the Farnsworth or Lanthony test as determined by McNemar's Exact Test for correlated proportions.

Table 2.3-4a and **2.3-4b** summarize CCI's for each matched pair for the Farnsworth and Lanthony color vision tests, respectively. CCI's for the four unmatched PPDCC children are also included. CCI for the worst eye for each child are presented as well as CCI for the average for both eyes since there is evidence that eyes within the same individual can respond differentially to contaminant exposure. Wilcoxon matched-pairs signed-rank tests (including or excluding six-year-olds; eyes averaged or worst eye only) indicated no significant differences between PPDCC and comparison children on CCI for either the Farnsworth or Lanthony color vision tests.

Farnsworth color vision for two of the four PPDCC children for whom matches were unavailable was judged to be abnormal by the ophthalmologist. Lanthony color vision for all four of the unmatched PPDCC children was judged to be abnormal. **Table 2.3-4a** and **2.3-4b** show that CCI's for these children ranged from 1.0 to 1.8 for the Farnsworth color vision test and from 1.9 to 2.4 for the Lanthony color vision test. With the exception of a single CCI for one eye, these values are within the range observed for the comparison children. So, although these children were not included in statistical analyses, their color vision test performance appears to be similar to that of comparison children matched to other PPDCC children.

Nevertheless, the abnormal Lanthony color vision noted in the four unmatched PPDCC children raised concern that perhaps perc exposure had influenced color vision in these children. To explore this possibility, the statistical association between Lanthony color vision test CCI and hours spent at day care for all 17 PPDCC children was determined using Spearman's correlation coefficient based on ranks. The correlation coefficient (0.170) was not significant (p=0.51) indicating that Lanthony color vision test scores were not significantly associated with the number of hours spent at the PPDCC before August 8, 1998 (i.e. the number of hours exposed to perc). This supports the notion that CCI is unrelated to exposures to perc, i.e., there is no association between CCI and perc exposure.

All PPDCC and comparison children, including the four unmatched PPDCC children, making errors tended to make blue-yellow errors or blue-yellow errors in combination with red-green errors. Thus there did not appear to be a difference in the type of errors made between PPDCC and comparison children.

2.4 Neuropsychological Function

Thirteen PPDCC and 13 comparison children completed at least a portion of neurobehavioral testing. Two PPDCC children completed only the first day of neurobehavioral testing. Data for these two children are therefore limited to the CMS, motor testing from the HRNB-OC or the Reitan-Indiana Neuropsychological Test Battery, the Purdue Pegboard, and portions of the WISC-III. Three PPDCC children did not complete the NES-2 (two of these children could not be scheduled; data for the third child could not be obtained due to equipment failure), and NES-2 data for a fourth PPDCC child was lost. For one comparison child, data for one visual memory test was unuseable; therefore the Visual Immediate Index, Visual Delayed Index, and General Memory Index could not be calculated.

As shown in **Table 2.4-1** there were no statistically significant differences between PPDCC and comparison children on any measure of neuropsychological function. Nor were there significant differences between groups when six-year-olds were excluded from analyses (data not shown). The difference between groups approached significance on the Right/Left Differences Summary Scale from the HRNB-OC; WISC-III Full Scale IQ, Performance IQ, and Perceptual Organization Index; the Pattern Memory subtest (number correct) from the NES-2; and the Total Disorders scale from the CBLC. On each of these measures, the PPDCC children performed better than the control children.

Table 2.4-2 illustrates that summary scores of all 13 PPDCC children and nearly all the comparison children on the Reitan-Indiana Neuropsychological Test Battery or the HRNB-OC fell within the normal range. When individual performance on specific tests within these test batteries was compared to normative values, most PPDCC and comparison children evaluated fell within the normal range. However, an equal but small number of PPDCC and comparison children performed within the impaired range on motor testing. In addition, a very small number of PPDCC and comparison children performed within the impaired range on a measure of abstraction and reasoning. Finally, a very small number of PPDCC children performed poorly on copying geometric designs which is a measure of visuospatial ability. Despite their low performance on a specific test within one of these test batteries, each of these children's overall performance fell within the normal published range, and was not indicative of neurological impairment.

Table 2.4-3 illustrates that on tasks measuring general intellectual function (WISC-III tasks), individual scores for both PPDCC and comparison children ranged from average to very superior. Mean scores for the PPDCC group also ranged from high average to superior. Mean socres of the comparison group were high average. Table 10 also illustrates that on tasks measuring memory (Children's Memory Scales), PPDCC children scored in the low average to very superior range; comparison children scored in the borderline (low average) to very superior range. Mean scores for PPDCC children ranged from high average to superior; mean scores for comparison children ranged from average to superior.

Table 2.4-4 shows that mean performance of the PPDCC and comparison children on the Purdue Pegboard test fell within the average range for the dominant and nondominant hands. Mean performance fell within the low average to average range on the trials using both hands.

A very small number of the PPDCC children performed within the impaired range on both the number of omission errors and number of false positive errors on the Continuous Performance Test (CPT) from the NES-2. There were no other scores at this impairment level across the tests administered from the NES-2.

None of the exposed children obtained scores within the clinically significant range on the Childrens Behavioral Checklist. Their parents did not indicate clinically significant emotional or behavioral problems.

3.0 Discussion

No adverse effects on visual function were detected among PPDCC children in this follow-up evaluation.

Seventeen PPDCC children from a group of 28 children with the greatest possible exposures to perc had normal VCS when tested about 55 months (4 ½ years) after exposure stopped. In fact, PPDCC children actually performed better than matched comparison children.

Color vision of the PPDCC children evaluated in this follow-up evaluation did not differ significantly from color vision of the age- and gender-matched comparison children. This was true for both the Farnsworth and Lanthony color vision tests and for all measures of color vision -- normal/abnormal clinical judgements, numbers of major errors; and, average or worst CCI's. Additionally, color vision, reflected by performance on the Lanthony color vision test, was unrelated to a measure of perc exposure, i.e., number of hours spent at the PPDCC prior to August 8, 1998.

It is not possible to compare VCS or color vision of the children evaluated in this follow-up evaluation with their VCS or color vision at the time of the original PPDCC investigation. Children participating in the follow-up evaluation were all less than six years old at the time of the original investigation and so were too young to perform these tests. It can only be concluded that visual function, including VCS and color vision, of the PPDCC children evaluated in this follow-up evaluation appears normal about 4 ½ years after exposure to 1,800 to 2,400 ug/m^3 perc for a period averaging about three years.

As a group, neuropsychological function of the 13 PPDCC children evaluated did not differ significantly from neurobehavioral function of the 13 comparison children evaluated. Differences between PPDCC and comparison children approached significance on several individual measures of neurobehavioral function with the PPDCC children performing better than the comparison children. Additionally, PPDCC children performed well within normative ranges when performance on neurobehavioral tests was compared to published normative ranges for the tests used. Further, parents' responses on the Child Behavior Checklist indicated that PPDCC children had no clinically significant emotional or behavioral problems. Based on these findings, neuropsychological function among the small group of PPDCC children tested has not been adversely impacted by exposure to perc.

It is not possible to compare neuropsychological function of the group of children evaluated in this follow-up evaluation with neuropsychological function of children evaluated at the time of the original PPDCC investigation. The spectrum of tests administered was different and the ages of the children evaluated were different. However, in both cases PPDCC children showed no adverse neuropsychological effects due to perc exposure, and, in fact, for many specific tests actually performed better than their matched comparison groups.

4.0 Conclusions

This follow-up evaluation included children enrolled in the NYS VOC Exposure Registry who had possibly experienced perc exposures in the 1,800-2,400 ug/m3 range while attending a daycare center. They averaged about nine to ten years old at the time of the follow-up and had been exposed to perc for an average of about three years while attending preschool at the PPDCC.

VCS was clinically normal in all PPDCC and comparison children. There were no statistically significant differences in VCS scores between matched pairs of PPDCC and comparison children. PPDCC children actually performed significantly better at a single VCS frequency.

Color vision was clinically abnormal in some PPDCC and some comparison children. There were no significant differences in color vision between matched pairs of PPDCC and comparison children. Analysis of the correlation between hours spent at the PPDCC (i.e., exposed to perc) and color vision showed that color vision test performance was not related to this measure of perc exposure.

Neuropsychological function of the PPDCC children was in the average to superior range and did not differ significantly from neuropsychological function of the comparison children.

NYSDOH AND NYSDEC REVIEW OF PERC LEVELS IN BUILDINGS WITH CO-LOCATED DRY CLEANERS

The NYSDOH and NYSDEC compiled information on indoor perc levels measured in residences and businesses co-located with perc dry cleaners and dry cleaner facility characteristics available from files and databases maintained by the NYSDEC, NYCDOHMH and NYCDEP. Although the data available were not collected for the purpose of evaluating the effect of state dry cleaner regulations on reducing perc exposures in mixed-use buildings containing dry cleaners, they are of use in evaluating overall trends in indoor air perc levels within New York State with respect to dry cleaner regulation implementation and/or dry cleaner operating characteristics. Summaries of these data were provided to the U.S. EPA Office of Air Quality Planning and Standards.

In 1997 NYS DEC adopted dry cleaner regulations that are more stringent than the National Emission Standard for Hazardous Air Pollutants (NESHAP) for Source Categories: Perchloroethylene Dry Cleaning Facilities rule promulgated by the U.S. EPA. These regulations (i.e., 6NYCRR Part 232) included gradually more restrictive controls over fugitive perc emissions over the 1997 to 2003 period. **NTable 1.0-1** presents seven key regulatory time periods pertaining to dry cleaners in NYS and the requirements phased-in under Part 232.

NFigure 1.0-1 is a scatterplot of all indoor air perc data collected in co-located areas for facilities statewide and illustrates the gradually declining perc levels from before implementaion of 6NYCRR Part 232 to the present.

Other information provided to EPA included 1) a summary of indoor per concentrations measured statewide in co-located buildings and associated descriptive statistics during the 7 key regulatory time periods**;** 2) a list of mixed-use NYC facilities for which indoor perc measurements exceeded the NYSDOH residential perc guideline of 100 μg/m3 on at least one occasion and that were sampled during at least three regulatory time periods; 3) 10 randomly selected mixed-use NYC dry cleaners sampled during each regulatory time period (69 unique facilities total) selected for further investigation; 4) a summary of facility characteristics of the dry cleaners included in the NYC Perc project (24 facilities); 5) a summary of dry cleaners in small business centers (strip malls); and 6) a subset of data from NFigure 1.0-1 for which indoor air levels exceeded 5,000 ug/m3 in co-located areas after 1999. This information should be useful to the U.S. EPA as the residual risk assessment for perc required under the NESHAP for Source Categories: Perchloroethylene Dry Cleaning Facilities is completed.

REFERENCES

ACGIH (2001) Tetrachloroethylene Biological Exposure Index. American Conference of Governmental Industrial Hygienists, Cincinnati Ohio.

Achenbach, T.M. (2002) Child Behavior Checklist. Burlington, VT: University of Vermont Department of Psychiatry.

Agency for Toxic Substances and Disease Registry (1995) Adult Environmental Neurobehavioral Test Battery (Amler, RW; Anger WK; Sizemore OJ, Eds.).U.S. Department of Health and Human Services, Atlanta GA

Agency for Toxic Substances and Disease Registry (1996) Pediatric Environmental Neurobehavioral Test Battery (Amler, RW; Gibertini, M, Eds.).U.S. Department of Health and Human Services, Atlanta GA

Amin TA, Bindra S, Narang RS. (1998) Evaluation of passive samplers for analysis of chlorinated solvents. J AOAC INT 81: 1027-1032.

Ashley, DL, Bonin, MA, Cardinali, FL, McCraw, J.M, and Wooten, JV (1994) "Blood concentrations of volatile organic compounds in a nonoccupationally exposed US population and in groups with suspected exposure", Clin Chem 40: 1401-1404.

Bowman, KJ (1982) A method for quantitative scoring of the Farnsworth Panel D-15. Acta Opthalmol 60:907-916.

Cardinali, FL, Ashley, DL, Wooten, JV, McCraw, J.M, and Lemire, SW (2000) The use of solid-phase microextraction in conjunction with a benchtop quadrupole mass spectrometer for the anlysis of volatile organic compounds in human blood at the low parts-per-trillion level. J Chrom Sci 38:49-54.

Cardinali FL., McCraw JM, Ashley DL, Bonin M, Wooten, J. (1995) Treatment of vacutainers for use in the analysis of volatile organic compounds in human blood at the low parts-per trillion level. J Chrom Sci 33:557-560.

Castillo L, Baldwin M, Sassine M.-P, Mergler D. 2001. Cumulative exposure to styrene and visual functions. Am J Ind Med 39:351-360.

Chen, HI, Paschal, DC, Miller, DT, Morrow, JC. (198) Determinatin of total and inorganic mercury in whol blood by on-line digestion with flow injection Atom Spec 19:176-179.
Chen et al. 1998

Churchill, JE, Kaye, WE, and Ashley, DL (2001) "Recent chemical exposures and blood volatile organic compound levels in a large population-based sample", Arch Environ Health, 56:157-166.

Cohen, MJ (1997). Children's Memory Scale Manual. San Antonio, TX: The Psychological Corporation.

Constantinou, M and McCaffrey, RJ. 2003. Using the TOM for evaluating children's effort to perform optimally n neuropsychological measures. Child Neuropsychol. 9:81-90.

Dallas, CE, Muralidhara, S, Chen, XM, Ramanathan, R, Varkonyi, P, Gallo, JM, Bruckner JV (1994) Use of a physiologically based model to predict systemic uptake and respiratory elimination of perchloroethylene Toxicol and Appl Pharmacol 128:60-68.

Evans, G.W. and Kantrowitz, E. (2002) "Socioeconomic status and health: the potential role of environmental risk exposure", *Annu Rev Pub Health*, **23**, 303-331.

Frenette, B.; Mergler, D.; Bowler, R. (1991) Contrast-sensitivity loss in a grouop of former microelectronics workers with normal visual acuity. Optom. Vis. Sci. 68(7):556-560.

Gardner, R.A., & Broman M. (1979). The Purdue Pegboard: Normative data on 1334 school children. Journal of Clinical Child Psychology, 8, 156-162.

Geller AM. 2001. A table of color distance scores for quantitative scoring of the Lanthony Desaturate color vision test. Neurotoxicol Teratol 23:265-267.

Gobba, F., Righi, E., Fantuzzi, G., Rocccatto, L., Predieri, G., and Aggazzotti, G. (2003) "Perchloroethylene in alveolar air, blood, and urine as biologic indices of low-level exposure", *J Occup Environ Med*, **45**, 1152-1157.

Gong, Y, Kishi, R, Kasai, S, Katakura, Y, Fujiwara, K, Umemura, T, Kondo, T, Sata, T, Sata, F, Tsukishima, E, Tozaki, S, Kawai, T, Miyama, Y (2004) Visual dysfunction in workers exposed to a mixture of organic solvents NeuroToxicol 24:703-710.

Guillemin, M. and Gubéran, E. (1982) Value of the simultaneous determination of PCO2 in monitoring exposure to 1,1,1-trichloroethane by breath analysis. Brit J Ind Med, 39:161-168.

Guyton, A.C. and Hall, J.E. (1996) *Textbook of Medical Physiology, 9th Ed.,* Philadelphia, W.B. Saunders Company.

International Agency for Research on Cancer (1995) *Drycleaning, some chlorinated solvents and other industrial chemicals.* IARC monographs of the evaluation of carcinogenic risks to humans, **63**, 159-221.

Mergler, D.; Huel, G.; Bowler, R.; Frenette, B.; Cone, J. (1991) Visual dysfunction among former microelectronics assembly workers. Arch. Environ. Health 46(6):326-334

Miller, DT, Paschal, DC, Gunter, EW, Stroud, PE, D'Angelo, J (1987) Determination of lead in blood using electrothermal atomization atomic absorption spectrometry with L'vov platform and matrix modifier Analyst 112:1701-1704.

Needham, L.L., and Sexton, K. (2000) Assessing children's exposure to hazardous environmental chemicals: an overview of selected research challenges and complexities J Expo Anal Environ Epidemiol 10:611-629.

New York State Department of Environmental Conservation (2003) DEC Policy. CP-29 Environmental Justice and Permitting. Available: http://www.dec.state.ny.us/website/ ej/ejpolicy.html

New York State (1997) Part 232-Perchloroethylene Dry Cleaning Facilities. New York Codes, Rules and Regulations (6NYCRR). Environmental Conservation Rules and Regulations. 2351-2354. Available: http://www.dec.state.ny.us/ website/regs/232.htm

New York State Department of Health (1999) Pumpkin Patch Day Care Center Investigation. Public Review Draft. Albany NY:Center for Environmental Health. Bureau of Toxic Substance Assessment.

New York State Department of Health (2004) Pumpkin Patch Day Care Center Investigation. Final Report. Albany NY:Center for Environmental Health. Bureau of Toxic Substance Assessment.

Northridge, ME, Stover, GN, Rosenthal, JE, Sherard, D (2003) Environmental equity and health: understanding complexity and moving forward Am J Pub Health 93:209-214.

Opdam, J.J.G. and Smolders, J.F.J. (1986) Alveolar sampling and fast kinetics of tetrachloroethene in man. I. Alveolar sampling Br J Ind Med 43:814-824.

Paramei, GV, Meyer-Baron, M, Seeber, A (2004) Impairments of colour vision induced by organic solvents: a meta-analysis study NeuroToxicol 25:803-816.

Pellizzari, ED, Perritt, RL, Clayton, CA (1999) National human exposure assessment survey (NHEXAS): exploratory survey of exposure among population subgroups in EPA Region V J Exp Anal Environ Epidem 9:49-55.

Pesudovs, K, Hazel, CA, Doran, RML, Elliott, DB (2004) The usefulness of Vistech and FACT contrast sensitivity charts for cataract and refractive surgey outcomes research Br J Ophthalmol 88:11-16

Raymer, JH, Pellizzari, ED, Thomas, KW, Cooper, SD (1991) Eliminaiton of volatile organic compounds in breath after exposure to occupatinal and environmental microenvironments J Exp Anal Environ Epi 1:439-451.

Reitan, R.M. & Wolfson, D. (1992). Neuropsychological evaluation of young children. Tucson, AZ: Neuropsychology Press.

Reitan, R.M., & Wolfson, D. (1992) Neuropsychological evaluation of older children. Tucson, AZ: Neuropsychology Press.

Rosner, B. Fundamentals of Biostatistics, Fourth Edition. (1995) Wadsworth Publishing Company, Belmont CA

Schaper, M, Demes, P, Kiesswetter, Zupanic, M, Seeber, A (2004) Colour vision and occupational toluene exposure: results of repeated examinations Toxicol Lett 151:193-202.

Schreiber JS, Hudnell, HK, Geller AM, House DE, Aldous KM, Force ME, Langguth KW, Prohonic EJ, Parker, JC. 2002. Apartment residents' and day care workers' exposures to etrachloroethylene and deficits in visual contrast sensitivity. Environ Health Perspect 110:655-664.

Schwenk, M, Gundert-Remy, U, Heinemeyer, G, Olejniczak, K, Stahlmann, R, Kaufmann, W, Bolt, H.M, Greim, H, von Keutz, E, Gelbke, HP (2003) Children as a sensitive subgroup and their role in regulatory toxicology: DGPT workshop report Arch Toxicol 77:2-6.

Sexton, K, Adgate, JL, Church, TR, Hecht, SS, Ramachandran, G, Greaves, IA, Fredrickson, AL, Ryan, AD, Camella, SG, Geisser, MS (2004) Children's exposure to environmental tobacco smoke: using diverse exposure metrics to document ethnic/racial differences Environ Hlth Persp 112;392-397.

Sexton, K, Wagener, DK, Selevan, SG, Miller, TO, Lybarger JA (1994) An inventory of human exposure related data bases J Expo Anal Environ Epiodemiol 4:95-109.

Sexton, K, Olden, K, Johnson, BL (1993) "Environmental justice": the cenral role of research in establishing a credible scientific foundation for informared decision making Toxicol Ind Hlth 9:685-727

Shah JJ, Heyerdahl EK. (U.S. Environmental Protection Agency) 1988. National ambient volatile organic compounds (VOCs) database update.

Snodgrass, WR (1992) Physiological and biochemical differences between children and adults as determinants of toxic response to environmental pollutants IN: Similarities and Differences beween children and adults: implications for risk assessment (eds. Philip S. Guzelian, Carol J. Henry, and Stephen s. Olin), International Life Sciences Institute, ILSI Press Washington DC

Stein, VB, Narang, RS, Wilson, L, Aldous, KM (1996) A simple, reliable method for the determination of chlorinated volatile organic in human breath and air using glass sampling tubes J Anal Toxicol 20;145-150.

Stein, J, Schettler, T, Wallinga, D, Valenti, M (2002) In harm's way: toxic threats to child development J Dev Behav Pediatr 23(1 Suppl):S13-22.

Storm JE, Mazor KA. 2004. Update of residential tetrachloroethylene exposure and decreases in visual contrast sensitivity (VCS). Environmental Health Perspectives (112):A862-864.

U.S. Census Bureau. 2002. Census 2000 Summary File 1 and 3 (SF1 and 3) Technical Documentation. Washington, DC.

U.S. Postal Service 2000. New York Zip+4 State Directory, Volume III of IV, Long Eddy thru Ozone Park. Memphis, Tennessee

Wechsler, D. (1991). WISC-III Manual. San Antonio, TX: The Psychological Corporation.

Westgard JO, Barry, PL, Hunt, MR, Groth, A (1981) A multi-rule Shewhart chart for quality control in clinical chemistry. Clin Chem 27:493-501.

APPENDIX

Table 1.5-1. Summary of Analytes – NYC Perc Project

Indoor Air	Exhaled Breath	Blood
Perc	Perc	Perc
1,1,1-trichloroethane	carbon dioxide	1,1,1-trichloroethane
1,4-dichlorobenzene		1,1,2,2-tetrachloroethane
benzene	Exploratory only:	1,1,2-trichloroethane
carbon tetrachloride	1,1,1-trichloroethane	1,1-dichloroethane
ethylbenzene	carbon tetrachloride	1,1-dichloroethene
trichloroethene	trichloroethene	1,2-dichlorobenzene
toluene		1,2-dichloroethane
m-,p-xylene		1,2-dichloropropane
o-xylene		1,3-dichlorobenzene
styrene		1,4-dichlorobenzene
		2,5-dimethylfuran
		benzene
		bromodichloromethane
		bromoform
		carbon tetrachloride
		chlorobenzene
		chloroform
		cis-1,2-dichloroethene
		dibromochloromethane
		dibromomethane
		ethylbenzene
		hexachloroethane
		m-,p-xylene
		methylene chloride
		o-xylene
		xtyrene
		tert-butyl-methyl-ether
		toluene
		trans-1,2-dichloroethene
		trichloroethene
		lead
		mercury

Table 3.1-1.

Residential Buildings Characterized and Sampled - NYCity Perc Project

	Initial Strategy*							Modified Strategy**						
	xxxxxxxxxxx	10026	10029	10035	10128	10021		10010	10022	10023	10024	10019	10009	Total
Total Dry Cleaner Facilities	**44**	**60**	**8**	**27**	**7**	**63**	**147**	**25**	**52**	**46**	**41**	**3**	**-**	**523**
On-site (complaint)	2	4	-	-	-	4	9	2	4	3	3	2	-	**33**
On-site (no complaint)	23	20	3	11	2	14	27	7	18	9	13	-	-	**147**
Drop-off	13	28	3	14	3	32	92	16	30	33	25	1	-	**290**
Unknown	6	8	2	2	2	13	19	-	-	1	-	-	-	**53**
Dry Cleaner Facilities Surveyed	**36**	**47**	**6**	**21**	**3**	**48**	**99**	**2**	**4**	**11**	**2**	**3**	**-**	**282**
On-site (complaint)	2	4	-	-	-	4	9	2	4	3	2	2	-	**32**
On-site (no complaint)	23	20	3	11	2	14	25	-	-	6	-	-	-	**104**
Drop-off	6	15	1	9	-	17	52	-	-	2	-	1	-	**103**
Unknown	5	8	2	1	1	13	13	-	-	-	-	-	-	**43**
Dry Cleaner Buildings Surveyed Meeting Inclusion Criteria	**14**	**15**	**2**	**7**	**2**	**14**	**22**	**2**	**3**	**3**	**1**	**2**	**-**	**87**
On-site (complaint)	2	4	-	-	-	4	8	2	3	2	1	2	-	**28**
On-site (no complaint)	12	10	2	7	2	8	13	-	-	1	-	-	-	**55**
Drop-off	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Unknown	-	1	-	-	-	2	1	-	-	-	-	-	-	**4**
Dry Cleaner Buildings Recruitment Attempted	**19**	**14**	**2**	**8**	**2**	**27**	**15**	**2**	**3**	**1**	**1**	**-**	**-**	**94**
On-site (complaint)	2	4	-	-	-	4	8	2	3	1	1	-	-	**25**
On-site (no complaint)	12	6	2	8	2	9	4	-	-	-	-	-	-	**43**
Drop-off	5	4	-	-	-	12	2	-	-	-	-	-	-	**23**
Unknown	-	-	-	-	-	2	1	-	-	-	-	-	-	**3**
Dry Cleaner Buildings Sampled	**10**	**2**	**2**	**5**	**1**	**2**	**4**	**1**	**2**	**-**	**-**	**-**	**-**	**29**
On-site (complaint)	1	-	-	-	-	1	4	1	2	-	-	-	-	**9**
On-site (no complaint)	5	1	2	5	1	1	-	-	-	-	-	-	-	**15**
Drop-off	4	1	-	-	-	-	-	-	-	-	-	-	-	**5**
Dry Cleaner Households Sampled	**32**	**5**	**10**	**11**	**1**	**5**	**4**	**3**	**3**	**-**	**-**	**-**	**-**	**74**
On-site (complaint)	7	-	-	-	-	4	4	3	3	-	-	-	-	**21**
On-site (no complaint)	17	4	10	11	1	1	-	-	-	-	-	-	-	**44**
Drop-off	8	1	-	-	-	-	-	-	-	-	-	-	-	**9**
Control Buildings Identified	**48**	**69**	**16**	**36**	**5**	**68**	**43**	**3**	**3**	**1**	**1**	**-**	**-**	**293**
Control Buildings Sampled	**8**	**4**	**6**	**9**	**-**	**6**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**36**
Control Households Sampled	**16**	**5**	**8**	**14**	**-**	**9**	**5**	**4**	**-**	**-**	**-**	**-**	**-**	**61**

*Initial Strategy - Survey and sample all dry cleaner buildings
**Modified Strategy - Survey and sample dry cleaner buildings which have complaints and are using Perc on-site
Pilots are included in this table

Created: 2/22/2005
Table 3.1-1. Buildings Sampled.xls

Table 3.1-1.

Residential Buildings Characterized and Sampled - NYCity Perc Project

	Initial Strategy*							Modified Strategy**						
	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	xxxxx	**Total**
Total Dry Cleaner Facilities	**44**	**60**	**8**	**27**	**7**	**63**	**147**	**25**	**52**	**46**	**41**	**3**	**-**	**523**
On-site (complaint)	2	4	-	-	-	4	9	2	4	3	3	2	-	**33**
On-site (no complaint)	23	20	3	11	2	14	27	7	18	9	13	-	-	**147**
Drop-off	13	28	3	14	3	32	92	16	30	33	25	1	-	**290**
Unknown	6	8	2	2	2	13	19	-	-	1	-	-	-	**53**
Dry Cleaner Facilities Surveyed	**36**	**47**	**6**	**21**	**3**	**48**	**99**	**2**	**4**	**11**	**2**	**3**	**-**	**282**
On-site (complaint)	2	4	-	-	-	4	9	2	4	3	2	2	-	**32**
On-site (no complaint)	23	20	3	11	2	14	25	-	-	6	-	-	-	**104**
Drop-off	6	15	1	9	-	17	52	-	-	2	-	1	-	**103**
Unknown	5	8	2	1	1	13	13	-	-	-	-	-	-	**43**
Dry Cleaner Buildings Surveyed Meeting Inclusion Criteria	**14**	**15**	**2**	**7**	**2**	**14**	**22**	**2**	**3**	**3**	**1**	**2**	**-**	**87**
On-site (complaint)	2	4	-	-	-	4	8	2	3	2	1	2	-	**28**
On-site (no complaint)	12	10	2	7	2	8	13	-	-	1	-	-	-	**55**
Drop-off	-	-	-	-	-	-	-	-	-	-	-	-	-	**0**
Unknown	-	1	-	-	-	2	1	-	-	-	-	-	-	**4**
Dry Cleaner Buildings Recruitment Attempted	**19**	**14**	**2**	**8**	**2**	**27**	**15**	**2**	**3**	**1**	**1**	**-**	**-**	**94**
On-site (complaint)	2	4	-	-	-	4	8	2	3	1	1	-	-	**25**
On-site (no complaint)	12	6	2	8	2	9	4	-	-	-	-	-	-	**43**
Drop-off	5	4	-	-	-	12	2	-	-	-	-	-	-	**23**
Unknown	-	-	-	-	-	2	1	-	-	-	-	-	-	**3**
Dry Cleaner Buildings Sampled	**10**	**2**	**2**	**5**	**1**	**2**	**4**	**1**	**2**	**-**	**-**	**-**	**-**	**29**
On-site (complaint)	1	-	-	-	-	1	4	1	2	-	-	-	-	**9**
On-site (no complaint)	5	1	2	5	1	1	-	-	-	-	-	-	-	**15**
Drop-off	4	1	-	-	-	-	-	-	-	-	-	-	-	**5**
Dry Cleaner Households Sampled	**32**	**5**	**10**	**11**	**1**	**5**	**4**	**3**	**3**	**-**	**-**	**-**	**-**	**74**
On-site (complaint)	7	-	-	-	-	4	4	3	3	-	-	-	-	**21**
On-site (no complaint)	17	4	10	11	1	1	-	-	-	-	-	-	-	**44**
Drop-off	8	1	-	-	-	-	-	-	-	-	-	-	-	**9**
Control Buildings Identified	**48**	**69**	**16**	**36**	**5**	**68**	**43**	**3**	**3**	**1**	**1**	**-**	**-**	**293**
Control Buildings Sampled	**8**	**4**	**6**	**9**	**-**	**6**	**1**	**2**	**-**	**-**	**-**	**-**	**-**	**36**
Control Households Sampled	**16**	**5**	**8**	**14**	**-**	**9**	**5**	**4**	**-**	**-**	**-**	**-**	**-**	**61**

*Initial Strategy - Survey and sample all dry cleaner buildings
**Modified Strategy - Survey and sample dry cleaner buildings which have complaints and are using Perc on-site
Pilots are included in this table

Created: 2/22/2005
Table 3.1-1. Buildings Sampled.xls

Table 3.1-4a. Level of effort (LOE) and cost associated with contacting households to determine eligibility.

Recruitment method	Households: Total	Households: Contacted	Contact proportion[a]	LOE (hr)	LOE (hr) / household[b]	Cost	Cost / household[b]
Combined	5995	2513	0.42	742	0.29	$41,311	$16
Dry Cleaner	2780	1261	0.45				
Reference	3215	1252	0.39				
Mail/Telephone	5341	2138	0.40	403	0.19	$28,858	$13
Dry Cleaner	2611	1159	0.44				
Reference	2730	979	0.36				
Door to Door	654	375	0.57	339	0.90	$12,453	$33
Dry Cleaner	169	102	0.60				
Reference	485	273	0.56				

[a]Households contacted / Total households.
[b]LOE or cost / Households contacted.

Table 3.1-4b. Level of effort (LOE) and cost associated with participating households.

Recruitment method	Households: Eligible	Households: Participating	Participation proportion[a]	LOE (hr)	LOE (hr) / household[b]	Cost	Cost / household[b]
Combined	169	126	0.75	742	6	$41,311	$328
Dry Cleaner	89	65	0.73				
Reference	80	61	0.76				
Mail/Telephone	117	82	0.70	403	5	$28,858	$352
Dry Cleaner	66	43	0.65				
Reference	51	39	0.76				
Door to Door	52	44	0.85	339	8	$12,453	$283
Dry Cleaner	23	22	0.95				
Reference	29	22	0.76				

[a]Households participating / Households eligible.
[b]LOE or cost / Households participating.

Table 3.1-5a. Household and individual level demographic and socioeconomic characteristics for participants in buildings with (exposed) and without (non-exposed) dry cleaners.

Household Level	Dry Cleaner (n=65)	Reference (n=61)	*p* value	Summary
Self reported characteristics				
Race/ethnicity			0.0721	NS
African American (%)	12.3	19.7		
Hispanic (%)	20.0	21.3		
White (%)	47.7	54.1		
Other (%)[a]	20.0	4.9		
Reported income			0.0498*	
<$15,000 (%)	10.7	16.4		
$15,000 to $29,999 (%)	6.1	11.5		
$30,000 to $44,999 (%)	3.1	8.2		
$45,000 to $59,999 (%)	9.2	1.6		
>$60,000 (%)	43.1	50.8		
No response (%)	27.7	11.5		
Primary Language			0.0726	NS
English (%)	83.1	93.2		
Spanish (%)	16.9	6.6		
Individual Level				
Adults	67	61		
Age	41.7 ± 0.9	43.3 ± 1.0	0.2726	NS
Gender (% female)	74.6	88.5	0.0442*	
Currently employed (%)[b]	64.6	64.4	0.9807	NS
Length of residency (yr)	10.3 ± 0.9	10.3 ± 0.9	0.9880	NS
Years of education[b]	14.9 ± 0.5	15.3 ± 0.4	0.5281	NS
Children	68	71		
Age	9.5 ± 0.3	10.0 ± 0.3	0.3226	NS
Gender (% female)	55.8	40.8	0.0761	NS
Length of residency (yr)	7.7 ± 0.4	8.4 ± 0.4	0.2835	NS
Years of education	4.6 ± 0.3	4.2 ± 0.3	0.4037	NS

[a]Includes Chinese, Japanese American Indian, Jewish and those reporting more then one race/ethnicity.
[b]Reported for 65 exposed and 59 non-exposed participants.
*Significantly different ($p < 0.05$).

Table 3.1-5b. Household and individual level demographic and socioeconomic characteristics for exposed and non-exposed participants within recruitment method.

Recruitment Method	Mail/Telephone			Door to Door		
Household Level	Dry Cleaner (n=43)	Reference(n=37)	*p* value	Dry Cleaner (n=22)	Reference (n=22)	*p* value
Self reported characteristics						
Race/ethnicity			0.0915			0.3292
African American (%)	-	5.1		36.4	45.5	
Hispanic (%)	2.3	2.6		54.6	54.6	
White (%)	72.1	84.6		-	-	
Other (%)[a]	25.6	7.7		9.1	-	
Reported income			0.1026			0.2226
<$15,000 (%)	-	-		31.8	45.6	
$15,000 to $29,999 (%)	2.3	-		13.6	31.8	
$30,000 to $44,999 (%)	2.3	10.3		4.6	4.6	
$45,000 to $59,999 (%)	11.6	2.6		4.6	-	
>$60,000 (%)	65.1	79.5		-	-	
No response (%)	18.6	7.7		45.6	18.2	
Language			NA			0.0260*
English (%)	100.0	100.0		50.0	81.8	
Spanish (%)	-	-		50.0	18.1	
Individual Level						
Adults	44	39		23	22	
Age	45.8 ± 0.9	45.7 ± 0.9	0.9632	34.0 ± 1.3	39.0 ± 2.1	0.0478*
Gender (% female)	72.7	84.6	0.1896	78.3	95.5	0.0899
Currently employed (%)[b]	51.6	48.4	0.6608	55.6	44.4	0.6232
Length of residency (yr)	10.4 ± 1.2	8.6 ± 0.9	0.2259	10.0 ± 1.6	13.3 ± 1.7	0.1812
Years of education[b]	16.7 ± 0.4	16.2 ± 0.4	0.5559	11.1 ± 0.7	12.0 ± 0.5	0.3460
Children	41	42		27	29	
Age	8.7 ± 0.4	10.0 ± 0.5	0.5392	9.4 ± 0.5	10.0 ± 0.5	0.4167
Gender (% female)	42.9	53.7	0.3248	59.3	37.9	0.1105
Length of residency (yr)	7.8 ± 0.6	7.8 ± 0.6	0.9607	7.5 ± 0.7	9.2 ± 0.6	0.0651
Years of education	4.3 ± 0.4	4.7 ± 0.5	0.5291	4.0 ± 0.5	4.4 ± 0.5	0.5877

[a]Includes Chinese, Japanese American Indian, Jewish and those reporting more then one race/ethnicity.
[b]Current employment and years of education information was not collected for two exposed and non-exposed adults participants recruited using DD.
*Significantly different (p <0.05).

Table 3.1-6. Significant Correlations Between Socioeconomic and Other Characteristics

	Race/ethnicity			Language Spoken at Home			Age			Years of School			Drinks/week		
	n	Corr Coeff	p value	n	Corr Coeff	p value	n	Corr Coeff	p value	n	Corr Coeff	p value	n	Corr Coeff	p value
Reference Adults															
Annual Income Range	59	-0.83	<0.01	58	-0.53	<0.01	52	0.35	0.01	58	0.74	<0.01	56	0.62	<0.01
Race/ethnicity				59	0.49	<0.01	53	-0.37	<0.01	59	-0.72	<0.01	57	-0.59	<0.01
Language Spoken at Home										59	-0.44	<0.01	57	-0.32	0.02
Age										53	0.43	<0.01	51	0.42	<0.01
Years of School													57	0.47	<0.01
Cigarettes/day													56	0.39	<0.01
Dry Cleaner Building Adults															
Annual Income Range	59	-0.65	<0.01	57	-0.6	<0.01	53	0.56	<0.01	57	0.68	<0.01	57	0.33	0.01
Race/ethnicity				65	0.52	<0.01	61	-0.52	<0.01	65	-0.52	<0.01			
Language Spoken at Home							60	-0.36	<0.01	65	-0.47	<0.01	65	-0.29	0.02
Age										60	0.49	<0.01	60	0.29	0.02
Years of School													65	0.4	<0.01
Reference Children															
Annual Income Range	70	-0.84	<0.01	70	-0.41	<0.01									
Race/ethnicity				71	0.38	<0.01									
Age										63	0.98	<0.01			
Dry Cleaner Building Children															
Annual Income Range	60	-0.65	<0.01	59	-0.58	<0.01									
Race/ethnicity				67	0.47	<0.01									
Age										64	0.89	<0.01			

Table 3.2.1. Perc levels (ug/m^3) in residential dry cleaner buildings.

Building Designation	Building Census Block Group Category: Low Income	Building Census Block Group Category: Minority	Building Prior Complaint	Number of Floors	Floor(s) sampled	Perc (ug/m^3): Mean Apartment Level [a]	Perc (ug/m^3): Maximum Building Level
e368			x	15	14	5(PL)	5 (PL)
e702		x		6	1, 4, 5, 6	5 (PL), 5 (PL), 5 (PL), 10	10
e56				14	3, 3	5 (PL), 12	12
e103				11	7	13	13
e369			x	4	3	27	27
e107			x	11	5, 11, 11, 11,	8, 28, 13, 39	39
e41		x		16	15, 16, 16	9, 42, 10	42
e432			x	17	15, 15	49, 36	49
e53				26	3, 5	61, 8	61
e63				16	4, 5, 7, 10, 17, 17	5 (PL), 5 (PL), 5 (PL), 5 (PL), 80, 13	80
e252			x	6	1	84	84
e64		x		13	3, 6, 7, 8	99, 5 (PL), 28, 22	99
e47			x	12	2, 3, 4, 5, 6, 8, 11	5 (PL), 12, 92, 5 (PL), 25, 69, 194	194
e703	x	x		7	1, 3, 4, 6, 7, 7	216, 41, 130, 12, 45, 78	216
e404			x	16	2, 2, 3	5 (PL), 322, 5 (PL)	322
e249			x	4	2	352	352
e431			x	7	2	372	372
e152				13	2, 7, 8, 11	400, 5 (PL), 15, 17	400
e18a		x		4	3	695	695
e4	x	x		4	3	760	760
e6	x	x		4	2, 4	215, 2100	2100
e700	x	x		3	3	2135	2135
e22		x		6	1, 4, 4, 4, 4, 6	84, 710, 4600, 225, 335, 8	4600
e5	x	x		4	3	5000	5000

Number apartments sampled:	65	
Mean < background (11 ug/m^3)	21	32%
Background (11 ug/m^3) < mean $\leq$ 100 ug/m^3	27	42%
100 ug/m^3 < mean $\leq$ 1000 ug/m^3	13	20%
Mean >1000 ug/m^3	4	6%
Number buildings sampled:	24	
Building maximum < background (11 ug/m^3)	2	8%
Background (11 ug/m^3) < building maximum $\leq$ 100 ug/m^3	10	42%
100 ug/m^3 < building maximum $\leq$ 1000 ug/m^3	8	33%
Building maximum >1000 ug/m^3	4	17%

[a] mean of duplicate values for main living space; quantities of perc present but below the detection limit of 5 ug/m^3 (i.e. 5 (PL)) were assigned half the detection limit (2.5 ug/m^3) for all quantitative analysis. Perc values correspond to floors sampled.

P:\Bureau\Perc\NYC_PERC\Reports-Presentations-FactSheets\Final Report\2005 Tables\Table 3.2-1 Perc Levels by Bldg.doc

Table 3.2-2 Current and previously reported perc levels (ug/m^3) in apartments and buildings with and without dry cleaners.

Study	Sampling Period	Dry cleaner type	Buildings sampled	Apartments sampled	Perc (ug/m^3)[a] Geometric mean	Median	Range
Current NYCity Perc Project New York City NY	2001-2003	Onsite	24	65	35	28	3-5000
		Minority	10	29	75	78	3-5000
		Non-minority	14	36	19	14	3-400
		Low income	5	11	256	215	12-5000
		Non-low income	19	54	23	16	3-4600
		Drop-off	5	9	6	3	3-29
		None	36	61	3	3	3-92

May 1997-Effective date 6NYCRR Part 232, New York State Dry Cleaner Regulations

Study	Sampling Period	Dry cleaner type	Buildings sampled	Apartments sampled	Geometric mean	Median	Range
NYSDOH (Unpublished data) New York City, NY[b]	1996-1997	Onsite	8	18	336	530	19-5500
Wallace et al. 1995 New York City, NY	1994-1995	Onsite	12	29	361	441	7-25000
		None	8	10	3	6	1-19
NYSDOH (Unpublished data) New York City, NY	1991-1993	Onsite-AM	16	20	1326	2091	6-24667
		Onsite-PM	1	5	4629	5900	400-48000
Schrieber et al. 1993 Albany, NY	1991-1992	Onsite-AM	6	6	3061	2790	300-55000
		Onsite-PM	6	6	212	4865	100-36500
		None-AM	6	6	35	44	10-103
		None-PM	6	6	46	56	22-77

[a]Values below the detection limit (5 ug/m^3)were assigned one half the detection limit (2.5 ug/m^3) prior to log transformation and derivation of summary statistics
Sampling times varied by study and ranged from 4 to 24 hours.
[b]subset of buildings included in Schreiber et al. (2002)

Table 3.2-3 Significant Correlations Between Socioeconomic Factors, Other Characteristics and Perc Exposure

	Annual Income Range			Race/ethnicity			Language Spoken at Home			Years of School		
	n	Corr Coeff	p value	n	Corr Coeff	p value	n	Corr Coeff	p value	n	Corr Coeff	p value
Adults												
Reference Adults												
VOC index (w/perc)							44	0.323	0.03			
Dry Cleaner Building Adults												
Perc Exposures												
Indoor Air Perc	59	-0.31	0.02	67	0.25	0.04				65	-0.39	<0.01
Home Breath Perc												
Clinic Breath Perc										54	-0.34	0.01
Blood Perc							65	0.52	<0.01	55	-0.28	0.04
Children												
Reference Children												
VOC Index (w/o perc)	54	-0.27	0.05									
Dry Cleaner Building Children												
Perc Exposures												
Indoor Air Perc	60	-0.3	0.02									
Home Breath Perc												
Clinic Breath Perc												
Blood Perc	41	-0.42	<0.01				42	0.36	0.02			

Table 3.2-4 Perc Exposure in Minority and Non-minority Households and Residents of Dry Cleaner Buildings in New York City

	Minority[a]				Non-Minority[b]			
	n	Geometric Mean	Median	25th - 75th Quartiles	n	Geometric Mean	Median	25th - 75th Quartiles
Indoor Air Perc (ug/m^3)	26	82.3*	80.3	9.4 - 699.5	31	16.4	16.5	4.2 – 69.0
Alveolar Breath Perc (ug/m^3)								
Adults-home	22	28.2	25.3	11.4 – 72.6	29	15.3	11.6	6.9 - 31.7
Adults-clinic	24	22.9**	17.3	5.1 - 81.8	25	9.6	8.0	5.2 - 20.84
Children-home	29	22.0	19.0	4.0 – 110.0	24	15.5	12.0	6.5 – 34.6
Children-clinic	24	12.3	10.7	3.1 – 61.0	27	8.5	6.9	4.0 – 14.0
Blood Perc (ng/mL)								
Adults-clinic	21	1.96*	0.48	0.12 – 1.90	28	0.54	0.13	0.08 – 0.21
Children-clinic	18	1.07**	0.23	0.09 – 0.57	21	0.54	0.11	0.06 – 0.16

[a] African-American or Hispanic alone, or African-American or Hispanic in combination with any other race
[b] non-Hispanic White only
* significantly higher than non-minority, $p<0.01$
** significantly higher than non-minority, $p<0.05$

Table 3.2-5 Perc Exposure in Households and Residents of Dry Cleaner Buildings in New York City with Different Annual Incomes

	Annual Income Range											
	< $30,000				$30,000 to $60,000				> $60,000			
	n	Geometric Mean	Median	$25^{th} – 75^{th}$ Quartiles	n	Geometric Mean	Median	$25^{th} – 75^{th}$ Quartiles	n	Geometric Mean	Median	$25^{th} – 75^{th}$ Quartiles
Indoor Air Perc (ug/m^3)	17	105.6*	91.5	11.6 - 699.5	10	38.09	50.4	4.99 - 215.0	30	17.6*	15.6	8.2 - 42.0
Alveolar Breath (ug/m^3)												
Adults-home	14	34.1	27.6	8.8 – 113.5	10	20.9	23.6	6.9 – 45.3	28	15.2	11.7	6.9 – 29.8
Adults-clinic	16	27.7*	17.3	5.1 – 128.1	9	18.5	20.4	12.0 – 33.0	25	8.3	7.4	5.2 – 14.1
Children-home	21	27.7	32.3	5.4 – 117.3	8	13.7	18.8	4.6 – 29.0	24	16.1	13.7	7.7 – 31.5
Children-clinic	17	15.2	12.7	4.6 – 66.6	9	15.8	19.5	7.2 – 23.7	26	8.2	6.7	4.0 – 14.0
Blood Perc (ng/mL)												
Adults-clinic	16	2.16*	0.48	0.15 - 7.40	8	0.77	0.23	0.10 - 0.84	25	0.50*	0.13	0.11 - 0.21
Children-clinic	14	1.17*	0.30	0.16 - 1.50	6	0.61	0.31	0.07 - 0.57	21	0.51*	0.11	0.08 - 0.11

* significantly higher than >$60,000, p<0.05

Table 3.3-1a. Demographic and Socioeconomic Characteristics – Participants with VCS Results

	Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3
Households	N=53	N=56	N=43	N=13
Race/ethnicity				
Minority[a]	26 (49%)	27 (48%)	17(40%)	10 (77%)
Majority[b]	27 (51%)	29 (52%)	26 (60%)	3 (23%)
Annual Income				
<$30,000	20 (38%)	11 (20%)	6 (14%)	5 (38%)
$30,000 - $60,000	6 (11%)	10 (18%)	7 (16%)	3 (23%)
>$60,000	26 (49%)	28 (50%)	26 (60%)	2 (15%)
No Response	1 (2%)	7 (13%)	4 (9%)	3 (23%)
Individuals				
Adults	N=46	N=54	N=42	N=12
Age (yrs +/ std)	43.9 ± 7.7	42.7 ± 7.7	44.9 ± 5.6	35.0 ± 9.5
Gender (% female)	39 (85%)	42 (78%)	33 (79%)	9 (75%)
Currently Employed (%)	33 (72%)	36 (67%)	28 (67%)	8 (67%)
Residence Duration (yrs +/ std)	9.4 ± 6.7	10.3 ± 7.9	10.5 ± 8.0	9.7 ± 7.6
Years of Education (yrs +/ std)	15.5 ± 3.0	15.2 ± 3.6	16.0 ± 2.8	12.3 ± 4.6
Smoking Category				
Non-Smoker	20 (43%)	26 (48%)	19 (45%)	7 (58%)
Fomer Smoker	16 (35%)	20 (37%)	18 (43%)	2 (17%)
Current Smoker	9 (20%)	7 (13%)	4 (10%)	3 (25%)
No Response	1 (2%)	1 (2%)	1 (2%)	0 (0%)
Alcohol Use				
Does not Drink	13 (28%)	14 (26%)	9 (21%)	5 (42%)
2 or less drinks/wk	20 (43%)	21 (39%)	14 (33%)	7 (58%)
3 or more drink/wk	12 (26%)	19 (35%)	19 (45%)	0 (0%)
No Response	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Children	N=53	N=50	N=39	N=11
Age (yrs +/ std)	10.9 ± 2.8	10.2 ± 2.6	10.4 ± 2.7	9.5 ± 2.4
Gender (% female)	22 (42%)	28 (56%)	22 (56%)	6 (55%)
Residence Duration (yrs +/ std)	8.5 ± 3.8	8.2 ± 3.2	8.5 ± 3.2	7.0 ± 3.2
Years of Education (yrs +/ std)	4.9 ± 2.9	4.4 ± 2.5	4.6 ± 2.6	3.7 ± 2.4

[a] all not non-Hispanic White
[b] non-Hispanic White

Table 3.3-1b. Demographic and Socioeconomic Characteristics – Parent/Child Pairs with VCS Results

	Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3
Households	N=42	N=45	N=36	N=9
Race/ethnicity				
Minority	17 (40%)	22 (49%)	16 (44%)	6 (67%)
Majority	25 (60%)	23 (51%)	20 (56%)	3 (33%)
Annual Income				
<$30,000	12 (29%)	9 (20%)	5 (14%)	4 (44%)
$30,000 - $60,000	6 (14%)	8 (18%)	7 (19%)	1 (11%)
>$60,000	24 (57%)	23 (51%)	21 (58%)	2 (22%)
No Response	0 (0%)	5 (11%)	3 (8%)	2 (22%)
Individuals				
Adults	N=43	N=45	N=36	N=9
Age (yrs +/ std)	44.3 ± 7.5	43.4 ± 7.7	45.2 ± 5.7	36.4 ± 10.5
Gender (% female)	36 (84%)	34 (76%)	28 (78%)	6 (67%)
Currently Employed (%)	31 (72%)	32 (71%)	26 (72%)	6 (67%)
Residence Duration (yrs +/ std)	9.7 ± 6.8	11.7 ± 7.9	11.7 ± 8.1	11.4 ± 8.0
Years of Education (yrs +/ std)	15.6 ± 3.0	15.5 ± 3.7	16.2 ± 2.9	12.7 ± 5.1
Smoking Category				
Non-Smoker	18 (42%)	20 (44%)	14 (39%)	6 (67%)
Fomer Smoker	15 (35%)	18 (40%)	17 (47%)	1 (11%)
Current Smoker	9 (21%)	6 (13%)	4 (11%)	2 (22%)
No Response	1 (2%)	1 (2%)	1 (3%)	0 (0%)
Alcohol Use				
Does not Drink	12 (28%)	12 (27%)	8 (22%)	4 (44%)
2 or less drinks/wk	18 (42%)	18 (40%)	13 (36%)	5 (56%)
3 or more drink/wk	12 (28%)	15 (33%)	15 (42%)	0 (0%)
No Response	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Children	N=45	N=48	N=38	N=10
Age (yrs +/ std)	10.8 ± 2.8	10.2 ± 2.7	10.3 ± 2.7	9.5 ± 2.6
Gender (% female)	18 (40%)	27 (56%)	22 (58%)	5 (50%)
Residence Duration (yrs +/ std)	8.3 ± 3.7	8.2 ± 3.3	8.5 ± 3.2	7.0 ± 3.4
Years of Education (yrs +/ std)	4.8 ± 2.9	4.4 ± 2.6	4.6 ± 2.6	3.7 ± 2.5

Table 3.3-2a. Perc and VOC Exposures – Participants with VCS Results

	Adults				Children			
	Buildings with No Dry Cleaner	Buildings with Dry Cleaner			Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups			All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3			<100 ug/ m^3	> 100 ug/m^3
Perc								
Indoor Air (ug/m^3)	N=46	N=54	N=42	N=12	N=53	N=50	N=39	N=11
Geometric Mean	2.7	27.9	12.4	477.9	3.0	25.6	12.4	335.8
Median	2.3	25.5	12.5	375.9	2.3	27.0	12.5	337.5
25th and 75th percentiles	1.5 –3.9	8.0 – 91.5	4.6 – 42.0	268.9 – 735.3	1.8 – 4.2	8.0 – 91.5	4.3 – 44.3	215.0 – 699.5
Range	0.9 – 23.6	0.6 – 2182.8	0.6 – 99.0	126.6 – 2182.8	0.9 – 39.0	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0
Alveolar Breath (ug/m^3)								
Home	N=41	N=48	N=36	N=12	N=46	N=44	N=35	N=9
Geometric Mean	4.5	31.6	19.2	141.4	3.6	20.6	12.2	159.5
Median	4.9	25.9	17.5	172.3	3.9	18.4	14.3	176.4
25th and 75th percentiles	2.2 – 8.5	13.3 – 81.8	10.2 – 30.5	92.6 – 213.9	1.9 – 6.1	8.2 – 41.9	5.2 – 25.4	128.6 – 192.5
Range	0.4 – 35.7	3.3 – 937.3	3.3 – 172.2	17.3 – 937.3	0.8 – 16.7	2.3 – 674.7	2.3 – 107.6	18.4 – 674.7
MSSM	N=33	N=48	N=37	N=11	N=38	N=46	N=36	N=10
Geometric Mean	4.8	19.4	13.3	70.2	3.3	12.2	8.2	50.0
Median	5.6	16.2	12.9	57.3	3.4	9.7	8.1	55.3
25th and 75th percentiles	2.4 – 8.6	9.1 – 44.3	8.0 – 24.8	48.3 – 114.5	2.1 – 5.3	4.8 – 23.0	4.2 – 14.5	23.0 – 64.5
Range	0.9 – 24.5	2.6 – 1007.1	2.6 – 61.0	14.2 – 1007.1	0.5 – 14.7	2.8 – 191.1	2.8 – 53.7	18.6 – 191.1
Blood (ug/L)	N=36	N=49	N=38	N=11	N=31	N=35	N=28	N=7
Geometric Mean	0.05	0.21	0.13	1.28	0.04	0.15	0.11	0.51
Median	0.04	0.15	0.13	1.30	0.02	0.11	0.11	0.57
25th and 75th percentiles	0.02 – 0.08	0.09 – 0.40	0.08 – 0.21	0.53 – 1.90	0.02 – 0.05	0.08 – 0.36	0.07 – 0.16	0.37 – 0.89
Range	0.02 – 0.25	0.02 – 37.00	0.02 – 0.48	0.11 – 37.00	0.02 – 0.41	0.02 – 1.60	0.02 – 1.60	0.11 – 1.50
VOCs (ppb)								
Indoor Air	N=33	N=50	N=39	N=11	N=40	N=47	N=36	N=11
Geometric Mean	11.7	22.2	15.4	80.2	11.8	21.7	15.5	65.8
Median	10.2	18.4	16.5	71.7	10.6	19.6	16.6	69.6
25th and 75th percentiles	8.7 – 17.7	11.7 – 36.8	11.5 – 20.5	43.0 – 114.9	8.7 – 16.7	11.7 – 41.1	10.6 – 20.9	41.8 – 111.1
Range	4.7 – 27.2	5.3 – 331.9	5.3 – 46.5	36.8 – 331.9	4.7 – 35.1	6.1 – 114.9	6.1 – 46.5	36.8 – 114.9
VOCs (without perc) (ppb)								
Indoor Air	N=33	N=50	N=39	N=11	N=40	N=47	N=36	N=11
Geometric Mean	11.0	12.4	11.9	14.0	11.0	12.1	11.9	12.9
Median	9.6	11.4	11.2	15.7	9.4	11.2	11.3	10.0
25th and 75th percentiles	7.9 – 15.5	9.7 – 15.6	9.5 – 14.8	9.9 – 19.7	7.7 – 15.4	9.4 – 15.6	9.4 – 14.8	9.3 – 19.7
Range	4.3 – 26.3	5.2 – 39.3	5.2 – 39.3	7.7 – 24.3	4.3 – 34.1	6.0 – 39.3	6.0 – 39.3	7.7 – 24.3

Table 3.3-2b. Perc and VOC Exposures – Parent/Child Pairs with VCS Results

	Adults				Children			
	Buildings with No Dry Cleaner	Buildings with Dry Cleaner			Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups			All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3			<100 ug/ m^3	> 100 ug/m^3
Perc								
Indoor Air (ug/m^3)	N=42	N=45	N=36	N=9	N=42	N=45	N=36	N=9
Geometric Mean	2.8	25.9	13.8	324.7	2.8	25.9	13.8	324.7
Median	2.3	26.5	12.8	337.5	2.3	26.5	12.8	337.5
25^{th} and 75^{th} percentiles	1.5 – 4.2	8.6 – 83.9	4.8 – 46.5	215.5 – 400.0	1.5 – 4.2	8.6 – 83.9	4.8 – 46.5	215.5 – 400.0
Range	0.9 – 23.6	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0	0.9 – 23.6	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0
VOCs (ppb)								
Indoor Air	N=30	N=42	N=33	N=9	N=30	N=42	N=33	N=9
Geometric Mean	11.6	21.6	16.0	65.1	11.6	21.6	16.0	65.1
Median	10.6	19.5	16.6	69.6	10.6	19.5	16.6	69.6
25th and 75th percentiles	8.7 – 17.7	12.4 – 36.8	11.5 – 20.5	43.0 – 74.8	8.7 – 17.7	12.4 – 36.8	11.5 – 20.5	43.0 – 74.8
Range	4.7 – 27.2	6.1 – 114.9	6.1 – 46.5	36.8 – 114.9	4.7 – 27.2	6.1 – 114.9	6.1 – 46.5	36.8 – 114.9
VOCs (without perc) (ppb)								
Indoor Air	N=30	N=42	N=33	N=9	N=30	N=42	N=33	N=9
Geometric Mean	10.9	12.5	12.1	13.8	10.9	12.5	12.1	13.8
Median	10.0	11.4	11.3	15.7	10.0	11.4	11.3	15.7
25th and 75th percentiles	7.3 – 15.5	9.5 – 15.6	9.5 – 14.8	9.9 – 19.7	7.3 – 15.5	9.5 – 15.6	9.5 – 14.8	9.9 – 19.7
Range	4.3 – 26.3	6.0 – 39.3	6.0 – 39.3	7.7 – 24.3	4.3 – 26.3	6.0 – 39.3	6.0 – 39.3	7.7 – 24.3
Alveolar Breath (ug/m^3)								
Home	N=38	N=40	N=31	N=9	N=40	N=43	N=34	N=9
Geometric Mean	4.8	28.6	18.4	131.7	3.6	20.7	12.0	159.5
Median	5.0	21.7	16.2	165.7	3.9	18.4	14.0	176.4
25th and 75th percentiles	2.2 – 8.5	12.9 – 81.8	9.6 – 27.8	102.2 – 183.5	1.8 – 6.2	8.2 – 44.2	5.2 – 25.4	128.6 – 192.5
Range	0.9 – 35.7	3.3 – 570.2	3.3 – 172.2	17.3 – 570.2	0.8 – 16.7	2.3 – 674.7	2.3 – 107.6	18.4 – 674.7
MSSM	N=33	N=40	N=32	N=8	N=31	N=45	N=36	N=9
Geometric Mean	4.8	17.7	14.1	44.4	3.4	12.1	8.2	55.8
Median	5.6	16.2	12.9	54.5	3.3	9.3	8.1	58.4
25th and 75th percentiles	2.4 – 8.6	9.4 – 39.7	8.8 – 24.9	33.5 – 58.8	2.1 – 5.6	4.8 – 23.0	4.2 – 14.5	33.1 – 64.5
Range	0.9 – 24.5	2.6 – 114.5	2.6 – 61.0	14.2 – 114.5	0.5 – 14.7	2.8 – 191.1	2.8 – 53.7	20.2 – 191.1
Blood (ug/L)	N=34	N=41	N=33	N=8	N=26	N=33	N=27	N=6
Geometric Mean	0.05	0.19	0.13	0.76	0.04	0.15	0.11	0.50
Median	0.04	0.15	0.13	0.89	0.02	0.11	0.11	0.55
25^{th} and 75^{th} percentiles	0.02 – 0.09	0.11 – 0.37	0.09 – 0.27	0.53 – 1.40	0.02 – 0.06	0.08 – 0.27	0.07 – 0.16	0.37 – 0.89
Range	0.02 – 0.25	0.02 – 2.80	0.02 – 0.48	0.11 – 2.80	0.02 – 0.41	0.02 – 1.60	0.02 – 1.60	0.11 – 1.50

Table 3.3-3a. Significance of Decreasing Trend (Cochran-Armitage Exact Trend Test) in Percent of Residents of Buildings With or Without a Dry Cleaner (Indoor Air Perc < 100 ug/m^3 or > 100 ug/m^3) Scoring the Maximum Visual Contrast Sensitivity (VCS) Score

Spatial Frequency (cpd)	Maximum VCS Score	Percent with Maximum Score							
		Adult Residents				Child Residents			
		No Dry Cleaner in Building (n=46)	Dry Cleaner in Building Indoor Air Perc (ug/m^3) < 100 ug/m^3 (n=42)	Dry Cleaner in Building Indoor Air Perc (ug/m^3) >100 ug/m^3 (n=12)	p	No Dry Cleaner in Building (n=53)	Dry Cleaner in Building Indoor Air Perc (ug/m^3) < 100 ug/m^3 (n=39)	Dry Cleaner in Building Indoor Air Perc (ug/m^3) >100 ug/m^3 (n=11)	p
1.5	100	52.2	52.4	50.0	0.46	64.2	61.5	45.5	0.23
3	160	34.7	21.4	25.0	0.13	43.4	59.0	45.5	0.21
6	180	28.3	14.3	8.3	0.03	43.4	33.3	18.2	0.05
12	120	13.0	7.1	8.3	0.21	37.7	33.3	0	0.02
18	65	8.6	2.4	0	0.06	37.7	46.2	9.1	0.18

Table 3.3-3b. Significance of Decreasing Trend (Cochran-Armitage Exact Trend Test) in Percent of Adults with Maximum VCS Score at 6, 12 and 18 cpd – Stratified by Race/ethnicity or Annual Income

Sample	Spatial Frequency	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p
			< 100 ug/m^3	>100 ug/m^3	
Stratified by Race/ethnicity					
Minority Adults Only	6	30.0 (n=20)	17.6 (n=17)	11.1 (n=9)	0.16
	12	20.0 (n=20)	11.8 (n=17)	0 (n=9)	0.07
Non-Minority Adults Only	6	36.9 (n=26)	12.0 (n=25)	0 (n=3)	0.09
	12	7.7 (n=26)	4.0 (n=25)	33.3 (n=3)	0.41
Stratified by Income					
Low Income Adults Only	6	35.7 (n=14)	16.7 (n=6)	20.0 (n=5)	0.30
	12	28.6 (n=14)	16.7 (n=6)	0 (n=5)	0.15
Higher Income Adults Only	6	25.0 (n=32)	15.6 (n=32)	0 (n=4)	0.14
	12	6.2 (n=32)	6.2 (n=32)	25.0 (n=4)	0.32

Table 3.3-3c. Significance of Decreasing Trend (Cochran-Armitage Exact Trend Test) in Percent of Children with Maximum VCS Score at 6, 12 and 18 cpd – Stratified by Race/ethnicity or Annual Income

Sample	Spatial Frequency	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p
			< 100 ug/m^3	>100 ug/m^3	
Stratified by Race/ethnicity					
Minority Children Only	6	46.2 (n=26)	27.8 (n=18)	0 (n=8)	<0.01
	12	50.0 (n=26)	27.7 (n=18)	0 (n=8)	<0.01
Non-Minority Children Only	6	40.7 (n=27)	38.1 (n=21)	66.7 (n=3)	0.43
	12	25.9 (n=27)	438.1 (n=21)	0 (n=3)	0.58
Stratified by Income					
Low Income Children Only	6	47.6 (n=21)	16.7 (n=6)	0 (n=5)	0.02
	12	47.6 (n=21)	0 (n=6)	0 (n=5)	<0.01
Higher Income Children Only	6	38.7 (n=31)	34.5 (n=29)	25.0 (n=4)	0.37
	12	29.0 (n=31)	37.9 (n=29)	20 (n=4)	0.49

Table 3.3-4. Summary of Significance of Child-Adult Differences in VCS (Kruskal-Wallis Test for Matched Pairs) (n=45 reference pairs; n=38 dry cleaner pairs w/<100 ug/m3 perc; n=10 pairs w/>100 ug/m3 perc)

			Worst Eye			Averaged Eyes		
Spatial Frequency	Exposure	Number of Pairs	Mean Difference	Chi Square Statistic	p value	Mean Difference	Chi Square Statistic	p value
1.5 cpd	Reference	45	3.4	0.626	0.73	2.4	0.880	0.64
	< 100 ug/m3	38	0.9			-1.3		
	> 100 ug/m3	10	-1.0			-1.6		
3 cpd	Reference	45	5.1	1.721	0.43	6.4	1.560	0.46
	< 100 ug/m3	38	15.6			10.7		
	> 100 ug/m3	10	17.1			20.0		
6 cpd	Reference	45	22.2	0.582	0.75	18.8	3.709	0.16
	< 100 ug/m3	38	15.1			6.9		
	> 100 ug/m3	10	27.7			33.2		
12 cpd	Reference	45	29.4	5.782	0.06	30.1	3.70	0.16
	< 100 ug/m3	38	26.5			21.6		
	> 100 ug/m3	10	0.8			10.9		
18 cpd	Reference	45	21.6	1.232	0.54	20.9	1.125	0.57
	< 100 ug/m3	38	24.8			22.1		
	> 100 ug/m3	10	17.7			16.7		

Table 3.4-1a. Demographic and Socioeconomic Characteristics – Participants with Farnsworth Results

	Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3
Households	N=54	N=57	N=44	N=13
Race/ethnicity				
Minority	26 (48%)	27 (47%)	17(39%)	10 (77%)
Majority	28 (52%)	30 (53%)	27 (61%)	3 (23%)
Annual Income				
<$30,000	20 (37%)	11 (19%)	6 (14%)	5 (38%)
$30,000 - $60,000	6 (11%)	10 (18%)	7 (16%)	3 (23%)
>$60,000	27 (50%)	28 (49%)	26 (59%)	2 (15%)
No Response	1 (2%)	8 (14%)	5 (11%)	3 (23%)
Individuals				
Adults	N=48	N=54	N=42	N=12
Age (yrs +/ std)	44.1 ± 7.7	42.4 ± 7.9	44.5 ± 5.9	35.0 ± 9.5
Gender (% female)	41 (85%)	42 (78%)	33 (79%)	9 (75%)
Currently Employed (%)	33 (69%)	36 (67%)	28 (67%)	8 (67%)
Residence Duration (yrs +/ std)	9.4 ± 6.6	10.4 ± 7.8	10.7 ± 7.9	9.7 ± 7.6
Years of Education (yrs +/ std)	15.7 ± 3.1	15.2 ± 3.5	16.0 ± 2.8	12.3 ± 4.6
Smoking Category				
Non-Smoker	22 (46%)	26 (48%)	19 (45%)	7 (58%)
Fomer Smoker	16 (33%)	20 (37%)	18 (43%)	2 (17%)
Current Smoker	9 (19%)	7 (13%)	4 (10%)	3 (25%)
No Response	1 (2%)	1 (2%)	1 (2%)	0 (0%)
Alcohol Use				
Does not Drink	15 (31%)	14 (26%)	9 (21%)	5 (42%)
2 or less drinks/wk	20 (42%)	22 (41%)	15 (36%)	7 (58%)
3 or more drink/wk	12 (25%)	18 (33%)	18 (43%)	0 (0%)
No Response	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Children	N=54	N=50	N=39	N=11
Age (yrs +/ std)	10.8 ± 2.9	10.2 ± 2.6	10.4 ± 2.7	9.5 ± 2.4
Gender (% female)	24 (44%)	28 (56%)	22 (56%)	6 (55%)
Residence Duration (yrs +/ std)	8.4 ± 3.7	8.2 ± 3.2	8.5 ± 3.2	7.0 ± 3.2
Years of Education (yrs +/ std)	4.8 ± 2.9	4.4 ± 2.5	4.6 ± 2.6	3.7 ± 2.4

Table 3.4-1b. Demographic and Socioeconomic Characteristics – Participants with Lanthony Results

	Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3
Households	N=54	N=57	N=44	N=13
Race/ethnicity				
Minority	26 (48%)	27 (47%)	17(39%)	10 (77%)
Majority	28 (52%)	30 (53%)	27 (61%)	3 (23%)
Annual Income				
<$30,000	20 (37%)	11 (19%)	6 (14%)	5 (38%)
$30,000 - $60,000	6 (11%)	10 (18%)	7 (16%)	3 (23%)
>$60,000	27 (50%)	28 (49%)	26 (59%)	2 (15%)
No Response	1 (2%)	8 (14%)	5 (11%)	3 (23%)
Individuals				
Adults	N=48	N=54	N=42	N=12
Age (yrs +/ std)	44.1 ± 7.7	42.4 ± 7.9	44.5 ± 5.9	35.0 ± 9.5
Gender (% female)	41 (85%)	42 (78%)	33 (79%)	9 (75%)
Currently Employed (%)	33 (69%)	36 (67%)	28 (67%)	8 (67%)
Residence Duration (yrs +/ std)	9.4 ± 6.6	10.4 ± 7.8	10.7 ± 7.9	9.7 ± 7.6
Years of Education (yrs +/ std)	15.7 ± 3.1	15.2 ± 3.5	16.0 ± 2.8	12.3 ± 4.6
Smoking Category				
Non-Smoker	22 (46%)	26 (48%)	19 (45%)	7 (58%)
Fomer Smoker	16 (33%)	20 (37%)	18 (43%)	2 (17%)
Current Smoker	9 (19%)	7 (13%)	4 (10%)	3 (25%)
No Response	1 (2%)	1 (2%)	1 (2%)	0 (0%)
Alcohol Use				
Does not Drink	15 (31%)	14 (26%)	9 (21%)	5 (42%)
2 or less drinks/wk	20 (42%)	22 (41%)	15 (36%)	7 (58%)
3 or more drink/wk	12 (25%)	18 (33%)	18 (43%)	0 (0%)
No Response	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Children	N=50	N=40	N=30	N=10
Age (yrs +/ std)	11.2 ± 2.7	10.7 ± 2.6	11.0 ± 2.6	9.7 ± 2.4
Gender (% female)	23 (46%)	22 (55%)	16 (53%)	6 (60%)
Residence Duration (yrs +/ std)	8.7 ± 3.6	8.4 ± 3.4	8.9 ± 3.4	7.0 ± 3.4
Years of Education (yrs +/ std)	5.2 ± 2.8	4.9 ± 2.4	5.2 ± 2.4	4.0 ± 2.3

Table 3.4-1c. Demographic and Socioeconomic Characteristics – Parent/Child Pairs with Lanthony Results

	Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3
Households	N=41	N=34	N=26	N=6
Race/ethnicity				
Minority	18 (44%)	18 (53%)	13 (50%)	5 (63%)
Majority	23 (56%)	16 (47%)	13 (50%)	3 (38%)
Annual Income				
<$30,000	13 (32%)	9 (26%)	5 (19%)	4 (50%)
$30,000 - $60,000	6 (15%)	7 (21%)	6 (23%)	1 (13%)
>$60,000	21 (51%)	15 (44%)	14 (54%)	1 (13%)
No Response	1 (2%)	3 (9%)	1 (4%)	2 (25%)
Individuals				
Adults	N=41	N=34	N=26	N=8
Age (yrs +/ std)	44.6 ± 7.9	42.8 ± 8.4	45.2 ± 6.2	35.1 ± 10.3
Gender (% female)	34 (83%)	27 (79%)	21 (81%)	6 (75%)
Currently Employed (%)	27 (66%)	27 (79%)	22 (85%)	5 (63%)
Residence Duration (yrs +/ std)	10.3 ± 6.8	11.3 ± 6.7	11.2 ± 6.2	11.5 ± 8.5
Years of Education (yrs +/ std)	15.8 ± 3.1	15.0 ± 4.0	15.9 ± 3.1	12.1 ± 5.2
Smoking Category				
Non-Smoker	19 (46%)	17 (50%)	12 (46%)	5 (63%)
Fomer Smoker	14 (34%)	14 (41%)	13 (50%)	1 (13%)
Current Smoker	7 (17%)	3 (9%)	1 (4%)	2 (25%)
No Response	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Alcohol Use				
Does not Drink	14 (34%)	10 (29%)	6 (23%)	4 (50%)
2 or less drinks/wk	17 (41%)	12 (35%)	8 (31%)	4 (50%)
3 or more drink/wk	9 (22%)	12 (35%)	12 (46%)	0 (0%)
No Response	1 (2%)	0 (0%)	0 (0%)	0 (0%)
Children	N=43	N=37	N=28	N=9
Age (yrs +/ std)	11.2 ± 2.8	10.7 ± 2.6	10.9 ± 2.6	9.8 ± 2.6
Gender (% female)	20 (47%)	20 (54%)	15 (54%)	5 (56%)
Residence Duration (yrs +/ std)	8.6 ± 3.6	8.6 ± 3.4	9.1 ± 3.2	7.0 ± 3.6
Years of Education (yrs +/ std)	5.3 ± 2.8	4.9 ± 2.5	5.1 ± 2.5	4.0 ± 2.4

Table 3.4-2a. Perc and VOC Exposures – Participants with Farnsworth Results

	Adults				Children			
	Buildings with No Dry Cleaner	Buildings with Dry Cleaner			Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups			All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3			<100 ug/ m^3	> 100 ug/m^3
Perc								
Indoor Air (ug/m^3)	N=48	N=54	N=42	N=12	N=54	N=50	N=39	N=11
Geometric Mean	2.7	27.9	11.1	477.9	3.0	25.6	12.4	335.8
Median	2.3	23.0	12.3	375.9	2.3	27.0	12.5	337.5
25th and 75th percentiles	1.5 –4.0	7.1 – 91.5	4.3 – 38.9	268.9 – 735.3	1.6 – 4.2	8.0 – 91.5	4.3 – 44.3	215.0 – 699.5
Range	0.9 – 23.6	0.6 – 2182.8	0.6 – 99.0	126.6 – 2182.8	0.9 – 39.0	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0
Alveolar Breath (ug/m^3)								
Home	N=43	N=48	N=36	N=12	N=48	N=44	N=35	N=9
Geometric Mean	4.5	31.1	18.8	141.4	3.5	20.6	12.2	159.5
Median	4.9	25.9	17.5	172.3	3.7	18.4	14.3	176.4
25th and 75th percentiles	2.2 – 8.5	13.3 – 81.8	10.2 – 30.5	92.6 – 213.9	1.9 – 6.1	8.2 – 41.9	5.2 – 25.4	128.6 – 192.5
Range	0.4 – 35.7	3.3 – 937.3	3.3 – 172.2	17.3 – 937.3	0.8 – 16.7	2.3 – 674.7	2.3 – 107.6	18.4 – 674.7
MSSM	N=35	N=47	N=36	N=11	N=38	N=46	N=36	N=10
Geometric Mean	4.8	19.6	13.3	70.2	3.2	12.2	8.2	50.0
Median	5.6	16.7	12.5	57.3	3.3	9.7	8.1	55.3
25th and 75th percentiles	2.4 – 8.6	8.9 – 48.3	7.9 – 24.9	48.3 – 114.5	2.0 – 4.9	4.8 – 23.0	4.2 – 14.5	23.0 – 64.5
Range	0.9 – 24.5	2.6 – 1007.1	2.6 – 61.0	14.2 – 1007.1	0.5 – 14.7	2.8 – 191.1	2.8 – 53.7	18.6 – 191.1
Blood (ug/L)	N=38	N=49	N=38	N=11	N=31	N=35	N=28	N=7
Geometric Mean	0.05	0.21	0.12	1.28	0.04	0.15	0.11	0.51
Median	0.04	0.15	0.12	1.30	0.02	0.11	0.11	0.57
25th and 75th percentiles	0.02 – 0.08	0.09 – 0.40	0.08 – 0.21	0.53 – 1.90	0.02 – 0.05	0.08 – 0.36	0.07 – 0.16	0.37 – 0.89
Range	0.02 – 0.25	0.02 – 37.00	0.02 – 0.48	0.11 – 37.00	0.02 – 0.41	0.02 – 1.60	0.02 – 1.60	0.11 – 1.50
VOCs (ppb)								
Indoor Air	N=34	N=49	N=38	N=11	N=41	N=47	N=36	N=11
Geometric Mean	12.0	22.1	15.2	80.2	12.1	21.7	15.5	65.8
Median	10.6	17.4	16.0	71.7	11.0	19.6	16.6	69.6
25th and 75th percentiles	8.7 – 18.7	11.7 – 36.8	11.5 – 19.8	43.0 – 114.9	8.7 – 17.7	11.7 – 41.1	10.6 – 20.9	41.8 – 111.1
Range	4.7 – 35.1	5.3 – 331.9	5.3 – 46.5	36.8 – 331.9	4.7 – 35.1	6.1 – 114.9	6.1 – 46.5	36.8 – 114.9
VOCs (without perc) (ppb)								
Indoor Air	N=34	N=49	N=38	N=11	N=41	N=47	N=36	N=11
Geometric Mean	11.4	12.3	11.9	14.0	11.2	12.1	11.9	12.9
Median	10.0	11.3	11.2	15.7	9.4	11.2	11.3	10.0
25th and 75th percentiles	7.9 – 18.4	9.7 – 15.6	9.5 – 14.8	9.9 – 19.7	8.0 – 15.5	9.4 – 15.6	9.4 – 14.8	9.3 – 19.7
Range	4.3 – 34.1	5.2 – 39.3	5.2 – 39.3	7.7 – 24.3	4.3 – 34.1	6.0 – 39.3	6.0 – 39.3	7.7 – 24.3

Table 3.4-2b. Perc and VOC Exposures – Participants with Lanthony Results

	Adults				Children			
	Buildings with No Dry Cleaner	Buildings with Dry Cleaner			Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups			All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3			<100 ug/ m^3	> 100 ug/m^3
Perc								
Indoor Air (ug/m^3)	N=48	N=54	N=42	N=12	N=50	N=40	N=30	N=10
Geometric Mean	2.7	25.6	11.1	477.9	2.9	28.7	12.7	330.0
Median	2.3	23.0	12.3	375.9	2.3	31.6	13.6	329.9
25th and 75th percentiles	1.5 –4.0	7.1 – 91.5	4.3 – 38.9	268.9 – 735.3	1.6 – 3.9	7.0 – 112.8	4.3 – 44.3	215.0 – 699.5
Range	0.9 – 23.6	0.6 – 2182.8	0.6 – 99.0	126.6 – 2182.8	0.9 – 39.0	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0
Alveolar Breath (ug/m^3)								
Home	N=43	N=48	N=36	N=12	N=45	N=34	N=26	N=8
Geometric Mean	4.5	31.1	18.8	141.4	3.4	24.5	13.8	157.5
Median	4.9	25.9	17.5	172.3	3.5	18.9	17.0	160.2
25th and 75th percentiles	2.2 – 8.5	13.3 – 81.8	10.2 – 30.5	92.6 – 213.9	1.9 – 5.9	9.6 – 62.1	8.2 – 26.1	107.0 – 382.3
Range	0.4 – 35.7	3.3 – 937.3	3.3 – 172.2	17.3 – 937.3	0.8 – 16.7	2.3 – 674.7	2.3 – 107.6	18.4 – 674.7
MSSM	N=35	N=47	N=36	N=11	N=34	N=36	N=27	N=9
Geometric Mean	4.8	19.6	13.3	70.2	2.9	13.5	9.1	43.1
Median	5.6	16.7	12.5	57.3	3.0	13.0	8.6	52.1
25th and 75th percentiles	2.4 – 8.6	8.9 – 48.3	7.9 – 24.9	48.3 – 114.5	2.0 – 4.4	5.7 – 28.2	3.8 – 16.8	23.0 – 59.6
Range	0.9 – 24.5	2.6 – 1007.1	2.6 – 61.0	14.2 – 1007.1	0.5 – 14.7	2.8 – 153.2	2.8 – 53.7	18.6 – 153.2
Blood (ug/L)	N=38	N=49	N=38	N=11	N=28	N=32	N=25	N=7
Geometric Mean	0.05	0.21	0.12	1.28	0.04	0.14	0.10	0.51
Median	0.04	0.15	0.12	1.30	0.02	0.11	0.11	0.57
25th and 75th percentiles	0.02 – 0.08	0.09 – 0.40	0.08 – 0.21	0.53 – 1.90	0.02 – 0.05	0.08 – 0.30	0.07 – 0.13	0.37 – 0.89
Range	0.02 – 0.25	0.02 – 37.00	0.02 – 0.48	0.11 – 37.00	0.02 – 0.41	0.02 – 1.50	0.02 – 0.51	0.11 – 1.50
VOCs (ppb)								
Indoor Air	N=34	N=49	N=38	N=11	N=38	N=38	N=28	N=10
Geometric Mean	12.0	22.1	15.2	80.2	12.0	22.3	15.2	64.9
Median	10.6	17.4	16.0	71.7	10.6	20.1	16.5	68.3
25th and 75th percentiles	8.7 – 18.7	11.7 – 36.8	11.5 – 19.8	43.0 – 114.9	8.7 – 17.7	11.7 – 41.1	10.6 – 21.8	41.8 – 111.1
Range	4.7 – 35.1	5.3 – 331.9	5.3 – 46.5	36.8 – 331.9	4.7 – 35.1	6.1 – 114.9	6.1 – 43.4	36.8 – 114.9
VOCs (without perc) (ppb)								
Indoor Air	N=34	N=49	N=38	N=11	N=38	N=38	N=28	N=10
Geometric Mean	11.4	12.3	11.9	14.0	11.2	11.7	11.4	12.7
Median	10.0	11.3	11.2	15.7	9.4	11.0	11.3	10.0
25th and 75th percentiles	7.9 – 18.4	9.7 – 15.6	9.5 – 14.8	9.9 – 19.7	8.0 – 15.5	9.4 – 14.9	9.4 – 14.5	9.3 – 19.7
Range	4.3 – 34.1	5.2 – 39.3	5.2 – 39.3	7.7 – 24.3	4.3 – 34.1	6.0 – 37.2	6.0 – 37.2	7.7 – 24.3

Table 3.4-2c. Perc and VOC Exposures – Parent/Child Pairs with Lanthony Results

	Adults				Children			
	Buildings with No Dry Cleaner	Buildings with Dry Cleaner			Buildings with No Dry Cleaner	Buildings with Dry Cleaner		
		All	2 Exposure Groups			All	2 Exposure Groups	
			<100 ug/ m^3	> 100 ug/m^3			<100 ug/ m^3	> 100 ug/m^3
Perc								
Indoor Air (ug/m^3)	N=41	N=34	N=26	N=8	N=41	N=34	N=26	N=8
Geometric Mean	2.7	28.9	13.8	316.3	2.7	28.9	13.8	316.3
Median	2.3	31.2	13.6	329.9	2.3	31.2	13.6	329.9
25th and 75th percentiles	1.5 –3.9	9.0 – 99.0	4.6 – 44.3	204.5 – 525.7	1.5 –3.9	9.0 – 99.0	4.6 – 44.3	204.5 – 525.7
Range	0.9 – 23.6	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0	0.9 – 23.6	0.7 – 710.0	0.7 – 99.0	126.6 – 710.0
VOCs (ppb)								
Indoor Air	N=29	N=32	N=24	N=8	N=29	N=32	N=24	N=8
Geometric Mean	12.3	22.1	15.5	64.0	12.3	22.1	15.5	64.0
Median	11.0	18.5	16.5	68.3	11.0	18.5	16.5	68.3
25th and 75th percentiles	8.7 – 18.7	12.1 – 39.3	11.3 – 21.4	42.4 – 91.4	8.7 – 18.7	12.1 – 39.3	11.3 – 21.4	42.4 – 91.4
Range	4.7 – 35.1	6.1 – 35.1	6.1 – 43.4	36.8 – 114.9	4.7 – 35.1	6.1 – 35.1	6.1 – 43.4	36.8 – 114.9
VOCs (without perc) (ppb)	N=29	N=32	N=24	N=8	N=29	N=32	N=24	N=8
Indoor Air	11.6	12.0	11.5	13.6	11.6	12.0	11.5	13.6
Geometric Mean	10.4	11.3	11.3	14.7	10.4	11.3	11.3	14.7
Median	8.0 – 18.4	9.4 – 15.1	9.4 – 14.5	9.1 – 19.7	8.0 – 18.4	9.4 – 15.1	9.4 – 14.5	9.1 – 19.7
25th and 75th percentiles	4.3 – 34.1	6.0 – 37.2	6.0 – 37.2	7.7 – 24.3	4.3 – 34.1	6.0 – 37.2	6.0 – 37.2	7.7 – 24.3
Range								
Alveolar Breath (ug/m^3)								
Home	N=36	N=29	N=21	N=8	N=40	N=33	N=25	N=8
Geometric Mean	4.3	35.1	20.1	135.9	3.5	24.7	13.7	157.5
Median	4.9	27.0	20.4	172.3	3.6	19.0	16.2	160.2
25th and 75th percentiles	2.1 – 6.7	13.4 – 108.8	13.2 – 27.8	95.9 – 212.1	1.8 – 6.2	9.6 – 62.1	8.2 – 26.1	107.0 – 382.3
Range	0.9 – 35.7	3.3 – 570.2	3.3 – 172.2	17.3 – 570.2	0.8 – 16.7	2.3 – 674.7	2.3 – 107.6	18.4 – 674.7
MSSM	N=31	N=31	N=23	N=8	N=28	N=34	N=26	N=8
Geometric Mean	4.4	20.9	16.0	44.4	2.9	13.3	9.0	47.9
Median	4.6	18.7	15.7	54.5	3.0	11.8	8.5	55.3
25th and 75th percentiles	2.3 – 7.1	12.0 – 48.3	9.3 – 28.5	33.5 – 58.8	2.0 – 4.6	5.5 – 29.2	3.8 – 16.8	28.1 – 62.1
Range	0.9 – 24.5	4.1 – 114.5	4.1 – 61.0	14.2 – 114.5	4.1 – 114.5	2.8 – 153.2	2.8 – 53.7	20.2 – 153.2
Blood (ug/L)	N=32	N=32	N=25	N=7	N=24	N=29	N=23	N=6
Geometric Mean	0.04	0.22	0.15	1.00	0.04	0.13	0.09	0.50
Median	0.02	0.21	0.15	1.20	0.02	0.11	0.11	0.55
25th and 75th percentiles	0.02 – 0.07	0.11 – 0.46	0.09 – 0.29	0.53 – 1.50	0.02 – 0.05	0.07 – 0.24	0.06 – 0.13	0.37 – 0.89
Range	0.02 – 0.25	0.02 – 2.80	0.02 – 0.48	0.52 – 2.80	0.02 – 0.41	0.02 – 1.50	0.02 – 0.51	0.11 – 1.50

Table 3.4-3. Significant Correlations -- Socioeconomic Factors, Personal Characteristics, Color Vision

		Farnsworth				Lanthony			
		CCI		Major Errors		CCI		Major Errors	
	n	Corr Coeff	p value	Corr Coeff	p value	Corr Coeff	p value	Corr Coeff	p value
Adults*									
Annual Income	92	-0.3	< 0.01	-0.11	ns	-0.43	<0.01	-0.51	<0.01
Race/ethnicity	101	0.25	0.01	0.07	ns	0.32	<0.01	0.35	<0.01
Language at Home	101	0.22	0.03	0.04	ns	0.22	0.03	0.32	<0.01
Years of School	101	-0.22	0.03	-0.13	ns	-0.32	<0.01	-0.41	<0.01
Age	101	0	ns	0.04	ns	-0.24	0.01	-0.22	0.03
Children									
Annual Income	97	-0.19	ns	-0.24	0.02	-0.31	<0.01	-0.18	ns
Race/ethnicity	104	0.19	0.05	0.22	0.03	0.28	<0.01	0.14	ns
Language at Home	104	0.23	0.02	0.23	0.02	0.27	0.01	0.12	ns
Years of School	104	-0.2	0.04	-0.07	ns	-0.36	<0.01	-0.3	<0.01
Age	104	-0.2	0.04	-0.05	ns	-0.35	<0.01	-0.29	<0.01

* Significant correlations not observed between smoking (cigarettes smoked per day)
or alcohol consumption (drinks per week) and color vision

Table 3.4-4a. Color Vision - Significance of Decreasing Trend (Cochran-Armitage Exact Trend Test) in Percent of Residents of Buildings With or Without a Dry Cleaner (Indoor Air Perc < 100 ug/m^3 or > 100 ug/m^3) Making No Major Errors

Color Vision Test	Percent with No Major Errors							
	Adult Residents				Child Residents			
	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p
		< 100 ug/m^3	>100 ug/m^3			< 100 ug/m^3	>100 ug/m^3	
Farnsworth (n=total sample size)	97.9 (n=48)	95.2 (n=41)	100.0 (n=12)	0.62	88.9 (n=54)	89.7 (n=39)	90.9 (n=11)	0.52
Lanthony (n=total sample size)	77.1 (n=48)	85.7 (n=42)	75.0 (n=12)	0.44	56.0 (n=50)	80.0 (n=30)	50.0 (n=10)	0.28

Table 3.4-4b. Significance of Decreasing Trend (Cochran-Armitage Exact Trend Test) in Percent of Residents of Buildings With or Without a Dry Cleaner (Indoor Air Perc < 100 ug/m^3 or > 100 ug/m^3) Making No Major Errors on the Farnsworth Color Vision Test

	Percent with No Major Errors							
	Adult Residents				Child Residents			
	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p
		< 100 ug/m^3	>100 ug/m^3			< 100 ug/m^3	>100 ug/m^3	
Stratified by Race/ethnicity								
Minority Only (n=total sample size)	95.0 (n=20)	94.1 (n=17)	100.0 (n=9)	0.51	81.5 (n=27)	83.3 (n=18)	87.5 (n=8)	0.46
Non-minority Only (n=total sample size)	100.0 (n=28)	95.8 (n=24)	100.0 (n=3)	0.50	96.3 (n=27)	95.2 (n=21)	100.0 (n=3)	0.72
Stratified by Income								
Low Income Only (n=total sample size)	92.9 (n=14)	83.3 (n=6)	100.0 (n=5)	0.58	81.8 (n=22)	66.7 (n=6)	100.0 (n=5)	0.42
Higher Income Only (n=total sample size)	100.0 (n=33)	96.7 (n=30)	100.0 (n=4)	0.51	93.6 (n=31)	93.1 (n=27)	100.0 (n=4)	0.58

Table 3.4-4c. Significance of Decreasing Trend (Cochran-Armitage Exact Trend Test) in Percent of Residents of Buildings With or Without a Dry Cleaner (Indoor Air Perc < 100 ug/m^3 or > 100 ug/m^3) Making No Major Errors on Lanthony Color Vision Test

	Percent with No Major Errors							
	Adult Residents				Child Residents			
	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p	No Dry Cleaner in Building	Dry Cleaner in Building Indoor Air Perc (ug/m^3)		p
		< 100 ug/m^3	>100 ug/m^3			< 100 ug/m^3	>100 ug/m^3	
Stratified by Race/ethnicity								
Minority Only (n=total sample size)	55.0 (n=20)	76.5 (n=17)	66.7 (n=9)	0.25	48.2 (n=27	80.0 (n=7)	42.9 (n=7)	0.36
Non-minority Only (n=total sample size)	92.9 (n=28)	92.0 (n=25)	100.0 (n=3)	0.61	65.2 (n=23)	80.0 (n=15)	66.7 (n=3)	0.37
Stratified by Income								
Low Income Only (n=total sample size)	50.0 (n=14)	50.0 (n=6)	60.0 (n=5)	0.47	45.4 (n=22)	66.7 (n=6)	40.0 (n=5)	0.54
Higher Income Only (n=total sample size)	87.9 (n=33)	96.8 (n=31)	75.0 (n=4)	0.53	63.0 (n=27)	86.4 (n=22)	100.0 (n=3)	0.03 (INCR)

INCR – Increasing trend

Table 3.4-5. Color Confusion Indices for Adults and Children (un-paired)

		Adults				Children		
	Exposure Group	Mean	Median	Range		Mean	Median	Range
Farnsworth								
	Reference	1.028	1.000	1.000-1.281		1.058	1.000	1.000-1.634
	< 100 ug/m3	1.020	1.000	1.000-1.471		1.030	1.000	1.000-1.219
	> 100 ug/m3	1.010	1.000	1.000-1.116		1.037	1.000	1.000-1.275
	Chi Square Statistic	4.936				0.458		
	p-value	0.08				0.79		
Lanthony								
	Reference	1.100	1.000	1.000-1.523		1.199	1.000	1.000-2.022
	< 100 ug/m3	1.083	1.000	1.000-2.038		1.093	1.000	1.000-1.714
	> 100 ug/m3	1.107	1.000	1.000-1.430		1.305	1.000	1.000-1.904
	Chi Square Statistic	0.452				6.476		
	p-value	0.80				0.04		

Table 3.4-6. Summary of Significance of Child-Adult Differences in Color Vision (Kruskal-Wallis Test for Matched Pairs)

Color Vision Test	Number of pairs		Mean Difference	Chi Square Statistic	p value
Farnsworth	Reference	47	0.019	1.560	0.75
	<100 ug/m3	36	-0.004		
	>100 ug/m3	10	0.029		
Lanthony	Reference	43	0.041	9.727	<0.01
	<100 ug/m3	28	-0.046		
	>100 ug/m3	9	0.301		

PTable 1.5–1. Neuropsychological Tests Grouped by Domain

GENERAL INTELLECTUAL FUNCTIONING
• Wechsler Intelligence Scale for Children – III (WISC-III) Full Scale IQ Verbal IQ Performance IQ Verbal Comprehension Index Perceptual Organization Index Processing Speed Index Freedom From Distractibility Index
ATTENTION/INFORMATION PROCESSING SPEED
• Children's Memory Scale (CMS) Attention and Concentration Index • WISC-III Freedom from Distractibility Index Processing Speed Index • Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14) (HRNB-OC) Speech-Sounds Perception Test Seashore Rhythm Test
VISUOSPATIAL ABILITY
• WISC-III Perceptual Organization Index • Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14) Trail Making Test- Part A • Reitan-Indiana Neuropsychological Test Battery (ages 5-8) Matching Figures Test Matching V's Test Star Drawing Concentric Squares Drawing Target Test
REASONING AND LOGICAL ANALYSIS
• Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14) Category Test Trail Making Test – Part B • Reitan-Indiana Neuropsychological Test Battery (ages 5-8) Category Test Color-Form Test Progressive Figures Test

MEMORY
• Children's Memory Scale Visual Immediate Memory Index Visual Delayed Memory Index Verbal Immediate Memory Index Verbal Delayed Memory Index General Memory Index Learning Index Delayed Recognition Index • Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14) Tactual Performance Test – Memory Tactual Performance Test – Localization • Reitan-Indiana Neuropsychological Test Battery (ages 5-8) Tactual Performance Test – Memory Tactual Performance Test – Localization
MOTOR FUNCTIONS
• Purdue Pegboard • Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14) Finger Tapping Test Grip Strength Name Writing Tactual Performance Test – Total completion time • Reitan-Indiana Neuropsychological Test Battery (ages 5-8) Finger Tapping Test Marching Test Tactual Performance Test – Total completion time
SENSORY-PERCEPTUAL FUNCTIONS
• Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14) Bilateral Sensory Perception Tactile Finger Recognition Finger-Tip Number Writing Tactile Form Recognition • Reitan-Indiana Neuropsychological Test Battery (ages 5-8) Bilateral Sensory Perception *Tactile Finger Recognition* Finger-Tip Number Writing Tactile Form Recognition

PTable 1.5–2. Neuropsychological test scores used in the analyses

Wechsler Intelligence Scale for Children – III (WISC-III)

1. Full Scale IQ – reflects every measure in WISC-III
2. Verbal IQ – reflects verbally based measures
3. Performance IQ – reflects visuospatial measures, nonverbal reasoning, processing speed measures
4. Verbal Comprehension Index – reflects acquired knowledge, verbal reasoning
5. Perceptual Organization Index – reflects nonverbal reasoning, attentiveness to visual detail, visuomotor abilities
6. Freedom From Distractibility Index – measures attention
7. Processing Speed Index – measures ability to process visual information quickly

Children's Memory Scale (CMS)

8. Visual Immediate Memory Index – measures immediate memory for visual/nonverbal information
9. Visual Delayed Memory Index – measures retention of visual/nonverbal information
10. Verbal Immediate Memory Index – measures immediate memory for auditory/verbal information
11. Verbal Delayed Memory Index – measures retention of auditory/verbal information
12. General Memory – reflects immediate and delayed memory tests; a "global measure" of memory functioning
13. Attention and Concentration – measures attention and processing speed
14. Learning Index – measures rate of learning across repeated learning trials
15. Delayed Recognition Index – measures retrieval of information learned on immediate recall trials

Reitan-Indiana Neuropsychological Test Battery

16. Level of Performance – reflects overall performance on all tests within the battery
17. Right/Left Differences – compares performance on tasks with right/left hands; measures comparative functioning of right/left cerebral hemispheres
18. Dysphasia and Related Variables – measures deficits in language abilities
19. Total Neuropsychological Deficit Score – combines scores of all tests in battery

Halstead-Reitan Neuropsychological Battery for Older Children (HRNB-OC)

20. Level of Performance - reflects overall performance on all tests within the battery
21. Right/Left Differences– compares performance on tasks with right/left hands; measures comparative functioning of right/left cerebral hemispheres
22. Dysphasia and Related Variables – measures deficits in language abilities
23. Total Neuropsychological Deficit Score – combines scores of all tests in battery

Purdue Pegboard - measures eye-hand coordination, manual dexterity, motor speed

24. Dominant Hand
25. Nondominant Hand
26. Both Hands

Neurobehavioral Evaluation System – 2 (NES-2)

27. Finger Tapping – Preferred Hand
28. Finger Tapping – Nonpreferred Hand
29. Finger Tapping – Alternating Hands
30. Continuous Performance Test – Reaction Time
31. Continuous Performance Test – Nonresponses
32. Continuous Performance Test – False Positives
33. Hand-Eye Coordination
34. Pattern Memory- # correct
35. Pattern Memory – average latency for response
36. Simple Reaction Time
37. Visual Digit Span Forward
38. Visual Digit Span Backward

Child Behavior Checklist (CBLC)

39. Internalizing Disorders
40. Externalizing Disorders
41. Total Disorders
42. DSM Affective Problems
43. DSM Anxiety Problems
44. DSM Somatic Problems
45. DSM Attention Deficit/Hyperactivity Problems
46. DSM Oppositional Defiant Problems
47. DSM Conduct Problems

PTable 2.2–1a. Characteristics of Children Participating in PPDCC Follow-up Evaluation – Vision Tests

Matched Pairs

		PPDCC Participants	Comparison Participants
Number (n)		13	13
Gender	Males	4	4
	Females	9	9
Age (yrs) (mean ± SEM)		9.7 ± 0.6	9.9 ± 0.7
Max hrs/week at day care (mean ± SEM)		42.8 ± 1.7	37.3 ± 2.8
Total hrs at day care (mean ± SEM)		7471.5 ± 632.8	6459.0 ± 1181.9
Total PPDCC hrs before 8/8 (mean ± SEM)		6199.4 ± 567.5	-
Time since exposure (months) (mean ± SEM)		56.3 ± 1.8	-

All Participants

		PPDCC Participants	Comparison Participants
Number (n)		17	13
Gender	Males	8	4
	Females	9	9
Age (yrs) (mean ± SEM)		9.2 ± 0.5	9.9 ± 0.7
Max hrs/week at day care (mean ± SEM)		42.5 ± 1.5	37.3 ± 2.8
Total hrs at day care (mean ± SEM)		7503.1 ± 541.1	6459.0 ± 1181.9
Total PPDCC hrs before 8/8 (mean ± SEM)		6397.5 ± 499.1	-
Time since exposure (months) (mean ± SEM)		54.9 ± 1.5	-

PTable 2.2–1b. Characteristics of Children Participating in PPDCC Follow-up Evaluation – Neurobehavioral Assessment

All Participants

		PPDCC Participants	Comparison Participants
Number (n)		13	13
Gender	Males	7	4
	Females	6	9
Age (yrs) (mean ± SEM)		9.1 ± 0.5	10.2 ± 0.7
Max hrs/week at day care (mean ± SEM)		41.8 ± 1.7	37.3 ± 2.8
Total hrs at day care (mean ± SEM)		7125.8 ± 498.5	6459.0 ± 1181.9
Total PPDCC hrs before 8/8 (mean ± SEM)		6518.8 ± 582.5	-
Time since exposure (months) (mean ± SEM)		55.8 ± 2.0	-

PTable 2.3–1. Visual Contrast Sensitivity Scores for PPDCC and Comparison Children

Matched Pairs (including 6 year olds)

Spatial Frequency (cpd)	PPDCC Group (n=13)		Comparison Group (n=13)	
	Mean VCS	**Std Deviation**	**Mean VCS**	**Std Deviation**
1.5	83.5	21.3	78.2	17.8
3	129.0	38.7	105.0	37.1
6	125.4	41.3	112.1	40.1
12	75.2 *	31.4	46.9	16.8
18	31.0	13.4	22.2	11.6

Matched Pairs (not including 6 year olds)

Spatial Frequency (cpd)	PPDCC Group (n=11)		Comparison Group (n=11)	
	Mean VCS	**Std Deviation**	**Mean VCS**	**Std Deviation**
1.5	83.1	22.4	79.8	19.0
3	127.0	41.4	105.9	39.6
6	119.5	41.3	109.1	36.6
12	75.3 **	33.8	46.5	15.1
18	29.5	13.8	22.0	11.7

* Significantly different from comparison, Wilcoxon signed-rank test for matched pairs, p=0.0068

** Significantly different from comparison, Wilcoxon signed-rank test for matched pairs, p=0.0273

PTable 2.3–2. Discordant and Concordant Pairs – Clinical Judgement of Color Vision Test Performance in PPDCC and Comparison Children

		Discordant Pairs		Concordant Pairs		
	PPDCC Child:	Abnormal	Normal	Abnormal	Normal	TOTAL
	Matched Comparison Child:	Normal	Abnormal	Abnormal	Normal	
Including 6-year-olds	Farnsworth Number of Pairs	2	0	1	10	13
	Lanthony Number of Pairs	2	3	3	5	13
Not including 6-year-olds	Farnsworth Number of Pairs	0	0	1	10	11
	Lanthony Number of Pairs	1	3	2	5	11

PTable 2.3–3. Discordant and Concordant Pairs – Major Errors on Color Vision Tests in PPDCC and Comparison Children

		Discordant Pairs		Concordant Pairs		
	PPDCC Child:	≥1 Error	No Errors	No Errors	≥1 Error	TOTAL
	Matched Comparison Child:	No Errors	≥1 Error	No Errors	≥1 Error	
Including 6-year-olds	Farnsworth Number of Pairs	1	4	8	0	13
	Lanthony Number of Pairs	1	2	4	6	13
Not including 6-year-olds	Farnsworth Number of Pairs	1	2	8	0	11
	Lanthony Number of Pairs	1	2	4	4	11

PTable 2.3–4a. Summary of Farnsworth Color Vision Test Performance Differences Between PPDCC and Comparison Children

PAIR	Average of Both Eyes			Worst Eye		
	PPDDC	Comparison	Difference	PPDDC	Comparison	Difference
1	1.00	1.00	0.00	1.00	1.00	0.00
2	1.00	1.00	0.00	1.00	1.00	0.00
3	1.05	1.66	-0.62	1.09	1.77	-0.68
4	1.00	1.00	0.00	1.00	1.00	0.00
5	1.06	1.00	0.06	1.13	1.00	0.13
6	1.00	1.08	-0.08	1.00	1.10	-0.10
7	1.00	1.28	-0.28	1.00	1.28	-0.28
8	1.52	1.12	0.40	1.58	1.24	0.34
9	1.00	1.00	0.00	1.00	1.00	0.00
10	1.00	1.00	0.00	1.00	1.00	0.00
11	1.00	1.10	-0.10	1.00	1.20	-0.20
12	1.00	1.09	-0.09	1.00	1.17	-0.17
13	1.06	1.00	0.06	1.13	1.00	0.13
14	1.00	---	---	1.00	---	---
15	1.00	---	---	1.00	---	---
16	1.46	---	---	1.57	---	---
17	1.52	---	---	1.77	---	---

PTable 2.3–4b. Summary of Lanthony Color Vision Test Performance Differences Between PPDCC and Comparison Children

PAIR	Average of Both Eyes			Worst Eye		
	PPDDC	Comparison	Difference	PPDDC	Comparison	Difference
1	1.00	1.18	-0.18	1.00	1.27	-0.27
2	1.03	1.09	-0.05	1.06	1.10	-0.03
3	1.21	2.05	-0.83	1.43	2.06	-0.63
4	1.62	1.38	0.24	1.75	1.45	0.29
5	1.11	1.00	0.11	1.17	1.00	0.17
6	1.05	1.16	-0.11	1.10	1.32	-0.22
7	1.55	1.75	-0.20	1.69	1.75	-0.06
8	2.24	1.53	0.71	2.30	1.68	0.62
9	1.26	1.16	0.09	1.35	1.22	0.14
10	1.05	1.68	-0.63	1.10	1.69	-0.59
11	1.63	1.26	0.37	1.82	1.33	0.48
12	1.52	1.08	0.45	1.65	1.16	0.49
13	1.48	1.00	0.48	1.68	1.00	0.68
14	1.92	---	---	2.03	---	---
15	2.05	---	---	2.36	---	---
16	1.78	---	---	1.92	---	---
17	1.99	---	---	1.99	---	---

PTable 2.4–1. Comparison of PPDCC and Comparison children on neuropsychological measures

	Exposed				Controls					
Variable	N	M	SD	Range	N	M	SD	Range	*t*	*p*
Reitan-Indiana[a]										
Level of Performance	4	**4.00**	3.74	0-9	6	**9.83**	7.88	2-20	-1.36	0.21
Right/Left Difference	4	**6.00**	1.83	4-8	6	**7.17**	2.71	3-11	-0.75	0.48
Dysphasia/Related Var.	4	**1.50**	2.38	0-5	6	**1.50**	2.35	0-5	0.00	1.00
Total NDS Score	4	**11.50**	5.32	5-18	6	**18.50**	12.52	6-34	-1.04	0.33
HRNB-OC[a]										
Level of Performance	7	**14.00**	9.09	5-32	7	**9.71**	5.02	4-19	1.09	0.30
Right/Left Difference	7	**5.57**	1.90	3-8	7	**9.14**	3.44	3-13	-2.41	0.03
Dysphasia/Related Var.	7	**0.57**	0.98	0-2	7	**0.57**	0.79	0-2	0.00	1.00
Total NDS Score	7	**20.14**	9.89	8-38	7	**19.43**	6.8	7-26	0.16	0.88
WISC-III										
Full Scale IQ	12	**126.50**	12.98	96-146	13	**115.31**	11.48	97-137	2.34	0.03
Verbal IQ	12	**127.08**	15.77	93-155	13	**116.85**	13.69	93-135	1.74	0.10
Performance IQ	12	**122.00**	13.30	98-141	13	**110.69**	9.95	89-133	2.42	0.02
VerbalComprehen.	12	**126.58**	13.32	98-150	13	**116.31**	13.13	95-137	1.94	0.07
Perceptual Org.	12	**122.25**	12.85	100-144	13	**111.00**	10.72	90-133	2.39	0.03
Freedom from Distr.	11	**121.00**	11.02	98-137	13	**113.15**	16.52	90-148	1.34	0.19
Processing Speed	11	**117.18**	13.93	91-137	13	**115.08**	10.28	99-131	0.43	0.68
CMS										
Visual Immediate	13	**114.15**	13.70	91-143	12	**107.92**	13.57	91-131	1.14	0.27
Visual Delayed	13	**115.54**	12.84	97-140	12	**106.08**	13.37	75-125	1.80	0.08
Verbal Immediate	13	**118.92**	15.15	91-137	13	**117.15**	14.28	94-143	0.31	0.76
Verbal Delayed	13	**116.46**	14.60	85-134	13	**118.00**	15.86	88-146	-0.28	0.80
General Memory	13	**123.38**	16.33	92-143	12	**120.00**	11.62	100-139	0.59	0.56
Attention/Conc	13	**120.62**	16.54	88-146	13	**115.69**	15.8	97-137	0.78	0.45
Learning	13	**116.00**	12.29	94-137	13	**111.38**	12.29	91-128	0.96	0.35
Delayed Recog	13	**111.77**	11.45	88-112	13	**109.77**	13.12	82-128	0.41	0.68

[a] Lower scores represent better performances on these measures.
Dysphasia/Related Var.= Dysphasia and Related Variables   Total NDS Score = Total Neuropsychological Deficits Score.

Variable	Exposed N	Exposed M	Exposed SD	Exposed Range	Controls N	Controls M	Controls SD	Controls Range	F	*p*
Purdue Pegboard[b]										
DH	13	**12.77**	2.20	9-17	13	**12.78**	1.70	10-15	0.43	0.52
NDH	13	**12.15**	2.68	8-17	13	**11.92**	1.75	9-16	1.38	0.25
Both	13	**9.54**	2.37	6-14	13	**9.70**	2.36	7-14	0.12	0.74
NES-2[b]										
Finger Tapping										
Preferred	9	**103.67**	28.93	67.0-166.0	13	**104.23**	20.86	66.0-139.0	0.09	0.77
Nonpreferred	9	**94.11**	27.35	65.0-160.0	13	**93.15**	26.26	52.0-153.0	0.46	0.51
Alternating	9	**128.33**	41.03	68.0-210.0	13	**135.15**	35.41	50.0-178.0	0.02	0.89
CPT										
Reaction Time (ms)	9	**552.78**	74.51	429.0-680.0	13	**556.08**	72.81	446.0-656.0	1.35	0.26
Nonresponses	9	**5.11**	9.36	0-29.0	13	**4.31**	4.23	0-12.0	0.01	0.97
False Positives	9	**3.00**	4.00	1-13.0	13	**1.85**	2.48	0-8.0	0.47	0.5
Hand-Eye Coord.										
log rms error	9	**2.26**	0.17	1.9-2.5	13	**2.24**	0.41	1.7-2.9	0.09	0.76
Pattern Memory										
#correct/25	9	**20.22**	2.05	17.0-23.0	13	**18.31**	4.67	11.0-23.0	6.13	0.02
average latency (sec)	9	**6.57**	2.37	4.5-12.6	13	**7.38**	2.45	5.0-11.3	1.41	0.25
SRT (ms)	9	**454.33**	112.47	285.0-585.0	13	**480.31**	141.57	308.0-723.0	2	0.17
Visual Digit Span										
Forward Span	9	**6.00**	1.12	5.0-8.0	13	**5.54**	1.39	4.0-9.0	1.01	0.33
Backward Span	9	**4.56**	1.33	3.0-7.0	13	**4.62**	1.26	3.0-7.0	0.01	0.94

[b] The child's age was used as a covariate in the statistical analysis.

	Exposed				Controls					
Variable	N	M	SD	Range	N	M	SD	Range	*t*	*p*
Internalizing Disorders	13	**45.54**	7.70	33-60	13	50.08	11.21	34-74	-1.20	0.24
Externalizing Disorders	13	**44.15**	5.94	34-56	13	50.31	9.31	34-71	-2.01	0.06
Total Disorders	13	**42.23**	6.18	36-53	13	49.38	10.36	32-71	-2.14	0.04
DSM Affective Problems	13	**51.54**	3.07	50-60	13	53.62	8.40	50-78	-0.84	0.41
DSM Anxiety Problems	13	**52.15**	3.74	50-60	13	55.62	8.53	50-75	-1.34	0.19
DSM Somatic Problems	13	**52.38**	3.88	50-61	13	53.38	5.66	50-66	-0.53	0.60
DSM Attention deficit/ hyperactivity problems	13	**51.15**	2.23	50-58	13	53.23	5.38	50-66	-1.29	0.21
DSM Opposition defiant	13	**51.77**	3.39	50-62	13	54.69	6.47	50-73	-1.44	0.16
DSM Conduct Problems	13	**50.92**	1.50	50-54	13	55.00	7.12	50-70	-2.02	0.06

PTable 2.4–2. Description of Performance Ranges of PPDCC and Comparison Children/Adolescents

Reitan-Indiana Neuropsychological Test Battery (ages 5-8)	**Group**	**Mean**	**Range**	**Cut-off for impairment (Impaired : >/= cut-off)**
Level of Performance	PPDCC	4.00	0-9	31-32
	Control	9.83	2-20	
Right/Left Differences	PPDCC	6.00	4-8	11-12
	Control	7.17	3-11	
Dysphasia/Related Variables	PPDCC	1.50	0-5	10-11
	Control	1.50	0-5	
Total Neuropsychological Deficits Scale Score	PPDCC	11.50	5-18	54-55
	Control	18.50	6-34	
Halstead-Reitan Neuropsychological Battery for Older Children (ages 9-14**)**				
Level of Performance	PPDCC	14.00	5-32	33-34
	Control	9.71	4-19	
Right/Left Differences	PPDCC	5.57	3-8	9-10
	Control	9.14	3-13	
Dysphasia/Related Variables	PPDCC	0.57	0-2	3-4
	Control	0.57	0-2	
Total Neuropsychological Deficit Scale Score	PPDCC	20.14	8-38	43-44
	Control	19.43	7-26	

PTable 2.4–3. Description of Performance Ranges of PPDCC and Comparison Children

	Group	Mean	Range	PERFORMANCE LEVEL Average	Range
GENERAL INTELLECTUAL FUNCTIONING					
WISC-III Full Scale IQ	PPDCC	126.50	96-146	Superior	Average to Very Superior
	Control	115.31	97-137	High Average	Average to Very Superior
WISC-III Verbal IQ	PPDCC	127.08	93-155	Superior	Average to Very Superior
	Control	116.85	93-135	High Average	Average to Very Superior
WISC-III Performance IQ	PPDCC	122.00	98-141	Superior	Average to Very Superior
	Control	110.69	89-133	High Average	Low Average to Superior
WISC-III Verbal Comprehension Index	PPDCC	126.58	98-150	Superior	Average to Very Superior
	Control	116.31	95-137	High Average	Average to Very Superior
WISC-III Perceptual Organization Index	PPDCC	122.25	100-144	Superior	Average to Very Superior
	Control	111.00	90-133	High Average	Average to Very Superior
WISC-III Processing Speed Index	PPDCC	117.18	91-137	High Average	Average to Very Superior
	Control	115.08	99-131	High Average	Average to Very Superior
WISC-III Freedom from Distractibility Index	PPDCC	121.00	98-137	Superior	Average to Very Superior
	Control	113.15	90-148	High Average	Average to Very Superior
MEMORY					
Children's Memory Scale: Visual Immediate Memory Index	PPDCC	114.15	91-143	High Average	Average to Very Superior
	Control	107.92	91-131	Average	Average to Very Superior
Children's Memory Scale: Visual Delayed Memory Index	PPDCC	115.54	97-140	High Average	Average to Very Superior
	Control	106.08	75-125	Average	Borderline to Superior
Children's Memory Scale: Verbal Immediate Memory Index	PPDCC	118.92	91-137	High Average	Average to Very Superior
	Control	117.15	94-143	High Average	Average to Very Superior
Children's Memory Scale: Verbal Delayed Memory Index	PPDCC	116.46	85-134	High Average	Low Average to Very Superior
	Control	118.00	88-146	High Average	Low Average to Very Superior
Children's Memory Scale: General Memory Index	PPDCC	123.38	92-143	Superior	Average to Very Superior
	Control	120.00	100-139	Superior	Average to Very Superior
Children's Memory Scale: Learning Index	PPDCC	116.00	94-137	High Average	Average to Very Superior
	Control	111.38	91-128	High Average	Average to Superior
Children's Memory Scale: Delayed Recognition Index	PPDCC	111.77	88-112	High Average	Low Average to High Average
	Control	109.77	82-128	Average	Low Average to Superior

PTable 2.4–4. Description of Performance Ranges of PPDCC and Comparison Children

Purdue Pegboard	Group	Mean	Range	Performance Level
Dominant hand # pegs placed	PPDCC	12.77	9-17	Average
	Control	12.78	10-15	Average
Nondominant hand # pegs placed	PPDCC	12.15	8-17	Average
	Control	11.92	9-16	Average
Both hands # pegs placed	PPDCC	9.54	6-14	Low Average/Average
	Control	9.70	7-14	Low Average/Average

NTable 1.0-1. Description and Date Ranges for Seven Key Regulatory Time Periods

Time Period	Key Regulatory Requirements
1. Pre-NESHAP: Prior to September 23, 1993	Before NESHAP took effect
2. NESHAP: September 23, 1993 to May 14, 1997	After NESHAP was established but before NYS Part 232 took effect; control requirements based on Perc purchases
3. Part 232: May 15, 1997 to November 14, 1997	Only new equipment allowed to be used in dry cleaning shops and transfer machines prohibited
4. Part 232: November 15, 1997 to May 14, 1999	First and second generation equipment required to achieve compliance, new shops required to install only third or fourth generation units
5. Part 232: May 15, 1999 to December 24, 1999	Last date to comply with vapor barrier/room enclosure requirement and training certification required for all new facilities
6. Part 232: December 25, 1999 to December 31, 2000	Mandatory yearly facility inspections
7. Part 232: January 1, 2001 to August 5, 2003 (last date of data)	Upgrade second generation machines to fourth generation, and retrofit or upgrade third generation machines to fourth generation machines; only fourth generation machines can be sold, leased or installed.

NTable 1.0-2. Summary Statistics for Seven Regulatory Time Periods.

Time Period	**Number of Facilities**	**Number of Samples**	**% of Samples > Background* (2.9 μg/m³)**	**% of Samples > 100 μg/m³**	**% of Samples > 1,000 μg/m³**	**Range (μg/m³)**	**Geometric Mean (μg/m³) (Standard Deviation)**	**25th Percentile (μg/m³)**	**50th Percentile (μg/m³)**	**75th Percentile (μg/m³)**
1. **Pre-NESHAP:** prior to September 23, 1993	30	52	98.1	82.7	32.7	1.5 – 752,380	609.7 (10.7)	252.5	602.5	2,458.5
2. **NESHAP:** September 23, 1993 – May 14, 1997	64	705	98.9	78.6	39.4	0.7 – 170,000	507.2 (7.6)	130	530	2,300
3. **Part 232:** May 15, 1997 – November 14, 1997	37	142	100	62.0	14.1	5 – 11,500	150.5 (5.7)	40	160	450
4. **Part 232:** November 15, 1997 – May 14, 1999	54	407	99.5	52.3	21.9	1 – 20,000	155.4 (7.6)	26	140	790
5. **Part 232:** May 15, 1999 – December 24, 1999	36	181	100	68.5	21.0	5 – 11,000	251.6 (5.4)	70	290	900
6. **Part 232:** December 25, 1999 – December 31, 2000	30	115	100	60.0	26.1	5 – 6,600	235.6 (5.9)	65	180	1,100
7. **Part 232:** January 1, 2001 – August 5, 2003	57	556	99.3	47.7	12.2	1.8 – 7,000	98.1 (6.6)	20	91.5	390

Background value (2.9 μg/m³) is upper range (90th percentile) of indoor perc concentrations (DOH, 2004)

NTable 1.0-3: New York City dry cleaners:

Eleven facilities with at least one measured sample in areas colocated with dry cleaners greater than or equal to 100 ug/m^3 and sampled during at least three of the regulatory time periods.

Facility	County	Reason for Initial Sampling	Pre-NESHAP Prior to Sept. 23, 1993			NESHAP Sept. 23, 1993 - May 14, 1997			DEC Part 232 May 15, 1997 - Nov. 15, 1997			DEC Part 232 Nov. 15, 1997 - May 15, 1999			DEC Part 232 May 15, 1999 - Dec. 25, 1999			DEC Part 232 Dec. 25, 1999 - Jan. 1, 2001			DEC Part 232 Jan. 1, 2001 - Aug 5, 2003		
			Concentration Range (ug/m3)	n	Sample Duration (H:M)	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Concentration Range (ug/m3)	n	Sample Duration (H:M)
DC-14	New York	Complaint				2,900 - 3,300	3	6:00	150 - 220	4	2:00	30 - 500	6	2:00									
DC-19	New York	Complaint				45 - 3,600	6	2:00	120 - 1,900	6	2:00										260 - 340	6	2:00
DC-29	New York	Complaint				100 - 220	3	2:00 - 3:39	35 - 150	4	2:00	180 - 190	2	2:00	40	2	2:00						
DC-31	New York	Complaint	2,472 - 752,380	2	5:30 - 6:00							2900	2	2:00	700 - 800	4	2:00	360 - 2,500	6	2:00	100 - 250	7	2:00
DC-35	New York	Complaint				1,700 - 1,750	2	2:00	500 - 8,800	6	2:00	330 - 400	4	2:00	230 - 500	4	2:00	270 - 900	8	2:00	150 - 900	24	2:00
DC-44	New York	Complaint				400 - 3,900	3	2:00	200 - 2,100	6	2:00	150 - 1,400	6	2:00							366 - 378	2	25:39
DC-76	New York	Complaint				600	2	2:00	30 - 260	4	2:00										103 - 400	46	2:00 - 22:00
DC-77	New York	Complaint				50 - 6,910	166	1:30 - 22:00	10 - 640	20	4:02 - 17:50	10 - 70	30	4:00 - 17:40							5 - 41	8	23:16 - 26:00
DC-78	New York	Complaint				8,200 - 8,350	3	2:00	400 - 450	2	2:00	90 - 120	4	2:00	5	2	2:00						
DC-81	New York	Complaint				260 - 290	3	2:00	280 - 290	2	2:00	15 - 300	8	2:00									
DC-83	New York	Complaint				1,000 - 1,050	2	2:00	80 - 1,900	4	2:00	230 - 1,450	8	2:00	260 - 400	2	2:00						

Facility	County	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-14	New York	80 (2001 received late initial notification); now using hydrocarbon dry cleaning machine (as reported in 2003)	Third	Installed 1993	VB/RC	Late submission of initial notification; 3rd party inspection: 9/14/2002 and 9/12/2001 (operating third generation machine in compliance), 9/13/2000 (no comment)
DC-19	New York	65 (2002); 60 (06/09/2003 NYC DEP inspection)	Fourth	Installed in 2/1997	VB/RC/CA	Late submission of initial notification; 3rd party inspection 1/16/2004, 1/23/2003: (operating fourth generation machine in compliance). 1/25/2002: Violations documented are for failure to complete an annual 3rd party inspection in calendar year 2000. (NYCRR 232.16); complete an annual 3rd party inspection in calendar year 2001. (NYCRR 232.16); submit the NESHAP initial notification form. (40 CFR 63 M); install a general exhaust ventilation system by the 5/15/99 deadline. (6NYCRR 232.6); properly seal the vapor barrier room. (6NYCRR 232.6). NYC DEP inspection 6/9/2003 (operating fourth generation machine in compliance; residences four floors above the facility)
DC-29	New York	no data	Third	No data	VB/RC	In violation- no initial notification received; 3rd party inspection 1/20/2001, 1/21/2000 (operating third generation machine in compliance)
DC-31	New York	50 - 180 in 1993; 120 (2000); 60 (2001)	Transfer in 1993; Third (8/14/2000); Fourth (after 8/14/2000 but before 5/30/2001; exact date unknown)	Fourth installed after 8/14/2000 but before 5/30/2001	VB/RC/CA	Late submission with initial notification and 3rd party inspections: 8/5/2003 and 8/7/2002 (operating fourth generation machine in compliance); 8/4/2001 (in compliance); 8/14/2000 (operating third generation machine in compliance); 6/3/1999 (vapor barrier room completed. Seal was removed and operator allowed to operate.); 6/2/1999 (vapor barrier room was not complete. Machine sealed and tagged.) NYC DEP inspection on 5/30/2001 (operating fourth generation machine in compliance)
DC-35	New York	60 (1994 initial notification received); 30 (04/27/2001 NYC DEP inspection)	Fourth	Third party inspection states the facility was upgraded in 8/1997	VB/RC/CA	In violation of initial notification; details for initial installation of machine are missing; 3rd party inspections: 1/14/2004, 1/15/2003, 1/15/2002 (Failure to notify the Department by certified mail within 30 days of installation of the vapor barrier room and general exhaust system, and certify that it met all regulatory requirements), 1/15/2001 (operating fourth generation machine in compliance), 1/27/2000 (Notice of violation states failure to install a complete vapor barrier room and general exhaust ventilation system when replacing a machine; installed a fourth generation dry cleaning machine on 8/1997 and did not install the vapor barrier until 8/1998). 04/27/2001 NYC DEP inspection states fourth generation machine was operating propperly, vapor barrier was in compliance, but the owner was advised to seal all the opened spaces between pipes going through the ceiling of the store as soon as possible.
DC-44	New York	100 (year initial notification was received is not specified); 80 (11/13/2002 NYC DEP inspection)	Fourth	Installed in 4/1999	VB/RC/CA	In violation of initial notification, late submission; 3rd party inspection: 7/17/2003 (operating fourth generation machine in compliance); 5/26/2000 (The facility failed to obtain Registration of a 4th generation Mixed-use residential dry cleaning machine by the due date of December 25, 1999. As of the time of inspection, May 26, 2000, the facility has yet to apply. The facility failed to notify the DEC, by certified mail, within 30 days of installation of a vapor barrier. The individual failed to obtain Operator and Owner/Manager certifications for a 4th generation Mixed-use dry cleaning machine by the due date of March 25, 2000. The facility failed to file a NESHAP Initial Notification Report.) 11/13/2002 NYC DEP inspection states the facility is operating a fourth generation machine in compliance and a vapor barrier is in place as per regulation.
DC-76	New York	84 (1996 received initial notification); 60 (03/25/2003 NYC DEP inspection)	Fourth	Installed in 1996	VB/RC/CA	In compliance with initial notification; 3rd party inspection 11/21/2003; 11/21/2002; 11/23/2001; 11/24/2000 all stated fourth generation equipment and the facility was in compliance. NYC DEP inspection report 4/3/2002 (operating fourth generation machine in compliance). NYC DEP inspection report 3/25/03 states the facility operates a fourth generation machine and uses 60 gal Perc/yr. There was a vapor barrier in place, but the machine was not working properly. A high Perc concentration was found inside the machine's basket while the front loading door was opened (9746 ppm; above the 500 ppm limit).
DC-77	New York	no data	no data	no data	no data	In violation- no initial notification received; no 3rd party inspection on file; DEC inspection 10/20/2003 states this facility is a drop shop
DC-78	New York	200 (received late initial notification in 1999); 160 (03/09/2001 NYC DEP inspection; Perc consumption is for two machines)	One Fourth; Two Fourth per third party inspections 2000-2002	one fourth installed in 1999	VB/RC/CA	DEC inspection 10/22/2003 states the facility was in compliance with registration and third party inspection requirements, but a small hole (3 in. diameter) in the vapor barrier was noted. 3rd party inspections: 5/22/2003: no comments, in compliance; 5/22/2002: operating two fourth generation machines; 5/26/2001: violation noted-failure to comply with equipment standards and specification requirements; a Perc concentration of 550 ppm was detected in one machine; and 5/27/2000: violations: failure to submit registration, later permit application, and Perc concentrations of 900 ppm were detected in both fourth generation machines; NYC DEP inspection 3/9/2001 states the facility operates two fourth generation machines in compliance and uses 160 gal/yr. There was a vapor barrier in place.
DC-81	New York	no data	no data	no data	no data	Now currently operating as a drop shop (8/2004 yellow page listing and phone call inquiry)
DC-83	New York	no data	no data	No data	no data	In violation- no initial notification received; inspection and data review 7/22/2002; reported this facility is operating as a drop shop since May 1998

** Information may not be reflective of conditions present at time of sampling; majority of reports made after 1999 NYS DEC regulation requiring annual inspections

Concentration Range = The minimum and maximum perc concentrations (in ug/m3) measured at the particular dry cleaning facility during the specified regulatory time period.

n = The total number of samples taken during the specified time period at the dry cleaning facility

Sample Duration = The minimum and maximum times (in hours:minutes) the samples were taken for.

Perc Consumption (gals/yr) = The amount (in gallons) of perc solvent used by a dry cleaning facility, during the most recent 12 month reporting period (annually), as reported on the EPA NESHAP Initial Notification form and/or from NYC DEP inspection reports

Equipment Generation = The "generation" or type of dry cleaning machine being used at the dry cleaning facility as reported with the NESHAP Initial Notification Report, and/or as documented in the NYS DEC Part 232 required annual Compliance Inspection (a.k.a., "third part inspections") or NYC DEP dry cleaning facility inspection reports.

Equipment Age = The date the dry cleaning equipment was installed as self-reported on the EPA NESHAP Initial Notification form. The dates dry cleaning machines were upgraded were included when available in NYS DEC AFS database.

Vapor Barrier or Other Control = The use of vapor barriers/room enclosures (VB/RE), with dedicated general exhaust ventilation systems (GEVS) independent from any building HVAC systems, and the phasing-in of modern fourth generation dry cleaning equipment possessing both fourth generation dry cleaning equipment possessing both primary and secondary emission control systems.

Control Codes:

VB=Vapor Barrier

RC=Refrigerator Condenser

CA=Carbon Adsorber

Reported Facility Information = The NYS DEC AFS permitting database was accessed to obtain the following information: if the NESHAP Initial Notification report was received, the dates Compliance Inspections (a.k.a. "third party inspections") were conducted and any records that enforcement actions (Notices of Violation, "NOVs") had been taken against the facility along with any Part 232 or other pertinent facility -specific information.

NTable 1.0-4: New York City dry cleaners:

Randomly-selected facilites with at least one measured sample in areas colocated with dry cleaners and greater than or equal to 100 ug/m^3 from each time period

Pre-NESHAP: prior to September 23, 1993

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-80	Kings	DC study	890	1	5:40	600 (1993)	Transfer in 1992; Second in 1993	no data	no data	no data
DC-30	New York	DC study	255 - 3,335	5	3:40 - 4:00	100 (1992); 235 (1993)	Third in 1991	no data	RC (1993)	no data
DC-31	New York	Complaint	2,472 - 752,380	2	5:40 - 5:50	100 (1992); 50 - 180 (1993)	Second in 1992? / Transfer in 1993	no data	RC (1993)	Residence in same building as dry cleaner
DC-13	New York	Complaint	890	1	5:30	no data	no data	no data	no data	no data
DC-65	New York	Complaint	290	1	2:00	100 (2000 received late initial notification)	Third in 1993	no data	RC	no data
DC-4	New York	Complaint	555	1	5:30	no data	Transfer in 1993	no data	no control	no data
DC-50	New York	DC study	1,290 - 4,250	4	3:30 - 5:30	no data	no data	no data	no data	no data
DC-6	New York	DC study	50 - 2,580	4	2:55 - 5:30	300 (1992); 240 - 300 (1993)	Transfer in 1993	no data	CA	no data
DC-32	New York	Complaint	335 - 49,000	2	3:30	50	Second in 1993	no data	RC	no data

NESHAP: September 23, 1993 - May 14, 1997

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-50	New York	DC study	186 - 13,451	17	3:00 - 4:25	no data	Third in 1993	no data	RC	Initial notification never received. Facility closed by NYCDOH for high perc levels prior to Oct. 1993; in response, VB room with separate ventillation system built around dry-to-dry machine; Residence located in same building as dry cleaner
DC-20	New York	DC study	25 - 4,864	25	2:35 - 4:10	100 - 150 in 1993	Third in 1992	Second Installed in 1985	No control equip; RC/CA (1993)	Late submission of initial notification (2000); DEC AFS lists second generation (dry to dry) installed in 1985, no control equipment;
DC-26	New York	Complaint	7,950 - 8,700	2	2:00	185 in 1994	Transfer	Installed in 1976	No control equip	no data
DC-37	New York	Complaint	75 - 2,900	11	2:00	160 (2001 received late initial notification)	Fourth	Installed in 1994	RC/CA	no data
DC-46	New York	Complaint	200	2	2:00	130 (2002 received late initial notification)	Third	Installed in 1995	RC	no data
DC-51	New York	Complaint	470 - 520	3	2:00	74 (2001 received late initial notification)	Third	Installed in 1995	RC	no data
DC-72	New York	Complaint	60 - 825	8	2:00 - 24:17	no data				Initial notification was not received
DC-74	Bronx	DC study	210 - 245	3	2:00	100 (1996 received initial notification)	Fourth	Installed in 1996	RC/CA	no data
DC-76	New York	Complaint	600	2	2:00	84 (1996 received initial notification)	Fourth	Installed in 1996	RC/CA	no data
DC-82	New York	Complaint	300	2	2:00	no data	no data	no data	no data	Initial notification was not received;

DEC Part 232: May 15, 1997 - November 14, 1997

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gal/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-7	New York	Complaint	250	2	2:00	no data	no data	no data	no data	no data
DC-14	New York	Complaint	150 - 220	4	2:00	80 (2001 received late initial notification)	Third	Installed in 1993	RC	no data
DC-23	New York	Complaint	200	2	2:00	90 (2002 received late initial notification)	Fourth	Installed in 1996	RC/CA	10/20/2003 Routine inspection notes state owner has operated facility for 25 years and the fourth generation machine was installed in 1996
DC-25	New York	Complaint	140 - 145	2	2:00	200 (2001 received late initial notificaiton)	no data	no data	no data	Fourth generation machine was installed in 2001, but there was no data available for machine generation before 2001
DC-27	New York	Complaint	510 - 560	4	2:00	20 (2002 received late intial notification)	no data	no data	no data	Fourth generation machine was installed in 2002, but there was no data available for machine generation before 2002
DC-35	New York	Complaint	500 - 8,800	6	2:00	60 (1994 received initial notification)	Fourth	Upgraded to Fourth in 1997	RC/CA	no data
DC-36	New York	Complaint	620 - 11,500	4	2:00	no data	no data	no data	RC/CA	Residence in same building as dry cleaner; not in NYS DEC AFS
DC-67	New York	Complaint	2,100 - 6,000	4	2:00	no data	no data	no data	no data	not in NYS DEC AFS
DC-69	Kings	Complaint	140	2	2:00	130 (2000 received late initial notification)	no data	no data	no data	no data
DC-90	Kings	Complaint	190 - 230	4	2:00	120 (2001 received late initial notification)	no data	no data	no data	no data

DEC Part 232: November 15, 1997 - May 14, 1999

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-14	New York	Complaint	30 - 500	6	2:00	80 (2001 received late initial notification)	Third	Installed in 1993	VB/RC	no data
DC-22	New York	Complaint	70 - 1,100	17	2:00 - 16:30	60 (1992)	Third in 1992	no data	no data	Initial notification was not received
DC-29	New York	Complaint	180 - 190	2	2:00	75 (1992)	Third in 1992	no data	no data	In violation--no initial notification received; 3rd party inspection 1/20/2001 and 1/21/2000 facility operating a third generation machine in compliance; DOH shut down machine operation twice in 1995
DC-31	New York	Complaint	2900	2	2:00	100 (1993) 120 (2000 received late initial notification)	Second in 1993	no data	no data	6/2/1999 vapor barrier room was not complete; 6/3/1999 vapor barrier room was completed. Seal was removed and operator allowed to operate. 8/14/2000 third party inspection states facility is operating a third generation machine in compliance.
DC-35	New York	Complaint	330 - 400	4	2:00	60 (1994 received initial notification)	Fourth	Upgraded in 4/1997	VB/RC/CA	no data
DC-47	New York	Complaint	220 - 250	2	2:00	200 (1999 received late initial notification but it stated this was the Perc consumption data for third generation equipment installed in 1992)	Third	Installed in 1992	VB/RC	7/1/1999 3rd party inspection states third gen
DC-52	New York	Complaint	100	2	2:00	65	Third	Installed in 1992	VB/RC	no data
DC-57	New York	Complaint	1700	2	2:00	no data	no data	no data	no data	no data
DC-70	Kings	Complaint	80 - 2300	4	2:00	no data	Third in 1993	no data	RC	no data
DC-90	Kings	Complaint	140 - 160	2	2:00	no data	no data	no data	no data	no data

DEC Part 232: May 15, 1999 - December 24, 1999

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gal/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-27	New York	Complaint	300	2	2:00	no data	Fourth (per third party inspection 5/25/2000)	no data	VB/RC/CA	Third party inspection 5/25/2000 states facility operates a fourth generation machine and the following violation was noted: DEC Registration was not obtained by 12/25/99. Perceptible leak was found near pump.
DC-3	Kings	Complaint	170	2	2:00	60 (1994 received initial notification)	Third	Installed in 1989	VB/RC	machine and one violation was noted- the facility failed to maintain an Emergency preparedness checklist which violates 6 NYCRR Subdivision 232.12(c).
DC-10	New York	Complaint	1,000 - 1,400	4	2:00	no data	no data	no data	no data	no data
DC-31	New York	Complaint	700 - 800	4	2:00	100 (1993) 120 (2000 received late initial notification)	Second in 1993	no data	did not have a VB on 6/2/99 but installed VB 6/3/99	6/3/1999 Vapor barrier installed; 6/2/1999 no vapor barrier
DC-35	New York	Complaint	230 - 500	4	2:00	60 (1994 received initial notification)	Fourth	Upgraded in 4/1997	VB/RC/CA	1/27/2000 (Notice of violation states failure to install a complete vapor barrier room and general exhaust ventilation system when replacing a machine; installed a fourth generation dry cleaning machine on 8/1997 and did not install the vapor barrier until 8/1998).
DC-55	Queens	Complaint	160	2	2:00	no data	no data	no data	no data	no data
DC-45	New York	Complaint	10 - 190	8	2:00	110 (1999 received late initial notification)	Fourth	Installed in 1995	VB/RC/CA	no data
DC-64	Queens	Complaint	120 - 1,700	4	2:00 - 2:05	240 (2000 received late initial notification)	Third	Installed in 1991	VB/RC/CA	5/25/2000 third party inspection states facility is operating a fourth generation machine and the vapor barrier room was improperly sealed in violation of paragraph 232.6(a)(1).
DC-69	Kings	Complaint	1,100 - 1,300	2	2:00	late initial notification); 50 (9/2000 NYC DEP inspection report)	Third	no data	VB/RC	4/11/2000 NYS DEC third party inspection states third generation
DC-86	Queens	Complaint	1,000	2	2:00	10 (1999 received late initial notification)	Fourth	Installed in 1997	VB/RC/CA	4/14/2000 third party inspection states the facility was operating a fourth generation machine and the owner/manager and operator(s) of a mixed-use dry cleaning facility, were not certified as of 3/25/00 (232.14(a)(1)&(2)).

DEC Part 232: December 25, 1999 - December 31, 2000

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-52	New York	Complaint	5,000 - 5,100	2	2:00	65 (1994 received initial notification)	Third	Installed in 1992	VB/RC	12/26/2000 3rd party inspection states facility is operating a 3rd gen
DC-10	New York	Complaint	100 - 700	8	1:30 - 2:00	150 (2002 received late initial notification)	Third	no data	VB/RC	Did not receive initial not; only one 3rd party inspection on 12/12/2000 stating facility is operating one 3rd generation machine
DC-27	New York	Complaint	160 - 180	2	2:00	20 (2002 received late initial notification)	no data	no data	no data	no data
DC-28	New York	Complaint	100	4	2:00	120	Fourth	Installed in 1999	VB/RC/CA	8/3/2000; 6/4/1999: All 3rd party inspections on these dates state 4th gen
DC-34	Kings	Complaint	210 - 220	2	2:00	230 (1998 received late initial notification)	Noncompliant Second*	Installed in 1989	CA	6/3/2002 3rd party inspection states the machine at this facility was sealed by DOH on 4/5/2000
DC-35	New York	Complaint	270 - 900	8	2:00	60 (1994 received initial notification)	Fourth	Upgraded in 4/1997	VB/RC/CA	1/27/2000 (Notice of violation states failure to install a complete vapor barrier room and general exhaust ventilation system when replacing a machine; installed a fourth generation dry cleaning machine on 8/1997 and did not install the vapor barrier until 8/1998).
DC-49	Kings	Complaint	1,700 - 2,100	3	2:00	no data	no data	no data	no data	Initial notification was not received; no 3rd party inspection
DC-59	Kings	Complaint	150 - 160	2	2:00	no data	Third	no data	VB/RC	Initial notification was not received; 4/13/2000 3rd party inspection states third generation equipment
DC-69	Kings	Complaint	30 - 1,200	4	2:00	130 (7/2000 received late initial notification); 50 (9/2000 NYC DEP inspection report	Third	no data	VB/RC	4/11/2000 3rd party inspection states 3rd gen
DC-16	New York	Complaint	170 - 4,800	10	2:00	120 (date not recorded initial notification not received)/80 after upgrade (2000)	Third after upgrade	Upgraded in 2000 to Third	VB/RC	10/18/2000 3rd party inspection states the Owner/Manager and Operator Certifications were not obtained by the 3/25/00 deadline. The facility did not obtain a DEC Registration by the 12/25/99 deadline. The vapor barrier installation notification was not sent by certified mail within 30 days. The NESHAP initial certification was not received.

DEC Part 232: January 1, 2001 - August 5, 2003

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)	n	Sample Duration (H:M)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-9	New York	Complaint	650 - 1,400	6	2:00	120 (2000 received late initial notification)	Fourth	Fourth as of third party inspection in 2000	VB/RC/CA	1/5/2000 and 1/9/2001 third party inspection states facility is operating a fourth gen; 1/8/2003 third party inspection but no comment
DC-12	New York	Complaint	950 - 1,300	4	2:00	130 (2000 received late initial notification)	Third	Third installed in 1992	VB/RC	6/9/2001 [states the facility is operating a third generation machine and the violation documented is for failure to apply for a DEC registration by the 2/15/01 deadline for 3rd Generation machines (232.15 & 201.4)]; 6/21/2002 third party inspection states third gen; 6/12/2003 third party inspection; no violations noted, equipment generation not designated
DC-17	Kings	Complaint	50 - 970	34	2:00	45 (1999)	Fourth	Upgraded in December 1999 to fourth	VB/RC/CA	3/14/2001 third party inspection state facility is operating fourth gen
DC-35	New York	Complaint	150 - 900	24	2:00	30 (2001 NYC DEP inspection)	Fourth	Upgraded in 4/1997	VB/RC/CA	equipment generation, no violations noted; 1/15/2002 3rd party inspection states facility operates a 4th gen and failure to notify the Department by certified mail within 30 days of installation of the vapor barrier room and general exhaust system, and certify that it met all regulatory requirements. 1/15/2001 states facility operates a 4th gen machine;
DC-38	Kings	Complaint	200 - 1,300	7	2:00	120 (2003 received late initial notification)	Fourth	Installed in 2003; initial notification does not report installation of equiment and data before 2003	VB/RC/CA	8/27/2003 third party inspection states -Failure to comply with permitting requirements (232.15 and 201-4). -Failure to comply owner/manager and operator certification requirements (232.14). -Failure to comply with Part 232 compliance inspection requirements. Facility failed to conduct third-party compliance inspections in the years 2000, 2001, 2002 and 2003 (232.16). -Failure to submit a NESHAP initial notification and compliance report (232.5 & 40CFR63). -Failure to comply with reporting and record keeping requirements. Facility failed to maintain records, logs and checklists as required by 6NYCRR Part 232.12. -Failure to comply with hazardous-waste management requirements. Facility failed to properly manage and store perc-contaminated waste in tightly sealed containers as required in 6NYCRR part 232.10. -Failure to conspicuously display the DEC Part 232 posting notice for public
DC-61	Kings	Complaint	1,600 - 2,500	6	2:00	100 (2003 received late initial notification)	Fourth	Installed in 2003	VB/RC/CA	9/23/2003 3rd party inspection states fourth generation equipment and the facility is in compliance
DC-73	New York	Complaint	14 - 280	26	2:00	80 (2002 received late initial notification)	Fourth	Installed in 1996	VB/RC/CA	3/11/2000; 3/9/2001; 3/9/2002; 3/7/2003: third party inspection states fourth generation equipment and the facility is in compliance
DC-76	New York	Complaint	50 - 400	46	2:00 - 21:55	84 (1996 received initial notification)	Fourth	Installed in 1996	VB/RC/CA	11/21/2001; 11/21/2002; 11/21/2003: 3rd party inspection states 4th generation equipment and facility is in compliance
DC-87	New York	Complaint	110 - 250	6	2:00	no data	no data	no data	no data	no data
DC-84	New York	Complaint	210 - 7,000	39	2:00 - 24:15	180 (8/7/2003 NYC DEP inspection)	Two machines: a third upgraded to fourth and a fourth	Do not have dates of upgrade or installation	VB/RC/CA	no data

** Information may not be reflective of conditions present at time of sampling; majority of reports made after 1999 NYS DEC regulation requiring annual inspections

Concentration Range = The minimum and maximum perc concentrations (in ug/m3) measured at the particular dry cleaning facility during the specified regulatory time period.

n = The total number of samples taken during the specified time period at the dry cleaning facility

Sample Duration = The minimum and maximum times (in hours:minutes) the sample was taken for.

Perc Consumption (gals/yr) = The amount (in gallons) of perc solvent used by a dry cleaning facility, during the most recent 12 month reporting period (annually), as reported on the EPA NESHAP Initial Notification form and/or from NYC DEP inspection reports

Equipment Generation = The "generation" or type of dry cleaning machine being used at the dry cleaning facility as reported with the NESHAP Initial Notification Report, and/or as documented in the NYS DEC Part 232 required annual Compliance Inspection (a.k.a., "third part inspections") or NYC DEP dry cleaning facility inspection reports.

Equipment Age = The date the dry cleaning equipment was installed as self-reported on the EPA NESHAP Initial Notification form. The dates dry cleaning machines were upgraded were included when available in NYS DEC AFS database.

Vapor Barrier or Other Control = The use of vapor barriers/room enclosures (VB/RE), with dedicated general exhaust ventilation systems (GEVS) independent from any building HVAC systems, and the phasing-in of modern fourth generation dry cleaning equipment possessing both fourth generation dry cleaning equipment possessing both primary and secondary emission control systems.

Control Codes:

VB=Vapor Barrier

RC=Refrigerator Condenser

CA=Carbon Adsorber

Reported Facility Information = The NYS DEC AFS permitting database was accessed to obtain the following information: if the NESHAP Initial Notification report was received, the dates Compliance Inspections (a.k.a. "third party inspections") were conducted and any records that enforcement actions (Notices of Violation, "NOVs") had been taken against the facility along with any Part 232 or other pertinent facility -specific information.

NTable 1.0-5: New York City perc project

Facility	County	Reason for Initial Sampling	Concentration Range** (ug/m3)	n	Sample Date(s)**	Sample Duration (H:M)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information^
DC-42	New York	Special Project	750 - 770	2	December 3, 2002	24:22 - 24:30	90 (2001 received initial notification)	Fourth (2001)	Fourth installed in 2001	VB/RC/CA	In compliance with initial notification; 2/2001-2/2004 3rd party inspection states facility is operating a fourth gerneration machine in compliance
DC-2	New York	Special Project	4,800 - 5,200	2	January 14, 2003	25:00	320 (2003 received late initial notification)	Fourth (2003)	Installed (2002-2003)	VB/RC/CA	Late submission of initial notification; 5/2/2003 3rd party inspection states facility is operating a fourth generation machine in compliance.
DC-84	New York	Complaint	210 - 7,000	39	December 27, 2001 - July 2, 2003	2:00 - 24:15	no data	no data	no data	no data	In yellow pages file, but not in DEC AFS
DC-18	New York	Special Project	690 - 700	2	December 3, 2002	24:12	50 (4/14/2003 NYC DEP inspection)	Fourth	Fourth installed 2000-2001	VB/RC/CA	In compliance with initial notification; 6/10/2002 3rd party inspection states fourth generation in compliance; 6/10/2003 states fourth generation in compliance
DC-68	New York	Special Project	220 - 4,800	8	December 3, 2002 - January 14, 2003	23:00 - 24:44	100 (2002 received late initial notification; Perc consumption for fourth generation machine)	Third	Installed in 1992;	VB/RC	Late submission of initial notification; fourth generation machine installed 5/2003. 3rd party inspection 2/13/2002-2/13/2003 no equipment description given; facility in compliance.
DC-71	New York	Special Project	9 - 42	6	December 10, 2001 - April 15, 2002	23:40 - 24:01	late initial notification)	Fourth	Installed in 1996	VB/RC/CA	Late submission of initial notification; 3rd party inspection 3/13/2002 and 3/13/2003 states fourth generation machine and facility is in compliance
DC-52	New York	Complaint	2.1 - 5,100	42	January 15, 1998 - April 10, 2002	0:14 - 25:45	65 (1994 received initial notification)	Third	Installed in 1992	VB/RC	In compliance with initial notification; 3rd party inspection 12/26/2000. (At the time of inspection, an emission of 143 ppm was found by the water separator and an emission of 381 ppm was found by the pipe (steam) that enters and exits the coil housing. The facility failed to maintain a Weekly Operation and Maintenance Test properly.) 11/23/2001 stated operated one third generation machine which was removed on 4/11/2002 and was replaced by a Satec B440 hydrocarbon machine using Exxon DF 2000 solvent.
DC-75	New York	Special Project	8 - 73	5	January 14, 2002	23:03 - 23:20	120 (2000 received late initial notification)	Fourth	initial notification states a third was installed in 1996 but facility operated a fourth per 2/2000 3rd party inspection; exact installation date of fourth is unknown	VB/RC/CA	Late submission of initial notification; 2/2000-2/2003 3rd party inspection states facility is operating fourth generation equipment in compliance
DC-1	New York	Special Project	<5 - 16	5	December 10, 2001 - December 26, 2001	24:22 - 27:15	80 (1994 received initial notification)	Fourth	Installed in 2000	VB/RC/CA	3rd party inspections 5/25/2000 and 4/27/2001 state facility is operating fourth generation machine in compliance
DC-41	New York	Special Project	1.8 - 97	19	March 5, 2002 - May 21, 2002	0:51 - 26:45	120 (2000 received late initial	Fourth	Installed 3/1994	VB/RC/CA	Late submission of initial notification; 12/2001-12/2003 3rd party inspection states facility is operating fourth generation machine in compliance
DC-91	New York	Complaint	<5 - 101	12	March 18, 2002 - January 21, 2003	0:43 - 24:21	late initial notification)	Third	no data	VB/RC	Late submission of initial notification; 2/2001-2/2003 3rd party inspection states facility is operating a third generation machine in compliance
DC-60	New York	Special Project	12 - 13	3	February 25, 2002	0:30 - 2:24	late initial notification)	Third	Installed in 10/1993	VB/RC	Late submission of initial notification; 3rd party inspection 3/7/2002 and 2/27/2003 states Third generation
DC-58	New York	Complaint	8 - 55	11	May 14, 1997 - May 29, 2002	2:00 - 24:31	87 (1998 received initial notification)	Third*/Fourth	Third installed in 1998; Fourth possibly installed sometime before third party inspection on 3/16/2000; exact data is unknown	VB/RC/CA	In compliance with initial notification; 3rd party inspection 3/16/2000 (state the facility is operating a fourth generation machine and the vapor barrier room was improperly sealed. The door frame's material is wood, which is permeable to perc vapor in violation of Section 232.6.), 3/16/2001 and 3/16/2002 state facility is operating fourth generation machine in compliance
DC-62	New York	Special Project	<5 - 408	12	April 29, 2002 - October 8, 2002	0:44 - 24:34	100 (2000 received late initial notification)	Fourth	no data	VB/RC/CA	Late submission of initial notification; 2/26/2002 3rd party inspection states facility operates a fourth generation machine in compliance
DC-76	New York	Complaint	30 - 600	52	April 23, 1997 - March 24, 2003	2:00 - 21:49	84 (1996 received initial notification)	Fourth	Installed in 1996	VB/RC/CA	In compliance with initial notification; 3rd party inspection 11/21/2001-11/21/2003 states facility i operating fourth generation machine in compliance
DC-21	New York	Complaint	70 - 1,450	6	November 26, 1997 - June 11, 2002	2:00 - 24:07	300 (2000 received late initial notification)	Third*/Fourth	Third installed in 1998	VB/RC/CA (2001)	Late submission of initial notification; 3rd party inspection 9/28/2001 states fourth generation
DC-48	New York	Special Project	5	2	July 9, 2002	23:43 - 23:46	no data	no data	no data	no data	No initial notification; no data
DC-15	New York	Special Project	23 - 27	3	June 18, 2002	23:53 - 24:11	240 (1998 received initial notification)	Third	Installed in 1998	VB? (no inspections to verify)/RC	In compliance with initial notification; no 3rd party inspection on file
DC-16	New York	Complaint	<5 - 6,400	33	May 11, 1999 - January 31, 2003	2:00 - 23:58	120 before upgrade ; 80 after (date received unknown)	Fourth	Upgraded from third in 2000	VB/RC/CA	Initial notification has not been received, therefore, do not know equipment before upgrade; 3rd party inspection 10/08/2001 and 10/04/2002 states facility is operating a Fourth generation machine in compliance
DC-44	New York	Complaint	150 - 3,900	17	January 16, 1997 - July 23, 2002	2:00 - 25:39	submission of initial notification; exact received data not recorded; third party inspection on 5/26/2000 noted the initial notification report was not received)	Fourth	Installed in 4/1999	VB/RC/CA	3rd party inspection 5/26/2000 states fourth generation and the facility failed to obtain registration of a 4th generation mixed-use residential dry cleaning machine by the due date of December 25, 1999. As of the time of inspection, May 26, 2000, the facility has yet to apply. The facility failed to notify the DEC, by certified mail, within 30 days of installation of a vapor barrier. The individual failed to obtain Operator and Owner/Manager certifications for a 4th generation Mixed-use dry cleaning machine by the due date of March 25, 2000. The facility failed to file a NESHAP Initial Notification Report.
DC-66	New York	Complaint	25 - 60	10	June 16, 1999 - July 23, 2002	2:00 - 24:03	140 (2002 received late initial notification)	Third	no data	VB/RC	Late submission of initial notification. Third party inspections 9/15/2000 states failure to seal joints in ceramic tile floor means the vapor barrier room was improperly sealed. Failed to notify DEC of installation of vapor barrier room by certified mail within 30 days. NESHAP initial notification form was not received. Third party inspection 9/15/2001 and 9/14/2002 states facility operates a third generation machine in compliance.
DC-89	New York	Special Project	2,130 - 2,140	2	April 30, 2003	24:15	no data	Third	no data	VB/RC	No initial notification; Third party inspection 6/29/1999 states third generation
DC-53	New York	Special Project	<5 - 10	6	April 16, 2003	25:10 - 25:30	120 (2000 received late initial notification)	Fourth	Exact installation date of fourth is unknown but per the third party inspections is was after inspection 3/23/2000 and before 3/20/2001	VB/RC/CA	Late submission of initial notification; third generation machine installed in 1992; 3rd party inspection 3/23/2000 states facility is operating a third generation machine; 3/20/2001, 3/20/2002, and 3/19/2003 3rd party inspection states facility is operating a fourth generation machine in compliance.
DC-40	New York	Special Project	11 - 217	12	April 3, 2003 - April 30, 2003	4:03 - 26:42	60 (2000 received late initial notification)	Fourth	Installed in 1997	VB/RC/CA	3rd party inspection 9/24/2002 states fourth generation and failure to comply with dry cleaning owner/manager and operator training and certification requirements. Facility failed to obtain the owner/manager and operator certificates. This is a repeat violation. (6NYCRR232.14(a)(1)(2)). 11/19/2003 3rd party inspection states facility is operating a fourth generation machine and still fails to comply with dry cleaning owner/manager and operator training and certification requirements.

*Indicates a difference between initial notification description and third party inspection report description

**Samples may have been taken before Perc Project time period

^ Information may not be reflective of conditions present at time of sampling; majority of reports made after 1999 NYS DEC regulation requiring annual inspections

Concentration Range = The minimum and maximum perc concentrations (in ug/m3) measured at the particular dry cleaning facility during the specified regulatory time period.

n = The total number of samples taken during the specified time period at the dry cleaning facility

Sample Date(s) = The beginning and ending dates that samples were taken at the specified facility.

Sample Duration = The minimum and maximum times (in hours:minutes) the sample was taken for.

Perc Consumption (gals/yr) = The amount (in gallons) of perc solvent used by a dry cleaning facility, during the most recent 12 month reporting period (annually), as reported on the EPA NESHAP Initial Notification form and/or from NYC DEP inspection reports

Equipment Generation = The "generation" or type of dry cleaning machine being used at the dry cleaning facility as reported with the NESHAP Initial Notification Report, and/or as documented in the NYS DEC Part 232 required annual Compliance Inspection (a.k.a., "thrid part inspections") or NYC DEP dry cleaning facility inspection reports.

Equipment Age = The date the dry cleaning equipment was installed as self-reported on the EPA NESHAP Initial Notification form. The dates dry cleaning machines were upgraded were included when available in NYS DEC AFS database.

Vapor Barrier or Other Control = The use of vapor barriers/room enclosures (VB/RE), with dedicated general exhaust ventilation systems (GEVS) independent from any building HVAC systems, and the phasing-in of modern fourth generation dry cleaning equipment possessing both fourth generation dry cleaning equipment possessing both primary and secondary emission control systems.

Control Codes:

VB=Vapor Barrier

RC=Refrigerator Condenser

CA=Carbon Adsorber

Reported Facility Information = The NYS DEC AFS permitting database was accessed to obtain the following information: if the NESHAP Initial Notification report was received, the dates Compliance Inspections (a.k.a. "third party inspections") were conducted and any records that enforcement actions (Notices of Violation, "NOVs") had been taken against the facility along with any Part 232 or other pertinent facility -specific information.

NTable 1.0-6: Dry cleaning facilities located in strip malls

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3)^	n^	Sample Date(s)^	Sample Duration (H:M)^	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**
DC-11	Suffolk	Complaint	80 - 280	2	August 5, 2003	22:30 - 22:40	100 (1994 received initial notification)	Third	Installed in 1992	VB/RC	Third party inspections conducted: 9/30/2003 stated third generation mixed use; 5/9/2002; 5/9/2001 stated on the second inspection the facility was in compliance with all rule and regs. However, they still had not sent in the vapor barrier notification letter. 5/11/2000 stated owner failed to mail his vapor barrier notification letter. He also had a high Perc concentration in his drum and some leaks.
DC-33	Nassau	Complaint	350 - 20,000	11	April 4, 1997 - December 22, 1997	5:40 - 23:09	no data	no data	no data	no data	no data
DC-39	Nassau	Complaint	20 - 5,100	18	March 10, 1998 - April 3, 2001	23:09 - 24:11	350 (before upgrade per initial notification received 1994); 75 (1996 per initial notification)	Transfer upgraded to fourth in 1996	1996	VB/RC/CA	Initial notification database noted this is an existing large area source. As they have not installed carbon adsorber or refrigerated condenserbefore September 22, 1993, they are in violation. Third party inspections conducted: 10/14/2003; 10/15/2002; 10/17/2001; 10/24/2000: mixed-use facility with a fourth gen; a permit was issued on 2/28/2000. Facilities with fourth generation machines were required to register prior to December 25, 1999. An owner who does not register his facility on or before this date is in violation of Subpart 201-4. The owner of this facility didn't apply for a permit until 10/16/2000.
DC-43	Albany	DC survey	8 - 2,400	118	August 17, 1998 - May 15, 2000	3:17 - 100:10	775 (1994 received initial notification)	Fourth	Two machines installed in 1985 and 87	VB/RC/CA	Third party inspections conducted: 3/26/2001; 3/14/2000 several leaks found; facility inspected on 4/12/2000 and there were no leaks; 5/27/1999 stated vapor barrier and general exhaust system were complete.
DC-56	Westchester	BEEI-subsurface contamination	40 - 11,000	56	August 10, 1999 - November 10, 1999	3:12 - 4:52	Initial notification was not received therefore, there is no record of the owner's estimate of Perc consumption per year; only that the total Perc capacity of the machine is 165 gallons; this data was provide in response to the spill investigation	Fourth	Installed in 1999	VB/RC/CA	A Perc spill (less than one gallon) occurred at this facility on 7/14/99. The spill occurred when an operator mistakenly opened the valve to the button trap and Perc spilled on the floor. Because the floor of the vapor room was not properly sealed, a part 232 violation, Perc leaked to the Teen Center located below the facility. There were gaps and screw holes in the vapor barrier floor coverage and the vapor barrier was not of DEC approved material. Follow-up inspection (7/19 and 7/29) showed there was a leak at the lint/filter door (concentration was greater than 200 ppm). In addition, Perc concentration in the drum after the cycle was completed was greater than 900 ppm. Final inspection 8/17/99 indicated the vapor barrier room was in compliance; the floor was seal tested with two gallons of water and there were no leaks observed. There were no machine leaks.
DC-63	Nassau	Complaint	370 - 3,500	6	October 7, 1997 - December 18, 1997	23:39 - 23:57	no data	no data	no data	no data	Received late initial notification (2003) which stated facility is constructed in May 2000. Facility is upgraded in April 2003 by installing one dry to dry machine with refrigerator condenser & carbon adsorber as control device, perc use 120 gals/yr. 11/8/2000 third party inspection states facility is operating a third generation machine in compliance.
DC-85	Nassau	Complaint	2,600 - 3,300	4	June 30, 1998	24:13 - 24:19					Receive late initial notification (2000) which stated one dry to dry machine is installed in the year 2000 with refrigerator condenser & carbon adsorber as control device; perc use 230 gals/yr. 11/20/2000 third party inspection stated facility was operating a fourth generation machine and the following violations were noted: The Owner of the facility was required to have registration at the time of the start up of business operations(5/12/2000). The owner did not applly for a permit until 11/21/2000. The owner\manager and operator did not recieve certification prior to the start of business.
DC-54 *	Ontario	Complaint	14,000 - 50,400	2	March 2, 1992	1:23 - 1:25	no data	no data	no data	no data	no data

^samples taken in co-located businesses, and therefore reflect perc levels in nearby facilities, not in the dry cleaners themselves

*data for this facility are not included in the original statewide data set

** Information may not be reflective of conditions present at time of sampling; majority of reports made after 1999 NYS DEC regulation requiring annual inspections

Concentration Range = The minimum and maximum perc concentrations (in ug/m3) measured at the particular dry cleaning facility during the specified regulatory time period.

n = The total number of samples taken during the specified time period at the dry cleaning facility

Sample Date(s) = The beginning and ending dates that samples were taken at the specified facility.

Sample Duration = The minimum and maximum times (in hours:minutes) the sample was taken for.

Perc Consumption (gals/yr) = The amount (in gallons) of perc solvent used by a dry cleaning facility, during the most recent 12 month reporting period (annually), as reported on the EPA NESHAP Initial Notification form and/or from NYC DEP inspection reports

Equipment Generation = The "generation" or type of dry cleaning machine being used at the dry cleaning facility as reported with the NESHAP Initial Notification Report, and/or as documented in the NYS DEC Part 232 required annual Compliance Inspection (a.k.a., "third part inspections") or NYC DEP dry cleaning facility inspection reports.

Equipment Age = The date the dry cleaning equipment was installed as self-reported on the EPA NESHAP Initial Notification form. The dates dry cleaning machines were upgraded were included when available in NYS DEC AFS database.

Vapor Barrier or Other Control = The use of vapor barriers/room enclosures (VB/RE), with dedicated general exhaust ventilation systems (GEVS) independent from any building HVAC systems, and the phasing-in of modern fourth generation dry cleaning equipment possessing both fourth generation dry cleaning equipment possessing both primary and secondary emission control systems.

Control Codes:

VB=Vapor Barrier

RC=Refrigerator Condenser

CA=Carbon Adsorber

Reported Facility Information = The NYS DEC AFS permitting database was accessed to obtain the following information: if the NESHAP Initial Notification report was received, the dates Compliance Inspections (a.k.a. "third party inspections") were conducted and any records that enforcement actions (Notices of Violation, "NOVs") had been taken against the facility along with any Part 232 or other pertinent facility -specific information.

NTable 1.0-7: Detailed information on dry cleaning facilities with samples in colocated areas meauring perc concentrations > 5000 ug/m^3 in 1999 or late

Facility	County	Reason for Initial Sampling	Concentration Range (ug/m3) from 1991-2003	n^	Sample Date(s)	Sample Duration (H:M)^	Concentration > 5000 ug/m3 after 1998 (Sample Date)	Perc Consumption (gals/yr)	Equipment Generation	Equipment Age	Vapor Barrier or Other Control	Reported Facility Information**	NYC DEP Report
DC-2	New York	Special Project	4800 - 5200	2	January 14, 2003	23:00	5200 (January 14, 2003)	320 (2003 received late initial notification)	Fourth (2003)	Installed (2002-2003)	VB/RC/CA	Late submission of initial notification; 5/2/2003 3rd party inspection states facility is operating a fourth generation machine in compliance. Third party inspections: 5/15/2001 (operating one third generation; a combined NOV and SFCO for 2001/2002 inspection was sent); 5/22/2000 (third generation)	3/13/03: DOH sealed the machine, perc vapor concentration found in residential apartment was 4800-5200 ug/m3; inspection found high perc concentration inside machine's basket (841ppm) and above cleaned garment (201 ppm); very high vibration of the machine and its foundation; the machine has no certificate to operate. Machine was fourth generation. Vapor barrier was installed. 3/20/03: Follow-up inspection found the machine was working properly, perc concentration readings were within regulatory limits, and facility applied for certificate to operate.
DC-5	Nassau	Complaint	18 - 7600	7	March 5, 1999 - July 27, 1999	23:25 - 24:10	7600 (March 15, 1999)	58	Fourth	Installed in 1997	VB/RC/CA	Third party inspections completed: 7/24/2003, 7/25/2002, 7/31/2001, 8/1/2000 (stated mixed-use residential facility with a fourth generation machine.	Have not received yet
DC-8	Rockland	Complaint	45-20,955	11	November 9, 1994 - July 17, 2002	3:05 - 42:00	6500 (March 6, 2002)	no data	Third	Installed in 1990	VB/RC	Regional inspection conducted in response to complaint 2/08/2002 found facility was not in compliance with most Part 23 requirements: vapor barrier was not installed, no registration, no owner or operator certification, no third party inspections scheduled, leak detection equipment not on site, liquid leak observed from machine, liquid on floor, and floor not sealed. On 4/1/2002 the facility was still in non-compliance. On 7/24/2002 vapor barrier was installed, halogen leak detector on site, third pa inspection on 4/17/02, owner/operator certification completed.	Not within NYC DEP jurisdiction
DC-16	New York	Complaint	5 - 6400	33	May 11, 1999 - January 31, 2003	2:00 - 23:58	6200 (May 11, 1999) 6400 (May 11, 1999)	120 (date not recorded initial notification not received)/80 after upgrade (2000)	Third after upgrade	Upgraded in 2000 to Third	VB/RC	10/4/20002 3rd party inspection states facility operates 4th gen; 10/18/2000 3rd party inspection states the Owner/Manager and Operator Certifications were not obtained by the 3/25/00 deadline. The facility did not obtain a DEC Registration by the 12/25/99 deadline. The vapor barrier installation notification was not sent by certified mail within 30 days. The NESHAP initial certification was not received.	The owner changed; the dry cleaning machine has been removed; no more dry cleaning machines are there
DC-52	New York	Complaint	2.1 - 5100	42	January 15, 1998 - April 10, 2002	0:14 - 24:56	5000 (January 12, 2000) 5100 (January 12, 2000)	65 (1994 received initial notification)	Third	Installed in 1992	VB/RC	In compliance with initial notification; 3rd party inspection 12/26/2000: (At the time of inspection, an emission of 143 ppm was found by the water separator and an emission of 381 ppm was found by the pipe (steam) that enters and exits the coil housing. T facility failed to maintain a Weekly Operation and Maintenance Test properly.) 11/23/2001 stated operated one third generation machine which was removed on 4/11/2002 and was replaced by a Satec B440 hydrocarbon machine using Exxon DF 2000 solvent.	The perc dry cleaning machine has been removed and replaced by a new hydrocarbon dry cleaning machine
DC-56	Westchester	BEEI-subsurface contamination	40 - 11,000	56	August 10, 1999 - November 10, 1999	3:12 - 4:52	5000 (September 28, 1999) 6500 (September 28, 1999) 6600 (September 28, 1999) 11,000 (September 28, 1999)	initial notification was not received therefore, there is no record of the owner's estimate of Perc consumption per year; only that the total Perc capacity of the machine is 165 gallons; this data was provide in response to the spill investigation	Fourth	Installed in 1999	VB/RC/CA	A Perc spill (less than one gallon) occurred at this facility on 7/14/99. The spill occurred when an operator mistakenly opened the valve to the button trap and Perc spilled on the floor. Because the floor of the vapor room was not properly sealed, a part 232 violation, Perc leaked to the Teen Center located below the facility. There were gaps and screw holes in the vapor barrier floor coverage and the vapor barrier was not of DEC approved material. Follow-up inspection (7/19 and 7/29) showed there was a le at the lint/filter door (concentration was greater than 200 ppm). In addition, Perc concentration in the drum after the cycle was completed was greater than 900 ppm. Final inspection 8/17/99 indicated the vapor barrier room was in compliance; the floor was seal tested with two gallons of water and there were no leaks observed. There were no machine leaks.	no data
DC-79	Nassau	Complaint	5 - 7250	16	December 2, 1999 - January 31, 2000	24:00 - 24:21	6950 (December 2, 1999) 7250 (December 2, 1999)	no data	no data	no data	no data	Jan. 2003 inspection report states facility is no longer a perc dry cleaning facility; it now uses petroleum distillates for dry cleanir facility closed as of 1990 report.	no data
DC-86	Queens	Complaint	1000 - 6600	8	July 7, 1999 - August 1, 2000	2:00	5600 (February 10, 2000) 5900 (February 10, 2000) 5800 (May 5, 2000) 6600 (May 5, 2000)	10 (1999 received late initial notification)	Fourth	Installed in 1997	VB/RC/CA	4/14/2000 third party inspection states the facility was operating a fourth generation machine and the owner/manager and operator(s) of a mixed-use dry cleaning facility, were not certified as of 3/25/00 (232.14(a)(1)&(2)).	perc/year, vapor barrier was in place and in compliance, spill containment was available, no equipment leaks, general ventilation, no open spaces between pipes goi through floors, walls, or ceiling through which fugitive emissions can escape, overall the facility was in compliance. The reason for the inspection was to renew the C.O. and it
DC-84	New York	Complaint	220-7000	39	December 27, 2001 - July 2, 2003	2:00 - 24:15	5100 (December 27, 2001) 5200 (December 27, 2001) 5300 (December 27, 2001) 5400 (December 27, 2001) 6300 (December 27, 2001) 7000 (December 27, 2001)	180 (8/7/2003 NYC DEP inspection)	Two machines: a third upgraded to fourth and a fourth	Do not have dates of upgrade or installation	VB/RC/CA	no data	no data
DC-45	New York	Complaint	10 - 6600	24	February 5, 1998 - December 10, 1999	2:00 - 2:03	6600 (January 13, 1999)	110 (1999 received late initial notification)	Fourth	Installed in 1995	VB/RC/CA	9/11/2002 3rd party inspection states dry cleaning equipment has been removed from this location	Facility now closed; no other information available

^samples taken in co-located businesses, and therefore reflect perc levels in nearby facilities, not in the dry cleaners themselves

** Information may not be reflective of conditions present at time of sampling; majority of reports made after 1999 NYS DEC regulation requiring annual inspections

Concentration Range = The minimum and maximum perc concentrations (in ug/m3) measured at the particular dry cleaning facility during the specified regulatory time period.

n = The total number of samples taken during the specified time period at the dry cleaning facility

Sample Date(s) = The beginning and ending dates that samples were taken at the specified facility.

Sample Duration = The minimum and maximum times (in hours:minutes) the sample was taken for.

Perc Consumption (gals/yr) = The amount (in gallons) of perc solvent used by a dry cleaning facility, during the most recent 12 month reporting period (annually), as reported on the EPA NESHAP Initial Notification form and/or from NYC DEP inspection reports

Equipment Generation = The "generation" or type of dry cleaning machine being used at the dry cleaning facility as reported with the NESHAP Initial Notification Report, and/or as documented in the NYS DEC Part 232 required annual Compliance Inspection (a.k.a., "third part inspections") or NYC DEP dry cleaning facility inspection reports.

Equipment Age = The date the dry cleaning equipment was installed as self-reported on the EPA NESHAP Initial Notification form. The dates dry cleaning machines were upgraded were included when available in NYS DEC AFS database.

Vapor Barrier or Other Control = The use of vapor barriers/room enclosures (VB/RE), with dedicated general exhaust ventilation systems (GEVS) independent from any building HVAC systems, and the phasing-in of modern fourth generation dry cleaning equipment possessing both fourth generation dry cleaning equipment possessing both primary and secondary emission control systems.

Control Codes:

VB=Vapor Barrier

RC=Refrigerator Condenser

CA=Carbon Adsorber

Reported Facility Information = The NYS DEC AFS permitting database was accessed to obtain the following information: if the NESHAP Initial Notification report was received, the dates Compliance Inspections (a.k.a. "third party inspections") were conducted and any records that enforcement actions (Notices of Violation, "NOVs") had been taken against the facility along with any Part 232 or other pertinent facility -specific information.

Figure 1.2-1a. Race/Ethnicity by ZIP Code

Deleted to Preserve Participant Confidentiality

Figure 1.2-1b. Income by ZIP Code

Deleted to Preserve Participant Confidentiality

Figure 1.4-1. NYC Perc Project Participant Activities

Participant Home Visits

First Visit (Mon-Thurs, 3-8 pm)
- Adult Consent and Child Assent Obtained
- Duplicate Indoor Air (24 hour) Passive Sampling Devices (PSD) Deployed
- Medical/Residential/Occupational/Exposure History Questionnaires provided

Second Visit (approximately 24 hours after first visit)
- PSD Retrieved
- Exhaled Breath Samples Obtained
- Medical/Residential/Occupation/Exposure History Questionnaires retrieved

Participant Ophthalmology Research Clinic Visit

- Adult Consent and Child Assent Session Reviewed
- Comprehensive Eye Examination Including Visual Acuity
- Visual Contrast Sensitivity Examination
- Color Vision Examination
- NES-2 (November 2001-December 2001 Only)
- Exhaled Breath Samples Obtained
- Blood Samples Obtained

Figure 3.1-1a. Dry Cleaner Buildings Sampled

Deleted to Preserve Participant Confidentiality

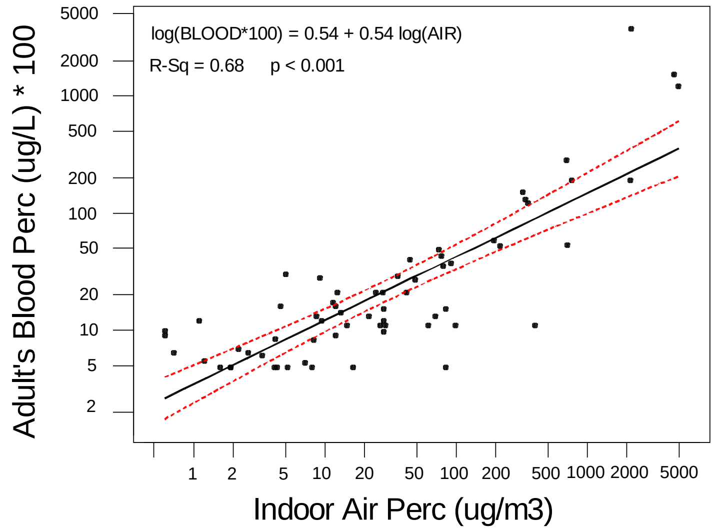
Figure 3.1-1b. Control Buildings Sampled

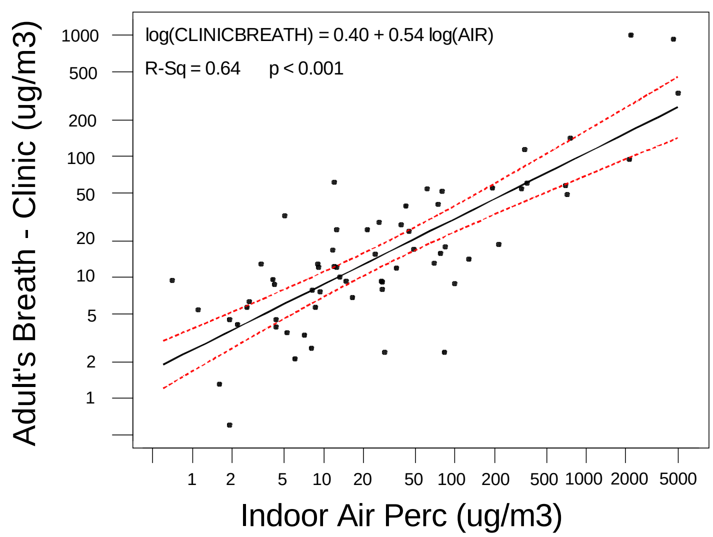
Deleted to Preserve Participant Confidentiality

Figure 3.2-1. Sampled Buildings and Maximum Perc Level Detected in Dry Cleaner Buildings

Deleted to Preserve Participant Confidentiality

Figure 3.2.-2a.


log(BLOOD*100) = 0.54 + 0.54 log(AIR)
R-Sq = 0.68 p < 0.001
Adult's Blood Perc (ug/L) * 100
Indoor Air Perc (ug/m3)


log(CLINICBREATH) = 0.40 + 0.54 log(AIR)
R-Sq = 0.64 p < 0.001
Adult's Breath - Clinic (ug/m3)
Indoor Air Perc (ug/m3)

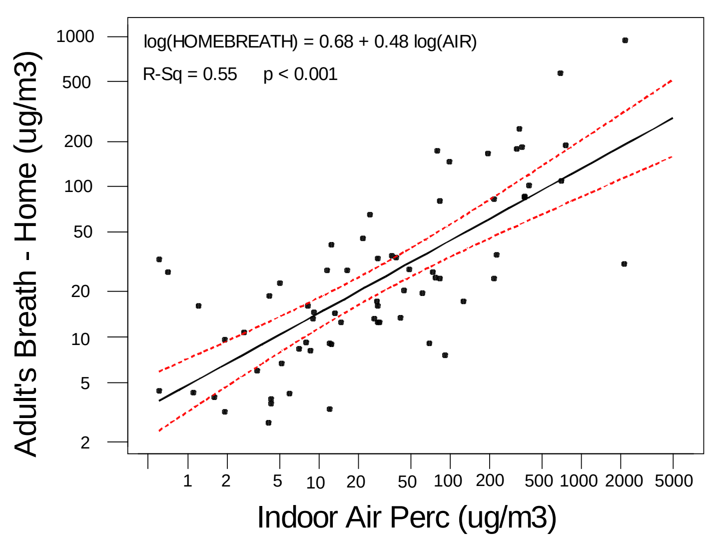
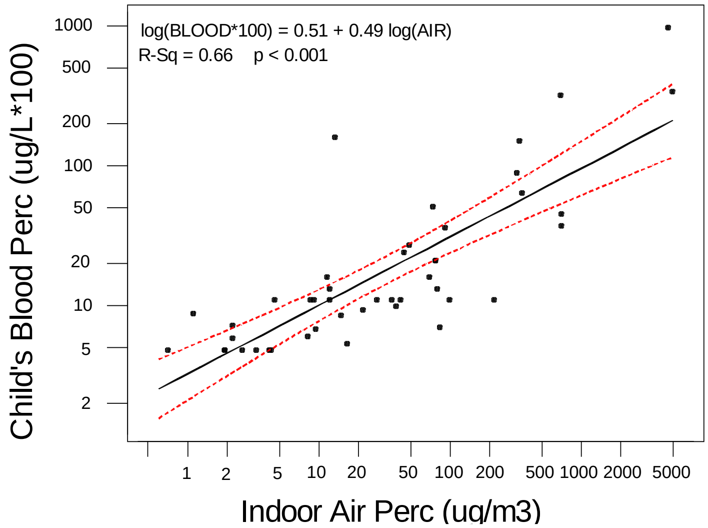
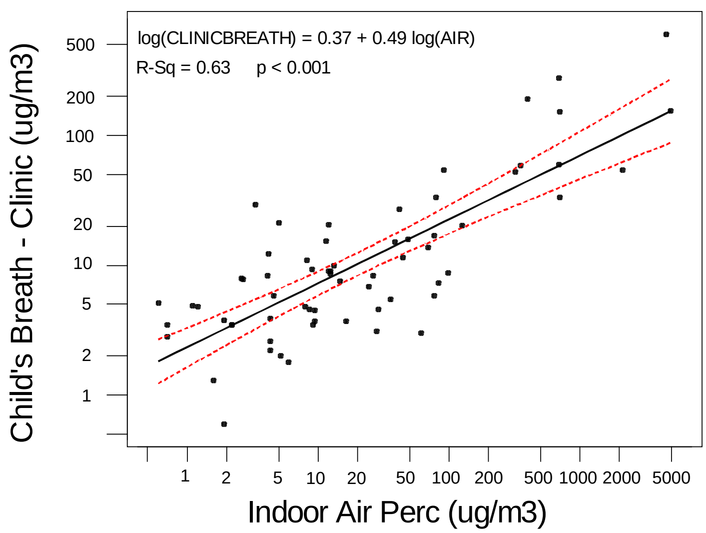
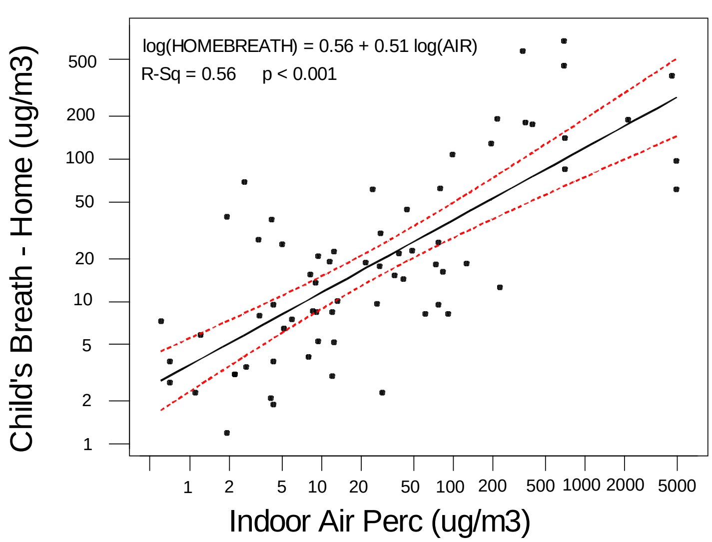

log(HOMEBREATH) = 0.68 + 0.48 log(AIR)
R-Sq = 0.55 p < 0.001
Adult's Breath - Home (ug/m3)
Indoor Air Perc (ug/m3)

Figure 3.2-2b.



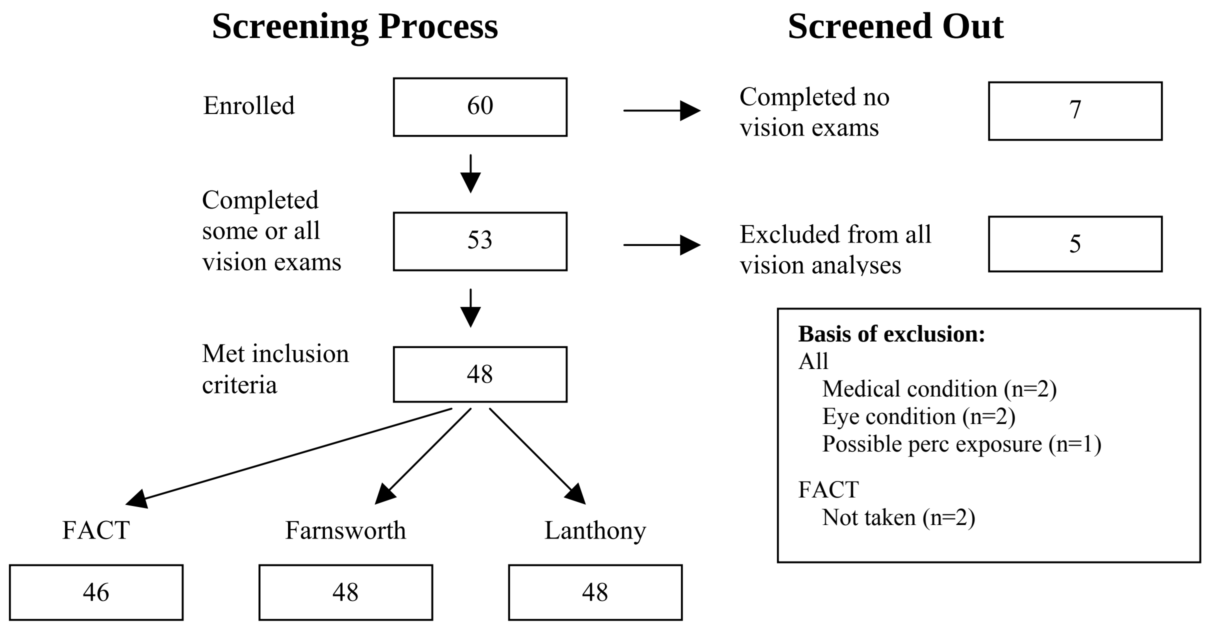




P:\Bureau\Perc\NYC_PERC\Reports-Presentations-FactSheets\Final Report\2005 Figures\Figure 3.2-2b Child Biomarkers.doc

Figure 3.3-1a. Non-Exposed (Control) Participants

Adults



Children

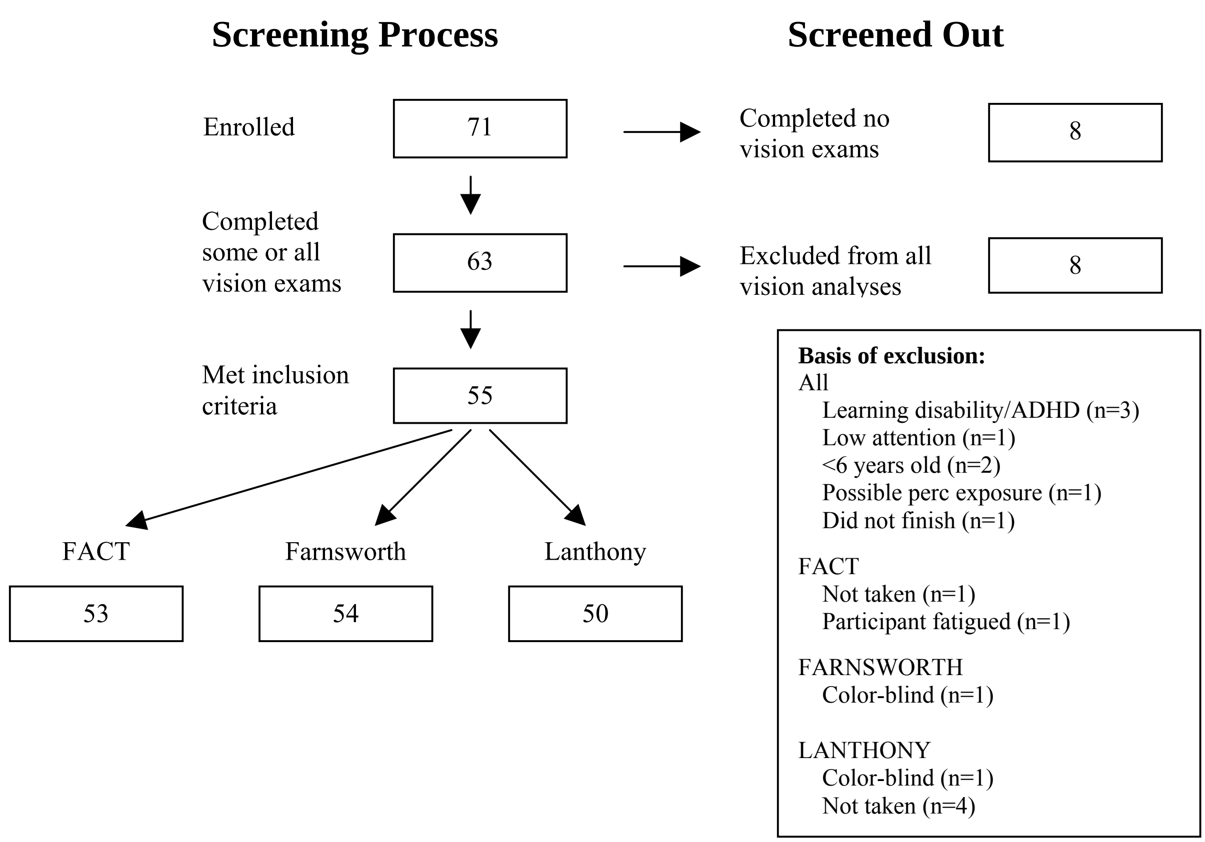
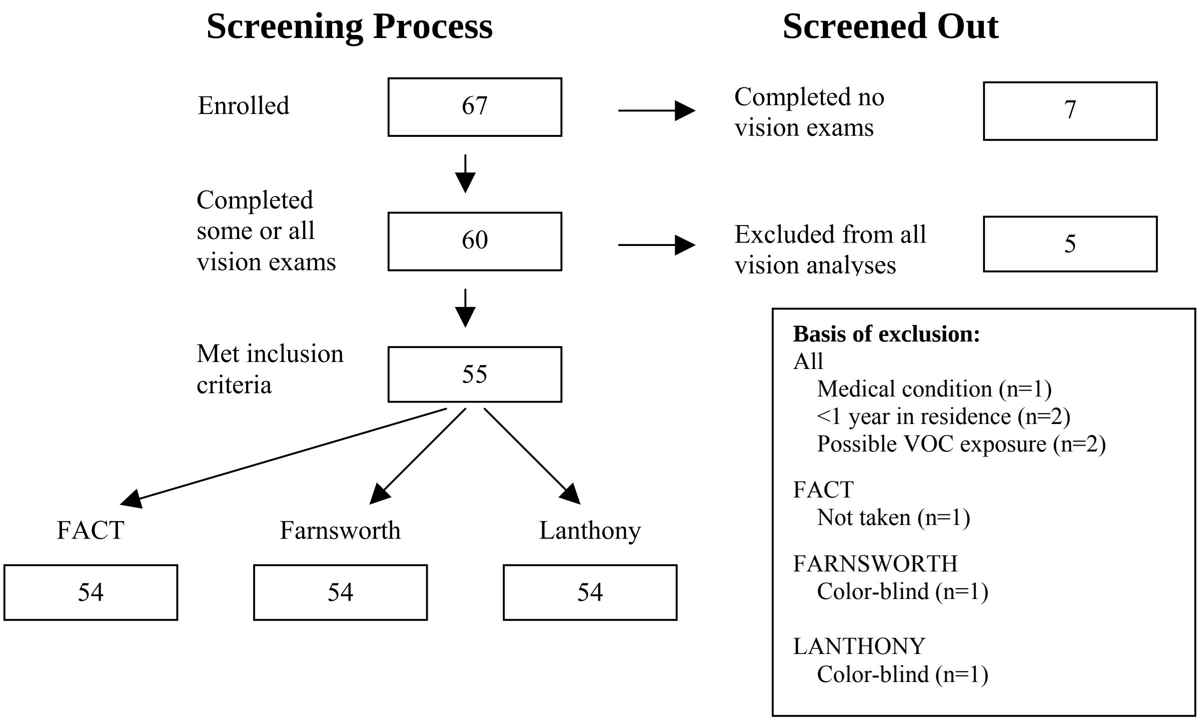


Figure 3.3-1b. Exposed Participants

Adults



Children

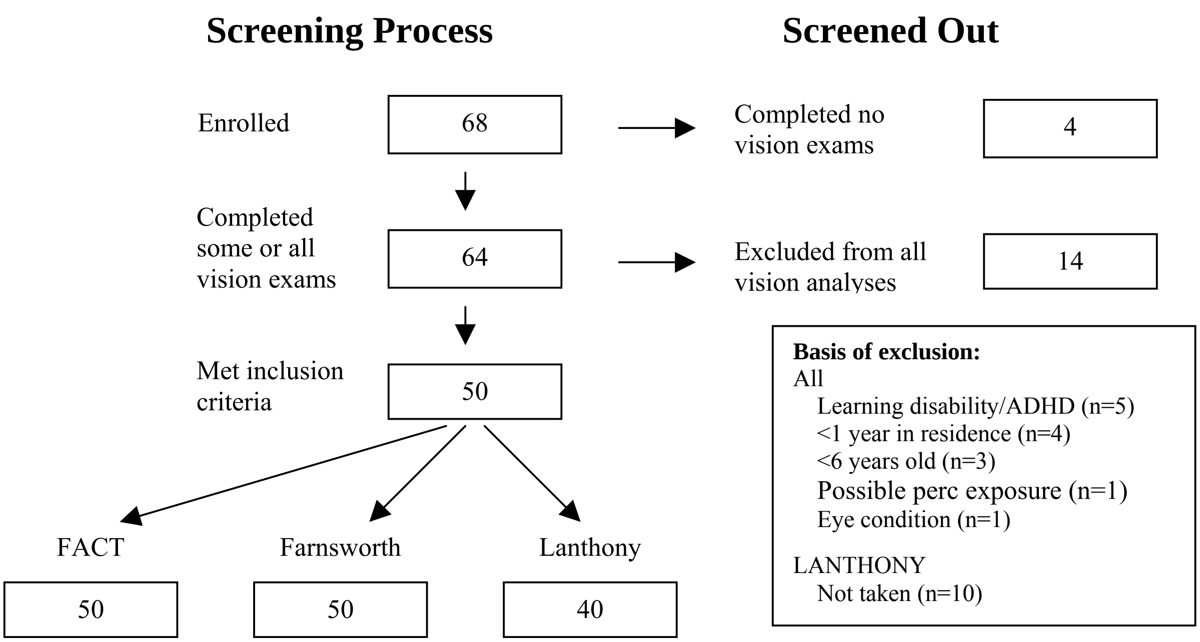


Figure 3.3 – 2a. VCS scores (worst eye) of adults living in buildings (a) with no dry cleaner and (b) with a drycleaner. Dashed lines reflect the minimum and maximum achievable scores, Functional Acuity Contrast Test, F.A.C.T. 100 (Stereo Optical Co., 3539 North Kenton Ave., Chicago IL 60641).

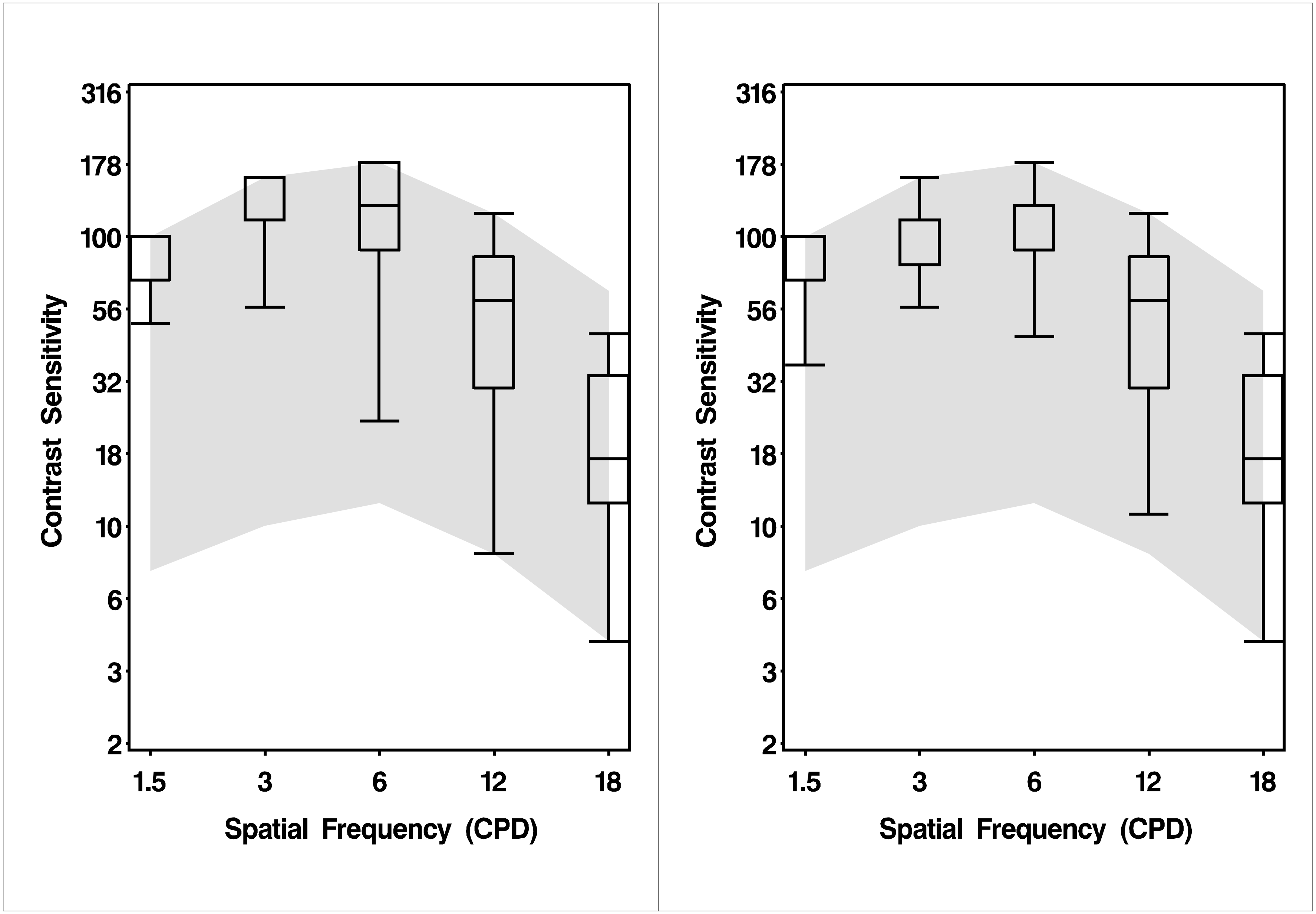


Figure 3.3 – 2b. VCS scores (worst eye) of children living in buildings (a) with no dry cleaner and (b) with a drycleaner. Dashed lines reflect the minimum and maximum achievable scores, Functional Acuity Contrast Test, F.A.C.T. 100 (Stereo Optical Co., 3539 North Kenton Ave., Chicago IL 60641).

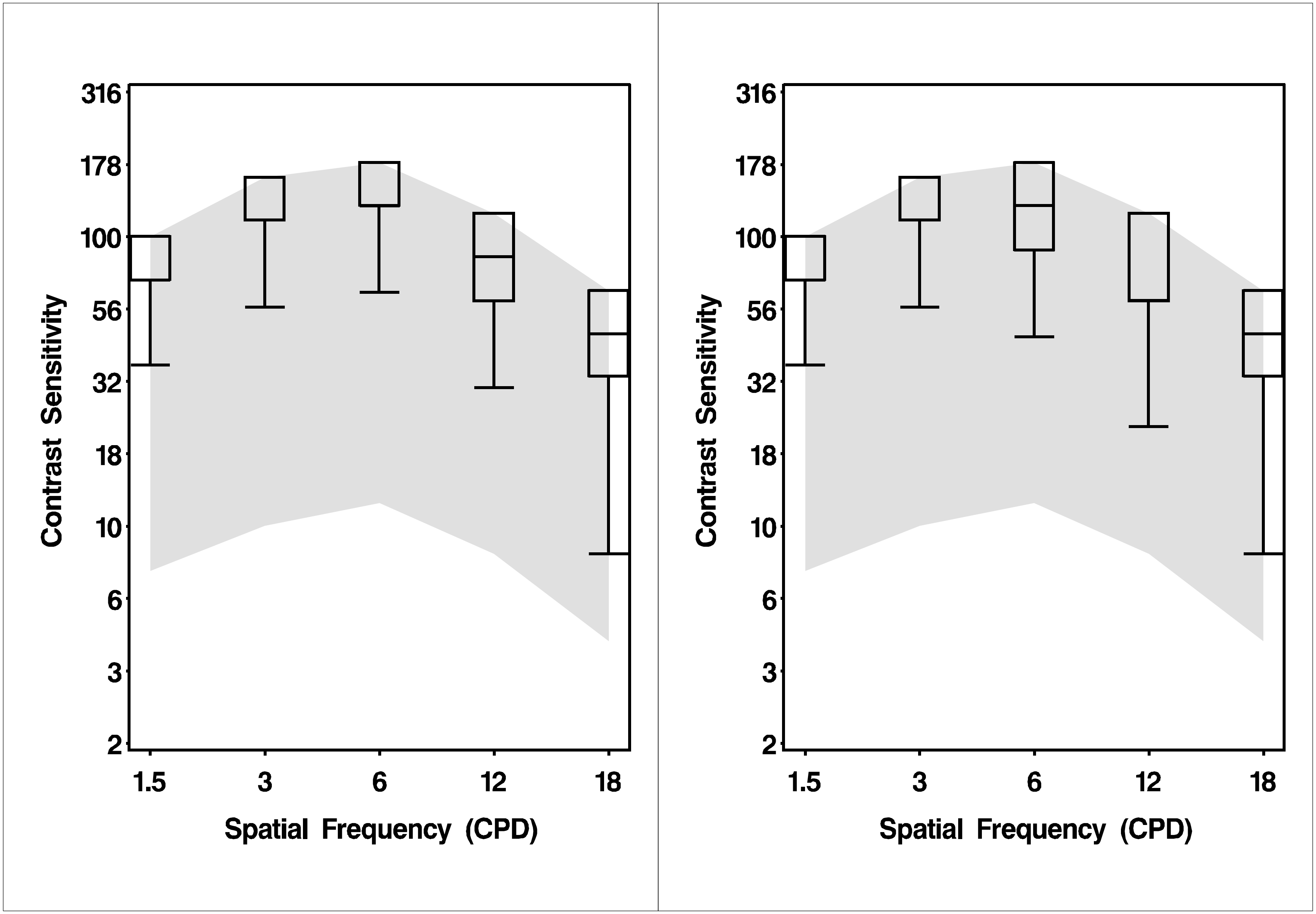


Figure 3.3 – 2c. Average VCS scores of adults living in buildings (a) with no dry cleaner and (b) with a drycleaner. Dashed lines reflect the minimum and maximum achievable scores, Functional Acuity Contrast Test, F.A.C.T. 100 (Stereo Optical Co., 3539 North Kenton Ave., Chicago IL 60641).

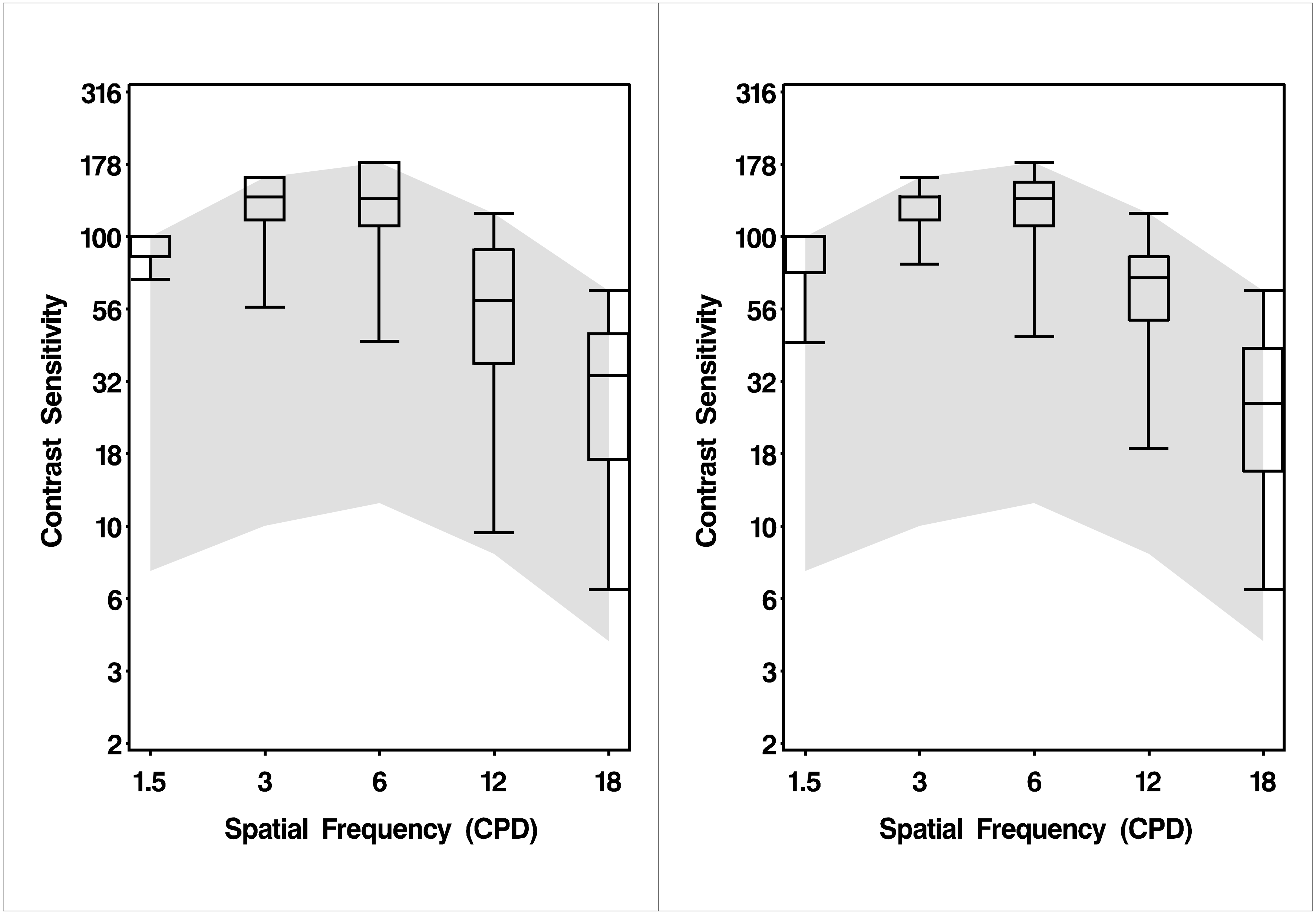


Figure 3.3 – 2d. Average VCS scores of children living in buildings (a) with no dry cleaner and (b) with a drycleaner. Dashed lines reflect the minimum and maximum achievable scores, Functional Acuity Contrast Test, F.A.C.T. 100 (Stereo Optical Co., 3539 North Kenton Ave., Chicago IL 60641).

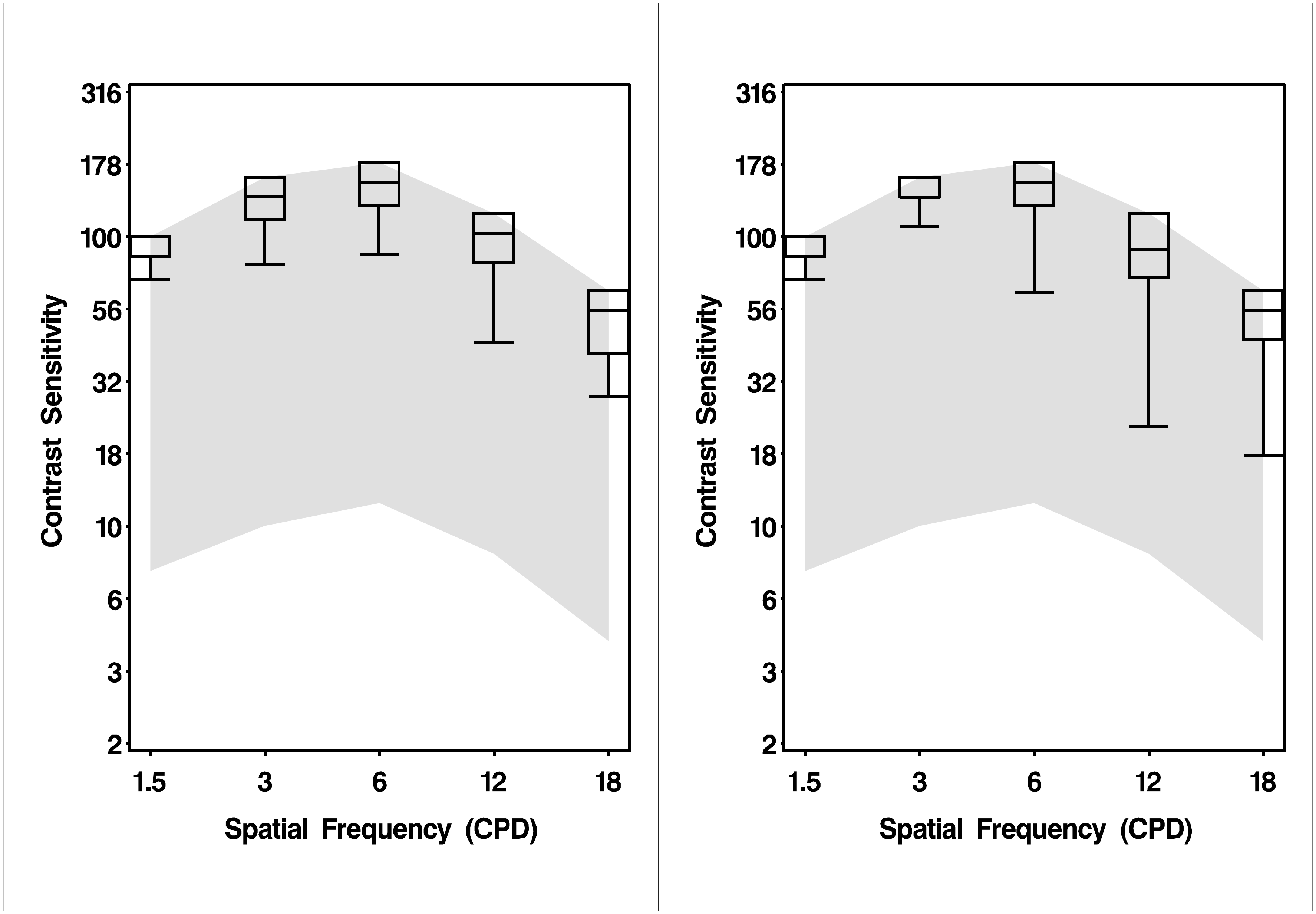


Figure 3.4−1. Farnsworth Color Confusion Index (CCI) for (a) Adults and (b) Children.

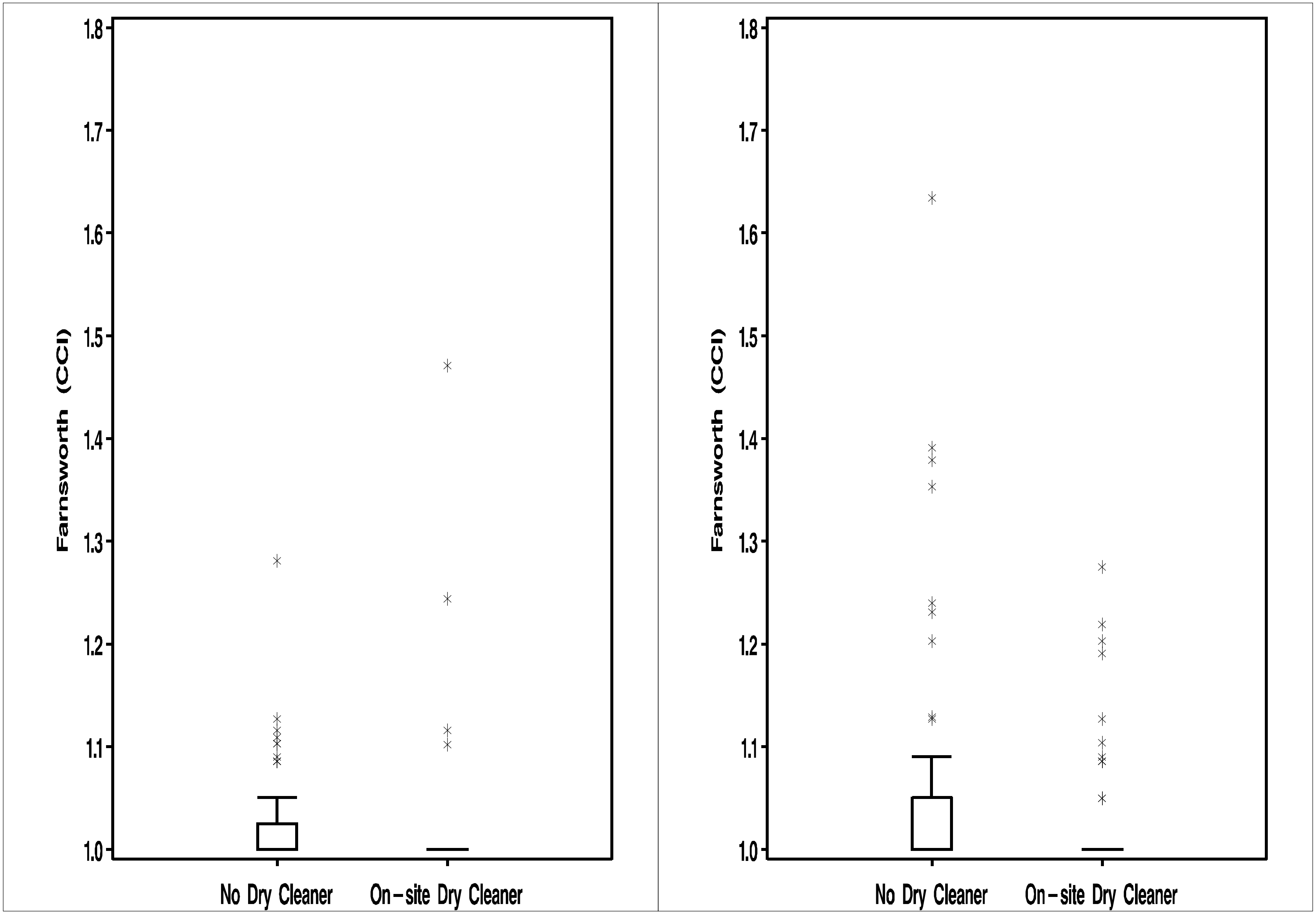
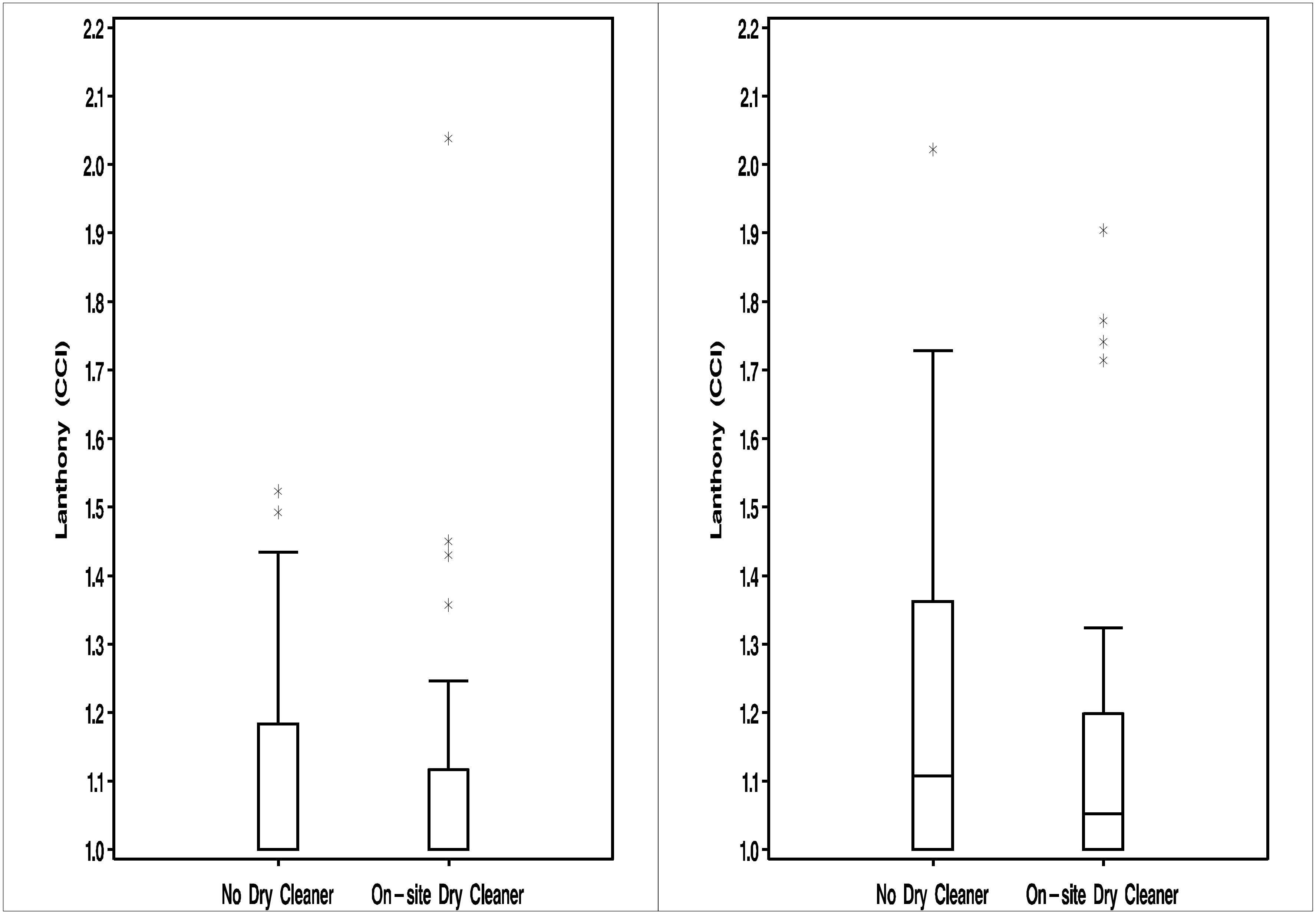
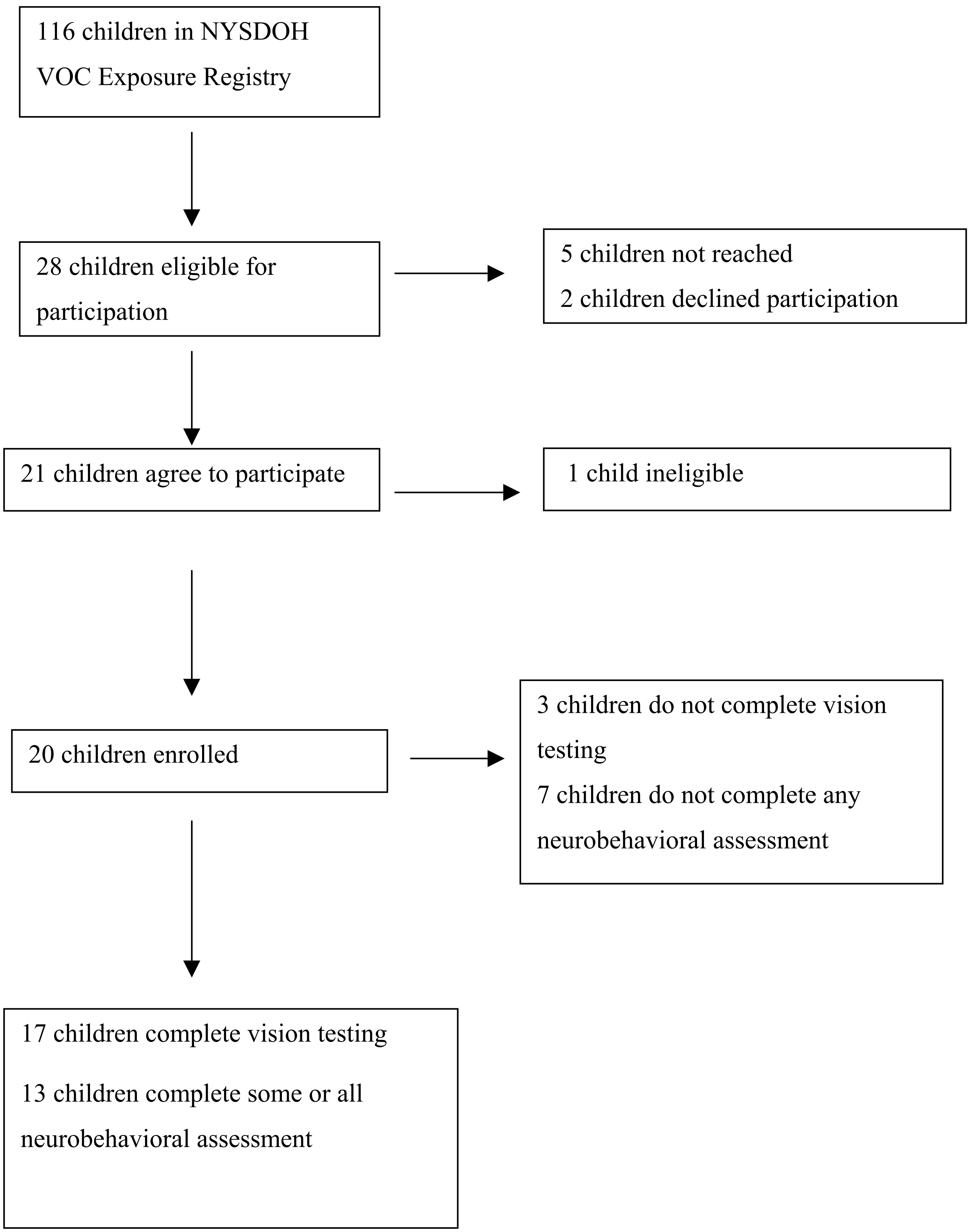


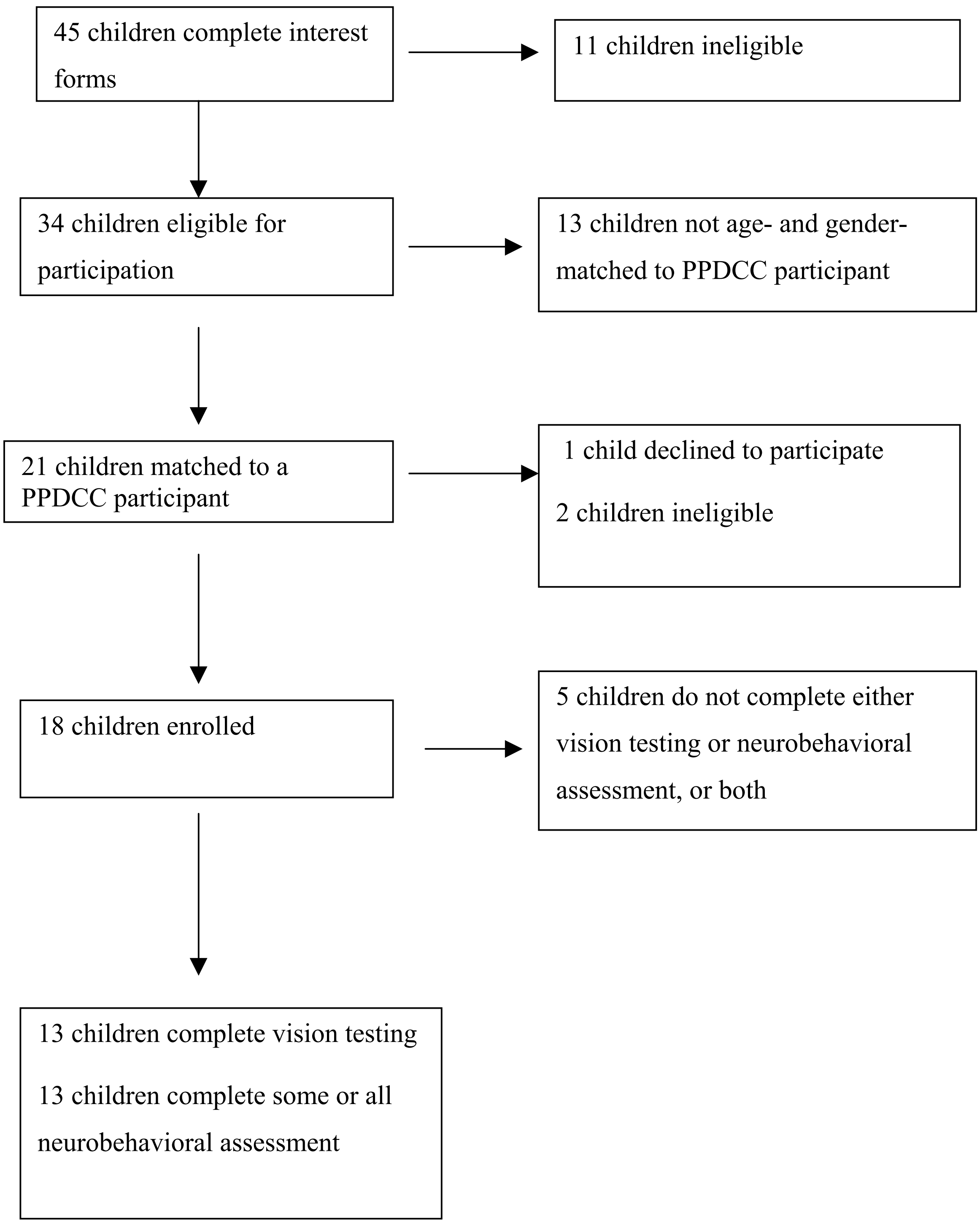
Figure 3.4 – 2. Lanthony Color Confusion Index (CCI) for (a) Adults and (b) Children.



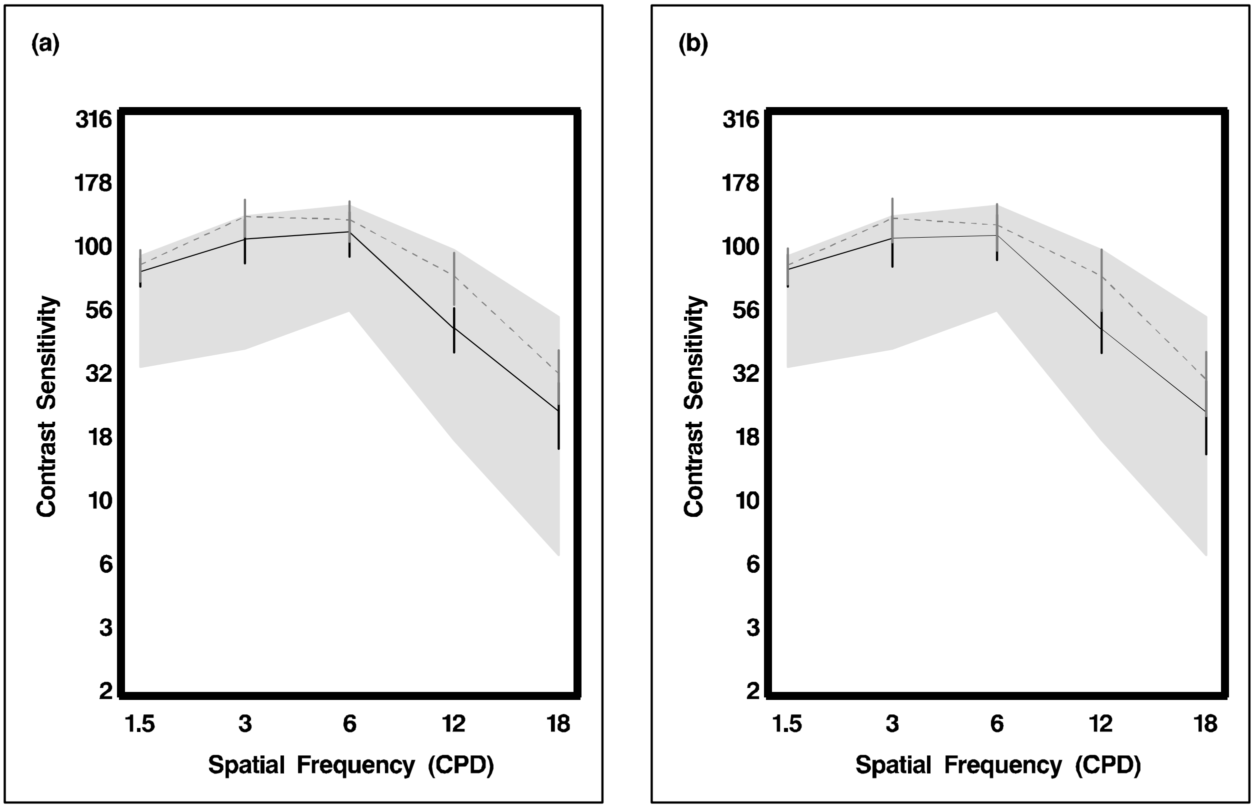
PFigure 2.1–1a. PPDCC Children – Follow-up Evaluation



PFigure 2.1–2b. Comparison Children – Follow-up Evaluation



PFigure 2.3–3. Visual Contrast Sensitivity Functions in PPDCC Children (dotted lines) and Matched Comparison Children (solid lines). (a) including pairs with 6 year olds; (b) not including pairs with 6 year olds.



NFigure 1.0–1. Scatter Plot of Perc Concentrations Statewide