Lower Respiratory Illness in Infants and Low Socioeconomic Status

ABSTRACT

Objectives. Infants from families of low socioeconomic status are said to suffer higher rates of lower respiratory illness, but this assertion has not been carefully examined.

Methods. We studied the frequency and determinants of lower respiratory illness in infants of different socioeconomic status (n = 393) by analyzing data from a community-based cohort study of respiratory illness during the first year of life in central North Carolina.

Results. The incidence of lower respiratory illness was 1.41 in the low socioeconomic group, 1.26 in the middle group, and 0.67 in the high group. The prevalence of persistent respiratory symptoms was 39% in infants in the low socioeconomic group, 24% in infants in the middle group, and 14% in infants in the high group. The odds of persistent respiratory symptoms in infants of low and middle socioeconomic status were reduced after controlling for environmental risk factors for lower respiratory illness. Enrollment in day care was associated with an increased risk of persistent symptoms among infants of high but not low socioeconomic status.

Conclusions. Infants of low socioeconomic status are at increased risk of persistent respiratory symptoms. This risk can be partly attributed to environmental exposures, most of which could be changed. (*Am J Public Health.* 1992;82:1119–1126)

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Introduction

Lower respiratory illnesses are major causes of childhood morbidity in the United States. Approximately 30% of infants less than 1 year of age visit a doctor for a lower respiratory illness, and about 1% of infants who are healthy at birth are hospitalized for the illness.[1–6] Although the vast majority of acute lower respiratory illnesses are without complication, recent studies indicate that the occurrence of these illnesses in infancy may predispose to the development of obstructive airways disease in later life.[7–9]

Clinical experience suggests that infants of low socioeconomic status have higher rates of lower respiratory illness than more socially advantaged infants, but few studies have investigated this relationship. Previous studies of socioeconomic status and lower respiratory illness have provided limited information because they have examined only differences in mortality rates or because they have been hospital rather than community based.[5,6,10] The major studies of respiratory illness in childhood have focused on lower respiratory illness in middle-class families or on upper respiratory illness.[11,12] Thus, it is unclear whether the clinical impression that infants of low socioeconomic status have higher rates of lower respiratory illness is correct, and if so, whether it reflects an increased incidence of this illness, more severe illness, or more chronic illness.

The objectives of this study were to determine whether rates of acute lower respiratory illness and chronic respiratory symptoms differ among socioeconomic status groups and to identify environmental risk factors that might account for whatever differences in rates of disease were observed and that might be amenable to clinical or public health intervention.

Methods

Study Sample

We analyzed data from the control group of a community-based randomized trial designed to study the effects of an intervention to reduce infants' exposure to tobacco smoke and, thereby, their rate of lower respiratory illness in the first year of life. In the trial, an attempt was made to enroll a large proportion of the infants born in Alamance and Chatham counties in central North Carolina between 1986 and 1988. Recruitment of families took place at three hospitals at which 80% of the births in these counties occur. All mothers who gave birth to infants who weighed more than 2000 g and who did not require neonatal care outside the normal newborn nursery were asked to participate. At the time of recruitment, families

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This paper was submitted to the Journal July 16, 1991, and accepted with revisions December 10, 1991.

were told only that the study was intended to investigate infant health during the first year of life.

Data about potential risk factors for lower respiratory illness were collected during home interviews when the infants were 3 weeks and 12 months of age. Information was elicited by questionnaires administered to the infants' mothers and included demographic, environmental, and psychosocial characteristics. Data collectors were not told the objectives of the study.

Measurement of Respiratory Illness

We used two measures of respiratory illness: acute lower respiratory illness and persistent respiratory symptoms.

Symptoms of acute lower respiratory illness were measured by telephone calls to the families every 2 weeks. Telephone interviewers used standardized data collection forms and inquired about respiratory as well as nonrespiratory symptoms. Only the families with telephones, who constituted 85% of the study sample, were questioned about the presence of acute symptoms.

Acute lower respiratory illness was defined as the parents' report of the presence of cough, wheezing, and rattling in the chest. The incidence of acute lower respiratory illness was expressed as the number of episodes per child year at risk. The choice of this definition was based on a separate study of patients from the University of North Carolina Hospitals outpatient department and a private pediatric practice.[13] In this study, the combination of symptoms of cough plus wheezing and rattling in the chest had a sensitivity of 88% (95% CI = 0.80, 0.96) and a specificity of 68% (95% CI = 0.60, 0.76) in identifying lower respiratory illness (likelihood ratio = 2.75; 95% CI = 2.07, 3.65).

The presence of persistent respiratory symptoms was measured at the 12-month home interview using the American Thoracic Society children's questionnaire for studies of respiratory illness.[14] The questionnaire was modified slightly to make it more appropriate for use with infants. Infants who were reported to "usually cough" or "occasionally wheeze" were classified as having persistent respiratory symptoms. All families in the study were asked about the presence of persistent symptoms, regardless of whether they had telephones.

Measurement of Risk Factors for Respiratory Illness

The infants' socioeconomic status was classified into three levels according to the highest level of education achieved by the head of the household. Families in which the head of the household did not graduate from high school were classified as low socioeconomic status. If the head of household had completed only high school, the family was placed in the middle socioeconomic group; if more than a high school education, the high group. We used educational achievement because it appears to be a relatively stable measure of socioeconomic status in young families, whose incomes or occupational status may be increasing. Education is also the socioeconomic status measure that is most closely associated with health outcomes in children.[15,16]

Each infant's exposure to tobacco smoke was measured as the number of cigarettes smoked in the infant's presence during the week prior to the 12-month home visit. We chose to measure exposure at the 12-month home visit because other evidence from this study indicated that the amount of exposure remained stable throughout the entire first year of life.[17] In these analyses, infants were considered exposed to tobacco smoke if any smoking occurred in their presence during this time period. The questionnaire that was used for this measurement is described in detail elsewhere.[18]

Infants were considered exposed to day care if they were with at least one other child who was not their sibling for more than 4 hours per week and if they were cared for by someone other than their parents.[19,20] Day-care exposure was measured at the 12-month home interview. Household crowding was defined as the number of persons per room in the house and was classified into three levels: less than 0.5 persons per room, 0.5 through 1.0 persons per room, or more than 1.0 persons per room. Infants were considered exposed to smoke from a wood stove if the wood stove was the primary source of home heating.

Feeding and stress were measured at the 3-week home interview. Infants were classified as bottle fed if they received only formula and as breast fed if they received human milk with or without formula. Mothers' psychological stress was measured at the first home interview by seven questions from the Rand Mental Health Inventory.[21] The scores on the individual questions were averaged to provide a summary measure of stress. The summary measure was grouped into tertiles to define low, medium, and high levels of stress. We used this grouping to increase the clinical interpretability of our results.

A family history of allergy was defined as the presence of asthma or hay fever in either parent. The season of an infant's birth was considered to be respiratory if the infant was born between October and March and nonrespiratory if the infant was born between April and September.[22]

Statistical Analyses

The variance of the incidence density of lower respiratory illness was computed using the Taylor series method.[23] The significance of the differences in incidence of lower respiratory illness across socioeconomic status groups was assessed by a test for linear trend using a Wald χ^2 statistic.[24]

Relationships between the respiratory risk factors, socioeconomic status, and persistent respiratory symptoms were summarized by prevalence relative risks, and statistical significance was assessed by χ^2 tests. After calculating the unadjusted relative risk of persistent respiratory symptoms for the low and middle socioeconomic groups compared with the high socioeconomic group, Cochran-Mantel-Haenzel methods were used to adjust the relative risk estimates and confidence intervals for the effects of individual risk factors.[25]

We used logistic regression to analyze to what extent the relationship between socioeconomic status and persistent respiratory symptoms could be accounted for by simultaneously considering interactions between socioeconomic status and other risk factors for lower respiratory illness and confounding by other risk factors.[26,27] In the models, only the risk factors associated with both the presence of persistent symptoms and socioeconomic status were considered.[27] The predictor variables in the full model were examined for evidence of collinearity using standard analysis techniques.[28] Crowding, stress, and socioeconomic status were included in the logistic models as interval variables after plots confirmed that each had a linear relationship with the outcome variable on a logit scale.[29]

To determine whether effect modification was present, the full model, which included all two-way interactions between the risk factors and socioeconomic status, was simplified by deleting statistically

nonsignificant interactions in a backward selection procedure (maximum likelihood χ^2 statistic; P value = .1 to remain in the model). Only two-way interaction terms were considered for inclusion in the models, and the sole significant interaction was between socioeconomic status and day care. After assessing for effect modification, we determined whether any of the risk factors could be removed from the model including the socioeconomic status and day-care interaction without an important change in the estimated effect of socioeconomic status.[27] The final model was used to estimate the prevalence of persistent symptoms for groups of infants given various risk factors.[25]

Results

Characteristics of Study Participants

There were 2332 births in which the infant was eligible to participate in the intervention trial. Of the eligible families, 1091 (47%) agreed to enroll. Of the 516 infants who were randomized to the control group, 396 (77%) completed the study and were included in the analysis for this paper. Three infants were excluded because their race was neither White nor Black. The socioeconomic status of the 393 infants studied was as follows: 20% low, 31% middle, and 49% high.

Compared with the 1241 infants from families refusing enrollment, study infants were more likely to be of high socioeconomic status and were more often Black (Table 1). Study infants were less likely to have mothers who smoked. In families in which mothers did smoke, however, study mothers and mothers from families refusing enrollment smoked the same average number of cigarettes per day. The 33 families without telephones, for whom we do not have a measurement of the incidence of acute lower respiratory illness, were more often of low or middle socioeconomic status than those in the study group as a whole. The distribution of socioeconomic status among those without telephones was as follows: 49% low, 42% middle, and 9% high. However, the distribution of other risk factors in these groups appeared similar to the distribution of risk factors in the entire sample.

When compared with the infants of the 120 families who enrolled but did not complete the study, infants of families who completed the study were more often of high socioeconomic status (49% vs 20%) but less often Black (30% vs 47%) and less likely to have mothers who smoked (21% vs 37%). The distribution among socioeconomic groups of potential risk factors for lower respiratory illness (household crowding, exposure to tobacco smoke) was the same among study infants and dropouts.

TABLE 1—Characteristics of Study Families and Families Refusing Enrollment

	Study Families, (n = 393)	Families Refusing Enrollment, (n = 1241)
Socioeconomic status		
Low	20	26
Middle	31	43
High	49	31
Black	30	23
Mother smoked	21	27
Mean no. of cigarettes mother smoked per day[a]	15	15

[a]Among mothers who smoked.

TABLE 2—Prevalence of Persistent Respiratory Symptoms in Socioeconomic Groups

Socioeconomic Status	n	Persistent Symptoms, %	Relative Risk (95% CI)
Low	79	39	2.9 (1.9, 4.5)
Middle	122	24	1.8 (1.1, 2.8)
High	192	14	1.0

TABLE 3—Relationship of Socioeconomic Status to Prevalence of Risk Factors for Respiratory Illness

	Socioeconomic Status, %		
Risk Factor	Low (n = 79)	Middle (n = 122)	High (n = 192)
Demographic			
Male	48	48	49
Black	49	40	16
Birthweight 2000–2499 g	10	5	2
Born in nonrespiratory season	43	57	52
Familial			
Family history of allergy	20	24	34
Family history of respiratory disease	15	16	18
Maternal stress (high)	51	37	16
Environmental			
Exposed to tobacco smoke	79	78	35
Household crowding (> 0.5 persons/room)	70	61	29
Wood stove	14	7	6
Gas cooking	17	13	6
Day care	28	44	52
Bottle fed	82	73	33

Frequency of Respiratory Illness

Both the incidence of acute lower respiratory illness and the prevalence of persistent symptoms had dose-response relationships with socioeconomic status. The incidence of acute lower respiratory illness (episodes per child year) was 1.41 for low socioeconomic infants, 1.26 for middle socioeconomic infants, and 0.67 for high socioeconomic infants (P = .009 for linear trend). The relationship between the prevalence of persistent respiratory symptoms and socioeconomic status was even more marked (Table 2). Among in-

TABLE 4—Relative Risk of Persistent Respiratory Symptoms among Infants Exposed to Risk Factors

Risk Factor	Relative Risk	95% CI	P
Demographic			
Male	1.06	0.73, 1.55	NS
Black	1.75	1.21, 2.56	.003
Birthweight 2000–2499 g	1.85	0.94, 3.62	NS
Born in nonrespiratory season	0.81	0.56, 1.18	NS
Familial			
Family history of allergy	1.26	0.81, 1.96	NS
Family history of respiratory disease	1.35	0.82, 2.24	NS
Maternal stress (high)	1.59	1.01, 2.49	0.45
Environmental			
Exposed to tobacco smoke	1.85	1.23, 2.77	.003
Household crowding (> 0.5 persons/room)	2.53	1.39, 3.21	<.001
Wood stove	1.25	0.65, 2.35	NS
Gas cooking	1.12	0.63, 2.04	NS
Bottle fed	2.07	1.32, 3.24	.001

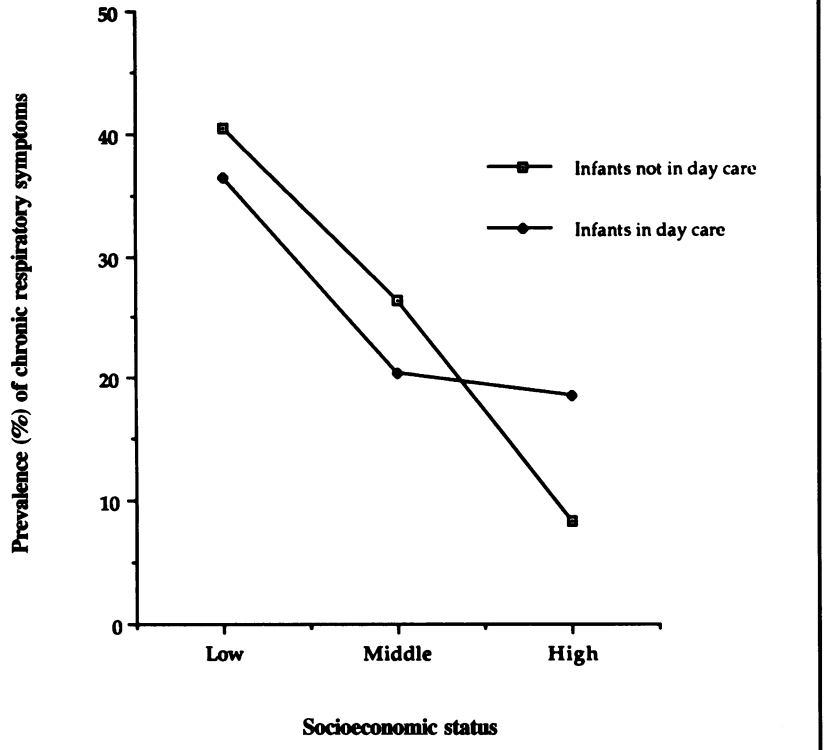

FIGURE 1—Effect of day care on prevalence of persistent respiratory symptoms.

fants of low socioeconomic status, 39% had persistent symptoms; only 14% had persistent symptoms in the high socioeconomic group. Infants in the low socioeconomic group were 2.9 (95% CI = 1.9, 4.5) times more likely than infants of high socioeconomic status to have persistent respiratory symptoms.

Infants who had persistent respiratory symptoms were more likely to have had an acute lower respiratory illness than those who did not have persistent symptoms. Of infants with persistent symptoms, 68% had at least one episode of acute lower respiratory illness, whereas only 32% of infants without persistent symptoms had any episodes of the illness ($P < .0001$, χ^2). However, the presence of persistent symptoms did not represent repeated episodes of acute lower respiratory illness. Among infants with persistent symptoms who had experienced an acute lower respiratory illness, most (63%) had only one or two episodes, and only 15% had more than three episodes.

Relationship of Risk Factors to Socioeconomic Status and Persistent Respiratory Symptoms

To investigate how much of the effect of socioeconomic status could be related to demographic, environmental, or psychosocial factors, we evaluated its association with persistent respiratory symptoms after controlling for risk factors for lower respiratory illness[30–37] that were also associated with both socioeconomic status and persistent respiratory symptoms in our data. We focused on persistent or continuing respiratory symptoms because they may be indicative of the long-term impact of acute respiratory illness. In these analyses, factors that contributed to the effect of socioeconomic status would lead to a decrease in the association between socioeconomic status and persistent respiratory symptoms.

Table 3 shows the relationship of the risk factors we studied to socioeconomic status, and Table 4 indicates their relationship to persistent respiratory symptoms. Of the demographic, familial, and environmental factors, only the infants' sex and season of birth were not associated with socioeconomic status. Although the association of low birthweight with persistent symptoms was not statistically significant ($P = .074$), the prevalence of this risk factor in the study sample was low (4.6%) because infants weighing less than 2000 g were excluded from the study. We decided to adjust for low birthweight in studying the relationship between socioeconomic status and persistent symptoms, however, because the magnitude of its relationship was clinically relevant (relative risk = 1.85) and because there was previous evidence of its association with persistent respiratory illness.[38] Thus, household crowding, exposure to tobacco smoke, style of feeding, birthweight, stress, and race were related to both socioeconomic status and persistent respiratory symptoms.

The effect of day care on persistent symptoms differed significantly according to the socioeconomic status of the infant (Figure 1). Among infants of high socioeconomic status, enrollment in day care was associated with an increase in the prevalence of persistent symptoms. In infants of low and middle socioeconomic status, however, enrollment in day care was associated with a reduction in the prevalence of persistent symptoms.

Effect of Risk Factors on the Relationship of Socioeconomic Status to Persistent Respiratory Symptoms

To evaluate the effect of the risk factors on the relationship between socioeconomic status and persistent respiratory symptoms, we compared the unadjusted relative risk of persistent symptoms in the low and middle socioeconomic groups with the relative risk of persistent symptoms after adjusting for each risk factor separately by stratified analysis (Table 5). The greatest reduction in the relative risk occurred after control for exposure to household crowding and tobacco smoke among infants of low socioeconomic status. Control for crowding decreased the relative risk among infants of low compared with high socioeconomic status from 2.9 to 2.2, and control for tobacco smoke exposure reduced the relative risk of persistent symptoms to 2.3.

We used logistic regression to evaluate how much of the effect of socioeconomic status on persistent symptoms might be produced by all the risk factors together. We compared the odds of persistent symptoms in a model that did not adjust for the effect of the risk factors with the odds of persistent symptoms in a model that adjusted for all the risk factors together (see Appendix). The odds ratios estimated from the models do not approximate the relative risks calculated by stratified analysis because of the high prevalence of persistent symptoms.

In the model that did not adjust for the effect of the risk factors, the odds ratio of persistent symptoms among infants of low compared with high socioeconomic status was 12.4 (95% CI = 7.5, 20.3) for those not in day care (Table 6). Among infants in day care, the odds ratio of persistent symptoms was 2.8 (95% CI = 1.6, 4.8). Control for all the risk factors reduced the odds of persistent symptoms among infants of low compared with high socioeconomic status from 12.4 to 6.9 (95% CI = 3.8, 12.2) for infants not in day care and from 2.8 to 1.3 (95% CI = 0.7, 2.4) for infants in day care. After accounting for all the risk factors, the effect of socioeconomic status remained significant only for infants not in day care.

To illustrate how much these risk factors contributed to the effect of socioeconomic status on persistent symptoms, we estimated the prevalences of persistent respiratory symptoms from the logistic model for infants of different socioeconomic status groups who were exposed to

TABLE 5—Effect of Socioeconomic Status on the Risk of Persistent Respiratory Symptoms

	Relative Risk (95% CI)		
	Low Socioeconomic Status	Middle Socioeconomic Status	High Socioeconomic Status[a]
Unadjusted	2.9 (1.9, 4.5)	1.8 (1.1, 2.8)	1.0
Adjusted			
Stress	3.5 (2.1, 5.7)	2.3 (1.3, 3.8)	1.0
Feeding	3.1 (1.8, 5.3)	2.1 (1.2, 3.7)	1.0
Birthweight	2.8 (1.8, 4.4)	1.7 (1.1, 2.8)	1.0
Race	2.6 (1.6, 4.2)	1.6 (0.99, 2.7)	1.0
Exposure to tobacco smoke	2.3 (1.5, 3.7)	1.5 (0.89, 2.4)	1.0
Crowding	2.2 (1.4, 3.6)	1.6 (0.99, 2.5)	1.0

[a]Reference group

TABLE 6—Unadjusted and Adjusted Odds of Persistent Respiratory Symptoms in Socioeconomic Groups

	Odds Ratio (95% CI)		
	Low Socioeconomic Status	Middle Socioeconomic Status	High Socioeconomic Status[a]
Infants not in day care			
Unadjusted	12.4 (7.5, 20.3)	3.5 (2.1, 5.8)	1.0
Adjusted[b]	6.9 (3.9, 12.2)	2.6 (1.5, 4.6)	1.0
Infants in day care			
Unadjusted	2.8 (1.6, 4.8)	1.7 (1.0, 2.9)	1.0
Adjusted[b]	1.3 (0.7, 2.4)	1.2 (0.6, 2.1)	1.0

[a]Reference group.
[b]Adjusted for crowding, tobacco smoke, bottle feeding, low birthweight, stress, Black race.

TABLE 7—Estimated Prevalence of Persistent Symptoms Due to Exposure to Risk Factors among Infants Not in Day Care

Risk Factor	Socioeconomic Status		
	Low	Middle	High
None	.22	.09	.04
Tobacco smoke alone	.28	.13	.05
Tobacco smoke, crowding	.59	.28	.15
All risk factors[a]	.80	.61	.37

[a]Risk factors: crowding, tobacco smoke, bottle feeding, low birthweight, stress, Black race.

TABLE 8—Estimated Prevalence of Persistent Symptoms Due to Exposure to Risk Factors among Infants in Day Care

Risk Factor	Socioeconomic Status		
	Low	Middle	High
None	.12	.11	.10
Tobacco smoke alone	.17	.15	.13
Tobacco smoke, crowding	.42	.39	.35
All risk factors[a]	.67	.64	.61

[a]Risk factors: crowding, tobacco smoke, bottle feeding, low birthweight, stress, Black race.

various risk factors. Tables 7 and 8 show the estimated effect of the risk factors among infants in day care (44% of the sample) and not in day care. For example, for infants of low socioeconomic status not in day care (Table 7) and not exposed to any risk factors, the prevalence of persistent symptoms would be about 22%. Exposure to tobacco smoke would increase the prevalence of persistent symptoms to 28%; crowding and smoking to 59%. Exposure to all the risk factors would increase the prevalence of persistent symptoms to 80%. Although these risk factors increased the probability of persistent respiratory symptoms in all socioeconomic groups, the effect of the risk factors on the prevalence of symptoms would be greatest in the low socioeconomic group. Among infants of low socioeconomic status, the difference in prevalence between those exposed to all the risk factors and those exposed to none would be 58%. Among infants of high socioeconomic status, however, the difference would be only 33%. For infants who were enrolled in day care, the effects of exposure to risk factors were similar in all three socioeconomic groups (Table 8).

Discussion

Our results indicate that infants of low socioeconomic status experience a higher incidence of acute lower respiratory illness and a higher prevalence of persistent respiratory symptoms than infants of high socioeconomic status. These results could have occurred if families of low socioeconomic background were more likely to report symptoms in their children. However, there is evidence that highly educated families are more likely than less-educated families to report respiratory symptoms.[39] In our assessment of the validity of our acute respiratory symptoms questionnaire, we did not detect clinically or statistically significant differences by socioeconomic status in responses to the questions, but our sample was small.

The differences we observed in the frequencies of respiratory symptoms across socioeconomic strata are also not explained by how we measured respiratory illness. Inaccuracy in the measurement of acute lower respiratory illness and persistent respiratory symptoms would have led to random misclassification of respiratory illness and diminished the observed differences between socioeconomic groups. Therefore, the effects of socioeconomic status we found are likely to be conservative estimates.

The large number of infants who were not in the study sample may limit the generalizability of our results. Only about half of the eligible families were enrolled in our study, and there were some differences in the distribution of risk factors and socioeconomic status between the study population and the target population. For example, infants in the study sample were of higher socioeconomic status, and fewer had mothers who smoked. This exposure to fewer risk factors among study infants compared with the population as a whole also indicates that our results may represent conservative estimates of the differences between socioeconomic groups.

Although socioeconomic status affects both the incidence of acute lower respiratory illness and the prevalence of persistent respiratory symptoms, its impact appears to be greater on the prevalence of persistent symptoms. One possible explanation for the differing effects of socioeconomic status on acute lower respiratory illness and persistent symptoms may be that factors related to socioeconomic status have a more pronounced effect on infants' risk of developing serious or chronic lower respiratory illness than on their risk of becoming infected. This explanation is consistent with the results of other studies that indicate that socioeconomic status appears to have little effect on rates of upper respiratory illness, but more of an effect on acute lower respiratory illness and a still greater influence on serious and chronic forms of this illness.[12,40]

There are insufficient data to assess the long-term clinical significance of persistent respiratory symptoms in 1-year-old infants. In studies of older children, however, a history of chronic cough and occasional wheezing has been associated with decrements in measurements of pulmonary function,[41] and such reduced ventilatory function may be associated with chronic obstructive airways disease.[7]

There is little direct information about differences in incidence of acute lower respiratory illness across socioeconomic groups. However, the one previous study of this question found differences in incidence rates that were similar to ours. Gardner et al.[42] described the incidence of lower respiratory illness in 23 low socioeconomic infants and 48 high socioeconomic infants who were participants in a community viral surveillance project in Houston. Lower respiratory illness was diagnosed by physical examination at home visits every 1 to 2 weeks. Although we used a telephone survey to identify illnesses in a larger and community-based cohort identified at birth, the incidence rates of lower respiratory illness they observed (1.43 episodes per child year in the low socioeconomic group, 1.0 episodes per child year in the middle socioeconomic group, and 0.72 episodes per child year in the high socioeconomic group) were similar to ours.

Previous evidence suggests that there are large differences in the severity of lower respiratory illness in infants of low compared with high socioeconomic status. For example, infants of low socioeconomic status who are healthy at birth have mortality rates from lower respiratory illness in the first year of life that are 2 to 4 times higher than those found among more advantaged children,[10,43] and other studies of infants suggest that hospitalization rates for lower respiratory illness are 5 to 10 times higher among poor as compared with middle-class infants.[5,44]

Chronic respiratory symptoms, too, are more prevalent in school-aged children of low socioeconomic status, but the effects of socioeconomic status on chronic respiratory symptoms in infancy have not been studied longitudinally. For example, Colley and Reid found the prevalence of chronic cough to be about three times higher in school children of low compared with high socioeconomic status.[45] Studies by Ware et al. and Schenker et al. also found that chronic cough and a history of serious "chest illness" in infancy were more common in children of low socioeconomic status.[46,47]

Of the risk factors for respiratory illness we found to be important in our study, most are supported by previous work.[30-37] The finding that day care was associated with a somewhat reduced prevalence of persistent symptoms in low socioeconomic families and an increased prevalence in high socioeconomic families was unexpected and has not been previously reported. It deserves exploration in another study. It is possible that the protective effect of day care among the infants of low and middle socioeconomic status could be related to the smaller size of their day-care groups or to a reduction in these infants' exposure to environmental factors such as tobacco smoke.[48] We found that families of low socioeconomic status tended to use day care less often and that infants in these families were more often cared for alone or in small groups (< 5 children), whereas infants of high socioeconomic status were more

commonly in large-group day-care settings in which the likelihood of exposure to infection is greater.

Our results indicate that much of the effect of socioeconomic status can be explained by factors that are related to the infant's home environment, most of which are mutable (exposure to tobacco smoke, crowding, stress, low birthweight, and bottle feeding). In addition, exposure to risk factors for respiratory illness is not only more common among families of low socioeconomic status, but the effect of the exposure also seems to be the greatest in this group, at least among infants not in day care. From a public health perspective, these findings indicate that infants of low socioeconomic status are especially likely to benefit from interventions that reduce their exposure to risk factors for respiratory illness. Given the high prevalence of persistent symptoms in infants of low socioeconomic status, even small changes in what are potentially mutable environmental risk factors could have a substantial impact on the health of poor infants.

Finally, our results indicate that a substantial portion of the effect of socioeconomic status cannot be explained by known environmental exposures. Thus, we should continue to study those at highest risk in order to understand better the factors that subject the socially disadvantaged to excessive burdens of illness. It may be necessary to develop interventions aimed not only at changing exposure to individual risk factors, but also at changing the social, political, and economic environment that promotes the effects of low socioeconomic status. □

Acknowledgments

This research was supported by Grant 28895 from the National Heart, Lung, and Blood Institute, National Institutes of Health; the Robert Wood Johnson Clinical Scholars Program; and the Primary Care Research Training Program. The study was approved by the Committee on Research Involving Human Subjects of the University of North Carolina School of Medicine.

We are grateful to the pediatricians of Alamance and Chatham counties, North Carolina, for supporting our study of their patients. The cooperation of the staffs of Alamance County Hospital, Alamance Memorial Hospital, and North Carolina Memorial Hospital is also greatly appreciated. We thank the staff of the Infant Health Study, whose work made this study possible. We also wish to thank Dr. Robert Fletcher, Codirector of the Robert Wood Johnson Clinical Scholars Program, for encouraging us to pursue this topic and for his guidance while Dr. Margolis conducted this research project as a Robert Wood Johnson Clinical Scholar.

The views expressed are those of the authors and do not necessarily represent those of the Robert Wood Johnson Foundation.

References

1. Glezen WP, Loda FA, Clyde WA Jr, et al. Epidemiologic patterns of acute lower respiratory disease of children in a pediatric group practice. *J Pediatr.* 1971;78:397–406.
2. Henderson FW, Clyde WA Jr, Collier A, et al. The etiologic and epidemiologic spectrum of bronchiolitis in pediatric practice. *J Pediatr.* 1979;95:183–190.
3. Foy HM, Cooney MK, Maletzky AJ, Grayston JT. Incidence and etiology of pneumonia, croup and bronchiolitis in preschool children belonging to a prepaid medical care group over a four-year period. *Am J Epidemiol.* 1973;97:80–92.
4. Maletzky AJ, Cooney MK, Luce R, Kenny GE, Grayston JT. Epidemiology of viral and mycoplasmal agents associated with childhood lower respiratory illness in a civilian population. *J Pediatr.* 1971;78:407–414.
5. Kim HW, Arrobio JO, Brandt CD, et al. Epidemiology of respiratory syncytial virus infection in Washington, D.C. I. Importance of the virus in different respiratory tract disease syndromes and distribution of infection. *Am J Epidemiol.* 1973;98:216–225.
6. Glezen WP, Denny FW. Epidemiology of acute lower respiratory disease in children. *N Engl J Med.* 1973;288:498–505.
7. Samet JM, Tager IB, Speizer FE. The relationship between respiratory illness in childhood and chronic air-flow obstruction in adulthood. *Am Rev Respir Dis.* 1983; 127:508–523.
8. Woolcock AJ, Leeder SR, Peat JK, Blackburn CRB. The influence of lower respiratory illness in infancy and childhood and subsequent cigarette smoking on lung function in Sydney school children. *Am Rev Respir Dis.* 1979;120:5–14.
9. McConnochie KM, Roghmann KJ. Bronchiolitis as a possible cause of wheezing in childhood: new evidence. *Pediatrics.* 1984; 74:1–10.
10. Spurlock CW, Hines MW, Skagg JW, Hernandez CE. Infant death rates among the poor and non-poor in Kentucky, 1982 to 1983. *Pediatrics.* 1987;80:262–269.
11. Dingle JH, Badger GF, Jordan WS Jr. *Illness in the Home: A Study of 25 000 Illnesses in a Group of Cleveland Families.* Cleveland, Ohio: The Press of Western Reserve University, 1964.
12. Monto AS, Ullman BM. Acute respiratory illness in an American community: the Tecumseh study. *JAMA.* 1974;227:164–169.
13. Margolis P. [The value of clinical history in detecting lower respiratory illness in infants]. Unpublished raw data; 1989.
14. Ferris BG. Epidemiology standardization project. *J Am Thorac Soc.* 1978;118:1–119.
15. Liberatos P, Link BG, Kelsey JL. The measurement of social class in epidemiology. *Epidemiol Rev.* 1988;10:87–121.
16. Cleland J, Van Ginneken J. Maternal schooling and childhood mortality. *J Biosoc Sci.* 1989;10(suppl):13–34.
17. Greenberg RA, Bauman KE, Strecher VJ, et al. Passive smoking in the first year of life. *Am J Public Health.* In press.
18. Bauman KE, Strecher VJ, Greenberg RA, Haley NJ. A comparison of biochemical and interview measures of the exposure of infants to environmental tobacco smoke. *Eval Health Professions.* 1989;12:179–191.
19. Anderson LJ, Parker RA, Strikas RA, et al. Day-care center attendance and hospitalization for lower respiratory tract illness. *Pediatrics.* 1988;82:300–308.
20. Fleming DW, Cochi SL, Hightower AW, Broome CV. Childhood upper respiratory tract infections: to what degree is incidence affected by day-care attendance? *Pediatrics.* 1987;79:55–60.
21. Ware JE Jr, Johnson SA, Davies-Avery A, Brook RH. *The Conceptualization and Measurement of Health for Adults in the Health Insurance Study: Volume III, Mental Health.* Santa Monica, Calif: Rand Corporation; 1978. R1987/3-HEW.
22. Denny FW, Clyde WA Jr. Acute lower respiratory tract infections in nonhospitalized children. *J Pediatr.* 1986;108:635–646.
23. Cochran WG. *Sampling Techniques.* New York, NY: Wiley; 1977:169–171.
24. Bishop YMM, Feinberg SE, Holland PW. *Discrete Multivariate Analysis: Theory and Practice.* Cambridge, Mass: The MIT Press; 1975.
25. Kleinbaum DG, Kupper LL, Morgenstern H. *Epidemiologic Research: Principles and Quantitative Methods.* Belmont, Calif: Lifetime Learning Publishers; 1982.
26. Koch G, Edwards S. Logistic regression. In: Johnson NL, Kotz SP, eds. *Encyclopedia of Statistics.* New York, NY: Wiley; 1983:128–133.
27. Greenland S. Modeling and variable selection in epidemiologic analysis. *Am J Public Health.* 1989;79:340–349.
28. Belsley DA, Kuh E, Welsch RE. Detecting and assessing collinearity. In: *Regression Diagnostics: Identifying Influential Data.* New York, NY: Wiley, 1980:85–160.
29. Harrell FE, Lee KL. The practical value of logistic regression. In: *Proceedings of the Tenth Annual SUGI Conference.* Cary, NC: SAS Users Group International; 1985: 1031–1036.
30. Samet JM, Marbury MC, Spengler JD. Health effects and sources of indoor air pollution. Part I. *Am Rev Respir Dis.* 1987; 136:1486–1508.
31. Samet JM, Marbury MC, Spengler JD. Health effects and sources of indoor air pollution. Part II. *Am Rev Respir Dis.* 1988; 137:221–242.
32. Wald ER, Dashefsky B, Byers C, Taylor F. Frequency and severity of infections in day care. *J Pediatr.* 1988;112:540–545.
33. Kovar MG, Serdula MK, Marks JS, Fraser DW. Review of the epidemiologic evidence for an association between infant feeding and infant health. *Pediatrics.* 1984; 74(suppl):615–638.
34. Fergusson DM, Horwood LJ, Shannon FT, Taylor B. Breast-feeding, gastrointestinal and lower respiratory illness in the first two years. *Aust Pediatr J.* 1981;17:191–195.
35. Watkins CJ, Leeder SR, Corkhill RT. The relationship between breast and bottle feeding and respiratory illness in the first

year of life. *J Epidemiol Community Health.* 1979;33:180–182.
36. Boyce WT, Jensen EW, Cassel JC, Collier AM, Smith AH, Ramey CT. Influence of life events and family routines on childhood respiratory tract illness. *Pediatrics.* 1977; 60:609–615.
37. Graham NMH, Douglas RM, Ryan P. Stress and acute respiratory infection. *Am J Epidemiol.* 1985;124:389–401.
38. Jason JM. Infectious disease-related deaths of low birth weight infants, United States, 1968 to 1982. *Pediatrics.* 1988;81: 58–62.
39. Tsui AO, DeClerque J, Mangani N. Maternal and sociodemographic correlates of child morbidity in Bas Zaire: the effects of maternal reporting. *Soc Sci Med.* 1988;26: 701–713.
40. Graham NMH. The epidemiology of acute respiratory infections in children and adults: a global perspective. *Epidemiol Rev.* 1990;12:149–178.
41. Mitchell C, Miles J. Lower respiratory tract symptoms in Queensland schoolchildren. The questionnaire: its reliability and validity. *Aust N Z J Med.* 1983;13:264–269.
42. Gardner G, Frank A, Taber LH. Effects of social and family factors on viral respiratory infection and illness in the first year of life. *J Epidemiol Community Health.* 1984; 38:42–48.
43. Druschel CM, Hale CB. Postneonatal mortality among normal birth weight infants in Alabama, 1908 to 1983. *Pediatrics.* 1987; 80:869–872.
44. Glezen WP, Paredes A, Allison JE, Taber LH, Frank AL. Risk of respiratory syncytial virus infection for infants from low-income families in relationship to age, sex, ethnic group, and maternal antibody level. *J Pediatr.* 1981;98:708–715.
45. Colley JRT, Reid DD. Urban and social origins of childhood bronchitis in England and Wales. *Br Med J.* 1970;2:213–217.
46. Ware JE Jr, Dockery DW, Spiro A, Speizer FE, Ferris BG. Passive smoking, gas cooking, and respiratory health of children living in six cities. *Am Rev Respir Dis.* 1984;129: 366–374.
47. Schenker MD, Samet JM, Speizer FE. Risk factors for childhood respiratory disease. The effect of host factors and home environmental exposures. *Am Rev Respir Dis.* 1983;128:1038–1043.
48. Wright AL, Holberg C, Martinez FD, Taussig LM, Group Health Medical Associates. Relationship of parental smoking to wheezing and nonwheezing lower respiratory tract illnesses in infancy. *J Pediatr.* 1991;118:207–214.

APPENDIX—Estimated Logistic Regression Model Parameters for Estimation of Prevalence of Persistent Respiratory Symptoms

Effect	β	SE	*P*
Intercept	−3.38	.548	.0001
Socioeconomic status	.967	.289	.0008
Crowding	.650	.265	.0141
Tobacco smoke	.347	.328	.291
Feeding	.099	.354	.779
Birthweight	.351	.636	.581
Race	.282	.329	.392
Stress	.155	.178	.383
Day care	.975	.494	.048
Day care × socioeconomic status	−.826	.398	.038

Note. The logistic model had the following form: logit P (persistent symptoms) = −3.38 + .967 (socioeconomic status) + .650 (crowding) + .347 (tobacco smoke) + .099 (feeding) + .351 (birthweight) + .155 (stress) + .282 (race) + .975 (day care) − .826 (day care × socioeconomic status). Exposure to tobacco smoke, bottle feeding and day care, and Black race and low birthweight were coded as dichotomous variables, with the presence of the variable coded as 1. Socioeconomic status (low, middle, high) and crowding (< .5, .5–1, > 1) were coded as three level ordinal variables, with low socioeconomic status and the most crowded living conditions coded as 2. Stress (low, medium, high) was coded into three levels, with the highest level coded as 3.