Child Maltreatment and Pediatric Health Outcomes: A Longitudinal Study of Low-income Children

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Objective   To examine if maltreatment predicted increased risk of hospital-based treatment prior to age 18 years for asthma, cardio-respiratory, and non-sexually transmitted infectious disease in a sample of low-income children.   **Methods**   This study used administrative data from multiple systems to follow children for 12–18 years ($N = 6,282$). Cox regression was used to explore the risk of first hospital treatment by disease category. Negative binomial regression was used to explore the relationship between recurrent maltreatment and total hospital care episodes.   **Results**   Controlling for individual, family, and community factors, children with maltreatment reports had a 74–100% higher risk of hospital treatment. Recurrent reports predicted a higher count of hospital care episodes.   **Conclusions**   The negative health impact of maltreatment prior to adulthood supports the need for early prevention and intervention to prevent initial and recurrent child abuse and improve capacity to meet healthcare needs of maltreated children.

Key words   child maltreatment; pediatric health outcomes; poverty; stressors.

In 2007, nearly six million American children were alleged victims of child maltreatment [US Department of Health and Human Services (DHHS), 2009]. While <25% receive a state-level designation of "victim," research has consistently found that children with investigated but unsubstantiated reports face similar risk of ongoing maltreatment and untoward outcomes (Hussey et al., 2005; Kohl, Jonson-Reid, & Drake, 2008). National estimates using the "victim" designation for whether or not maltreatment was present therefore understate the number of children at risk for later negative outcomes.

A recent estimate of the annual cost of abuse and neglect in the USA exceeded $103 billion, with <1% attributed to health (excluding injury) and mental healthcare (Wang & Holton, 2007). This, however, is likely a substantial underestimate for several reasons. First, analyses were restricted to those associated with children who suffered "demonstrable harm" from maltreatment according to the 1996 National Incidence Study, a high standard. Second, studies of adult healthcare use were used to help estimate prevalence of non-injury health problems. Little work has been done linking maltreatment to health problems in childhood or adolescence outside of obesity and eating disorders (Gilbert et al., 2009). We do not know if, or what type of, negative health outcomes among maltreated children appear prior to adulthood.

The present article adds to our understanding of whether or not adverse health outcomes are higher during childhood for children reported for maltreatment by using longitudinal data, health outcomes taken from medical records rather than parent ratings of child health, and controls for other risk factors. Health conditions (asthma, other cardio-respiratory illness, and non-sexually transmitted infection) were selected as outcomes because of their high prevalence, cost, and potential sensitivity to external stressors. Consistency of findings with cumulative stress and allostatic load theories was explored and elaborated.

Background

Many serious and costly pediatric conditions exist which may be associated with child maltreatment. Asthma is the

most common chronic disease of childhood in the USA (Centers for Disease Control and Prevention, 2001). In a recent study on trends in pediatric care emergency department (ED) usage, diseases such as asthma, pneumonia, pleurisy, and bronchitis topped the list of reasons children visit the ED (Kanter & Moran, 2006). Other bacterial and viral infections like pharyngitis are also common in childhood (Simon, 2008). Publicly insured children are more likely to use hospital and ED care (Elixhauser et al., 2002). Costs increase according to whether or not children are receiving regular pediatric care compared to acute care for chronic illness like asthma (Lara et al., 2002).

While research on pediatric illness among maltreated children is lacking, research on socioemotional and developmental outcomes suggest much higher risk for this population (Hussey et al., 2005; Kohl et al., 2009). The most recent national rate of children whose report of abuse or neglect resulted in an investigation or assessment by a child welfare agency was 47.2 per 1000 (US DHHS, 2009). If maltreatment is associated with higher risk of common and high-cost pediatric illnesses, this represents a substantial healthcare burden. Understanding whether or not maltreated children have a higher prevalence of care for such disorders during childhood may help inform improved targeting of health and child abuse prevention efforts, and may contribute to reductions in subsequent, related disorders (Forrest, Starfield, Riley, & Kang, 1997).

The majority of research examining child abuse and neglect and health outcomes focuses on adults. Maltreatment is generally measured retrospectively, which has problematic validity and reliability (Widom, Raphael, & Dumont, 2004). Studies report that adult survivors suffer higher rates of cardiovascular disease, ischemic heart distease, hypertension, inflammation, diabetes, chronic pain, headaches, chonic fatigue, irritable bowel syndrome, weight problems, eating disorders, and asthma (Bonomi, Cannon, Anderson, Rivara, & Thompson, 2008b; Corso, Edwards, Fang, & Mercy, 2008; Cromer & Sachs-Ericsson, 2006; Danese et al., 2008; Dong et al., 2004; Johnson, Cohen, Kasen, & Brook, 2002; Lang et al., 2008; Sachs-Ericsson, Kendall-Tackett, & Hernandez, 2007; Springer, Sheridan, Kuo, & Carnes, 2003, 2007). Women with a history of abuse are reported to generate between 36% (Bonomi et al., 2008a) and 93% (Tang et al., 2006) greater healthcare costs than their non-abused counterparts.

The consistent link between child maltreatment and adult health problems suggests that we need to know more about how child maltreatment affects health at a much earlier stage of development (Carlson & Chambelain,

2005; Furumoto-Dawson, Gehlert, Sohmer, Olopade, & Sacks, 2007). Work in this area is underdeveloped. Most studies are cross-sectional (with retrospective recall of maltreatment) or have examined only a single health outcome, such as asthma (e.g., Cohen, Canino, Bird, & Celedon, 2008). Furthermore, many of the studies rely on potentially unreliable maternal reports (Hoagwood et al., 2000) of child health status or treatment. Cohen and colleagues (2008) surveyed 1,213 Puerto Rican households and found retrospective recall of physical or sexual abuse was associated with higher rates of asthma among children, controlling for perceptions of neighborhood violence and other stressful life events. Graham-Bermann and Seng (2005), relying on maternal report, found a significant association between child abuse and a range of health issues in a cross-sectional study. Hussey, Chang, and Kotch (2006) found that adolescents who retrospectively recalled maltreatment also tended to have higher rates of obesity, depression, and substance use.

Only two prior longitudinal studies were located and results were inconclusive. Flaherty and colleagues (2006) examined the relationship of a range of ''adverse child experiences'' at age 4 years to maternal report of health status at age 6 years. There was a lower rate of ''poor health'' associated with these experiences, but a higher rate of ''illness requiring professional care.'' It is impossible to know if maltreatment was significant among the adverse experiences as maltreatment was not disaggregated (Flaherty et al., 2006). A study of sexual abuse survivors reported higher rates of obesity in adulthood, but not during childhood (Noll, Zeller, Trickett, & Putnam, 2007).

Theoretical Framework

The ecological theory of human development is widely accepted as the best framework for understanding maltreatment's impact on the child (Zielinski & Bradshaw, 2006). This perspective helps frame how the environment goes ''under the skin'' to affect physiology and cause disease (Carlson & Chamberlain, 2005; Gehlert et al., 2008). While the relationship between poverty and poor child health is well established (Aber, Bennett, Conley, & Li, 1997; Evans, 2003), the relationship of other environmental risks like maltreatment is understudied.

Within this framework, one potential mechanism for increased health problems among children who experience maltreatment and/or poverty is allostatic load (Evans 2003, 2004; Gordis, Granger, Susman, & Trickett, 2008; McEwen, 1998). Allostasis is the active, cyclical process that occurs when stress results in the over- or under-utilization of physiological resources in order to

regain homeostasis, or stability (Vig, Forsythe, & Vliagoftis, 2006). While allostasis can be beneficial in the short-term, chronic and repeated activation of these physiological resources cause wear and tear on organs and exhaust the body of resources, with damaging long-term effects (McEwen & Seeman, 1999). Allostatic load is a term for the cost to the body as it continually experiences stress responses. Organs of the pulmonary, respiratory, and circulatory systems are especially vulnerable to allostatic load (Cicchetti & Walker, 2001; Danese, et al., 2008; Dong, et al., 2004), but the immune system may also be compromised (McEwen, 1998).

Present Study

Thus, theoretical reasoning and a few empirical studies suggest maltreated children may manifest worse health outcomes before adulthood. This, however, remains to be established with longitudinal data which include neglect, which is more common than abuse (US DHHS, 2009). Although the present study did not include physiological measures, the disease category outcomes involve those systems thought to be sensitive to continual stress response. The present study investigated childhood nega-tive health outcomes for low-income children with and without investigated reports of maltreatment.

The primary research question addressed was: ''among low-income children, are maltreated children at higher risk of hospital care for asthma, cardio-respiratory disease, or other non-sexually transmitted infection, con-trolling for other stressors in the home and community?'' Two hypotheses guided analyses. First, compared to children not reported for abuse or neglect, children so reported would show increased risk of disease while con-trolling for other stressors and demographics. The second hypothesis is that risk for hospital care and repeat care for the aforementioned diseases will increase with additional maltreatment reports.

Methods

This article used data from a longitudinal study of services and outcomes for children in a major Midwestern metro-politan region from families receiving Aid to Families with Dependent Children (AFDC) between 1991 and 1994. The larger study includes two groups: (1) a group with a first report for abuse or neglect in 1993–1994 (the ''maltreatment group''); and (2) a group of similarly poor children with no record of child maltreatment reports (the ''comparison group''). The sample was limited to children whose first report occurred prior to the age of 12 years

(born 1982–1994) to allow comparison to the only similar existing study (i.e., Widom, 2000). The comparison group was matched to the maltreatment group by birth year and region of residence. Data cleaning resulted in the loss of 1.6% of the sample, leaving a total sample of 10,089.

Analysis Sample

The earliest hospital data were available beginning 1986 so subjects for the present analyses were restricted to those born in ≥ 1985 ($n = 8,543$) with non-missing records of birth ($n = 7,576$). Children in the poverty only group were followed prospectively and some had later reports of maltreatment. Because such reports could not occur until after the sampling period, these children had to be older at time of first report and so were excluded. Remaining subjects included 3,845 from the original maltreated group compared to 2,417 comparison (never reported) children. Due to the demographic characteristics of the low-income population in the study region, nearly 80% of the sample was African–American. At the end of the follow-up period (through 2006 or when a child turned 18 years), the mean child age was 16.62 years, with a range of 12–22 years. The study received approval from the Washington University Hilltop Human Subjects Committee.

Data

All data for the present study were extracted from state information systems. Data included vital statistics (birth and death), child abuse and neglect reports, child welfare service records, income maintenance, parent Medicaid mental health records pre-1995; statewide Medicaid reimbursed child healthcare (limited to hospital-based treatment for this study), ED records (these are universal except for Veteran's Administration hospitals), and child mental health and disability records from special education and the Department of Mental Health. While these administrative data cannot be used to assess unmet need or neurochemical or biological mechanisms, they do allow for precise dating of an allegation of abuse or neglect and healthcare treatment. This helps avoid limitations of retro-spective recall of maltreatment and/or services (Hoagwood et al, 2000; Widom et al, 2004). Administrative records miss unreported cases of maltreatment, but this serves as more conservative test of a relationship between maltreat-ment and child health. Medical records offer more granular descriptions of children's health conditions and may provide a more accurate estimate of healthcare use (Hoagwood et al., 2000).

Linkage between most of the data sets was facilitated by a common identifier across agencies. Other data were

linked according to a combination of individual identifiers. Coding decisions were based on the relevant extant literature, the need to aggregate at a sufficient level to insure confidentiality, and thorough understanding of the practices and policies related to the recording of data elements (Jonson-Reid & Drake, 2008).

Dependent Variables

Outcome categories were recoded from International Classification of Diseases 9 (ICD-9) diagnostic variables in the hospital care data. Diagnoses potentially associated with allostatic load were selected and verified in consultation with a pediatrician. Diagnoses were collapsed into asthma; non-asthma cardio-respiratory disease (e.g., hypertensive disease, cardio conditions secondary to infection, acute respiratory infection, chronic pharyngitis, sinusitis and tonsils, pneumonia, bronchitis and influenza); and other infections (e.g., intestinal, tuberculosis, bacterial (non-zoonotic), mycoses, and viral). We excluded infectious conditions that might have an intermediary health risk behavior like sexually transmitted diseases (STDs) or an environmental component like infection due to louse infestation. We excluded congenital conditions, obstruction, or syndromes likely present at birth.

For hypothesis one, we examined any of the three disease group outcomes and the risk of first hospital treatment (ED, inpatient, or hospital clinic) for each. For hypothesis two, descriptive statistics were run for total hospital care episodes by illness category and multivariate analyses conducted for the count of all hospital treatment episodes for all outcomes combined. For ease of communication, we reference hospital care rather than disaggregating emergency room, other hospital-based clinic, or inpatient care. Due to the characteristics of the study region, out-of-state medical care was unlikely to be commonplace.

Independent/Control Variables

Maltreatment

Independent variables included presence of a maltreatment report, type of maltreatment report, and number of maltreatment reports over time. While this excludes unreported maltreatment, prior work indicates substantive differences in later outcomes and risks between the ''maltreated'' and low-income-only groups (Jonson-Reid, Drake, & Kohl, 2009). Both substantiated and unsubstantiated reports were included due to the demonstrated similarity in their nature and predictive utility (Hussey et al., 2005; Kohl et al., 2009).

For hypothesis one, an overall indicator (yes/no and date of report) of maltreatment was used. In some cases,

a child's first report of maltreatment was preceded by the first episode of hospital care. Because a first report of maltreatment may not be indicative of when abuse or neglect actually began, we chose to handle the maltreatment variable in two ways. In the overall descriptive statistics in Table I, maltreatment is indicated by the presence or absence of a report without consideration of time ordering. In the predictive models, however, maltreatment was used as a time-varying variable. A child with a maltreatment report prior to the episode of the health outcome of interest was coded as ''maltreated'' while those whose reports follow the hospital episode were coded as ''not maltreated.'' This provided a more conservative estimate of the relationship of maltreatment to the outcome.

For hypothesis two, the sample was restricted to children with a report of maltreatment. Recurrent maltreatment was measured in two ways. First, reports were collapsed into categories (a single report, 2–3 reports, 4–6 reports, 7–9 reports, and >10 reports) to assess the bivariate relationship to hospital treatment for the health outcomes of interest. In multivariate analyses, the independent variable was the number of reports.

Child age at first report and first report type were also controlled in the multivariate model. Age at first report was a child's age in years at the time of the first report of abuse or neglect (0–11 years). Maltreatment type was measured according to a first type of neglect compared to abuse. Type of maltreatment was taken from the 44 reported subtypes recorded by the state agency (up to five subtypes per report) and recoded into major categories. For example, physical abuse included subtypes like: bruises, welts, red marks, internal injuries, etc; sexual abuse included fondling, digital penetration, etc.; neglect included lack of supervision, insufficient food and shelter, untreated illness or injury, etc.

Child and Family Demographics

Control variables included race (White = 1), gender (female = 1), year of birth (1985–1994). Because of the demographics of the region, virtually all subjects (98%) were Black or White. Parent demographics included age at birth of child and high school graduation. Given our AFDC sample, <2% of the parents were not females, single heads of household, so parent gender and family structure were not controlled.

Child Service/Health History

A dichotomous medical risk variable indicated a child was born very low birthweight, had serious health issues at birth, or a condition like cystic fibrosis, sickle cell anemia, etc. Also measured was the date of first childhood

Table I. Association of Variables with At Least One Episode of Hospital Care for Asthma, Cardio-respiratory, or Infectious Disease Compared to No Disease

	No Disease (N = 2554) %/M (SD)	Asthma (N = 909)[a] %/M (SD)	Cardio-respiratory (N = 2835)[a] %/M (SD)	Infectious (N = 1912)[a] %/M (SD)
Child characteristics				
Race (White)	21.5	13.7*	20.4	17.8**
Gender (Female)	50.3	40.1*	46.6**	48.3*
Medical risk infancy (Yes)	12.3	24.1*	20.8*	22.8*
Special education (Yes)	22.8	34.0*	28.4*	29.9*
Any public-funded MH tx (Yes)	6.6	9.6**	8.6**	8.2***
Family characteristics/stressors				
Parent Highschool graduate (Yes)	55.0	48.1**	48.8**	47.7*
Parent criminal record (Yes)	9.9	11.1	9.9	9.4
Parent psychiatric history (Yes)	11.7	16.2**	13.3	13.8***
Parent age at birth (14-49 yrs)	23.9 (6.1)	24.1 (6.4)	23.6 (6.3)***	23.3 (6.2)**
Number of AFDC services (1-11)	2.4 (1.6)	2.7 (1.7)*	2.7 (1.7)*	2.8(1.7)*
Census tract stressors				
Income (in 1000s)	24.0 (10.9)	21.9 (10.0)*	23.6 (10.6)**	22.6 (9.9)*
Mobility last 5 years				
Low <40% moved	41.3	38.2	37.5	38.4
Medium 40–60%	44.7	45.2	46.4	44.8
High >60%	13.9	16.6	16.1**	16.9**
Sample group				
AFDC Only	43.4	32.4	34.5	34.9
CA/N sample group	56.6	67.6*	65.5*	65.1*

[a]Disease categories are any incident of hospital care and thus subjects can be counted in more than one column.

Significance reported compared to no disease group: *$p < .0001$, **$.0001 < p < .01$, ***$.01 < p < .05$; proportions significance is from chi-square; mean differences are from t-tests.

mental health service (emotional disturbance in special education or Department of Mental Health ICD–9 diagnosis).

Parental and Community Characteristics

Chronic poverty was measured as the number of AFDC/Temporary Assistance to Needy Families (TANFs) spells. Other parent characteristics included criminal history (arrest or incarceration), psychiatric history (public-funded services for mental health or substance abuse vs. none), and education status (high school graduation as recorded on AFDC or child abuse or neglect (CA/N) report in 1993–1994 timeframe). Data were geocoded and linked to 1990 Census Summary Tape File—3 data. Household income (1990 dollars) was divided by $1,000 to support interpretation. For analyses, tract mobility was trisected evenly and categorized as high, medium, or low for ease of interpretation.

Analysis

Data management and analyses were done in Statistical Analysis Software (SAS) 9.1. First, simple bivariate statistics compared children with "any occurrence" of hospital care for asthma, other cardio-respiratory disease, and/or infectious disease to children without such care. Hypothesis one examined a "first hospital care episode" for each of the three disease outcomes for children reported for maltreatment with those not reported. Cox regression was used as the multivariate approach because of the capacity to model a dichotomous outcome, control for time at risk, adjust for potential subject clustering in census tracts using robust standard errors, and to incorporate time-varying variables. Time at risk was in years from birth to either a "first hospital care episode" of a disease outcome, death, or age 18 years. Maltreatment report and child mental health treatment were entered as time-varying covariates to insure proper time ordering and risk period comparisons (Allison, 1995). Bivariate survival analyses were utilized (not shown) to test the equality of survivor functions and to assess the assumption of proportionality. If a violation was found, a time interaction was created. The interaction term was tested in the multivariate model and only retained if significant, or if it altered the significance of other variables or the model fit.

The Cox regression output includes hazard ratios (exponentiated parameter coefficients), a magnitude of

effect measure similar to odds ratios in interpretation. A statistically significant hazard ratio >1 indicates an increased risk and between 0 and 1 reflects decreased risk. For continuous variables the hazard ratio is interpreted as the change per unit of measurement. Variables were entered in blocks: (1) child demographics only; (2) all child and family level characteristics; (3) child, family, and census tract characteristics; (4) all prior variables and maltreatment. Confidence intervals are provided for the final model.

For hypothesis two, the sample is restricted to those with a maltreatment report to further understand the role of chronic maltreatment and control for type and age at onset. A Cochran-Armitage Trend test was used to test the association of repeated maltreatment with hospital care for infection, asthma, or other cardio-respiratory illness. To further investigate the relationship between chronic maltreatment and disease, a negative binomial regression was used to model the count of hospital episodes for the three disease categories. This approach (appropriate for count data with substantial zero counts) was used with an offset for years at risk using the repeated statement to obtain robust standard errors (Allison, 1999; UCLA, 2009).

Results

The final sample for the study consisted of 6,282 children, 59.4% having a record of hospital care for asthma, or other cardio-respiratory diseases. A total of 909 (14.5%) had treatment for asthma, 2,835 (45.1%) had treatment for other forms of cardio-respiratory disease, and 1,912 (30.4%) were treated for infectious diseases. About 2.6% of the children were treated for asthma only during the study; 19.8% were treated for cardio-respiratory disease only; 9.6% were treated for other infectious disease only. The average age of the maltreated children at first hospital care was about 3 years. It was possible for one of the disease categories of interest to occur prior to a child's first report of abuse or neglect. About 21% of the children reported for maltreatment had their first report after the first recorded hospital care for at least one of the disease categories. First we examined the bivariate relationship of disease outcomes to maltreatment without considering time ordering (maltreatment report is yes or no).

Table I shows simple bivariate statistics comparing children with any hospital care by type of disease category to those without hospital care for these categories (n sizes refer to the children per outcome category). The outcome category sample sizes total >100% because some children experienced hospital care for more than one of the three

outcome categories. Compared to African–American children, White children (21% of the sample) were significantly less likely to have treatment for an asthma episode (only 13.7% of episodes, $p < .0001$) or infectious disease episode (though the difference was practically small, 17.8% vs. 21.5%, $p < .01$). Females had lower representation in all disease categories while children with disabilities (measured by special education status) were more likely to be in all three disease categories. Children with pre-existing health conditions were approximately 75–100% more likely to receive treatment for one of the three disease categories. Children whose parents had a high school diploma were less likely to have treatment for any disease category. For all disease categories, children in the maltreated group were over-represented compared to similarly poor children with no record of maltreatment.

Hypothesis 1: Compared to children not reported for abuse or neglect, children so reported will show increased risk of disease while controlling for other stressors and demographics. Cox regression models were used to examine the risk of first asthma, first cardio-respiratory, or first infectious disease episode (Tables II–IV). Variables were entered in hierarchical blocks to examine model improvement from demographic variables only, to inclusion of non-maltreatment stressor variables, to models with maltreatment included. The model of other cardio-respiratory and infectious disease required the addition of time interactions to address proportionality violations (Tables III—IV). In the interest of space, confidence intervals, as well as discussion of findings are provided for the final model only. For all models, there was a statistically significant difference in model fit between model 3 and model 4.

Associations with child demographics did not change materially from bivariate findings with the exception of a time interaction in the model of cardio-respiratory disease. In this model, White children had lower risk, but over time this changed (increase in 6% per year) so that by the end of the study period White children had higher risk (Table III). Females were less likely to have asthma or cardio-respiratory problems. Infant medical risk was associated with between a 41 and 62% increase in risk across all outcomes. The control for birth year indicated that the older children were more likely to experience hospital care. Measures of family poverty (AFDC/TANF use) and median household income in the census tract (in $1,000 increments) were significant covariates for asthma and infection, but only the measure of continued welfare use was significant for cardio-respiratory disease. An increase in the number of AFDC/TANF spells (range 1–11) was associated with risk of treatment for asthma or

Table II. Hazard Ratios from Cox Regression: Predicting Risk for First Hospital Care Episode for Asthma

	Model 1	Model 2	Model 3	Model 4	Confidence interval
Child					
Race (White)	0.59***	0.63**	0.70***	0.67***	0.55–0.82
Gender (Female)	0.67***	0.67***	0.67***	0.66***	0.58–0.76
Birth year (in years)	1.19***	1.18***	1.19***	1.14***	1.11–1.18
Infant health risk (Yes)		1.68***	1.69***	1.62***	1.40–1.89
Mental health tx (Yes)[a]		1.74**	1.69**	1.47*	1.03–2.09
Family/Environmental stressors					
Parent age at birth in years (13–50)		1.00	0.99	0.99	0.99–1.01
Parent HS graduate (Yes)		0.84*	0.89	0.94	0.82–1.08
Parent psychiatric history (Yes)		1.24*	1.22*	1.13	0.94–1.35
Number of AFDC services (1–11)		1.05**	1.05*	1.04*	1.001–1.08
Census tract					
Mobility (low, medium, high)			1.13*	1.13**	1.03–1.23
Income level (in $1000s)			0.99**	0.99**	0.98–0.99
Maltreatment report (time-varying)					
Any report (Yes)[a]				1.73***	1.47–2.04
	Wald sandwich $\chi^2 = 221.52$ df = 3, $p < .0001$	Wald sandwich $\chi^2 = 308.62$ df = 9, $p < .0001$	Wald sandwich $\chi^2 = 325.55$ df = 11, $p < .0001$	Wald sandwich $\chi^2 = 385.52$ df = 12, $p < .0001$	

[a]Indicates time varying covariates = 1 if occur prior to hospital care. *$p < .05$, **$p < .01$, ***$p < .001$.

Table III. Hazard Ratios from Cox Regression: Risk for First Hospital Care Episode for Cardio-Respiratory (Not Asthma)

	Model 1	Model 2	Model 3	Model 4	Confidence interval
Child					
Race (White)	0.82**	0.86**	0.86*	0.83**	0.74–0.94
Gender (Female)	0.89**	0.89**	0.89**	0.88**	0.82–0.95
Birth year (in years)	1.25***	1.25***	1.26***	1.18***	1.16–1.21
Infant health risk (Yes)		1.45***	1.46***	1.41***	1.29–1.55
Mental health tx (Yes)[a]		1.60**	1.60**	1.34	0.97–1.84
Family/Environmental stressors					
Parent age at birth in years (13–50)		0.99**	0.99**	0.98***	0.98–0.99
Parent highschool graduate (Yes)		0.90**	0.92*	0.99	0.91–1.07
Parent psychiatric history (Yes)		0.91	0.91	0.84*	0.73–0.97
Number of AFDC services (1–11)		1.06***	1.06***	1.05***	1.02–1.07
Census tract					
Mobility (low, medium, high)			1.13***	1.13***	1.07–1.19
Income level (in $1000)			1.00	0.99	0.99–1.00
Maltreatment report (time-varying)					
Any report (Yes)[a]				2.07***	1.87–2.29
Time interaction correction for proportionality					
Race × Time at risk	1.06***	1.06***	1.06***	1.05**	1.02–1.07
Parent Psych × Time at risk		1.04*	1.04*	1.03	1.00–1.06
	Wald sandwich $\chi^2 = 779.51$ df = 4, $p < .0001$	Wald sandwich $\chi^2 = 885.85$ df = 11, $p < .0001$	Wald sandwich $\chi^2 = 904.33$ df = 13, $p < .0001$	Wald sandwich $\chi^2 = 1254.11$ df = 14, $p < .0001$	

[a]Indicates time varying covariates = 1 if occur prior to hospital care.
*$p < .05$, **$p < .01$, ***$p < .001$.

Table IV. Hazard Ratios from Cox Regression: Risk for First Hospital Care Episode for Infection (Not Zoonotic)

	Model 1	Model 2	Model 3	Model 4	Confidence interval
Child					
Race (White)	0.82**	0.87*	0.94	0.89	0.78–1.02
Gender (Female)	0.94	0.93	0.93	0.92	0.84–1.00
Birth year (in years)	1.24***	1.25***	1.25***	1.18***	1.16–1.21
Infant health risk (Yes)		1.66***	1.66***	1.59***	1.43–1.78
Mental health tx (Yes)[1]		1.54*	1.51*	1.27	0.88–1.80
Family/Environmental stressors					
Parent age at birth in years (13–50)		0.98***	0.98***	0.97***	0.96–0.98
Parent highschool graduate (Yes)		0.91*	0.95	1.02	0.93–1.13
Parent psychiatric history (Yes)		0.90	0.91	0.82*	0.69–0.98
Number of AFDC services (1–11)		1.08***	1.08***	1.07***	1.04–1.09
Census tract					
Mobility (low, medium, high)			1.13**	1.13**	1.06–1.21
Income level (in $1000s)			0.99***	0.99***	0.98–0.99
Maltreatment report (time-varying)					
Any report (Yes)[a]				2.09***	1.85–2.36
Time interaction correction for proportionality					
Parent Psych × Time at risk		1.05**	1.05**	1.04*	1.01–1.08
	Wald sandwich $\chi^2 = 553.10$ df $= 3$, $p < .0001$	Wald sandwich $\chi^2 = 664.13$ df $= 10$, $p < .0001$	Wald sandwich $\chi^2 = 697.02$ df $= 12$, $p < .0001$	Wald sandwich $\chi^2 = 943.18$ df $= 13$, $p < .0001$	

[a]Indicates time varying covariates $= 1$ if occur prior to hospital care.
*$p < .05$, **$p < .01$, ***$p < .001$.

infectious disease (4 and 7% per spell, respectively). The older the parent (range 13–50 years) was at the birth of the child the lower the risk for cardio-respiratory and infectious disease (2 and 3% decrease per year of parent age, respectively). Greater mobility in the census tract was associated with higher risk. The hazard ratio for mental health decreased when maltreatment status was entered and only remained significant for asthma. Maltreatment increased risk from 73% for asthma to slightly more than double for the other two categories.

Hypothesis 2: Recurrent maltreatment predicts increased risk of disease. To examine the relationship between multiple reports and disease category, cases were limited to those who had a first report of maltreatment prior to a first hospital care episode for any of the outcomes of interest ($n = 2,906$). For bivariate analysis, the number of maltreatment reports was collapsed into five categories: 1 report (30.5% of subjects), 2–3 reports (about 33% of subjects), 4–6 reports (about 22% of subjects), 7–9 reports (about 5% of subjects), and >10 reports (about 3% of subjects). For each disease outcome, the Cochran-Armitage Trend test indicated an association between greater number of reports and the first hospital care episode for that disease category.

A negative binomial model was used to predict the total count of hospital care episodes across disease categories to further explore the relationship of chronic maltreatment to healthcare burden. The initial model dispersion parameter was significantly >1, indicating the negative binomial was superior to a poisson regression approach. A chi-square test was run on the difference in the log likelihood for the full model (–4847.82) compared to a null model (–4947.71) with six degrees of freedom and was significant ($p < .0001$), meaning the overall model was significant. The model was run using the repeated statement to obtain robust standard estimates. These were exponentiated to obtain the expected change in number of hospital care episodes. The change in expected count was 1.05 per additional report of maltreatment (range 1–23; $p < .0001$), controlling for child race and sex, maltreatment type (any neglect vs. abuse), age at first maltreatment report, substantiation of the first report, infant/congenital health risk, and mobility in the census tract. Increased age in years at first maltreatment report (range 0–11 years) was associated with a significant, but practically small (0.99) decrease in expected count of hospital care episodes. Females predicted count was lowered by 0.86 compared to males. Infant/congenital risk increased the predicted count by a factor of 1.74 ($p < .0001$). Maltreatment type (neglect compared to any abuse) and substantiation of the first report were not significant.

Discussion

The associations observed between child maltreatment and asthma, cardio-respiratory, and infectious disease controlling for other stressors were consistent with the theory of allostatic load. Other factors at the child, family, and community levels also increased the risk of hospital care. These findings were consistent with the ecological framework and research stressing the importance of environmental and multilevel factors in health (Gehlert et al., 2008).

Maltreatment

Our findings suggest that cost estimates based solely on adult health outcomes may substantially underestimate the increased healthcare burden associated with maltreatment. Our study adds to the small literature suggesting that differences in health outcomes associated with maltreatment appear much earlier (Flaherty et al., 2006). While limiting data to services provided in hospital settings may substantially underestimate the prevalence of disease, these are high cost venues for care (Lara et al., 2007) and important in their own right.

A lack of association between type of maltreatment and health outcomes is consistent with studies of behavioral and mental health outcomes (Gilbert et al., 2009). Most prior work was limited to physical or sexual abuse, but our work suggests neglect may be an equally important stressor. More work needs to be done to understand the role of neglect.

Other Child Level Factors

The finding that infant or congenital medical risk was also a consistent predictor of negative health outcomes is consistent with other research of low birthweight and numerous chronic disorders (Nanyonjo, Montgomery, Modeste, & Fujimoto, 2008). The resulting change in the effect of child mental health treatment when a report of abuse or neglect was controlled suggests a possible mediation effect. We choose not to complete a test of mediation because of the difficulty in interpreting the meaning of the relationship of treatment for mental health as compared to need to later health outcomes. Overall, our data were consistent with Danese and colleagues (2008) findings that services for mental health did not negate the relationship between maltreatment and health outcomes in adulthood.

Significant increased risk for non-White children remained only for the model of asthma and cardio-respiratory disease categories. This is consistent with other studies that have found that asthma

disproportionately affects racial and ethnic minorities (Cohen et al., 2008; Miller, 2000). Females were less likely to experience hospital care for asthma and cardio-respiratory disease categories. This is consistent with research indicating boys have higher rates of asthma (Almquist, Worm, & Leyneart, 2008) and risk factors for coronary heart disease (Raitakari, Porkka, Vilkari, Ronnemaa, & Akerblom, 1994). More work needs to be done in this area to understand whether gender effects are based on biology, socialization, or a combination of both.

Parent Characteristics

Children of older parents had lower risk of hospital care for non-asthma cardio-respiratory disease and infection. It may be that older parents are able to provide better care. Given the literature suggesting an effect of maternal depression on parenting behaviors and child healthcare (e.g., Minkovitz et al., 2005), it was somewhat surprising that parental mental health treatment was not positively associated with increased risk. On the other hand, those parents who seek out and obtain treatment for mental health problems may differ from those who have mental health needs but do not seek services.

Family and Community Poverty

Family and community poverty increased the risk for asthma and infectious disease separate from maltreatment. Chronic family poverty (increased number of AFDC/TANF spells) and higher neighborhood mobility was associated with higher risk of all disease groups. Other studies have found that children who are from lower socioeconomic status backgrounds have poorer health outcomes including cardiovascular and respiratory disease (Evans, 2003; Poulton et al., 2002). Poverty is also associated with increased risk of infant and congenital health problems (Starfield et al., 1991).

Strengths and Limitations

This study improves on prior work by using longitudinal data with a large enough sample to control for additional risks and stressors to examine adverse health outcomes in childhood. Further, the use of administrative records allowed for dating of alleged maltreatment and healthcare services use rather than retrospective recall or maternal ratings of child health. While these are significant contributions, there were also limitations.

While findings were consistent with allostatic load ideas, the data used did not include biochemical measures. Furthermore, administrative data limit the researcher to

exploring constructs that are already present in the data. For example, parental mental health was ascertained from service use rather than actual presence of disorder. The infectious disease category used in this study was broad. While infection risk may be higher among individuals with increased allostatic load due to a suppressed or dysregulated immune system (McEwen, 1998), there are other unique factors that should be considered. For example, several of the diseases included in this category including influenza, chicken pox, hepatitis, etc., have available immunizations. Only 77% of toddlers received the basic immunizations in 2001 with much lower immunization rates among minorities, low-income, and inner-city populations (American Academy of Pediatrics, 2003; CDC, 2001). The higher rates of infectious disease may be related to parent knowledge and healthcare disparities.

Implications

Research
This study supports the emerging literature suggesting that differences in health outcomes for maltreated children can be seen in childhood. Future research is needed to measure physiological mechanisms to see if allostatic load is responsible. Future research should also continue to explore the role of child neglect in childhood health outcomes. Research is also needed to understand whether or not children with poor health outcomes become adults with continuing or worsening health problems. If so, increased expenditures on known child health issues would clearly yield cost savings over the long term.

Policy and Practice
Genetic predispositions or environmental conditions such as poverty are either uncontrollable or deeply imbedded in our society, but child abuse and neglect is preventable. This should lend additional support to the value of the prevention of maltreatment. Many infant and congenital health problems are also preventable. The cost of infant mortality and adverse birth outcomes were estimated to take up 10% of the total national cost of children's healthcare in 1998 (US DHHS, 1998) and research suggests that low birthweight infants are at greater risk of maltreatment (Brown, Cohen, Johnson, & Salzinger, 1998). Targeted prevention and interventions for this extremely vulnerable group should continue to be a national priority.

There are also implications for healthcare practices. Attention should be paid to the health needs of children reported for maltreatment separate from concerns of immediate harm. As not all children who experience maltreatment are reported, pediatric healthcare professionals need to be sufficiently trained to detect child maltreatment, particularly among children experiencing chronic asthma, cardio-respiratory, or infectious disease. Being aware of a history of child maltreatment may enable intervention to prevent ongoing maltreatment and help ameliorate long-term negative health effects.

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