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Social disadvantage predicts growth outcomes in preadolescent children with cystic fibrosis

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1. Introduction

Socioeconomic status (SES) is a multi-dimensional construct that is used as an indicator of environmental influences on health and well-being [1–7]. A sociological approach to understanding the importance of SES for health outcomes may be informative. The idea of capital, broadly defined as resources and assets that affect well-being on an individual or group level, is derived from conventional measures of SES but incorporates the critical dimension of social relationships. Specifically, access to material resources (financial capital), non-material resources (human capital) and social relationships (social capital) may converge to influence health and well-being, but represent distinct resources [8–9].

Although it is preferable to measure multiple dimensions of SES, investigators often use a single measure, such as income. Braverman and others [10–12] have maintained that although SES measures are moderately correlated, they are neither interchangeable nor robust independent proxies for SES. Bauman et al. [1] examined the impact of social disadvantage on child health. Social disadvantage was defined by four risk factors that are commonly used as SES measures: race/ethnicity, income, parental education, family structure. While each factor was independently related to overall risk of poor health, only income, parental education and family structure were related to other health outcomes, namely the presence of a chronic medical condition, and to the presence of limited activity.

Cystic fibrosis (CF) is the most common genetic disease in children of European descent in the US, with variable effects on pulmonary function and growth. Using data from the US CF Registry, two studies have investigated the impact of income on health outcomes in children with CF [13–14]. Investigators reported a significantly higher risk of death, growth faltering and reduced pulmonary function in children from lower versus higher income families. The effects of other dimensions of SES were not examined.

The aim of this study was to explore the impact of SES on children with CF using a sociological approach. We examined the relationship between financial, human and social capital and growth and pulmonary status in preadolescent children with CF and pancreatic insufficiency (PI) over 24 months. For the purpose of this study, financial capital was defined as household income, human capital as primary caregiver education and social capital as family structure, specifically the number of caregivers in the household.

2. Materials and methods

2.1. Subjects

Subjects consisted of preadolescent children who participated in a prospective cohort study of growth, nutrition and pulmonary status. At enrollment, children were ages 6.0 to 8.9 years and had

Abbreviations: CF, cystic fibrosis; LME, longitudinal mixed effects model; PI, pancreatic insufficiency; SES, socio-economic status.

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mild to moderate CF lung disease and PI. Subjects were recruited from 13 CF Centers in the United States and followed for 24 months. The diagnosis of CF and PI were made at the home CF Center by clinical symptoms and duplicate quantitative pilocarpine iontophoresis sweat tests with chloride greater than 60 mEq/L, and 72-hour fecal fat analysis showing less than 93% absorption or a stool trypsin of less than 80 μg/g. Subjects were excluded if they had poor lung function (FEV_1 percent predicted <40%), liver disease, insulin-dependent diabetes mellitus, *Burkholderia cepacia* sputum colonization or growth-impairing medical conditions.

The protocol was approved by the Committee for the Protection of Human Subjects of the Institutional Review Board at Children's Hospital of Philadelphia and by the subjects' home institution. Informed, written consent was obtained from the parent or legal guardian; age-appropriate assent was obtained from each subject. Study visits were conducted at baseline, 6, 12, 18 and 24 months.

2.2. Advantage Index

In the absence of an existing measure, we devised an index that was influenced by our framework for understanding SES. We included an indicator of financial capital (household income), human capital (caregiver education) and social capital (caregiver status) to reflect different types of capital. Household income, primary caregiver's highest level of education and caregiver status were obtained by a questionnaire completed by the primary caregiver at baseline. Three levels of income were analyzed: less than $20,000, $20,000 to $74,999 and >$75,000. Three levels of education were analyzed: less than high school, completed high school but not college, and completed college or above. Caregiver status was reported as mother, father and/or guardian (including grandparent) and whether they lived with the child. Type of insurance, including Medicaid, was also obtained by caregiver report at baseline. School days missed and hospitalizations were monitored throughout the study.

For the Advantage Index, children were categorized into groups based on social risk factors (see Fig. 1). Cut points were set to reflect extremes of income: <$20,000 (federal poverty level) and >$75,000 (highest level of income recorded). For education, cut points were set to distinguish between common levels of schooling in the US, specifically the completion of high school and the completion of college. Caregiver status was determined based on single versus dual caregivers in the household. Children were included in the Social Advantage group if they met all criteria: household income >$75,000, primary caregiver with at least a college degree and dual caregivers. Children were included in the Social Disadvantage group if they had any one of the following social risk factors: household income <$20,000, primary caregiver education less than high school or a single caregiver. Thus, having any social risk factor (low income, limited primary caregiver education or single caregiver) offset the advantage of higher income, higher education or dual caregiver. Children in the No Social Disadvantage group had none of these social risk factors, but did not meet all criteria for inclusion in the Social Advantage group. For example, a child with two caregivers and a household income >$75,000, but whose primary caregiver did not have a college degree, was included in the No Social Disadvantage group.

2.3. Anthropometric measures

Weight and height were measured at all study visits using standard techniques [15], a scale accurate to 0.1 kg (Scaletronix, White Plain, NY) and a stadiometer accurate to 0.1 cm (Holtain, Crymych, UK). Body mass index (BMI; weight (kg)/height (cm^2)) was calculated. Parental height was collected for both biologic parents and used to obtain a mid-parent height [16]. The mid-parent height and subject's height were then used to calculate an adjusted height. *Z* scores for weight (WAZ), adjusted height (AHAZ) and body mass index (BMIZ) were calculated [17].

2.4. Pulmonary disease

FEV_1 was measured by spirometry at baseline, 12 and 24 months, following administration of inhaled albuterol and chest physiotherapy [18–19]. FEV_1 (% predicted) was calculated using the Wang equation [20].

2.5. Statistical analysis

Data analysis included both descriptive and inferential statistics. Baseline comparisons of continuous variables (age, growth and pulmonary status) by Advantage Index groups were performed by ANOVA, with post hoc student's *t* tests for individual group comparisons. For data that was not normally distributed, group differences were determined using Wilcoxon rank sum test.

Longitudinal mixed effects (LME) analysis [21] was used to determine whether financial, human or social capital groups, when considered separately and then combined into Advantage Index groups, predicted growth status (AHAZ, WAZ and

	Financial Capital (Household Income)		Human Capital (Primary Caregiver Education)		Social Capital (Caregiver Status)
Social Disadvantage =	< $20,000	**OR**	< High School	**OR**	Single Caregiver
No Social Disadvantage =	≥ $20,000	**AND**	≥ High School	**AND**	Dual Caregivers
Social Advantage =	≥ $75,000	**AND**	> College Degree	**AND**	Dual Caregivers

Fig. 1. Advantage Index groups.