Family Hardships and Serum Cotinine in Children With Asthma

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abstract

BACKGROUND AND OBJECTIVE: A better understanding of how poverty-related hardships affect child health could highlight remediable intervention targets. Tobacco smoke exposure may be 1 such consequence of family hardship. Our objective was to explore the relationship between family hardships and tobacco exposure, as measured by serum cotinine, a tobacco metabolite, among children hospitalized for asthma.

METHODS: We prospectively enrolled a cohort of 774 children, aged 1 to 16 years, admitted for asthma or bronchodilator-responsive wheezing. The primary outcome was detectable serum cotinine. We assessed family hardships, including 11 financial and social variables, through a survey of the child's caregiver. We used logistic regression to evaluate associations between family hardship and detectable cotinine.

RESULTS: We had complete study data for 675 children; 57% were African American, and 74% were enrolled in Medicaid. In total, 56% of children had detectable cotinine. More than 80% of families reported ≥1 hardship, and 41% reported ≥4 hardships. Greater numbers of hardships were associated with greater odds of having detectable cotinine. Compared with children in families with no hardships, those in families with ≥4 hardships had 3.7-fold (95% confidence interval, 2.0–7.0) greater odds of having detectable serum cotinine in adjusted analyses. Lower parental income and educational attainment were also independently associated with detectable serum cotinine.

CONCLUSIONS: Family hardships are prevalent and associated with detectable serum cotinine level among children with asthma. Family hardships and tobacco smoke exposure may be possible targets for interventions to reduce health disparities.

WHAT'S KNOWN ON THIS SUBJECT: Poverty is prevalent among children in the United States, and it has a clear association with negative health outcomes. Smoking and passive smoke exposure are both more common among socioeconomically disadvantaged populations and are associated with asthma morbidity.

WHAT THIS STUDY ADDS: Reported family hardships were common among children admitted for asthma or wheezing, and most were associated with detectable tobacco smoke exposure. The cumulative number of hardships was also associated with greater odds of tobacco smoke exposure.

Poverty is prevalent among children in the United States, and it has a clear association with negative health outcomes.[1–4] Asthma is the most common chronic disease of childhood, and children living in poverty have disproportionate asthma morbidity. Such children experience higher rates of hospitalization, emergency department visitation, and unscheduled visits to primary care, reducing quality of life for involved families and adding excess cost to the health care system.[5–9] Investigators have used different conceptual models to understand how poverty affects child health and, specifically, asthma morbidity, often focusing on measures of socioeconomic status (SES), but detailed pathways and potential intervention points remain unclear.[10–12]

Smoking and passive smoke exposure are both more common among socioeconomically disadvantaged populations[13] and associated with asthma morbidity.[14–16] Therefore, they may provide insight into how poverty "gets under the skin" of children with asthma. Evidence suggests that tobacco smoke exposure affects airflow and airway responsiveness in children, leading to poor asthma control and subsequent asthma morbidity.[15–18] Investigators have previously evaluated socioeconomic determinants of child tobacco smoke exposure, but common measures of SES such as income and education are challenging targets for intervention and probably only part of the explanation for the environment that children in poverty experience.[19]

Socioeconomic hardships, day-to-day challenges faced by families living in poverty such as difficulties paying bills or finding work, have been proposed as potentially explanatory and alternative models or pathways through which poverty affects health.[10,20,21] Such hardships, rooted in financial strain, have also been shown to predict lower rates of smoking cessation among smokers.[22]

Hardships that families face in the setting of low SES may be more easily affected by social, public health, and clinical interventions.[23,24] Therefore, using cotinine, a validated biomarker of tobacco smoke exposure, we sought to evaluate the association of socioeconomic hardships with a prevalent child environmental exposure: tobacco smoke.[25] Specifically, the objectives of this study were to determine whether there was a graded relationship of hardships, conceived as potentially remediable, with serum cotinine levels among children admitted to the hospital with asthma and to compare the associations of these hardships with those of more common and less modifiable SES measures with cotinine level.

METHODS

Study Design and Population

The Greater Cincinnati Asthma Risk Study (GCARS) is a population-based, prospective observational cohort that enrolled 774 children, aged 1 to 16 years, admitted between August 2010 and October 2011 to Cincinnati Children's Hospital Medical Center (CCHMC), an urban tertiary care hospital. Details related to GCARS inclusion and exclusion criteria have been previously described.[9,16] Briefly, patients were identified by use of the evidence-based clinical pathway for acute asthma or bronchodilator-responsive wheezing. Children were excluded if they had significant respiratory or cardiovascular comorbidity, if they lived outside the CCHMC 8-county primary service area, or if they had a non–English-speaking caregiver (~2% of those otherwise eligible for inclusion). The CCHMC Institutional Review Board approved this study.

Outcome: Serum Cotinine

We evaluated serum cotinine (half-life ~18 hours) as the primary outcome for this analysis. Trained nurses collected serum specimens

from patients as soon as possible after hospital admission (median of 22.8 hours, interquartile range 16.8–33.12), either through venipuncture or through an existing intravenous catheter. We centrifuged, froze, and batch-shipped samples for cotinine analysis. Investigators at Boston Children's Hospital used validated techniques to measure serum cotinine by using liquid chromatography tandem mass spectrometry.[16] The serum cotinine assays had a limit of detection (LOD) of 0.1 ng/mL.[16] We evaluated this measurement as a dichotomous variable split at the LOD so that children were noted as having detectable or nondetectable exposure.

Predictors

Hardship Measures

We assessed key reported socioeconomic hardships through a face-to-face survey completed with each patient's caregiver during the index admission. We characterized hardship by using previously validated questions that were chosen a priori, and 11 survey questions were included.[23,26–28] Specifically, financial hardship was assessed via questions relating to difficulty making ends meet, difficulty obtaining food, looking for work but being unable to find it, and having had to, for financial reasons, not pay rent or utilities, move in with others, pawn or sell possessions, or have creditors demand payment. A family's need to or inability to get help from others or borrow money during times of need was also assessed. Those answering yes to any of these 11 questions were considered to have that hardship or risk. We also created a cumulative hardship measure based on the number of hardships a family was experiencing. This cumulative measure was categorized as 0, 1, 2, 3, and 4 or more hardships.

Covariates

Our face-to-face survey also assessed demographic characteristics, such as patient age, gender, and race

(categorized as white, African American, and multiracial or other). We collected information on the education of the primary caregiver and annual household income. Both education and income were collected as ordinal variables for use as comparator measures of SES when we assessed our hardship measures.

Statistical Analysis

Our analytic sample consisted of subjects with complete exposure and outcome data ($n = 675$). We used t tests and χ^2 tests to make comparisons between children with and without complete exposure data. We calculated counts and percentages or arithmetic means and SDs for all variables measured.

To address our aims, first, we calculated the frequencies of children with and without detectable cotinine who had each of the reported hardships and compared expected frequencies using χ^2 tests. We repeated this analysis evaluating the cumulative number of hardships, income, and education. We also calculated the correlation of cumulative hardships, income, and education with detectable serum cotinine to compare the difference in strength of association. Second, we conducted a logistic regression analysis to evaluate the association of cumulative hardships with detectable serum cotinine. We conducted the same analysis for income and education separately to compare with hardships. Then we included all 3 potential predictors in the same analysis to elucidate their independent associations. Last, we conducted an adjusted analysis including child age, race, and gender along with hardships, income, and education. We used SAS version 9.3 (SAS Institute, Inc, Cary, NC) for all analyses.

RESULTS

Characteristics of Study Subjects

Complete data were available from 675 (87.2%) of the 774 study

TABLE 1 Participant Characteristics and Exposure

Characteristic	Included ($N = 675$), n (%) or Mean (SD)
Race	
White	222 (33.0)
African American	382 (56.8)
Multiracial or other	69 (10.3)
Gender	
Male	437 (64.7)
Female	238 (35.3)
Age, y	6.34 (4.04)
Type of insurance	
Private	150 (22.6)
Public	487 (73.5)
Self-pay	26 (3.9)
Income	
<$15 000	232 (34.8)
$15 000–$29 999	186 (27.9)
$30 000–$44 999	89 (13.4)
$45 000–$59 999	40 (6.0)
$60 000–$89 999	71 (10.7)
>$90 000	48 (7.2)
Caregiver education	
Less than high school	110 (16.4)
High school graduate	182 (27.2)
Some college	196 (29.3)
2-y college	87 (13.0)
≥4-y college	95 (14.2)
Serum cotinine	
Above LOD	381 (56.4)
Below LOD	294 (43.6)
Serum cotinine, median (Q1, Q3), ng/mL	0.16 (below LOD, 0.76)

LOD = 0.1 ng/mL. Q1 and Q3 represent the first and third quartile.

participants enrolled in GCARS. Of the participants in the analytic sample, 56.8% were African American, 62.7% reported an income <$30 000, 73.5% had public insurance, and 56.4% had detectable cotinine (Table 1). Children with missing cotinine or hardship data were younger than the analytic sample (4.9 ± 3.2 years vs 6.3 ± 4.0 years) but did not differ on race, gender, insurance, income, or parental education (data not shown).

Individual Family Hardships and Serum Cotinine Levels

Family hardships were common: 1 in 8 lacked money for food in the past month, 1 in 5 were unable to pay the full rent or mortgage in the previous year, and 1 in 2 had borrowed money from family and friends. Nearly all the individual hardships were significantly associated with a greater

frequency of the child having a detectable cotinine level and a higher median cotinine level (Table 2). For example, compared with children whose families reported having enough money to make ends meet, those in families with just enough or not enough money left to make ends meet at the end of the month were significantly more likely to have detectable cotinine (73.3% vs 49.7%; $P < .001$). Children in families in which the caregiver reported wanting work but being unable to find it also had significantly higher frequency of detectable cotinine (66.7% vs 48.3%; $P < .001$). Children in families who reported they "could not get help from family or friends if needed" were marginally more likely to have detectable cotinine (66.7% vs 55.1%; $P = .066$).

Cumulative Hardships and Serum Cotinine

More than 40% of families reported facing ≥4 hardships. Families with more cumulative hardships were significantly more likely to have a child with both a higher median serum cotinine level and a higher frequency of having a detectable serum cotinine level (Table 3). For example, children living in families with ≥4 reported hardships were significantly more likely to have detectable cotinine than children in families with no reported hardships (72% vs 17%, $P < .001$). Families reporting lower annual income and lower educational attainment of the primary caregiver were also more likely to have children with higher median levels of serum cotinine (both $P < .001$). Graded relationships between each of cumulative hardships, income, and education and serum cotinine were present. The Spearman correlation of the cumulative number of hardships, income, and education with child serum cotinine was 0.29, 0.37, and 0.34, respectively (all $Ps < .001$). African American children were also

TABLE 2 Family Hardships and Serum Cotinine Levels

Hardship Measures	Overall N (%)	Cotinine Median (Q1, Q3), ng/mL	Cotinine Above LOD, N (%)	P
	675	0.16 (<LOD, 0.76)	381 (56.4)	—
Not enough money left to make ends meet at the end of the month				
Yes	187 (26.5)	0.34 (<LOD, 0.95)	137 (73.3)	<.001
No	485 (73.5)	0.71 (<LOD, 0.66)	241 (49.7)	
No money for food ≥1 day last month				
Yes	89 (13.2)	0.28 (<LOD, 9.26)	61 (68.5)	.011
No	581 (86.8)	1.35 (<LOD, 7.04)	315 (54.2)	
Wanted work but could not find it in last 12 mo				
Yes	294 (43.8)	3.01 (<LOD, 9.84)	196 (66.7)	<.001
No	377 (56.2)	<LOD (<LOD, 5.13)	182 (48.3)	
Could not pay full rent or mortgage in last 12 mo				
Yes	136 (20.3)	2.83 (<LOD, 1.04)	88 (64.7)	.025
No	533 (79.7)	1.29 (<LOD, 6.69)	288 (54.0)	
Could not pay full utility bill in last 12 mo				
Yes	263 (39.4)	2.56 (<LOD, 8.40)	174 (66.2)	<.001
No	405 (60.6)	1.06 (<LOD, 6.69)	202 (49.9)	
Could not get help from friends or family if needed				
Yes	69 (10.3)	2.56 (<LOD, 9.20)	46 (66.7)	.066
No	603 (89.7)	1.23 (<LOD, 7.34)	332 (55.1)	
Could not count on people to lend $1000 if needed help				
Yes	282 (42.2)	2.92 (<LOD, 10.38)	191 (67.7)	<.001
No	387 (57.8)	<LOD (<LOD, 548.5)	185 (47.8)	
Borrowed money from friends or family in the last 12 mo				
Yes	360 (53.6)	2.45 (<LOD, 10.08)	237 (65.8)	<.001
No	312 (46.4)	<LOD (<LOD, 4.72)	141 (45.2)	
Pawned or sold possessions in the last 12 mo				
Yes	130 (19.3)	3.02 (<LOD, 10.73)	92 (70.8)	<.001
No	542 (81.7)	1.22 (<LOD, 6.69)	286 (52.8)	
Creditor demanded payment in the last 12 mo				
Yes	182 (27.2)	1.61 (<LOD, 6.69)	109 (59.9)	.249
No	488 (72.8)	1.56 (<LOD, 7.85)	268 (54.9)	
Moved in with other people in the last 12 mo to save money				
Yes	81 (12.1)	3.66 (<LOD, 11.55)	55 (67.9)	.024
No	591 (87.9)	1.41 (<LOD, 6.59)	323 (54.7)	

significantly more likely to have cotinine levels above the LOD when compared with their white counterparts (48.7% vs 39.0%, P = .02).

In unadjusted logistic regression analyses, having a larger cumulative number of hardships was associated with higher odds of the child having a detectable serum cotinine level (Table 4). If a family reported ≥4 hardships, the child had 7.1 (95% confidence interval [CI], 4.4–11.6) times the odds of having a detectable serum cotinine compared with a family reporting no hardships. A similar relationship was noted for the association between income and serum cotinine and for the association between educational attainment and serum cotinine.

In an adjusted analysis that included hardships, household income, and caregiver educational attainment along with child gender, age, and race, we found that the associations were similar to those in the unadjusted analysis (Table 4). Greater cumulative hardships, lower household income, and lower caregiver educational attainment each remained independently associated with having higher odds of the child having a detectable serum cotinine. In the adjusted model, families that reported ≥4 hardships had 3.7 (95% CI, 2.0–7.0) times the odds of having a detectable serum cotinine for the child compared with those reporting no hardships.

Additionally, in separate analyses we tested for differences in associations

based on race. There was no significant interaction of race with hardships, income, or caregiver educational attainment in the adjusted regression analyses.

DISCUSSION

Family hardships and smoke exposure were common among children admitted to the hospital for asthma or bronchodilator-responsive wheezing, with >80% of families reporting ≥1 hardship and nearly 44% having detectable levels of exposure. In addition, the more hardships the family reported, the higher the odds of the child having a detectable serum cotinine level. The strength of the association was similar to that seen for both

TABLE 3 Detectable Serum Cotinine by Hardships, Income, Education, and Race

Potential Predictor	N (%)	Serum Cotinine Median (Q1, Q3), ng/mL	Spearman ρ	P	Cotinine Above LOD, N (%)	Pa
Cumulative hardships			0.295	<.001		<.001
≥4 of 11	274 (40.8)	3.23 (<LOD, 11.25)			197 (71.9)	
3	88 (13.1)	1.94 (<LOD, 8.47)			48 (54.6)	
2	91 (13.5)	1.45 (<LOD, 5.67)			52 (57.1)	
1	102 (15.2)	<LOD (<LOD, 5.35)			50 (49.0)	
0	117 (17.4)	<LOD (<LOD, 1.13)			31 (26.5)	
Income			0.368	<.001		<.001
<$15 000	232 (34.8)	4.28 (<LOD, 11.60)			168 (72.4)	
$15 000–$29 999	186 (27.9)	2.21 (<LOD, 8.03)			121 (65.1)	
$30 000–$44 999	89 (13.4)	<LOD (<LOD, 3.75)			43 (48.3)	
$45 000–$59 999	40 (6.0)	1.41 (<LOD, 5.65)			21 (52.5)	
$60 000–$89 999	71 (10.7)	<LOD (<LOD, <LOD)			16 (22.5)	
>$90 000	48 (7.2)	<LOD (<LOD, <LOD)			5 (10.4)	
Education			0.337	<.001		<.001
Less than high school	110 (16.4)	5.70 (2.32, 16.37)			90 (81.8)	
High school graduate	182 (27.2)	1.89 (<LOD, 8.18)			107 (58.8)	
Some college	196 (29.3)	1.46 (<LOD, 5.94)			116 (59.2)	
2-y college	87 (13.0)	1.03 (<LOD, 7.43)			45 (51.7)	
≥4-y college	95 (14.2)	<LOD (<LOD, <LOD)			18 (19.0)	
Race			0.09	.02		.02
African American	382 (63.25)	2.01 (<LOD, 8.03)			108 (48.7)	
White	222 (36.75)	1.09 (<LOD, 5.70)			149 (39.0)	

a P value obtained from Mantel–Haenszel χ-square test for trend.

decreased income and lower levels of parental education attainment. Additionally, the relationship held when all 3 potential predictors were included in the same analysis. This is significant because it suggests independent associations, and hardships may be more modifiable than family income or parental educational attainment.

More than 80% of the families had ≥1 hardship. More than half of families reported the need to borrow money from friends or family in the last 12 months, and 2 in 5 wanted work but could not find it. All but 2 of the hardships were significantly associated with the child having detectable tobacco exposure as measured by the biomarker serum cotinine. There was also a graded relationship between the number of family hardships and the likelihood of a child having detectable exposure to tobacco. Indeed, nearly 72% of children in homes with ≥4 reported hardships had detectable tobacco exposure. This suggests that most hardships and increasing numbers of hardships are associated with exposure to a key environmental toxin known to adversely affect child health. There are many plausible explanations for the relationship of hardships and tobacco exposure. Downward social mobility and economic stress in childhood and adulthood are noted risk factors for

TABLE 4 Relationships of Hardships, Income, Education, and Race With Detectable Serum Cotinine: Logistic Regression Analyses

Potential Predictor	Unadjusted		Adjusteda	
	Odds Ratio for Cotinine Above LOD	95% CI	Odds Ratio for Cotinine Above LOD	95% CI
Cumulative Hardships				
≥4 of 11	7.1	4.4–11.6	3.7	2.0–7.0
3	3.3	1.9–6.0	1.4	0.7–3.0
2	3.7	2.1–6.6	2.9	1.4–6.0
1	2.7	1.5–4.7	2.2	1.1–4.3
0	Reference	Reference	Reference	Reference
Income				
<$15 000	22.6	8.6–59.5	12.5	3.2–50.0
$15 000–$29 999	16.1	6.1–42.4	10.5	2.7–40.4
$30 000–$44 999	8.0	2.9–22.2	7.8	2.0–30.6
$45 000–$59 999	9.5	3.1–29.0	11.5	2.8–48.3
$60 000–$89 999	2.5	0.9–7.4	2.9	0.7–11.4
>$90 000	Reference	Reference	Reference	Reference
Education				
<High school	19.3	9.5–39.0	6.1	2.6–14.7
High school graduate	6.2	3.4–11.0	2.2	1.1–4.5
Some college	6.2	3.5–11.2	2.4	1.2–4.9
2-y college	4.6	2.4–8.9	2.1	0.9–4.6
4-y college	Reference	Reference	Reference	Reference
Race				
African American	1.5	1.1–2.1	1.6	1.0–2.5
White	Reference	Reference	Reference	Reference

a Adjusted model included all potential predictors and child gender and age.

smoking[29]; smokers exhibit diminished stress response, increasing the likelihood of relapse due to hardships during abstinence[30,31]; and family hardships may constrain housing choices, which could limit the ability to create a smoke-free environment.[32] Another plausible explanation of increased exposure includes reverse causality, in which increased hardships are not directly associated with increased level of cotinine; rather, increased levels of cotinine are associated with increased hardships. Researchers have noted that living with an adult smoker is an independent risk factor for food insecurity.[33]

Smoking, passive smoke exposure, and higher exposure in multiunit housing have been shown to be more common among socioeconomically disadvantaged populations.[13–16,25] In our analysis, lower income, lower parental education levels, and African American race were also associated with worse child health environments, as indicated by higher levels of a child's serum cotinine. The strength of the associations of both income and education with serum cotinine was similar to that for hardships with serum cotinine (Spearman ρ 0.37 and 0.34, compared with 0.29). Importantly, cumulative hardships remained independently associated with serum cotinine even after income and education were adjusted for. Although low income and less education are not easy to address or mitigate, some of the measured hardships may be more amenable to interventions. Identifying such interventions will be particularly important for populations such as children admitted with asthma, who are at especially high risk for future morbidity and underlying hardships. Moreover, the associations of cotinine with cognition and child behavior provide additional impetus to develop effective interventions.

Smoking cessation interventions for parents of children with asthma have the potential to significantly improve child health outcomes and reduce health care utilization.[34–36] However, research has shown that to access smoking cessation interventions and sustain improvements, parents must possess sufficient motivation, persistence, attention, and energy.[36] These parental characteristics may be negatively affected by chronic hardship and strain based on resource depletion, threats to basic family needs, and worry about these threats. As a result, it is not surprising that most smoking cessation interventions have been largely ineffective for adults who experience hardships.[22,37–40] Additionally, a recent study has noted that maternal smokers reporting more smoke-related child sick visits, greater perceived life stress, and less social support were more likely to report significant depressive symptoms than mothers with fewer clinic visits, less stress, and greater social support.[41] Stress, depression, and hardships may affect child exposure levels and health, and depression may be another area for intervention.

Therefore, results of this study also provide support for interventions that are tailored to reduce hardships, such as social service consultation, assistance accessing critical resources (eg, job training programs, food assistance, public benefit programs), legal advocacy, and home visitations.[42–44] These types of interventions could address nearly all the survey items. In addition to the immediate benefits of improving self-efficacy, motivation, and trust, these interventions may also improve parents' ability to access smoking cessation interventions and maintain improvements. Interventions that address hardships may also reduce the unrelenting, cumulative stress that may be sustaining a smoker's need for nicotine.[45] Indeed, results of this study suggest that the effectiveness of evidence-based smoking cessation interventions may

be increased by targeting relevant sources of hardship.[42–45]

There were several limitations to this study. First, our sample was composed primarily of African American and white children. This factor could limit the generalizability of our findings, but our exposed proportion is similar to that reported in national surveys.[14] Another factor that could limit generalizability is that all these children were inpatients. Second, there is no single gold standard measure of family hardships. There are certainly other types of hardships, but the questions we included were representative of commonly asked questions in national surveys and studies of family hardships.[23,26,27] Third, there is potentially high correlation of variables such as income and caregiver education. However, when we included these variables in the same analysis, it improved the CI estimates and did not change the associations. Fourth, as noted earlier, there may be some element of reverse causation in which expenditures on cigarettes reduce disposable income and increase hardships. Fifth, we are not able to characterize the specific exposure source or housing type with our data.

CONCLUSIONS

Reported family hardships were common among our sample of children admitted for asthma or wheezing. Most reported hardships were associated with the child having a detectable biomarker of tobacco smoke exposure. The cumulative number of hardships was also powerfully associated with higher odds of tobacco smoke exposure. The hardship associations were similar in size and direction to those of lower income and parental educational attainment. Moreover, the associations of family hardships with child smoke exposure remained even after adjustment for income and education. However, these hardships

may present more realistic opportunities for intervention than reported family income or parental education. If effective interventions could be developed and applied, it may be a way to decrease child tobacco exposure among children with asthma and improve child health outcomes.

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