

Recruitment, Retention, and Compliance Results from a Probability Study of Children's Environmental Health in Economically Disadvantaged Neighborhoods

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The School Health Initiative: Environment, Learning, and Disease (SHIELD) study used a probability sample of children (second through fifth grades) from two low-income and racially mixed neighborhoods of Minneapolis, Minnesota, to assess childhood environmental health. Children were eligible to participate in SHIELD regardless of whether they or their families spoke a foreign language, their household had a telephone, or they were enrolled in a special education program. The overall enrollment rate in year 1 was 57%, with a substantial disparity between children from English-speaking (42%) versus non-English-speaking (71%) families. At the end of year 1, 85% were retained in the study. A relatively high percentage of children provided the two requested blood (82%) and urine (86%) samples in year 1, and 90% provided a valid spirometry sample. Eighty-two percent provided both requested volatile organic chemical badge samples, and both time-activity logs were obtained from 66%. However, only 32% provided both peak flow measurements. All percentages increased for those participating in the second year of the study. Results indicate that a school-based research design makes it feasible and practical to conduct probability-based assessments of children's environmental health in economically disadvantaged and ethnically diverse neighborhoods. There is an ongoing need, however, to improve understanding of the cultural, economic, psychologic, and social determinants of study participation among this population. **Key words:** asthma, children, enrollment, environmental tobacco smoke, low-income, lung function, metals, minorities, pesticides, probability sample, recruitment, retention, volatile organic chemicals. *Environ Health Perspect* 111:731–736 (2003). doi:10.1289/ehp.6015 available via <http://dx.doi.org/> [Online 4 February 2003]

Children's environmental health is an increasingly prominent policy issue (Clinton 1997; Kaiser 1999; Landrigan and Carlson 1995; Needham and Sexton 2000b; National Research Council 1993; Wargo 1998) as well as a pressing scientific issue (Carlson 1998; Galson 1998; Landrigan et al. 2000; Mukerjee 1998; Needham and Sexton 2000a, 2000b; Selevan et al. 2000). Poor minority children are thought to be particularly vulnerable because they tend to be both more exposed to many environmental hazards and more susceptible to related adverse health effects than the general population (Landrigan et al. 1999; Needham and Sexton 2000b; Sexton and Anderson 1993; Sexton 1997, 2001). Current and future exposure monitoring studies and epidemiologic investigations will necessarily involve intensive and repeated contacts with children and their families (Needham and Sexton 2000b). Yet relatively little has been published on recruiting, retaining, and monitoring children from low-income, ethnically diverse communities. Available information suggests that these populations present special challenges for investigators because they often lack telephones, do not speak English, change address frequently, and mistrust researchers, among other problems (Fitzgibbon et al. 1998; Janson et al. 2001; Julian and Gross 2000;

Mitchell et al. 1997; Pletsch et al. 1995; Pressel et al. 2001; Senturia et al. 1998; Sexton et al., 2000; Sorkness et al. 2001). In this article we summarize recruitment, retention, and compliance results from a novel school-based investigation of children's exposure to multiple hazardous chemicals in two low-income neighborhoods of Minneapolis.

Study Design and Methods

The School Health Initiative: Environment, Learning, and Disease (SHIELD) study examined children's exposure to complex mixtures of environmental agents [i.e., volatile organic chemicals (VOCs), environmental tobacco smoke, allergens, bioaerosols, metals, and pesticides]. It also incorporated a pilot epidemiologic study to examine links between measured exposures and effects on both respiratory health (e.g., spirometry and peak flow data) and learning outcomes (e.g., standardized test scores, measures of academic performance, attendance). A more detailed description of the SHIELD study design and monitoring methods has been published previously (Sexton et al. 2000).

Recruitment for year 1 occurred from November 1999 through January 2000, and reenrollment for year 2 took place from November 2000 through January 2001. Environmental, personal, and biologic data

were collected during two monitoring sessions in each school year. Numerous activities were undertaken before and during recruitment to inform and involve community members in the study (e.g., letters to key community groups, presentations at parent-teacher meetings and school open houses, distribution of brochures). In year 1, blood and urine samples were collected in February–March and April–May 2000. In year 2, blood and urine samples were collected in February–March and May 2001.

A stratified-random sampling design was used to ensure adequate numbers within defined subgroups of children with known sampling probabilities. Strata were defined by school attended (Lyndale, Whittier), grade (second, third, fourth, fifth), language category (English or non-English spoken at home), and sex (female, male), which produced 32 distinct strata. The goal was to have a sample of five children within each stratum (5×32), which meant a target sample size of 80 from each school. The sampling strategy

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ensured that these 80 children (referred to as "index" children) were from 80 different families.

Study population. Children living in the adjacent neighborhoods of Lyndale and Whittier were the focus of SHIELD. According to the 2000 Census (U.S. Census Bureau 2000), the Lyndale neighborhood had a population of 7,690 (4,274 white, 1,513 African American, 105 American Indian, 342 Asian or Pacific Islander, 1,041 other, 415 who identified themselves as being of two or more races), and the Whittier neighborhood had a population of 15,247 (8,161 white, 3,044 African American, 328 Native American, 841 Asian or Pacific Islander, 1,990 other, 883 self-identified as being of two or more races). Median household income from the 1990 Census (U.S. Census Bureau 1990) was \$15,392 in Lyndale and \$17,325 in Whittier, with more than 35% of all families (as well as more than 55% of all families with children younger than 18 years) living in poverty.

All 558 children enrolled in grades 2–5 at the Lyndale (269 children) and Whittier (289 children) elementary schools for the start of the 1999–2000 school year were eligible to participate in SHIELD. Children attending the Lyndale and Whittier elementary schools were among the poorest (90% or more below poverty) and least likely to speak English (34% at Lyndale and 42% at Whittier did not speak English) in the Minneapolis Public Schools (MPS) system. One hundred fourteen (70 at Lyndale and 44 at Whittier) spoke primarily Somali at home, 108 spoke primarily Spanish (12 at Lyndale and 96 at Whittier), 18 spoke primarily Cambodian (all at Lyndale), and 23 (all at Lyndale) spoke primarily other languages (including Laotian, Cree, and three African languages—Oromo, Amharic, Yoruba). A more complete description of this study population was published previously (Sexton et al. 2000).

Recruitment. Children and their families eligible to participate in SHIELD were identified and contacted on the basis of enrollment information obtained from the Student Accounting Department, MPS. The list included names, first language, addresses, telephone numbers, and other contact information. The recruitment procedures were similar for both years of SHIELD. In the fall of year 1, all randomly selected households received an initial contact letter (in the appropriate language) from the principal of their child's school describing the study, encouraging them to volunteer, and explaining that a recruiter would contact them. A bilingual education assistant from the schools contacted families that spoke Cambodian, Somali, or Spanish. English-speaking families were contacted by either a bilingual education assistant or an experienced recruiter with knowledge of the challenges involved in

conducting research studies among economically disadvantaged populations.

After successful contact, recruiters met with children/families in their homes to explain the study and answer any questions. For those who agreed to volunteer, recruiters obtained verbal and written consent/assent and administered the baseline questionnaire. Total time for the home visit was typically from 1 to 2 hr.

Only children who participated in year 1 were eligible for reenrollment, so we did not send another letter from the school principal in the fall of year 2. Otherwise, recruitment procedures were the same. To the extent possible, we tried to ensure that the same recruiter from year 1 approached each of the children and their families. The initial home visit, during which recruiters obtained signed consent/assent and administered the shorter year 2 baseline questionnaire, usually took about 30 min.

Children and families volunteering for SHIELD were offered, with institutional review board (IRB) approval, financial incentives for successful completion of research-related tasks. The total yearly compensation for successfully completing all research tasks (including providing blood and urine samples) could be as much as \$140 per child per year (\$280 for both years). In addition, children were given a choice of small gifts when they completed specific research-related tasks.

Statistical considerations. Sampling weights are stratum specific and depend on the number of children in the stratum as well as the number of grade-eligible siblings. Results are reported either as raw percentages or as weighted percentages adjusted for selection and nonresponse probabilities. Confidence intervals account for uncertainty from both sampling and nonresponse weights by bootstrapping (Efron and Tibshirani 1993).

Results

This section presents household income and education for SHIELD participants, and summarizes results of recruitment, retention, and compliance obtained during both years of the study.

Household income and education. A summary of income and highest education for households participating in SHIELD is provided in Table 1. It is evident from the data that, overall, most SHIELD households had low incomes, with 27% earning less than \$9,999 per year, 30% between \$10,000 and \$19,999 per year, and 21% between \$20,000 and \$29,999 per year. Only 8% of households earned between \$30,000 and \$39,999 per year, and just 3% earned more than \$50,000. There were some obvious ethnic/racial differences, with 61% of Somali households earning less than \$9,999 (vs. 16% African American, 17%

Table 1. Household income and highest household education by ethnicity/race.

	Ethnicity/race				Total
	African American	Somali immigrant	Hispanic	Other ^a	
Household income					
< \$9,999	6 (15.9)	24 (61.2)	8 (16.8)	9 (23.4)	47 (26.6)
\$10,000–19,999	7 (15.3)	12 (32.0)	27 (58.2)	7 (22.1)	53 (29.9)
\$20,000–29,999	9 (31.6)	1 (1.6)	4 (10.5)	7 (29.5)	21 (20.5)
\$30,000–49,999	5 (15.1)	1 (2.8)	0 (0)	2 (9.0)	8 (7.9)
≥ \$50,000	1 (3.5)	0 (0)	0 (0)	3 (8.4)	4 (3.1)
Not answered	7 (18.7)	1 (2.4)	7 (14.5)	2 (7.6)	17 (12.0)
Highest education in household					
Less than high school graduate	2 (4.0)	28 (75.9)	42 (90.5)	11 (33.1)	83 (44.4)
High school graduate or GED	19 (53.6)	6 (12.6)	2 (6.6)	10 (40.4)	37 (31.9)
College graduate or technical certification or greater	14 (42.5)	5 (11.5)	1 (1.5)	8 (24.5)	28 (23.0)
Missing	0 (0)	0 (0)	1 (1.5)	1 (2.0)	2 (0.8)

Data are frequency (%). Percentages are weighted to adjust for nonselection and nonresponse.

^aIncludes Native American ($n = 3$), Asian Laotian ($n = 4$), Asian Cambodian ($n = 8$), white ($n = 12$), and other ($n = 3$).

Table 2. Summary of recruitment and retention from years 1 and 2 of the SHIELD study.

Parameter		Year 1	Year 2
Enrollment ^a	No.	153/270	NA
	Raw rate	57%	
	Weighted rate ^b	56%	
Re-enrollment ^a	No.	NA	107/136
	Raw rate		79%
	Weighted rate		73%
Retention ^c	No.	130/153	101/107
	Raw rate	85%	94%
	Weighted rate	85%	95%

NA, not applicable.

^aNumber of children for whom consents and assents were obtained and a baseline questionnaire completed. ^bThe weighted rates are calculated using weighted counts that adjust for selection and response probabilities. ^cNumber of children providing at least one blood or urine sample and completing the follow-up questionnaire.

Hispanic, 23% other), and 19% of African Americans and 17% of "other" ethnic/racial groups earning more than \$30,000 per year (vs. 3% Somali and 0% Hispanic). To put these household incomes in perspective, the 2002 Health and Human Services poverty guidelines set the poverty level for a family of four at \$18,100 per year (range from \$8,860 for a single person to \$30,420 for a family of eight).

Regarding education, 44% of participating households had no occupant with a high school degree or equivalent, 32% had a high school graduate [or general educational development (GED) credit], and 23% had at least a college graduate or technical certificate holder. Again, there were differences by ethnicity/race, with 76% of Somali and 91% of Hispanic households having no occupant with at least a high school degree (vs. 4% African American and 33% other), and 43% of African-American households having an occupant with at least a college degree or

technical certificate (vs. 2% Hispanic, 12% Somali, 25% other).

Recruitment and retention. In year 1, a random sample of 311 "index" children was selected. Forty-one of these children had transferred out of the Lyndale and Whittier schools by the time recruiting ended. Of the remaining 270 eligible children, 153 index children were later enrolled in year 1. If the index child had siblings in grades 2–5, they were also asked to participate, and 51 siblings were enrolled in year 1. The original 153 index children (plus their 51 siblings) were eligible for year 2 provided they were registered at a school within the MPS system. One hundred seven index children along with 36 siblings were ultimately reenrolled for year 2. A child was considered to be enrolled (or reenrolled) when the parent or guardian signed the written consent form, the child signed the written assent form, and the parent or guardian completed the baseline questionnaire.

The overall enrollment rate for year 1 was 57%, with English-speaking families (42%) volunteering at a substantially lower rate than non-English-speaking families (71%). For year 2, the overall reenrollment rate was 79% and the disparity between English-speaking (62%) and non-English-speaking (88%) families persisted. A summary of overall recruitment results for both years is provided in Tables 2 and 3, and the reasons children were not enrolled (year 1) or reenrolled (year 2) are summarized in Table 4.

A breakdown by ethnicity of weighted enrollment rates for year 1 is provided in Table 5. Of the three largest ethnic groups, enrollment rates were relatively high for Hispanic children (80%) and children of Somali immigrants (66%). However, the enrollment rate for African-American children (35%) was significantly lower. Although absolute numbers were relatively small for other groups, enrollment rates were also reasonably high for Cambodian (89%) and white (71%) children, but comparatively low for Native-American (42%) and Laotian (39%) children.

A marginal breakdown of enrollment, reenrollment, and retention rates for SHIELD by stratification variables (school, grade, sex, and language) is provided in Table 6. Retention for both year 1 and year 2 is defined as the number (percentage) of participating children who provided at least one blood or urine sample and for whom a completed follow-up questionnaire was obtained. With weighted counts, statistically significant differences (χ^2 test, $p < 0.05$) were observed between children from English-speaking and non-English-speaking families for both enrollment (year 1) and reenrollment (year 2), and for retention in year 1. In all cases, children from non-English-speaking families were more likely to enroll, reenroll, and be retained in the study. Although other significant differences were found by sex (retention in both years), grade (retention year 1 and reenrollment year 2), and school (enrollment

Table 3. Summary of monitoring results from years 1 and 2 of the SHIELD study.

Data capture		At least one sample	Both samples	At least one sample	Both samples
Blood	No.	128/139	114/139	99/103	90/103
	Raw rate	92%	82%	96%	87%
	Weighted rate ^b	92%	85%	97%	92%
Urine	No.	143/153	131/153	105/107	100/107
	Raw rate	93%	86%	98%	93%
	Weighted rate	93%	87%	99%	97%
VOC Badge	No.	127/140	115/140	NA	NA
	Raw rate	91%	82%		
	Weighted rate	91%	83%		
TA log	No.	124/140	92/140	NA	NA
	Raw rate	89%	66%		
	Weighted rate	89%	67%		
Spirometry	No.	137/153	NA	103/107	NA
	Raw rate	90%		96%	
	Weighted rate	91%		98%	
Peak Flow ^a	No.	57/74	24/74	NA	NA
	Raw rate	77%	32%		
	Weighted rate	76%	34%		

Abbreviations: NA, not applicable; TA, time-activity.

^aNumber of children providing valid peak flow data for the winter and spring monitoring sessions 2000. ^bThe weighted rates are calculated using weighted counts that adjust for selection and response probabilities.

Table 4. Summary of reasons not enrolled for year 1 compared to reenrollment for year 2 of the SHIELD study (October 1999–July 2001) by number (%).^a

Reason	Year 1, 1999–2000			Year 2, 2000–2001		
	Non-English	English	Total	Non-English	English	Total
Transferred ^b	10 (7)	31 (19)	41 (13)	12 (12)	5 (9)	17 (11)
Contact problems ^c	25 (18)	35 (27)	60 (22)	2 (2)	8 (16)	10 (7)
Follow-through problems ^d	4 (3)	20 (15)	24 (9)	3 (3)	5 (10)	8 (6)
Refused ^e	11 (8)	22 (17)	33 (12)	5 (6)	6 (12)	11 (8)
Enrolled	98 (71)	55 (42)	153 (57)	76 (88)	31 (62)	107 (79)
Total attempted to contact	148 (100)	163 (100)	311 (100)	98 (100)	55 (100)	153 (100)

^aPercent transferred indicates number transferred/total attempted to contact; percent contact problems, percent follow-through problems, percent refused, and percent enrolled indicates number/(total selected minus number transferred).

^bDuring year 1, a child who transferred out of one of the two schools of interest was considered ineligible for the study; during year 2, only children who transferred outside the local school district were considered ineligible. A child who transferred to a school within the local school district was still considered eligible and was monitored at that school if the family agreed. ^cInclude disconnected and wrong phone number, phone busy or no answer after numerous attempts, and no response to letters or personal home visits. ^dInclude no-shows or cancellations for scheduled appointments, multiple call backs, or no response to several messages. ^eIncludes those who refused by sending back postcards and those who declined recruiters because they were too busy, had recent surgery, did not want to provide blood sample, or for no stated reason.

Table 5. Enrollment rates (%) for index children within ethnic groups.

Ethnic group	No.	Year 1 Enrollment ^a	
		No.	Rate (95% CI) ^b
Native American	7	3	42 (15–69)
Black, U.S. born	101	36	35 (28–42)
Black, Somali	60	40	66 (56–76)
Asian, Cambodian	9	8	89 (72–100)
Asian, Laotian	11	4	39 (16–62)
Hispanic	59	47	80 (72–88)
White	17	12	71 (54–87)
Other	6	3	47 (14–80)
χ^2 (p -value) ^b			70.9 (< 0.0001)

^aEnrollment rate indicates number enrolled children/number eligible children selected. ^bThe rates, χ^2 statistic and associated p -value are calculated using weighted counts that adjust for selection probabilities. The normal approximation to the binomial distribution is used to calculate the confidence intervals.

and retention year 1), no clear patterns were apparent.

Collection of blood and urine samples.

Rates of data capture for blood and urine samples are presented in Table 3. These results are further broken down in Table 7 according to stratification variables. As shown in Table 7, statistically significant differences (chi-square statistic, $p < 0.05$) were found between: schools (children at Lyndale were consistently more likely to provide blood samples in both years, and urine samples in year 1), grades (blood and urine samples in both years), sex (blood and urine samples in

year 2), and language (in year 2, students from English-speaking homes were more likely to provide both samples of blood and urine and at least one urine sample than were children from non-English-speaking homes).

Ninety-seven index children agreed to provide blood and urine samples for both year 1 and year 2 of SHIELD. The maximum possible number of biologic samples from each of these children was four blood and four urine samples (collected in the winter and spring of both years). We obtained all four blood samples from 77 children (84%), three or more from 91 children (93%), and two or more

from 96 children (> 99%). Results for urine collection were somewhat higher, with 93 children (91%) providing four samples, and 105 (99%) providing three or more samples.

Collection of personal VOC, time-activity, and lung-function data. In year 1, index children were asked to wear a small passive monitor (clip-on badge) for 48 consecutive hr (before the blood sample) to measure airborne VOC concentrations. Each child was also asked (year 1 only), with the help of parents/guardians, to maintain a 48-hr diary (in the form of a simple questionnaire) of time spent in seven microenvironments (inside at home, school, other; outside at home, school, other; in transit). In the spring of both years, the school nurse at each school conducted lung spirometry for children enrolled in SHIELD. In addition, for year 1 only, all students in the 4th and 5th grades at both schools (whether they were enrolled in SHIELD or not) were asked, as part of an in-class experiment, to participate in measurements (using small, hand-held flow measuring devices) of peak expiratory flow and forced expiratory volume in 1 sec (FEV₁).

A summary of data capture for personal VOC badges, time-activity diaries, and lung function tests is given in Table 3. Data capture rates were relatively high for personal VOC badges (83% provided both samples), personal time-activity diaries (67% provided both samples), and spirometry data (> 90% of the children completed this testing each year). Complete peak flow data were obtained at progressively decreasing rates, starting in fall 1999 (91%) and continuing in the winter (76%) and spring (47%). Only 34% (weighted percentage) of the children provided valid peak

Table 6. Enrollment, reenrollment, retention, and weighted rates for index children.

	No.	Year 1				Year 2			
		Enrollment ^a		Retention ^b		Reenrollment ^a		Retention ^b	
		No.	Rate (%) ^c	No.	Rate (%) ^c	No.	Rate (%) ^c	No.	Rate (%) ^c
School									
Lyndale	138	71	51	62	88	49	74	47	96
Whittier	132	82	62	68	80	58	72	54	95
χ^2 (p-value) ^c		5.7 (0.017)		5.5 (0.019)		0.1 (0.763)		0.5 (0.498)	
Grade									
2	72	41	59	33	77	26	71	25	95
3	68	38	53	29	82	27	80	27	100
4	64	38	61	36	93	28	79	26	93
5	66	36	51	32	87	26	62	23	94
χ^2 (p-value) ^c		2.9 (0.409)		12.3 (0.006)		10.9 (0.012)		7.6 (0.056)	
Sex									
Female	130	72	54	60	80	52	74	50	98
Male	140	81	58	70	88	55	72	51	93
χ^2 (p-value) ^c		0.9 (0.348)		6.7 (0.010)		0.1 (0.739)		6.6 (0.010)	
Language									
English	132	55	41	43	80	31	58	29	94
Non-English	138	98	71	87	89	76	89	72	97
χ^2 (p-value) ^c		42.6 (< 0.0001)		5.9 (0.015)		55.6 (< 0.0001)		1.3 (0.262)	

^aYear 1: Enrollment rate indicates number enrolled children/number eligible children; year 2: enrollment rate indicates number reenrolled children/number enrolled children from year 1 who are eligible for year 2 enrollment. ^bRetention rate indicates number children who gave at least one blood or urine sample and did year end questionnaire/number enrolled children. ^cThe rates, χ^2 statistic, and associated p-value are calculated using weighted counts that adjust for selection and response probabilities.

Table 7. Blood and urine compliance and weighted rates (%) for index children.

	No.	Year 1								Year 2							
		Blood ^a				Urine ^b				Blood				Urine			
		Both ^c	At least one ^c	Both ^c	At least one ^c	Both ^c	At least one ^c	Both ^c	At least one ^c	Both ^c	At least one ^c	Both ^c	At least one ^c	Both ^c	At least one ^c	Both ^c	At least one ^c
		No.	Rate ^d	No.	Rate ^d	No.	Rate ^d	No.	Rate ^d	No.	Rate ^d	No.	Rate ^d	No.	Rate ^d	No.	Rate ^d
School																	
Lyndale	57	90		58	91	66	94	66	94	44	97	46	99	46	97	48	99
Whittier	57	79		70	92	65	81	77	93	46	86	53	94	54	96	57	99
χ^2 (p-value) ^c		10.9 (0.001)		0.04 (0.848)		17.7 (< 0.0001)		0.2 (0.658)		15.4 (< 0.0001)		7.9 (0.005)		0.01 (0.910)		0.06 (0.800)	
Grade																	
2	25	77		27	83	33	82	36	89	24	100	24	100	26	100	26	100
3	25	83		32	96	30	85	36	96	23	85	25	90	26	98	27	100
4	37	97		38	100	37	97	38	100	26	96	28	100	27	98	28	100
5	27	83		31	88	31	86	33	88	17	85	22	95	21	89	24	96
χ^2 (p-value) ^c		17.1 (0.0007)		25.7 (< 0.0001)		11.7 (0.008)		17.0 (0.0007)		26.9 (< 0.0001)		21.5 (< 0.0001)		20.7 (0.0001)		15.1 (0.002)	
Sex																	
Female	53	81		61	90	61	85	68	92	47	96	50	100	51	99	52	100
Male	61	87		67	93	70	89	75	94	43	88	49	94	49	95	53	98
χ^2 (p-value) ^c		3.1 (0.079)		1.2 (0.274)		2.0 (0.156)		0.8 (0.378)		10.8 (0.001)		13.1 (0.0003)		6.2 (0.013)		3.5 (0.06)	
Language																	
English	40	87		46	94	47	89	52	94	29	96	29	96	31	100	31	100
Non-English	74	82		82	90	84	86	91	93	61	87	70	97	69	93	74	98
χ^2 (p-value) ^c		2.3 (0.127)		2.5 (0.112)		0.8 (0.381)		0.3 (0.567)		10.8 (0.001)		0.3 (0.613)		14.9 (0.0001)		4.1 (0.043)	

^aThe denominator used to calculate blood compliance rates is the number of children who, at the beginning of each year, agreed to provide blood samples. ^bThe denominator used to calculate urine compliance rates is the number of children who enrolled each year. ^cSamples: both or at least one. ^dThe rates, χ^2 statistic, and associated p-value are calculated using weighted counts that adjust for selection and response probabilities.

flow samples for both the winter and spring 2000 monitoring sessions.

The primary reason that requested VOC badges and time-activity diaries were not obtained from some children was that they had transferred to another school. The relatively low data capture rate for peak flow data is explained at least partially by the demanding nature of the testing, which required that children be present in class on mornings and afternoons of at least two of three testing days during the designated testing week, and successfully complete three valid FEV₁ measurements in both the morning and afternoon.

Discussion

In a probability sample, much emphasis is usually placed on collecting data from a relatively small sample with known probabilities so that findings can be generalized to the larger population. Comparatively little has been published, however, on recruitment, retention, and data capture results for probability-based environmental health studies, particularly those that focus on children (Adgate et al. 2000; Callahan et al. 1995; Janson et al. 2001; Mitchell et al. 1997; Pletsch et al. 1995; Senturia et al. 1998). Notwithstanding the current paucity of information, it has become apparent that economically disadvantaged groups and people of color present a special challenge for a variety of reasons, including mistrust of investigators, frequent address changes, and lack of telephones (Fitzgibbon et al. 1998; Janson et al. 2001; Julian and Gross 2000; Pletsch et al. 1995; Preloran et al. 2001; Pressel et al. 2001; Senturia et al. 1998; Sexton et al. 2000; Sorkness et al. 2001).

The SHIELD data on recruitment, retention, and compliance are based on a probability sample of economically disadvantaged and ethnically diverse children. No randomly selected children were deemed ineligible for SHIELD regardless of whether they and their family spoke English, their household had a telephone, or they were enrolled in a special education program. Of the children/families enrolled, many changed addresses frequently, spoke little or no English, did not have a telephone, endured economic hardships, and exhibited a variety of nontraditional lifestyles and living arrangements. Moreover, because the Lyndale and Whittier neighborhoods are home to many immigrants (Somali, Mexican and Latino, Cambodian, Laotian), 45% of the index children in year 1 and 49% in year 2 were not born in the United States. Immigrant children participating in SHIELD year 1 had been in this country for a median of 3 years.

Enrollment rates. Seventy-one percent of non-English-speaking families, including many recent immigrants, volunteered to participate in

SHIELD year 1. Bilingual education assistants at Lyndale and Whittier were hired as recruiters to contact Spanish, Cambodian, and Somali families. Because they knew and were known by members of their respective ethnic/racial communities, the bilingual education assistants were highly effective recruiters of non-English-speaking families.

In contrast, the year 1 response rate for English-speaking families (primarily African American) was only 42%. Despite the invaluable assistance we received from the MPS (e.g., contact information), this population presented a wide variety of recruitment problems: They transferred their children more often (19% vs. 7% for non-English speaking families), were harder to contact (27% vs. 18% for non-English-speaking families), more frequently posed follow-through challenges after they were contacted (15% vs. 3% for non-English-speaking families), and were more likely to refuse requests to participate (17% vs. 8% for non-English-speaking families). In year 1, 51% of the English-speaking versus 40% of the non-English-speaking families moved or changed their phone number at least once. In several cases the children were willing to enroll or reenroll, but their parents could not be contacted to obtain their consent despite repeated attempts. It is unlikely that traditional contact methods (random digit dialing, mailings based on commercially available address lists) would have been effective in identifying, let alone recruiting, many of the English-speaking African-American families with grade-eligible children.

Our experience suggests that without investing substantially more time and resources, there is little likelihood of improving response rates significantly for African-American children/families in the Lyndale and Whittier neighborhoods. It was difficult to find recruiters with the same level of connection to the African-American community, as was the case for our Somali, Hispanic, and Cambodian recruiters. The simple expedient of increasing incentives is probably not a realistic option because of IRB concerns about possible economic coercion. Contacting parents/guardians directly through their children (e.g., accompanying the child home after school) raises confidentiality and privacy issues.

Sample collection. Obtaining blood and urine samples from elementary school children is always a challenge. In SHIELD, successful collection of blood samples depended directly on the ability, personality, and skill of the phlebotomist. It is essential that the pediatric phlebotomist have substantial experience in taking venipuncture samples from children, be able to take the sample quickly and relatively painlessly, and be skilled at reassuring children and putting them at ease. Similarly, the key to

collecting urine samples was the involvement of the school nurses who were well known to the children. Their familiarity to the students and friendly demeanor encouraged the children to feel comfortable about providing a sample. They also supervised the sample collection process to ensure privacy for the children as well as validity of the samples.

The children did a good job of adhering to the VOC-badge monitoring protocol, thereby contributing to the overall completeness and validity of the data. At the beginning of the 48-hr monitoring period, field technicians uncapped the badge and affixed it (in the breathing zone) to an article of clothing worn by the child. Overnight while the child was sleeping, the badge was placed near his or her head, and then in the morning it was reaffixed to the clothing. Before class each monitoring day, the child reported to the school nurse, who recorded whether the badge was being worn properly and gave the child a decorated pencil. Badges were retrieved and capped by field technicians at the end of the 48-hr monitoring period.

Results indicate that, with proper care, it is practicable to obtain personal VOC measurements and time-activity data for elementary school children. In-school spirometry testing by school nurses generally worked well, and valid measurements were obtained from more than 90% of participating children in both years. In-class peak flow testing of 4th and 5th graders was less successful over time, owing to the relatively complicated nature of the protocol.

Summary and Conclusions

Recruitment, retention, and data capture rates for SHIELD were comparable with other children's studies (Adgate et al. 2000; Mitchell et al. 1997; Senturia et al. 1998), despite the complexity and comparatively invasive nature of the SHIELD protocols. The data indicate that a school-based, probability sampling strategy is a practical, affordable, and effective method for studying children's environmental health in poor minority neighborhoods. The primary advantages of a school-based design are numerous: *a*) The process of identifying households with age-eligible children is direct, simple, and relatively inexpensive; *b*) contact information (i.e., names, telephone numbers, addresses) and sociodemographic information (e.g., race/ethnicity of child, language spoken at home) is readily available, provided appropriate safeguards are in place to protect privacy; *c*) the involvement of school personnel (e.g., recruitment letter from the principals, use of bilingual education assistants as recruiters) lends credibility to the study and increases the likelihood that children/families will volunteer to participate; *d*) information available

from the schools (e.g., race/ethnicity of child, language spoken at home, academic performance, standardized test scores) makes it easier to assess differences in responders and nonresponders; and *e*) the in-school collection of biologic samples (blood and urine) and testing of lung function (spirometry and peak flow) is a convenient and effective way to monitor children's environmental health.

Notwithstanding these advantages, the enrollment rate for English-speaking, predominantly African-American families was just 42%, compared with 71% for non-English-speaking families (predominantly Somali and Hispanic). Once enrolled, however, virtually all children/families participated fully in this relatively burdensome study, doing their best to comply with sometimes-demanding study protocols and willingly providing blood and urine samples. The primary reason that children/families dropped out of SHIELD was that they moved and/or transferred to another school. Although results from SHIELD are encouraging, findings also indicate that there is a continuing need to improve our understanding of cultural, economic, psychologic, and social factors that encourage or discourage participation among this population.

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