Median Household Income and Mortality Rate in Cystic Fibrosis

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ABSTRACT. *Context.* **Poverty has been shown to be a determinant of health outcomes in many epidemiologic studies.**

Objective. **The goal of this study was to assess the association between household income and the mortality rate in cystic fibrosis (CF) patients.**

Design, Setting, and Patients. **We selected white patients diagnosed before 18 years old and having 1 or more records in the Cystic Fibrosis Foundation Patient Registry since 1991. These 23 817 patients were linked to the 1990 US Census by their zip code of residence. The median household income was adjusted for state level differences in cost of living using the 1998 Consumer Price Index.**

Interventions. **None.**

Main Outcome Measures. **We examined the association between categories of the median household income and the mortality rate. We examined the association between income categories and age-related changes in pulmonary function and body weight as well as specific nutritional and pulmonary therapies.**

Results. **We found a strong monotonic association between the median household income and the mortality rate. The test of trend was significant, and this effect was maintained after adjustment for a variety of patient and disease characteristics. When the lowest income category (<$20 000) is compared with the highest (≥$50 000), the adjusted incidence rates were 90.3 and 62.6 per 10 000 person years, respectively; this represents a 44% increased risk of death in the lowest income category. Patients living in areas with lower median household income also had consistently lower pulmonary function and body weight than did those living in higher income areas. The differences in weight percentiles and forced expiratory volume in 1 second are substantial in magnitude, they appear at an early age, and they persist into adulthood for these CF patients. Prescribed nutritional treatments and screening for CF-related diabetes were significantly higher among patients living in areas with lower median household income. Prescription of deoxyribonuclease and inhaled tobramycin was not significantly associated with median household income.**

Conclusion. **There was a strong association between lower household income and increased mortality rate among CF patients. Additional understanding of this effect will require more complete and direct measurement of socioeconomic status and a better understanding of treatment adherence, local environmental conditions, and especially the care of CF patients during the early years of life.** *Pediatrics* **2003;111:e333–e339. URL: http://www.pediatrics.org/cgi/content/full/111/4/e333;** ***socioeconomic, cystic fibrosis, treatment variation, survival.***

ABBREVIATIONS. CF, cystic fibrosis; CI, confidence interval; FEV_1, forced expiratory volume in 1 second; BMI, body mass index; CFF, Cystic Fibrosis Foundation; CDC, Centers for Disease Control and Prevention; GI, gastrointestinal; TOBI, tobramycin.

The relationship between socioeconomic status and mortality is well established. As early as 1840 Edwin Chadwick noted that in the borough of Derby, England, the gentry and professionals had a life expectancy of 49 years while tradesmen lived for 38 years and laborers for 21 years.[1] More modern studies confirm that the economically advantaged fare better on mortality and most measures of health status.[2,3] This finding has been one of the most consistent in epidemiology despite the complexity of measuring socioeconomic status and its relationship to occupation, education, and income.[4] The cause of differences in mortality associated with socioeconomic status is far less clear. The increased mortality risk associated with disadvantage has been attributed to multiple factors including barriers in access to medical care or to prescribed treatments, less complete patient and parent understanding and knowledge of the medical condition, and lower adherence to prescribed medical care. Other possibilities include poor nutrition, greater exposure to environmental hazards, and stresses that may have a negative impact on immunity and family function.[1,5]

Cystic fibrosis (CF) is the most frequently occurring lethal autosomal genetic disease in white populations.[6] It is caused by mutations in a single gene on the long arm of chromosome 7 that encodes the CF transmembrane conductance regulator. These mutations result in defective chloride transport of sodium and water resulting in viscous secretions and, clinically, in destruction and scarring of various exocrine ducts. Clinical consequences include bronchiectasis and obstructive pulmonary disease, pancreatic insufficiency, obstructive biliary tract disease, and azospermia in affected men. During the past 2 decades, a substantial increase in survival has been documented, and now many CF patients survive to adult-

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Preliminary results from this study were presented at the 14th Annual North American Cystic Fibrosis Conference; Baltimore, MD; November 9–12, 2000.

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hood.[7] Relatively little is known about the effect of socioeconomic status on the outcomes of CF. Using vital statistics data on CF from England and Wales in 1959–1986, Britton[8] found that social class (defined by occupation class: manual labor vs nonmanual labor) was significantly associated with CF mortality (hazard ratio: 2.75 [manual vs nonmanual] 95% confidence interval [CI]: 2.13, 3.52). In a study of CF patients in the United States, Schechter et al[9] compared 1885 CF patients who qualified for Medicaid with 13 337 who did not. They found that medically indigent patients had twice the mortality rate (hazard ratio: 2.10 [Medicare eligible vs noneligible]; 95% CI: 1.75, 2.50) as the rest of the pediatric CF population.

The goal of this study was to assess the association between median household income, assessed at the zip code level, and the mortality rate among a racially homogeneous group of CF patients receiving medical care at specialized clinical care centers. We also assessed the association of median household income to pulmonary function and body weight percentiles among CF patients, and examined the relationships between income and prescribed treatments for pulmonary disease and malnutrition, and screening for CF-related diabetes.

METHODS

Data Collection: CF Patient Registry

Since 1982, the Cystic Fibrosis Foundation (CFF) has maintained a registry of annual information on all patients seen at CF Care Centers in the United States. The registry includes data on patient demographics, complications and other clinical information, and the date of death or date last known to be alive. The variables available in the CF Patient Registry include:

- Demographic variables: sex (male, female), date of birth, date of death, zip code of residence, race (white, black, Asian or Pacific Islander, Aleut or Eskimo, American Indian, other, or missing), and ethnicity (Hispanic origin or descent, other, or missing).
- Presentation and complications: age at diagnosis, complications at birth (meconium ileus/intestinal obstruction), presentation (active or persistent respiratory symptoms, failure to thrive/malnutrition, meconium ileus/intestinal obstruction, family history, electrolyte imbalance, prenatal diagnosis, neonatal screening, nasal polyps/sinus disease, rectal prolapse, liver problems, other).
- Laboratory and clinical values: sweat test values, genotype, forced expiratory volume in 1 second (FEV_1), height and weight, and blood glucose. In these analyses genotype data were categorized as heterozygous ΔF508, homozygous ΔF508, neither mutation ΔF508.

Because of the relatively small number of nonwhite and Hispanic subjects ($N = 3212$) and deaths ($N = 426$) in this group and because race and ethnicity often confound the relationship between socioeconomic status and mortality, these analyses were confined to the white subjects.

Using registry data and information from the Clinical Practice Guidelines for Cystic Fibrosis,[10–12] we defined groups of patients eligible for treatments of pulmonary and nutritional problems and appropriate for screening for CF-related diabetes:

- Supplemental oral or tube feeding for patients at risk of nutritional failure defined as follows: age 0 to 2, weight 10th to 25th percentile; age 2 to 20, body mass index (BMI) 10th to 25th percentile, height not at genetic potential. Over 20 years with BMI 19 to 20.
- Parenteral or enteral feeding of patient in nutritional failure, defined as follows: anyone with ideal body weight <90%, age 0 to 2 weight <10th percentile or height <5th percentile; age 2 to 20, BMI <10th percentile, >20 years with BMI <19.
- Prescription of aerosolized tobramycin (TOBI) among patients ≥5 years of age with FEV_1 25% to 75% and sputum cultures positive for *Pseudomonas aeruginosa*.
- Prescription of deoxyribonuclease (Pulmozyme; Genentech, Inc, South San Francisco, CA) among patients ≥5 years old, with respiratory compromise defined as FEV_1 <90% or 1 or more acute exacerbations during the past year.
- Annual screening for CF-related diabetes among nondiabetics >13 years old.

Data Collection: Household Income

Socioeconomic status is a complex construct and most comprehensive measures consider occupation, education, and income. The CF Patient Registry has not captured individual level patient or parental education, income, and occupation; therefore, data from the United States Census of the Population (1990) were used to provide information on the median household income at the zip code level. The Census data were merged with the CF Patient Registry data using the patient's zip code.[13] We selected white, non-Hispanic patients diagnosed before 18 years old. Patients were included if they contributed at least 1 record to the CFF Patient Registry between 1991 and 2000. This includes patients born before 1991 who survived at least until that time, and patients born from 1991 to 2000. These 24 480 patients were linked to the 1990 US Census by their zip code of residence. A total of 1383 (5.7%) of patients lacked zip code information and could not be merged with the Census data. About 10% of the patients have >1 valid zip code, but we believe that this leads to random misclassification of household income and an underestimate of the effect of income on mortality. Since the patient registry was initiated in 1982 and the follow-up analyses include deaths through 2000, the 1990 Census (reflecting 1989 income) provides an approximate midpoint measure of median household income in the patient's zip code of residence. Because the cost of living varies across the United States, we adjusted the median household income for the Consumer Price Index (on a state level) using data from the fiscal year 1998.[14]

The data set used for these analyses included white patients diagnosed before 18 years old (since late diagnosis is associated with milder or atypical disease) with known information on sex, age at diagnosis, presentation of CF, zip code of residence, and having 1 or more records in the CFF Patient Registry since 1991. The resulting data set includes 23 817 CF patients seen at CF Care Centers from 1982 to 2000.

Statistical Analysis

The exposure variable in these analyses was median annual household income of the zip code in which the patient resides. This was categorized as <$20 000, $20 to $29 999, $30 to $39 999, $40 to $49 999, and ≥$50 000. The dependent variable was patient survival. These data are presented as incidence density mortality rates (deaths/person-time of follow-up).[15] The data were adjusted for the potentially confounding effects of sex, age at diagnosis, and presentation of CF by direct standardization across income categories using the natural distribution of the data. These covariates were chosen because of previous analyses that identified them as potential confounding variables.[16] They are characteristics of patients or their disease that are associated with survival and that are not a consequence of treatment. Tests of trend were performed using Cox proportional hazards regression. We assessed the effect of income categories on age-related changes in pulmonary function and body weight for patients 0 to 18 years old in the CFF Patient Registry from 1991 to 2000 using generalized estimating equations to adjust for the same covariates described above. Pulmonary function was as measured by the percentage of expected value for the mean annual FEV_1 using the Knudson equations.[17] Body weight was represented by the National Center for Health Statistics 2000 (Centers for Disease Control and Prevention [CDC]) weight percentiles.[18] The data set contained 167 177 annual measurements on the 23 817 patients. Rates of screening for CF-related diabetes and of prescribed nutritional and pulmonary treatments were based on data included in the 2000 CF Patient Registry and the sample size varied based on the eligibility of the patients for specific screening or treatment.

All analyses were done using Stata Statistical Software, version 6.0 (Stata Corporation, College Station, TX).

RESULTS

There are 23 817 patients in the data set with 3256 deaths during 418 541 person-years of follow-up. The mean household income at the zip code level was $31 153. The proportion of individuals in each of the 5 household income categories is as follows: <$20 000 (7.3%), $20 000 to $20 999 (38.5%), $30 000 to $30 999 (30.9%), $40 000 to $40 999 (15.2%), and ≥$50 000 (8.1%).

Table 1 summarizes the individual variables and their distributions across income categories. Females make up 46.5% of all patients. Looking from the lowest to the highest income category, females comprise 44.9% to 47.2% of the population (P_{trend} = .426). The mean age at diagnosis is consistently 2.1 years (P_{trend} = .684). The clinical presentation of CF is a complex variable that varies somewhat with income. Overall, only 8.4% of these patients present asymptomatically, but there is a significant trend for an asymptomatic presentation to increase with increasing median income—from 7.8% in the lowest income category to 10.5% at >$50 000 ($P_{trend}$ < .001. Respiratory-only presentation comprises 17.7% (P_{trend} = .287), gastrointestinal (GI) only is 22.4% (P_{trend} = .083), both GI and respiratory presentation is 31.8% from a low of 27.5% in the highest income group to 34.5% in the lowest income category (P_{trend} < .001), and meconium ileus comprises 19.7% (P_{trend} = .063) of these patients.

Approximately 66% of these patients have genotype information and there is some variation in the genotypes across income categories, but the homozygous ΔF508 genotype dominates and varies from 52.2% to 58.2% of the population (P_{trend} = .143). Heterozygous ΔF508 genotype varies from 36.0% to 37.3% of the population (P_{trend} < .001), while in only 9.9% of the population is neither CF gene ΔF508 (P_{trend} < .001). In an absolute sense, these are relatively small differences in genotype that reach statistical significance in this large data set. Genotype was not randomly missing; the rate of genotyping was higher in areas with higher median family income and among patients born in recent years.

Data on the relationship between median household income and mortality rate are summarized in Table 2. The crude incidence rate of death decreases from 90.8 per 10 000 person years in those patients who live in zip codes where the median household income is <$20 000, to 62.9 per 10 000 person years where the income is >$50 000 ($P_{trend}$ < .001). The effect of median household income on the mortality rate was monotonic across income categories; each increase in income was associated with a decrease in the mortality rate. After adjustment for the potentially confounding effects of sex, age at diagnosis, and presentation of CF, there was little change in the mortality rate (Fig 1). The incidence of death decreases steadily across income categories (P_{trend} < .001). When the lowest income category (<$20 000) is compared with the highest (≥$50 000), the adjusted incidence rates were 90.3 and 62.6 per 10 000 person years, respectively (relative risk: 1.44; 95% CI: 1.20, 1.73; P < .001). This represents a 44% increased risk of death in the lowest income category. When we examined only those with the ΔF508 homozygous genotype, similar results were observed (relative risk: 1.65; 95% CI: 1.13, 2.45; P = .005).

Fig 2, A and B summarize the relationships between median household income and FEV_1 and weight. The FEV_1 can not be reliably measured before patients are 6 years old. At 6 years old, the absolute difference in mean FEV_1 from the lowest to the highest income category was 5.5% of predicted (P < .001). The association between income category and FEV_1 at 6 years old was monotonic (P_{trend} < .001). In this patient population, the mean FEV_1 declined from 94% of predicted at age 6% to 68% of predicted at 18 years old. This was an annual decline of 2.2%. At each age, patients in the higher income categories have better FEV_1 values than do those in the lower income categories. Overall, the mean CDC weight percentiles (Fig 2B) increase rapidly from birth to ~2 years old and reach a maximum at ~4 years old and then decline. At every age, patients in the higher income categories have higher weight percentiles than do patients in the lower income categories. Patients in the lowest income category had a mean CDC weight percentile at 4 years old, 7.3 percentage points lower than those in the highest income category (P_{trend} < .001). The overall annual decline in CDC weight percentile was 1.1% (P < .001) between 3 years old and 18 years old.

Analyzing the data for patients 6 to 18 using generalized estimating equations and covariates age,

TABLE 1. Patient and Disease Characteristics by Income Category

Variables	Income					*P* Trend
	<$20K 7.3%	$20–29K 38.5%	$30–39K 30.9%	$40–49K 15.2%	≥$50K 8.1%	
Sex (% female)	44.9	46.7	46.5	46.5	47.2	.426
Age at diagnosis (mean years)	2.1	2.1	2.1	2.1	2.1	.684
Presentation of CF (%)						
Asymptomatic	7.8	7.9	8.3	9.3	10.5	<.001
Respiratory only	16.9	17.5	17.9	17.7	17.9	.287
GI only	21.2	22.5	22.3	22.8	23.5	.083
Meconium ileus	19.6	19.2	19.8	20.3	20.5	.063
Respiratory and GI	34.5	32.9	31.7	29.9	27.5	<.001
Genotype						
Homozygous ΔF508	54.3	58.2	55.8	54.5	52.2	.143
Heterozygous ΔF508	36.0	33.2	34.1	34.5	37.3	<.001
Neither mutation ΔF508	9.7	8.6	10.1	11.0	10.5	<.001

TABLE 2. Mortality Rates by Household Income Categories

Variable	Income					Overall	*P* Trend
	<$20K	$20–29K	$30–39K	$40–49K	$50K+		
Number of subjects	1744	9180	7347	3628	1918	23 817	
Person-years of follow-up	29 513	159 113	130 471	64 966	34 479	418 541	
Number of deaths	268	1296	996	479	217	3256	
Crude incidence rate*	90.8	81.5	76.3	73.7	62.9		<.001
Adjusted† incidence rate*	90.3	81.5	76.4	73.6	62.6		<.001

* Incidence rate per 10 000 person years of follow-up.
† Adjusted for sex, age at diagnosis, and presentation.

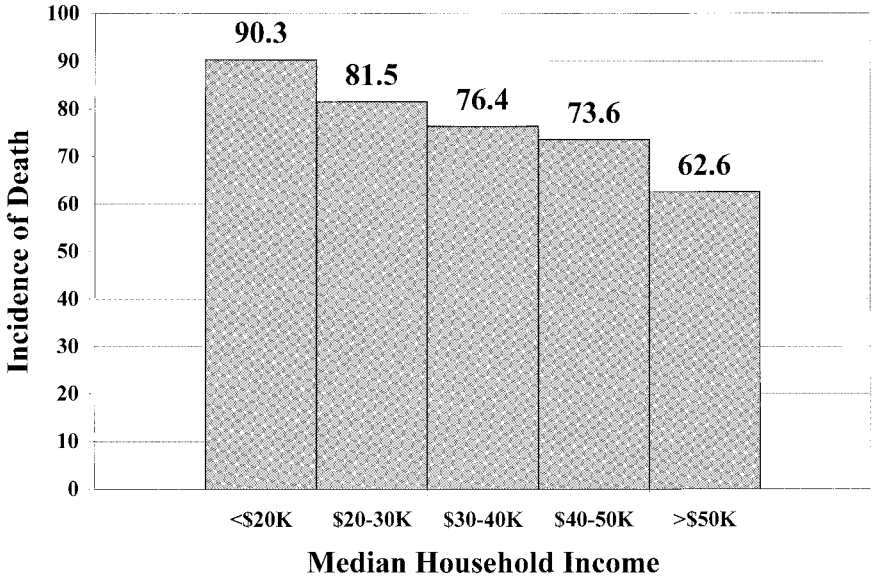

Fig 1. Adjusted incidence of death among white CF patients (per 10 000 person-years of follow-up).

sex, age at diagnosis, and presentation, the Consumer Price Index-corrected income categories are associated with declines in both FEV_1 and weight percentile at $P < .0001$.

We used data from the 2000 CF Registry to examine the current rates of prescribed pulmonary and nutritional treatments and the rates of screening for CF-related diabetes among patients from areas with lower and higher household incomes (Table 3). Supplemental feeding (oral or enteral) in patients at risk of nutritional failure decreased significantly across income categories ($P_{trend} < .001$). The rate in the lowest income category (<$20 000) was 50.7% and this rate declined as income increased reaching 33.9% in the highest income category (≥$50 000). Similar results were seen for enteral or parenteral feeding among patients in nutritional failure. The rates decreased significantly ($P_{trend} < .001$) from 15.4% in lowest income category to 9.2% in the highest income category. Annual glucose screening for CF-related diabetes ranged from 80.0% in the lowest income group to 72.4% in the highest income category (P_{trend} .003). There was no significant trend between income categories and the use of deoxyribonuclease (Pulmozyme) or aerosolized TOBI.[19]

DISCUSSION

We found a strong monotonic association between the median household income and the mortality rate of CF patients. The test of trend was significant ($P <$ .001), and this effect was maintained after adjustment for a variety of patient and disease characteristics. When the lowest income category (<$20 000) was compared with the highest (≥$50 000), the adjusted incidence rates were 90.3 and 62.6 per 10 000 person years, respectively; this represents a 44% increased risk of death in the lowest income category. When we examined patients that were ΔF508 homozygous, we found an increased risk of similar magnitude. CF patients living in areas with lower median household income had consistently lower pulmonary function and body weight than did those living in higher income areas. Using recent data we found similar, or higher, rates of prescribed pulmonary and nutritional treatments in low-income areas.

There are two limitations to these analyses. Typically, epidemiologic studies use individual-level data for both exposure and outcome. Sometimes group-level data ("ecologic data") are substituted for individual-level data. This is done when the exposure variable was not measured or is difficult to measure on an individual level. The primary concern is that the apparent effect observed on aggregate level is sometimes not seen on an individual level.[20] In the current study, only the exposure variable, median household income, is an ecologic variable. A necessary assumption of this approach is homogeneity within a given geographic area. This, of course, may be incorrect, especially in urban areas where even very small areas (eg, a block) can be heterogeneous with respect to household income. In general, if the misclassification of the subject's income is ran-

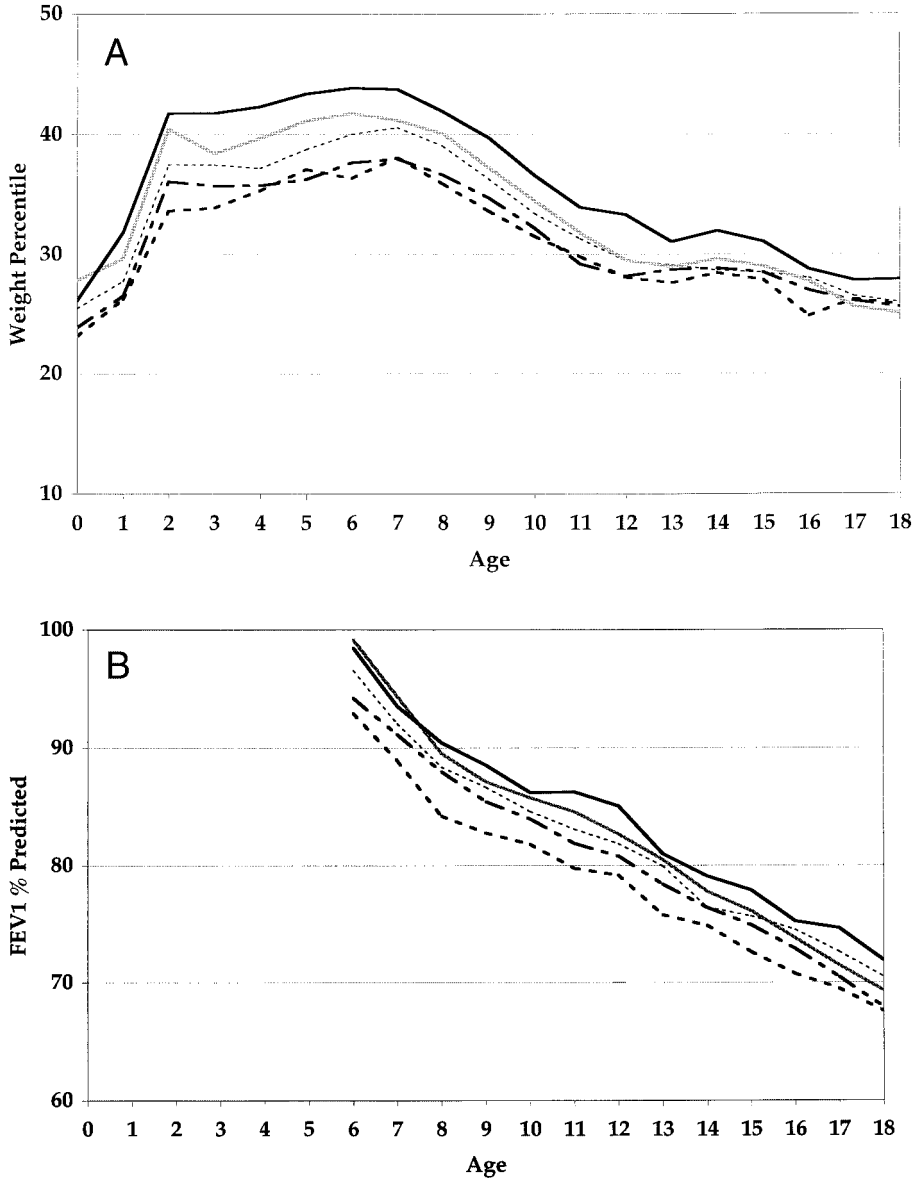

Fig 2. A, Mean FEV_1 versus age by income category. B, Mean CDC weight percentile versus age by income category. –––, <$20K; ——, $20–30K; ----, $30–40K; —, $40–$50K; ——, >$50K.

domly distributed with respect to the mortality rate, the effect of any misclassification will be to understate the effect of income on survival. Some have concluded that ecologic data reflect the effects of the environment or the living conditions and that the census-based methodology offers a valid and useful approach to overcoming the absence of socioeconomic data in most US medical records. Others have concluded that group or area-based measures have been most useful in identifying high-risk groups for health planning and the design of individual-based studies.[21] In these analyses, household income is used as a proxy for some aspects of socioeconomic status. Socioeconomic status is a complex construct and most comprehensive measures of social class incorporate Weber's view of 3 dimensions including occupation, education, and income.[22]

Previous studies of the effect of various aspects of socioeconomic status on mortality or disease severity of CF patients have been reported. We described the results of Britton's study of social class (measured by the occupational class of the patient or their parents). Although we measured different aspects of socioeconomic status, our results are consistent in direction with those reported. These results are also consistent with those reported by Schechter et al[23] who conducted a cross-sectional analysis of 261 CF patients in North Carolina using Medicaid insurance coverage as a proxy for low family income. They found that patients eligible for Medicare had lower pulmonary function than those who were not Medicare eligible (FEV_1 84.6% vs 91.9%; $P = .01$). This effect was noted in the youngest children on whom spirometry was performed and continued through childhood. In a further study of 49 patients, Schechter et al found that social and environmental factors leading to worse pulmonary function may cluster in low socioeconomic status families.[24,25] In a study of CF patients in the United States, Schechter et al compared 1885 CF patients who qualified for Medicaid to 13 337 that did not. They found that medically indigent patients had twice the mortality rate (hazard ratio: 2.10 [Medicare eligible vs noneligible] 95% CI: 1.75, 2.50) as the rest of the pediatric CF population.[9]

TABLE 3. Treatment Characteristics by Household Income Categories: 2000 CF Patient Registry

Screening or Prescribed Treatment	Eligible Patients	Number of Patients	<$20K	$20–30K	$30–40K	$40–50K	≥$50K	*P* Trend
Supplemental feeding (oral or enteral) in patients at risk of nutritional failure (% treated)	Age 0–2 weight 10–25th percentile; Age 2–20 BMI 10–25th percentile; Height not at genetic potential* >20 y with BMI 19–20[41]	3039	50.7	45.7	43.8	39.5	33.9	<.001
Enteral or parenteral feeding in patients in nutritional failure (% treated)	Anyone with ideal body weight <90%; Age 0–2 weight <10th percentile or height <5th percentile; age 2–20 BMI <10th percentile[a] >20 y with BMI <19[41]	4797	15.4	16.0	15.0	12.8	9.2	<.001
Glucose screening for CF-related diabetes (% screened)	Annual screening of nondiabetics >13 y old	7494	80.0	77.3	75.6	77.2	72.4	.003
Deoxyribonuclease (Pulmozyme) (% treated)	Age ≥5 y, FEV_1 <90% or 1 or more acute exacerbations during the past year	13537	56.9	53.8	55.7	55.9	54.3	.685
Aerosolized TOBI (% treated)	Age ≥5 y, FEV_1 25%-75%, for suppression of *P aeruginosa*	4413	68.0	67.5	66.7	68.8	69.0	.293

* 2001 CFF Nutrition Consensus Guidelines.

The current study extends these findings by demonstrating that the apparent effect of income on pulmonary function nutritional status and mortality is ordinal and not confined solely to the lowest income groups. Furthermore, we have demonstrated that the effect obtains even in a racially similar patient group that is homozygous for the ΔF508 mutation.

The effect of socioeconomic status on pulmonary function among school children has also been reported. In a cross-sectional study of 989 school children in Montreal, Demissie et al[26] found that socioeconomic status (based on parental income and education) was significantly associated with pulmonary function among boys. The lowest socioeconomic status group had an FEV_1 8.6% lower than the highest socioeconomic status group. A trend of smaller magnitude was seen among girls but did not reach statistical significance. These studies on socioeconomic status and mortality and disease severity are important to the care of CF patients for several reasons. The mortality differences shown by Britton and in this current study are large in magnitude and cannot be ignored. The pulmonary function differences shown by Schechter et al, Demissie et al, and in the current study are substantial. These associations between socioeconomic status and adverse outcomes are seen, although each of these studies used proxy variables to measure socioeconomic status. The actual effect of comprehensively measured socioeconomic status on mortality and disease severity may be substantially larger than that reported in these studies.

Is it plausible that factors such as occupation, education, and income are important predictors of mortality in CF? The possible effects of socioeconomic status on health outcomes have been reviewed by Liberatos et al,[22] Jolly et al,[1] and Berkman and Kawachi.[27] Income provides access to good housing and to health care, a nutritious diet, and possibly the ability to avoid poor environmental conditions. Occupation exerts an influence on job security, the degree of personal autonomy, and the rewards of working. Education is associated with social networks and problem-solving skills and can also influence health-related behaviors. Further understanding of the components of socioeconomic status may uncover areas that would be appropriate targets for intervention.

To consider whether access to medical care or clinicians' prescribing patterns could be responsible for some of the observed differences, we examined the rates of common nutritional and pulmonary therapies by income categories in the 2000 CF Patient Registry. The rates of prescribed nutritional treatments in the current study were actually higher for patients from low-income areas. The prescribed rates of pulmonary treatments (deoxyribonuclease and inhaled TOBI) were similar to those patients living in higher income areas. However, treatments prescribed may not be available to patients and treatments that are available may not be administered. Treatment of CF involves multiple medications, supplemental oral or enteral feedings, chest physical therapy, and treatments administered by nebulizer. The treatments are expensive, time consuming, and sometimes unpleasant. There is a large literature on treatment adherence in CF and poor adherence is a possible cause of these findings.[28–32] Local environmental conditions may also play a role. These include exposure to sources of indoor air pollution such as cigarette smoking, heat and cooking sources, and poor air quality.[33–35] Cigarette smoking is more common in lower socioeconomic groups and has been associated with low birth weight.[36] Among CF patients, exposure to cigarette smoking has been associated with poorer clinical status.[35] Recent studies suggest that early diagnosis and early treatment of CF may be important predictors of subsequent outcomes.[37–40]

The results of the current study show a strong association between local household income and mortality rate among CF patients. This was true even in a racially homogeneous patient group and among patients that were genetically similar. We found poorer nutritional status and pulmonary function among patients who lived in lower income areas.

The differences in weight percentiles and FEV_1 are substantial in magnitude, they appear at an early age, and they persist into adulthood for these CF patients. The results of this study are descriptive but not prescriptive because we do not yet understand the cause of the association between mortality rate and living in an area with lower household income. Additional understanding of this effect will require more complete and direct measurement of socioeconomic status and a better understanding of treatment adherence, local environmental conditions, and especially the care of CF patients during the early years of life.

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