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# Issues in Design and Implementation in an Urban Birth Cohort Study: The Syracuse AUDIT Project

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**ABSTRACT** *The Syracuse AUDIT (Assessment of Urban Dwellings for Indoor Toxics) project is a birth cohort study of wheezing in the first year of life in a low-income urban setting. Such studies are important because of the documented serious risks to children's health and the lack of attention and published work on asthma development and intervention in communities of this size. We studied 103 infants of mothers with asthma, living predominantly in inner-city households. Our study combines measurements of a large panel of indoor environmental agents, in-home infant assessments, and review of all prenatal and postnatal medical records through the first year of life. We found multiple environmental pollution sources and potential health risks in study homes including high infant exposure to tobacco smoke. The prevalence of maternal smoking during pregnancy was 54%; postnatal environmental tobacco smoke (ETS) exposure was nearly 90%. The majority (73%) of homes showed signs of dampness. Participants' lives were complicated by poverty, unemployment and single-parenthood. Thirty-three percent of fathers were not involved with their children, and 62% of subjects moved at least once during the study period. These socioeconomic issues had an impact on project implementation and led to modification of study eligibility criteria. Extensive outreach, follow-up, and relationship-building were required in order to recruit and retain families and resulted in considerable work overload for study staff. Our experiences implementing the project will inform further studies on this and other similar populations. Future reports on this cohort will address the role of multiple environmental variables and their effects on wheezing outcome during the first year of life.*

**KEYWORDS** *Birth cohort, Childhood exposure, Indoor pollution, Maternal asthma, Study design, Tobacco smoke exposure, Wheeze.*

## INTRODUCTION

Increasing prevalence of childhood asthma is a major public health issue nationally and internationally. Of particular concern is the disproportionate impact on urban communities in the United States, where asthma prevalence is higher for low income, minority, urban children,[1–4] and asthma severity is greatest in impoverished inner-city areas.[5–7] The same associations are not seen in all countries.[8–10] A

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number of studies have sought to understand these disparities by evaluation of home, social, cultural, and psychological environments of children living in urban areas.[11,12] Indoor environmental pollutants, deteriorated housing, poverty, stress from urban living, and access to medical care are all thought to be important. Reports focused on inner-cities have documented home environmental characteristics of asthmatic children in urban areas of large U.S. cities.[13–18] Roaches, rodents, dampness and mold, tobacco smoke, combustion gases, dust mites and pets emerge as important risk factors associated with asthma morbidity. Socioeconomic risk factors also include caregiver stress and neighborhood violence. Despite this awareness, little is known about environmental exposures in infancy and their relation to respiratory symptoms and development of asthma in the low income urban setting.

Several birth cohorts have been followed longitudinally, assessing various environmental and other risk factors associated with wheezing in infancy and development of asthma.[19–24] These studies involved populations of moderately high socioeconomic status based on family income and education. Urban poor children have been studied but rarely from birth. The national cooperative inner-city asthma study identified factors associated with asthma morbidity among children ages 4 to 9 living in large (population >500,000) U.S. cities. Other studies have also focused on environmental risk factors and interventions in the inner-city setting.[16–18] We have intensively studied a birth cohort of infants genetically at risk for asthma living in Syracuse, NY. Our study combines, in the low-income urban setting, measurements of a large panel of indoor environmental agents, in-home infant assessments, and review of all prenatal and postnatal medical records through the first year of life. The principal objectives of the study were to: (1) establish baseline data on indoor pollutants, housing conditions, family characteristics and prenatal history of inner city infants and (2) monitor infant health during the first year of life in order to determine the association between the assessed parameters with wheeze and other health outcomes. In this initial report, we present the study design and implementation issues, the characteristics of the study population, environmental observations, and implications for intervention and future studies.

## STUDY DESIGN

### Location

Children living in Syracuse, NY, face substantial risks to health and development. With a population of 147,000 in 2000, Syracuse has one of the highest poverty rates in the nation (27.3%), which ranks tenth among cities with population greater than 100,000.[25] Nearly 39% of Syracuse children under age five live below the federal poverty level. African American children are more than twice as likely to be poor as White children,[26] and the Latino child poverty rate is the second highest in the U.S.[27] Despite aggressive programs to reduce infant mortality in Syracuse, African American and Hispanic residents continue to experience high infant mortality rates (17.8 and 20.3 per 1,000 live births, respectively, in 1998–2001), more than double that of white residents.[28] During the same period, the average infant mortality rate in New York State was 6.0 per 1000.[29] Syracuse has also been combating elevated child blood lead levels. In 2001, five of the 36 zip codes in New York State with the highest incidence of children with elevated lead levels were in Syracuse.[30] Asthma hospitalization rates for children living in Syracuse inner-city

high poverty zip codes were higher than in surrounding areas, similar to the pattern seen in United States national data.[31] Total crime indices in Syracuse City zip codes were greater than the national mean.[32] Housing stock in Syracuse neighborhoods is old, the median year of construction for rental units was 1950 and 1940 for owner-occupied housing.[33]

### Organization

This study was the signature project for the nascent New York Indoor Environmental Quality Center (NYIEQ).[34] Part of NYIEQ's mission includes facilitating and supporting research involving indoor environments. Creation of a new multidisciplinary and multi-institutional team was one of the specific goals of this project. Researchers from three local universities brought together expertise in medicine (pediatrics, pediatric pulmonology, epidemiology, public health), environmental exposures (mycology, chemistry, engineering, indoor environments) and community health.

### Enrollment and Eligibility

We sought to enroll a group of 120 pregnant asthmatics, in anticipation that at least 100 of their infants would be maintained in the study through their first year of life. Based on previous research regarding the heritability of asthma,[35] we hypothesized that by enrolling asthmatic mothers, the prevalence of wheeze in the first year of life in our infant sample would approach 40%.

Eligibility criteria for the baby included gestational age $\geq$37 weeks, birth weight $\geq$2,500 g (5.5 lb), absence of major congenital abnormality or disease, and single birth. Mothers were required to have medically documented history of asthma, speak English or Spanish, and plan to stay in their home for one year. Geographic requirements included residence in Syracuse or an adjacent urban location and adequate home safety and security.

### Personal Approach Strategy

High risk impoverished urban populations such as ours are often reticent to participate in research. Recognized barriers to participation include lack of telephones, frequent address changes, inability to speak English and failure to keep appointments.[36] To maximize enrollment and retention, an intensely personal approach by the study's family nurse practitioner (GH), was extended during all phases of the study, from recruiting to maintaining contact and relationship, not just with mothers, but with their extended families, obstetric offices, delivery hospitals and pediatric providers as well. Her prior work experiences in the community and her fluency in Spanish also were instrumental in this effort. The nurse practitioner (NP) was the key and consistent point of contact for participants. The NP recruited and enrolled, tracked births, scheduled appointments, conducted home visits, examined babies and collected clinical samples. She also made referrals to social service and similar agencies when participants needed assistance with their problems. We anticipated that a trusting, beneficial relationship would develop from this personal style and that participants would be motivated to continue with the study. We expected that future phases of the study would benefit from establishing a good reputation in the community. Although the project was not planned as an intervention, it was also hoped that the welfare of at-risk infants in our community would be enhanced from regular visits with the NP. The major features of AUDIT's design are summarized in Table 1.

**TABLE 1. Syracuse AUDIT study overview**

| Stage/time | Activity | Information collected |
|---|---|---|
| Recruitment | | |
| Apr. 2001–Aug. 2002 | • Patient flyer signed at prenatal care site<br>• Telephone contact for interest and eligibility | • Address<br>• Phone number<br>• Maternal asthma status |
| Initial interview | | |
| May 2001–Aug. 2002 | • Home visit by nurse practitioner within one month of telephone contact<br>• Informed consent obtained | • Demographics<br>• Family history of asthma allergic rhinitis and eczema<br>• Perceptions and knowledge about asthma<br>• Household tobacco smoking<br>• Home safety and security assessment |
| Birth | | |
| Jun. 2001–Sept. 2002 | • Collection of cord blood sample | • Serum cotinine and IgE levels |
| Clinical assessment | | |
| Sept. 2001–Sept. 2003 | • Home visit by nurse practitioner at ages 3, 6, 9 and 12 months and collection of urine samples<br>• Collection of blood sample at 12 months | • Physical exam of infant<br>• Health interview/questionnaire with mother<br>• Urinary cotinine: creatinine ratio<br>• Serum IgE level |
| Indoor environmental sampling | | |
| Dec. 2001–Mar. 2003 | • Home visit by field inspection team<br>• Air samples<br>• Settled dust collection<br>• Walkthrough inspection<br>• Repeat sampling in 40% of homes | • Temperature, humidity, carbon monoxide, carbon dioxide<br>• Particulate matter<br>• Nitrogen dioxide, volatile organic compounds<br>• Allergens<br>• Fungi<br>• Endotoxin |
| Medical record review | | |
| Sept. 2002–Nov. 2003 | • Assessment and summary of medical records | • Prenatal chart(s)<br>• Maternal delivery chart<br>• Infant neonatal chart<br>• Pediatric chart(s) |

## MATERIALS AND METHODS

### Recruitment and Retention of Participants

Recruitment began following approval by the Institutional Review Board of SUNY Upstate Medical University. Written informed consent was obtained from all participants. There were 14 prenatal recruitment sites serving the low income urban population in Syracuse, including university, community, county, and private practice settings. In order to recruit sufficient participants, we did not restrict recruitment within these sites based on income. Patient prenatal charts at these sites

were reviewed to identify prospective participants with a reported medical diagnosis of asthma.

Chart reviews at the recruitment sites identified 370 pregnant asthmatics. Of those, 184 were determined to be potentially eligible and agreed to be contacted by study staff. One hundred thirty-five subjects consented to the study; 103 completed all phases. The reasons for non-completion were seven infants did not meet birth eligibility criteria (one multiple birth, one fetal demise, one stillbirth, four pre-term births), 12 moved outside the study target area, three withdrew after judging the study "too much trouble," and eight had insufficient data for complete analysis. Four infants were placed in foster care from birth, two continued in the study with the written consent of the legal guardian, the other two were not included.

Participants received reimbursements for home visits. Staggered payments encouraged continuation in the study: $10 at the initial interview, $20 for 3-, 6-, and 9-month visits, and $30 at the final visit. Because the study placed significant demands on participants, small incentives were judged as important to retention.

### Home Visits

The NP conducted the first home visit, typically during the third trimester of pregnancy. During this visit, she obtained detailed contact information, explained the study in detail, and collected maternal personal asthma history, including recent symptoms and medications, family history of asthma, allergy, eczema and smoking. She collected specific information on the asthma, allergy and eczema status of the mother's other children, maternal siblings and parents, the baby's father, and paternal parents and siblings. The NP also recorded the mothers' perceptions about asthma and other major health concerns in the community. Maternal report determined mothers' and infants' ethnicities. "White" meant white, non-Latino. Babies of mixed parentage were included as "other."

The NP assessed the safety and security of each home for study personnel and air monitoring equipment. A standard form evaluated the basic home structure, entrances, stairs, elevators, lighting, loitering, and menacing dogs. One home was excluded for safety concerns.

Because of frequent missed appointments, the NP adopted the practice of calling two weeks before, the day before and the hour before all appointments. Despite this protocol, participants were not home for scheduled appointments about 20% of the time.

### Clinical Assessment and Sample Collection

To assess changes in respiratory health of the infants over the first year of life, the NP visited participants' homes every three months to examine the children. Each visit lasted 40 to 90 min. The NP administered an interval questionnaire, performed a physical examination of the baby, and collected a urine specimen from the infant. The mother or primary caregiver answered structured questions about infant diet, including breastfeeding, formulas, and introduction of milk, liquids, and solid foods types. Caregivers were also asked about primary care well and illness visits, acute care facility visits and hospitalizations. Information was collected on any medications used, including oral and inhaled medications, nose drops, creams, ointments and lotions. Information on day care, smoking in the home and employment was also acquired. Holding a job at each of the four clinical home visits was defined as regular employment. Intermittent employment meant being employed at least once during one of the quarterly visits. The NP observed and

recorded evidence of smoking, pests in the home, pets, mold, and musty odors. The physical exam was performed according to recommendations by the American Academy of Pediatrics for age-specific well childcare.[37] The exam included vital signs, chest auscultation, thorough multiple systems review with particular attention to respiratory and dermatological signs.

Umbilical cord blood for IgE and cotinine was collected via needle and syringe at delivery. Two 0.5 ml aliquots of serum were prepared and kept frozen in batches in the order collected. To assure that cord blood samples were obtained, prenatal charts were marked with reminder cards and stickers. Labor and delivery charts also were labeled, and participants were given reminder cards to present at delivery. Labor and delivery sites were provided with an "Asthma Study" box stocked with labeled blood tubes and instructions. Despite these efforts, 21 of 103 samples were not collected.

Venous blood for IgE was drawn at the time of the New York State mandatory 12-month lead (Pb) level determination so that an additional needle stick would not be required. To optimize sample collection, the NP contacted all the pediatric clinical sites to flag participants' charts until the specimens were received. Labeled blood tubes and instructions were provided to these sites, study mothers and participating laboratories. Periodic calls reminded mothers about the test. Even so, 50 of 103 samples were not obtained.

Infant urine was collected for cotinine determination. At the beginning of each postnatal home visit, the NP placed a standard pediatric urine collection bag on the infant. The child was then fed a bottle of apple juice. When the infant voided, the urine was transferred to a sterile container and frozen. The NP often had to return several times to obtain the sample. Ninety-four percent of 412 possible samples were successfully collected.

Cotinine levels in cord blood serum and urine were measured by enzyme immunoassay by Metropolitan Life Insurance Laboratory, Elmsford, NY. To adjust for differences in concentration, urine creatinine was also measured. Results were reported in nanograms (ng) of cotinine per milliliter of cord blood and as cotinine:creatinine ratios (CCR) in ng of cotinine per mg of creatinine for urine. Cotinine, the chief metabolite of nicotine, provides an objective, quantitative measure of tobacco smoke exposure over the 2–3 days preceding collection. Commonly accepted thresholds for differentiating environmental tobacco smoke (ETS)-exposed from non-exposed children are cotinine greater than 10 ng/ml in blood[38] and CCR greater than 30 ng/mg in urine.[39]

### Medical Record Reviews

As an independent assessment of maternal and infant health, medical records were reviewed. A study pediatrician (TMH) reviewed, summarized, and coded records from the obstetrical care of the mother, including prenatal, maternal delivery, and infant neonatal charts. Summary forms were developed specifically for this study and were pre-tested prior to use. Data abstracted from those records included maternal demographic characteristics, asthma status and care, other medical and mental health conditions and treatment, psychosocial stressors, alcohol, drug and smoking status. Psychosocial stressors evaluated included financial concerns, abuse, domestic violence, extended family support, involvement of child protective services and unintended pregnancy. This study pediatrician obtained, reviewed and abstracted all medical records for each infant from sources including primary care, specialty care, non-emergency-room acute care, emergency room and hospital inpatient. For each three-month quartile, data were collected on growth, abnormal

respiratory findings, provider diagnoses, laboratory and X-ray results, treatments prescribed, and referrals made.

### Indoor Environmental Sampling

A trained three-person environmental sampling team visited each study home. A variety of measurements evaluated simultaneous exposure to multiple pollutants. Environmental measures were assessed only indoors; except for bio-aerosols, outdoor air pollution data was not collected. Several 24-hour sampling instruments were locked in a custom-fabricated box (approximately 0.6 $\times$ 1 $\times$ 1 m) with perforated aluminum exterior panels, which allowed free air movement to the sampling equipment and ensured child safety and equipment integrity. Sampling throughout the study period in all seasons was conducted in the main living area of the home. Real-time, direct readings were taken every minute over 24 hours for temperature, humidity, carbon dioxide and carbon monoxide. Real time airborne particle counts (in six size ranges from 0.3 to >5 $\mu$m) were recorded every 3 min over 24 h. Impactors collected air samples for particulate matter ($PM_{10}$ and $PM_{2.5}$) over a 24-hour period. Air samples for volatile organic compounds were collected onto multi-bed sorbent tubes. Passive monitors measured nitrogen dioxide over approximately 1 week. Bio-aerosol samples for viable fungi and bacteria were collected using single-stage impactors and culture media with sample times of 3 or 6 min. Time-resolved air samples for fungal spores were collected over 24 h onto coated, moving slides. Settled dust, vacuumed from the living room floor, kitchen floor and baby's sleeping place, was analyzed for dust mite, cat, dog and cockroach allergens as well as for endotoxin. A walk-through inspection was performed to record home and occupant characteristics. Homes were evaluated for dampness, cleanliness, pets, pests, smoking, and potential indoor pollutant sources. The team inspected the exterior and all accessible interior rooms, including basements and attics. Approximately 40% of homes received a second round of indoor environmental sampling, usually in a different season. The field team documented these findings both by visual inspection and by questioning the occupants. Dampness was defined as any observation or report of visible mold, standing water, water damage, plumbing leaks, or musty smell. Leaks or water problems that had been repaired and for which there was no current evidence were not counted. The presence of pests such as cockroaches and mice was determined by residents' reports or field team observation. Droppings and/or traps were considered positive evidence for pests. Carpeting was defined as wall-to-wall carpet or large area rugs in any room.

Field team members assigned an overall cleanliness rating for the house, ranging from "excellent," indicating immaculately clean, orderly and sanitary, to "extremely poor," meaning very disordered, dirty and unsanitary. Factors considered in the cleanliness evaluation included: degree of clutter or mess (toys, newspapers, clothes), overflowing garbage, uncontained laundry, debris, floor vacuumed or swept, dirty walls, dirty dishes, food waste on surfaces, observation of rodents, cockroaches, insects, repugnant odors, animal waste, mold, and overall disrepair of home.

### Reporting Results to Participants

Individual results from home environmental sampling were reported in a letter to each participant. Particulate matter ($PM_{2.5}$), carbon monoxide, carbon dioxide, cord blood and urinary cotinine, and nitrogen dioxide results were included and

health effects explained. Recommendations were made for reducing or keeping the pollutant levels low.

### Quality Control

For quality control purposes, a study pediatrician (TMH) accompanied the NP on 5% of home visits. All the records from the visits were verified for completeness, consistency and accuracy by this pediatrician prior to electronic data entry. Prenatal and pediatric chart summaries were verified by having other study physicians (MC, JLA) abstract the same records. Over 5% of medical records were audited in this manner. Agreement between physicians was high; approximately 95% of recorded items were the same. Similarly, 5% of all forms were audited for transcription and computer data entry accuracy. Defined medical outcomes (e.g., wheezing) were validated by separate review of the abstracted forms. A Quality Assurance Project Plan (QAPP) was implemented for the environmental sampling.

**TABLE 2. Syracuse AUDIT birth demographics ($n$ = 103)**

| | Percent |
|---|---|
| Maternal age at birth | |
| <20 | 16 |
| 20 to <30 | 63 |
| 30 to <40 | 20 |
| ≥40 | 1 |
| Infant gender | |
| Male | 45 |
| Female | 55 |
| Infant race/ethnicity | |
| African American | 44 |
| White | 38 |
| Latino | 11 |
| Other | 8 |
| Season of birth | |
| Winter (Dec–Feb) | 25 |
| Spring (Mar–May) | 26 |
| Summer (Jun–Aug) | 32 |
| Autumn (Sept–Nov) | 17 |
| Adults in the household | |
| One | 35 |
| Two | 25 |
| Three or more | 40 |
| Children in the household | |
| One | 21 |
| Two | 59 |
| Three | 14 |
| Four or more | 6 |
| Maternal marital status | |
| Single | 71 |
| Married | 26 |
| Separated | 3 |

## RESULTS

A total of 103 infants (born between June 2001 and September 2002) and caregivers completed all phases of the study. Table 2 shows some of the demographics at the time of infant delivery. Mean maternal age [SD = 5.8; (range 15–41)] was 25.4 years. The majority of principal caregivers were female (98%) and unmarried. Thirty-five percent of households had a single resident adult. The number of adults in a household ranged from 1 to 9. The majority (79%) of homes had two or more children. The number of children in the homes ranges from 1 to 7. The average household size was 4.7 people; average number of children was 2.1 and adults 2.6.

Home characteristics are listed in Table 3. Most participants (83%) rented a house or an apartment. Approximately 74% of homes were found to be reasonably clean ("excellent," "good," or "average" rating). The remaining 26% of homes were rated "poor" or "extremely poor." During recruitment, participants stated that they intended to remain in their homes for a full year. It rapidly became apparent that not enough participants would complete the study if this requirement were strictly followed; 62% of the families moved from one to seven times during the study year.

Environmental conditions noted on home visits are shown in Table 4. Half of the homes (48%) had cats or dogs; nearly one-quarter had cockroaches. Mice or rats were found less often; other pests such as spiders, ants, fleas and flies were present in about one-half of the homes. More than 70% of homes showed some

**TABLE 3. Syracuse AUDIT: housing characteristics ($n$ = 103)**

| | Percent |
|---|---|
| Housing type | |
| House owned | 15 |
| House rented | 58 |
| Apartment rented | 25 |
| Trailer | 2 |
| Cleanliness rating* by inspectors | |
| Excellent | 13 |
| Good | 29 |
| Average | 32 |
| Poor | 15 |
| Extremely poor | 11 |
| Kitchen cleanliness | |
| Food waste observed on surfaces | 33 |
| Unsealed garbage | 45 |
| Number of moves during study year | |
| None | 38 |
| One | 37 |
| Two | 15 |
| Three or more | 11 |

*"Excellent"—very clean, orderly, sanitary, no clutter, no garbage, good repair.

"Good"—clean, little or no clutter, floors and walls clean, no garbage, good repair.

"Average"—reasonably clean, clutter present, floor vacuumed or swept, garbage contained, decent repair.

"Poor"—dirty, clutter throughout, floor not swept or vacuumed, garbage not contained, some disrepair, evidence of pests.

"Extremely Poor"—very dirty, grossly unsanitary, floor and walls dirty, clutter everywhere, garbage overflowing, general disrepair, evidence of pests.

**TABLE 4. Syracuse AUDIT environmental observations ($n$ = 103)**

| | Percent |
|---|---|
| Pets* | |
| Dog(s) | 28 |
| Cat(s) | 20 |
| Others | 18 |
| No pets | 50 |
| Pests | |
| Roaches | 23 |
| Mice or rats | 12 |
| Other (insects, spiders) | 46 |
| Dampness | |
| Standing water or water damage | 71 |
| Observable mold | 24 |
| Any dampness, mold or musty smell | 73 |
| $NO_2$ source | |
| Gas stove | 76 |
| Carpeting | |
| Any living room wall-to-wall or area rugs | 65 |
| Any in residence | 78 |
| Floor cleaning method | |
| Vacuum cleaner used | 50 |
| Chemical sources | |
| Pesticide used | 26 |
| Pesticide present | 17 |
| Mothballs present | 4 |
| Dry cleaning present | 11 |

*Observations not mutually exclusive.

evidence of dampness. The majority of homes had carpeting (either wall-to-wall or area rugs), especially in the living or family rooms. Gas ranges were observed in approximately 75% of homes. Floor cleaning methods were split equally with half reporting vacuuming and half sweeping. Pesticides were used in 26% of homes, and the presence of various chemicals was noted.

Tobacco exposure indices are detailed in Table 5. This cohort had a high prevalence of tobacco exposure, both in utero and during the first year of life. Fifty-

**TABLE 5. Syracuse AUDIT: tobacco exposure ($n$ = 103, except where noted)**

| | Percent |
|---|---|
| Mother smoked during pregnancy | 54 |
| Households with smokers | 68 |
| Infant tobacco exposure first year* | |
| Urine cotinine:creatinine ≤30 ng/mg (not exposed) | 13 |
| Urine cotinine:creatinine >30 ng/mg (exposed) | 87 |
| Tobacco exposure at birth | Percent ($n$ = 82) |
| Cord blood cotinine ≤10 ng/ml (not exposed) | 60 |
| Cord blood cotinine >10 ng/ml (exposed) | 40 |

*Average of quarterly samples.

four percent of mothers smoked during pregnancy, and 68% of households acknowledged at least one smoker.

Cord blood was available from 82 of the 103 infants. Roughly 60% of samples showed cotinine levels above 10 ng/ml. We collected four separate urines from most infants. The mean urine CCR for each infant exceeded 30 ng/mg (significant ETS exposure) in 87%, and 90% had at least one individual urine value above that threshold.

Table 6 lists psycho-socio-economic characteristics of AUDIT participants. Thirty three percent of fathers in our study had no reported contact with the family during their baby's first year of life. Notably, 5% of the infants' fathers were listed as incarcerated. The majority of mothers (52%) completed high school, but 7% were teenagers still in secondary school. Only 4% had completed college. Despite regular or partial employment by 75% of fathers and 59% of mothers, family incomes were low enough that 82% were receiving Medicaid. Over half of the infants in the study stayed at home during the day, as opposed to day care. In addition to asthma, mothers in the AUDIT study often had other stressors. For 69%, the pregnancy was unplanned. More than a third of mothers experienced abuse either in the past and/or during the study. More than a fourth had been clinically depressed. Parenting difficulties were serious enough for involvement with Child Protective Services for 16%. Consumption of alcohol and/or use of illicit substances was reported by over one third of mothers, particularly during the first trimester. AUDIT mothers were rarely concerned about asthma as a community health issue. They were more often worried about pollution, drugs and alcohol, crime and violence, garbage and sewage.

## DISCUSSION

The AUDIT study provides insight into environmental risk factors for development of wheezing in a disadvantaged, at-risk urban population. We identified numerous sources of environmental pollutants and potential health hazards in our study homes. AUDIT also provides insight into issues and challenges involved in working with this population. We targeted a low-income urban population because they are disproportionately affected by asthma. Cities the size of Syracuse (<250,000 population) are not well studied for asthma development or for asthma intervention. Both birth cohort studies and inner-city asthma intervention projects in the U.S. have focused on larger cities.[12,15–18,21,22,40,41] Much of the U.S. population, however, lives in smaller cities,[33] so our results, experiences, methods, and issues are potentially relevant to many communities across the country. The lessons learned in implementing the project are also pertinent to follow-up of this cohort and were essential in the design of a recently initiated intervention project with a similar local population.

### Representativeness of Study Population

In order to examine the representativeness of our study sample, we compared our cohort with the larger population of women who gave birth in the City of Syracuse between 2000–2001[42] to babies of like weight and gestational age. Study mothers were similar to Syracuse City mothers in age at delivery (mean 25.4 versus 26.0 years), twice as likely to have smoked during pregnancy (54 v 26%), and more likely to be African American (44 v 34%) or Latino (11 v 3%). Our study

**TABLE 6. Syracuse AUDIT: psycho-socio-economic characteristics (*n* = 103)**

| | Percent |
|---|---|
| Residence by zipcode | |
| >20% of the population below poverty | 71 |
| Health insurance | |
| Private insurance | 18 |
| Medicaid | 82 |
| Father's involvement with infant | |
| Involved | 67 |
| Uninvolved | 33 |
| Mother's education | |
| Teen mother in secondary school | 7 |
| Incomplete high school (<12) | 37 |
| High school (=12) | 27 |
| Greater than high school (>12) | 25 |
| Unknown | 4 |
| Father's education | |
| Teen father in secondary school | 3 |
| Incomplete high school (<12) | 18 |
| High school (=12) | 44 |
| Greater than high school (>12) | 20 |
| Unknown | 16 |
| Mother's employment/involvement | |
| Regular job or student | 35 |
| Intermittently employed | 31 |
| Unemployed | 33 |
| In jail | 0 |
| Not involved with baby | 1 |
| Father's employment | |
| Regular job or student | 28 |
| Intermittently employed | 24 |
| Unemployed | 10 |
| In jail | 5 |
| Unknown | 33 |
| Infant daytime location | |
| Home | 55 |
| Day care center | 8 |
| Home day care with relative | 25 |
| Home day care with non-relative | 12 |
| Mothers with medically documented substance use | |
| Illicit drugs excluding alcohol at any time during pregnancy | 18 |
| Alcohol consumption at any time during pregnancy | 19 |
| Mothers with a medically documented history of ... | |
| Physical and/or sexual abuse/domestic violence | 39 |
| Poor prenatal care | 31 |
| Depression | 26 |
| Prior involvement from child protective services | 16 |
| Mother's perceptions of major community health concerns | |
| Drugs and alcohol | 25 |
| Crime and violence | 17 |
| Pollution | 33 |
| Garbage and sewage | 17 |

**TABLE 6.** ***Continued***

| | Percent |
|---|---|
| Mothers planning of pregnancy | |
| Unplanned pregnancy | 69 |
| Planned pregnancy | 17 |
| Did not answer | 14 |

population of mothers with asthma was more economically and educationally disadvantaged as compared with the general pregnant population in Syracuse. AUDIT used proxy measures for socioeconomic status: Medicaid eligibility, maternal education, and poverty level and median income in zip-code-of-residence. Study mothers were much more likely to be receiving Medicaid (81 v 43%). Fewer AUDIT mothers completed secondary school (52 v 68%). Median Study household income by zip code was essentially the same as for the city of Syracuse ($25,000), a figure substantially below the $41,994 median for U.S. households.[33] Our participants reflect the inner city poor, as 75% of them lived in zip codes with greater than 20% of the population below poverty levels. This may have resulted from an emphasis on recruiting from sites that served the poor and those on Medicaid. These sites were larger and tended to provide more potential recruits than others not focused solely on low income groups. In addition, our relatively small financial incentive ($100 total over a year) may have been a factor in influencing and selecting very low-income participants.

### Environmental Conditions

Infant exposure to tobacco smoke was assessed in several ways and was high by all measures. The level of caretaker-reported ETS exposure in our study population (68%) is higher than reported in nearly all other studies. A range from 41 to 67% household smoking was reported by asthma intervention studies conducted in low-income urban locations in Seattle, Chicago, East Baltimore, and Boston.[16–18,41] The National inner-city asthma study (NCICAS) involving multiple large cities, reported 58% household smoking.[43] These populations, while not birth cohorts, are similar to AUDIT's in the preponderance of non-white participants, poverty and poor maternal education. In contrast, birth cohort studies in U.S. cities show much less household smoking, ranging from 8 to 32%. Smoking during pregnancy was also much less in these groups (6–17%) than in AUDIT (54%).[19,21,22,24,44] Compared with AUDIT, these studies have higher maternal education and income and a greater number of white participants. Quarterly urine cotinine measurements established that nearly all (90%) of AUDIT infants had environmental tobacco smoke exposure in their first year of life. Tobacco smoke exposure is pervasive and clearly a major health risk for infants in this population. Smoking cessation, particularly during pregnancy, will be a main focus of the asthma intervention project just underway in this community. Similarly, tobacco smoke control will also be emphasized. Given the high level of smoke exposure, many possible control strategies will be utilized, including heat recovery ventilation, particulate filtration, and education and counseling for behavioral change. We note anecdotally that several participants, upon receiving the report of our results at the end of the study, were concerned about their infant's cotinine levels and, as a result, expressed desire to quit smoking or to modify their behavior to benefit their children.

Dampness is a recognized condition that may support fungal growth and release of bioaerosols into the indoor environment and may result in adverse health effects.[45] Dampness was observed in the majority (73%) of AUDIT homes. Consequently, dampness control is an important component of intervention efforts. Cockroaches and other pests carry known allergens capable of both sensitization and triggering of adverse health outcomes, including asthma. Twenty-three percent of AUDIT homes had cockroaches observed or reported, compared with a range of 18 to 68% reported by other inner-city studies. Similarly, rodents were reported in 17% of AUDIT homes compared with a range of 2 to 56%.[15,16,18,43] Over one quarter of homes were found with markedly dirty, cluttered and unsanitary conditions such that they were rated in the worst cleanliness categories. In kitchens, food waste on surfaces and unsealed garbage were common. These conditions sustain pest infestation and are likely related to observation of roaches and rodents. For intervention phases of the project, pest control and integrated pest management are expected to be required. Most homes had carpeting, yet only half of homes used vacuums for floor cleaning. Carpeting may serve to trap, retain and concentrate particulates and allergens. Ineffective cleaning may allow further build-up of these indoor pollutants. Vacuum cleaners, basic house-cleaning guidance and sanitation instruction are indicated for this population.

Our findings reinforce the need for local determination of exposures and population demographics in planning interventions in this community and others. The association between these environmental exposures and health outcomes in the infant cohort will be addressed in subsequent reports of this study.

### Psychosocial and Economic Conditions

Study participants faced substantial psychosocial and economic challenges. Their lives were burdened with poverty, unemployment, complicated living arrangements and single parenthood. Pregnancies were mostly unplanned and fully one-third of fathers were not involved with their children. We were unable to determine even basic demographic information about some of these fathers because mothers did not know their educational levels, employment situations and medical histories. Abuse, alcohol and drug use were other stresses regularly present in many participants' lives.

### Implementation Issues and Implications

Participants' multifaceted problems and needs affected many aspects of project implementation and serve to inform subsequent follow-up and intervention studies. The 'personalized' approach in dealing with participants together with their high level of need resulted in excessive demands on the NP. The goal was to build trusting relationships with our participants for the purpose of recruitment and retention, improving community health and paving the way for additional phases of the project. The complexity of the study population's lives made many social and economic problems priority issues over health issues. Thus, the NP was regularly dealing with issues more usually the province of a case-worker (e.g., unemployment, income and child support, clothing/books/toys needs, child-care, transportation, parenting issues, nutrition, unstable housing situations, substance abuse, unsanitary living conditions). The development of a trusting relationship probably was critical to the success of the study, but mechanisms to limit the demands on any one contact person should be included in the design of any future studies—a

preplanned strategy for referrals and follow-up by more than one person is essential. Other inner-city studies have reported that contact persons were easily overwhelmed by the complex needs of the participants' lives, contributing to staff turnover.[46] We recognize that the provision of this level of personal attention constituted a form of positive intervention, but not to do so would have been ethically unacceptable. The overwhelming set of problems in the subjects lives made participation in an 'asthma' study relatively low priority for them. Solving or facilitating solutions to some of these pressing problems was necessary so that participants could give their time and attention to the study. This kind of intervention was unlikely to change the outcome measures of the study.

We did not anticipate the high number of participants' moves, as we had specifically recruited them with the expectation that they would remain at their residence for a year. Modification of study retention criteria was necessary or we would not have had enough subjects to continue the project. In addition to frequent moves, participants changed phone numbers or intermittently had no phone. The result was a major unforeseen increase in staff time involved in locating and contacting people. Tracking over 100 families through the demanding study protocol for one year took extraordinary outreach effort and interpersonal skill. Without knowledge of and relationship with kinship and service provider networks, retention of a sufficient number of subjects would have been impossible. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) now makes access to such networks more difficult in the United States. In order to help keep track of subjects and observe privacy issues, we recommend additional logistical help. Assistance from community-based organizations in providing neighborhood contact persons could be particularly valuable to future studies.

We learned that while many changed housing, most participants stayed in Syracuse and did not change health providers. Because the study was designed to access pediatric records, we were able to find current addresses for 'lost' participants as well as the full pediatric health record for subjects even if they had not completed all home visits. In a community of our size, health provider records appear to provide a resource for locating participants as well as for medical information. Follow-up of the cohort will include obtaining the medical record from the health provider.

Our challenging study protocol affected implementation and participation. The protocol involved a total of 8 to 10 visits to the home for clinical assessment and environmental sampling. Environmental sampling required two consecutive days, with another visit a week later to retrieve a sampler. Some homes also had a full second round of environmental sampling in another season. Equipment set up and take down each took more than one h. Although quiet and childproof, the sampling equipment and enclosure required $0.6 \times 1.0$ $m^2$ of open floor space in the most frequently used room in the home. For many small homes, it was clearly in the way. While the protocol was designed to collect comprehensive data, it was disruptive and intrusive to some participants. It affected their enthusiasm and willingness to schedule appointments. Many participants refused to consider a second round of environmental sampling, resulting in the collection of only 40 of 60 planned second round samples. For further studies, we would limit the total number of visits and minimize disruption by consolidating clinical and environmental visits. Participation may also have been affected because clinical visits were reimbursed while environmental visits were not. In future studies, we would adjust this to reimburse all home visits. We would consider use of smaller, less intrusive sampling

equipment. Also, use of longer-term home sampling instrumentation with remote monitoring capabilities should be considered. This would allow more comprehensive characterization of the home indoor environment and facilitate sampling in more than one residential location in this mobile population.

When study staff were responsible for clinical sample collection (urine cotinine), compliance rates were 94%. In contrast, when clinical samples were collected by personnel at other sites, such as delivery hospitals, only 50–80% of planned samples were obtained. This has obvious implications for future study design.

Several birth cohort studies found family history, particularly maternal history of asthma,[19,35,47] to increase the likelihood of development of wheeze and asthma. We enhanced the likelihood of wheeze in our sample by recruiting only pregnant women who had asthma. Working in a relatively small urban area provided a limited pool of total pregnant asthmatics for recruitment. Consequently, the recruiting period was extended beyond what was planned, and this adversely impacted the total project timeline and budget. Despite our success with recruiting, this limited pool and budgetary concerns were the main determinants of our final number of participants. We recognize that this sample size will constrain the analyses of outcomes.

## CONCLUSIONS

The Syracuse AUDIT project is a birth cohort study that has successfully collected information on infants' health and environmental exposures in the first year of life. We studied infants whose urban, ethnic and socioeconomic demographics locate them within the part of the U.S. population that has experienced a disproportionate increase in asthma morbidity. The study contributes new data on the design and implementation of urban birth cohort studies of wheezing in infancy. A multidisciplinary, multi-institutional research team created for the project now serves as a framework to allow further related studies. Such studies are important here because of the documented serious risks to children's health and the lack of attention and published work on asthma development and intervention in communities the size of Syracuse. We gathered comprehensive data on environmental pollutants in the early postnatal period along with extensive prenatal and postnatal health information. We found numerous environmental pollution sources in our study homes, including high tobacco smoke exposure. Our knowledge of these conditions forms the basis for intervention planning in similar populations. Our participants had complicated living situations and confronted major psychosocial and economic difficulties. These issues impacted the study retention criteria and created unanticipated demands on study staff. The personal approach and relationship building efforts by our Nurse Practitioner proved successful in terms of recruiting, retention and data collection but also resulted in work overload. Locating the AUDIT project in a medium size urban community made it easier to track participants even when they moved but harder to recruit a sample of sufficient size. Future reports will address the relationships between multiple environmental variables and their associations with wheezing as well as other health outcomes during our cohort's first year of life. Follow-up of the cohort is important because wheezing in infancy is often transitory.[35] Our ability to collect information on these children as they mature will determine the extent to which this study will contribute further to understanding of asthma development.

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