The Economic Cost of Substandard Housing Conditions Among North Carolina Children

Conducted by
David Chenoweth, PhD
Chenoweth & Associates, Inc.

Introduction by
Chris Estes
North Carolina Housing Coalition

May 2, 2007

NORTH CAROLINA HOUSING COALITION
EDUCATING *and* ADVOCATING *for* CHANGE

Table of Contents

About the Author

Dr. David Chenoweth

Dr. Chenoweth is President of Chenoweth & Associates, Inc., an econometric data analysis and consulting firm. He has a Ph.D. from The Ohio State University where much of his initial research centered on prospective medicine and health risk appraisal (HRA). Using principles from various fields – economics, health education, epidemiology, and risk management – he developed the ***Proportionate Risk Factor Cost Appraisal***™ - a state-of-the-art cost analysis framework that he has in quantifying the cost of physical inactivity, obesity, and other risk factors for the states of California, Massachusetts, Maine, Michigan, North Carolina, New York, Texas, and Washington. He has worked with nearly 100 business, industry, and health care organizations on various data analysis and econometric evaluations.

He served on the economic impact of worksite health promotion panel convened by the Association for Fitness in Business in the early 1990s, and subsequently served several years as a monthly columnist for *Occupational Health & Safety*. He was invited to speak at a worksite health promotion forum in Czechoslovakia sponsored by the European Union in 2005. A year earlier, he served as the chief econometric analyst in creating the well-publicized *physical inactivity cost calc tool* sponsored by a grant from The Robert Wood Johnson Foundation. Dr. Chenoweth has written nine books on topics ranging from health care cost management strategies to evaluating worksite health promotion programs.

Recently, he served as the lead author on the health economic analysis portion of a major report sponsored by the Trust for Public Land. For nearly 14 years, he served as Chair of the Business & Industry committee of the N.C. Governor's Council on Physical Fitness and Health, is a member of the Medical Advisory Board for the Wellness Councils of America (WELCOA), and a member of the American College of Sports Medicine. He was awarded the President's Award by Region II of the Association for Worksite Health Promotion in 1995. Since 1979 he has served on the faculty in the College of Health & Human Performance at East Carolina University and teaches courses in planning, evaluation, and data analysis.

Chris Estes, MSW, MRP

Chris Estes is the Executive Director of the North Carolina Housing Coalition, a statewide nonprofit membership organization that provides advocacy and resource information on affordable housing for low to moderate income North Carolinians. Its mission is to lead a campaign for housing to ensure that low-income North Carolinians can live with dignity and opportunity.

Chris has served or is serving on the Housing Task Force of the NC Division of MH/DD/SA, Housing for Persons With Aids Task Force (HOPWA), United Way of NC Public Policy Committee, NC Asset Development Task Force, Interagency Coordinating Council for Homeless Programs, and NC Housing Choice Voucher Task Force. Chris is an adjunct faculty member at the UNC-CH School of Social Work and holds two master's degrees from UNC-Chapel Hill in Social Work and City & Regional Planning.

Introduction

With significant numbers of North Carolinians going without health care it is easy to pay less attention to reducing the environmental factors that result in poor health outcomes. The place you call home, whether a single room, apartment or owned home is the place where people spend the majority of their time. We have known for years that substandard housing can have a significant negative impact on children yet we have been extremely slow to aggressively fund efforts to remove these health factors from existing housing stock.

Over the past few years, several research studies have calculated the economic cost of specific environmental risk factors on children. Cost figures range from $404 million in Montana to $1.87 billion in the State of Washington. Although the preceding studies focused on the impact of environmental risk factors on ***all children***, this particular study focused on the impact of environmental-related risk factors on the health of NC children ***only living in substandard housing***.

> What we found in this research in that the conservative estimate of total costs due to substandard housing-attributable childhood illnesses, injuries, diseases, and disabilities among North Carolina children is nearly **$95 million** (2006 dollars).

The answers to the issue of substandard housing are (1) increase production of quality affordable housing so there are healthy affordable alternatives and (2) increase code enforcement authority, activity and resources for rehab and repair of both owner-occupied and rental housing to reduce health risks while preserving affordability.

There are excellent models for communities to follow, especially from the cities of Greensboro and Durham. These communities have worked to aggressively with their local governments to enforce building codes for rental housing but face significant resource challenges to ensure that these units become safe while remaining affordable for their residents.

The **NC Housing Trust Fund** is already positioned to be that funding resource through its support of the NC Housing Finance Agency's **Urgent Repair** program. This program provides funds to repair the homes of low-income homeowners to ensure they can safely remain living independently in their homes. The Trust Fund also produces quality affordable rental housing that provides a healthy alternative to the affordable yet substandard housing that exists in every community in our state.

<u>This study demonstrates the potential health impact of $50 million a year funding of the NC Housing Trust Fund</u>. This funding would serve 6,000 households a year; additionally is would produce 3,000 jobs, $30 million in state and local tax revenue and leverage a total of $250 million in housing development in our state.

Most importantly, this level of funding would produce a significant increase in the quality of affordable units needed to give people options other than substandard housing as well as increase the repair and rehab funds needed to expand important housing preservation programs across the state.

Overall, this study was designed to address measurable economic impacts of environmental risk factors commonly found within substandard housing on childhood illnesses and diseases. However, it does not account for the significant human [emotional, psychological, social, and physical] toll, as individuals and families grapple with developmental and lingering problems on a daily and, often, unrelenting basis. It also does not account for the health care costs of adults living in substandard housing, including the costs of direct health care, impacts on their families and lost work time.

By and large**, everyone pays** – sooner or later – for the negative impacts of substandard housing on the health, education, and welfare of North Carolina's children. North Carolina's taxpayers [and employers] essentially fund much of the direct health care costs for childhood illnesses and disabilities due to substandard housing conditions. Moreover, North Carolina's prospects for new and sustained economic growth are threatened when today' children (tomorrow's workers) are physically, mentally and/or intellectually handicapped by the damaging effects of their childhood environment. Such impacts have additional and sometimes multiplicative consequences on family members if parents or guardians cannot make a living due to caring for their affected children.

Although data by race and ethnicity is not readily available due to confidentiality, published research discussed in this report suggests a strong inverse relationship between socio-economic status and risk of congenital abnormalities for different ethnic populations. In the United States, African-American children are at least two times more likely to incur lead poisoning than Caucasian children, according to the latest data from the Centers for Disease Prevention and Control. Therefore, the human and financial costs of unhealthy housing are not evenly distributed across ethnic and racial lines.

Since all levels of government have a stake in the health of all children, it is incumbent for local, state and federal government officials work to work together to reduce, if not eliminate, the impact of substandard housing in North Carolina. By solving this dilemma, a large portion of future direct and indirect costs could be avoided and slow down today's health care cost spiral. In any public policy discussion, the health of ***all*** our children should be of paramount concern and priority.

We hope that this analysis will help inform future policy discussions regarding the NC Housing Trust Fund as well as local government efforts to insure that all North Carolina children have a healthy and productive future.

Chris Estes
Executive Director
North Carolina Housing Coalition

Executive Summary

The burden of many childhood illnesses and chronic diseases is increasing, as evidence by rising rates of asthma, developmental problems, birth defects and some types of cancer.[1] Although the causes of these conditions are complex and multi-factorial, a large body of research points to ***environmental and cultural risk factors*** as important contributors.[1-17] Unquestionably, many of these risk factors are commonly found in ***unhealthy housing***. For example, the following stories from Greensboro, NC demonstrate this strong correlation:[3]

"*Sue," a young mother, suffered serious respiratory problems when a plumbing leak resulted in mold. She had tried to get her landlord to repair the leak but he took so long that she and her son both got sick. When she finally decided to move out instead, her son recovered but she is still experiencing respiratory problems. Her son missed a lot of school—so the school has had to spend extra time helping him keep up—and Sue has been unable to work.*

"Jose's" daughter—just 19 months old—suffers from asthma; her doctor told her family to get their housing repaired or move to safer housing. Even when code enforcement inspectors cited housing standards and violations, their landlord refused to make repairs, saying that Mexicans did not get anything better.

"Luke" fell through the rotten porch floor, injuring his leg; inside his tiny apartment mold and kerosene fumes choke him because the gas furnace is defective. Code enforcement inspectors say the landlord "is just like that" when they condemned the apartments.

"Vickie" and 21 of her neighbors have contacted attorneys to help them complain about raw sewage seeping up in their apartment complex playground and water leaking into electrical fixtures that could electrocute their children.

In North Carolina, at least one of five (20%) homes is classified as substandard and/or unaffordable

---

According to The Centers for Disease Control and Prevention (CDC), housing conditions can significantly affect public health.[4] For example, childhood lead poisoning, injuries, respiratory diseases such as asthma, and quality of life issues have been linked to more than 6 million substandard housing units nationwide. Residents of these units are also at increased risk for fire, electrical injuries, falls, rodent bites, and other illnesses and injuries. Other issues of concern include exposure to pesticide residues, indoor toxicants, tobacco smoke, and combustion gases. The burning of oil, gas, and kerosene can release a variety of combustion products, including carbon monoxide, a known cause of illness and death.[4]

State Comparison Research

Over the past few years, several research studies have calculated the economic cost of specific environmental factors on childhood illnesses, disabilities, and health status. These costs include expenditures for health care and other treatments for children, and in most cases, they include additional costs in adulthood for cancer treatments, lost productivity, etc. Landrigan et al very conservatively estimated that certain childhood environmental diseases cost the U.S. as a whole an estimated $54.9 billion per year (1997 dollars).[5]

Estimates of the cost of environmental diseases for individual states have also found tremendous economic impacts. For example, a Washington state study estimated $1.875 billion[6] while cost estimates of environment-related childhood disease in Minnesota revealed that asthma, cancer, lead poisoning, birth defects, and neurobehavioral disorders cost about $1.57 billion.[6A] Moreover, a Massachusetts study estimated $1.6 billion for childhood diseases[7] while a study in the state of Montana, which included adults, estimated $404.6 million per year.[8]

The Landrigan study estimates the annual costs to the nation as a whole from childhood lead poisoning asthma, cancer, and neurobehavioral disorders. Using statistics on the rates of these diseases, they employed a panel of experts to estimate the annual costs. They then estimated the proportion of cases for which the disease is likely to be caused or aggravated by environmental conditions, i.e. the "environmentally attributable fraction" (EAF). The basic EAF equation they utilized, with some variations, was:

Costs = (disease rate) * (EAF) * (population size) * (cost-per-case)

Davies estimated costs for adult and childhood diseases in Washington state.[6] The Washington study used the preceding model and covered asthma, cancer, lead, cardiovascular disease, birth defects and neurobehavioral disorders. The Massachusetts study also used Landrigan's framework and included asthma, cancer, lead, birth defects and neurobehavioral disorders for children only. The Montana study included the same diseases as the Massachusetts study, but for both adults and children and included years of potential life lost for the state's ten leading causes of death. Finally, all of these studies focused on a macro-environmental perspective and, thus, ***did not*** attempt to calculate the costs of environmental factors ***confined to substandard housing.***

Methodology

Direct medical care costs on North Carolina children were initially obtained on specific conditions associated with environmental-attributable risk factors commonly found in substandard housing. Data were provided by the state's largest commercial health insurer (Blue Cross & Blue Shield of North Carolina) and the state's largest public sector database (N.C. Department of Health & Human Services).

Indirect non-medical cost were subsequently obtained from several peer-reviewed research studies and applied to the prevalence of North Carolina children living in substandard housing . Direct and indirect costs were then combined and supplemented with a multiple to factor in the percentage of children without any type of health insurance. Cost estimates for specific conditions and their respective rank are listed in table A.

TABLE A

Cost by Condition, In Millions, 2006 Dollars (Rank)

Condition	Total Cost	Direct Cost	Indirect Cost
Neurobehavioral	$ 47.8 (1)	$ 3.9 (1)	$ 43.8 (1)
Birth Defects	$ 7.5 (5)	$ 3.0 (3)	$ 4.5 (5)
Lead Poisoning	$ 20.0 (2)	$ .2 (6)	$ 19.8 (2)
Burns & Falls	$ 9.1 (4)	$ 1.9 (4)	$ 7.2 (3)
Asthma	$ 9.4 (3)	$ 3.7 (2)	$ 5.7 (4)
Cancer	$ .7 (6)	$ .5 (5)	$ .2 (6)
Total	**$ 94.81**	**$ 13.43**	**$ 81.38**

Neurobehavioral conditions were the most expensive direct –and- indirect cost entity. Although these conditions had slightly higher direct costs than the second- and third-ranked conditions (asthma and birth defects), **indirect** cost differences showed (a) far greater cost variance among the targeted conditions and (b) that ***lead poisoning***, in particular, commanded a much higher indirect cost than four of remaining five conditions. **Neurobehavioral** conditions generate high costs because they typically require extensive life maintenance services over a long period of time (e.g., lifetime). Moreover, **neurobehavioral** conditions, as well as ***lead poisoning,*** often result in significant intellectual deficits that compromise a person's employment prospects and lifetime income capabilities.

For this reason we believe this is the most conservative and most accurate analysis of substandard housing on North Carolina's children to date.

Scope of Study

This analysis estimates the costs for specific types of childhood illnesses, disabilities, and diseases that can be *attributable, to some degree, to environmental and cultural factors known to* ***predominantly exist in substandard housing***. In addition to using some of Landrigan's framework, we used other methods designed to factor in actual demographic, socio-economic, and health care utilization and cost trends specific to North Carolina children. Due to the specific scope of this study, substandard housing-related environmental factors included in this analysis met at least of the following criteria:

- Originate in –or- on an environmental medium, e.g., air, water, soil, surface, etc.
- Classified as a generally-accepted precursor or risk factor that, upon exposure, can adversely impact a child's health status.
- Classified as a chemical, metal, pesticide, gas, toxic substance, thermal hazard, flying object, unstable surface, or human activity to which a child and/or their mother may be exposed.
- Commonly exist in substandard housing

Specific conditions selected in this analysis were done so because they (1) were included in one or more previously-cited cost analyses,[5-8] (2) were cited in the professional literature as having some etiological basis with an environmental risk factor in children, and (3) can be subjected to health care utilization and cost valuations.

Specific conditions selected for this cost analysis are as follows:

Major Diagnostic Category	Condition
Neoplasm (Cancer)	Lymphoma Leukemia*
Congenital (Birth Defects)	Anencephaly Cleft lip Cleft palate Cleft palate w/ cleft lip Heart defects Hypospadias Limb reduction Omphalocele Spina bifida
Injury and Poisoning	Accidental falls Accidental burns Lead/metal poisoning
Neurobehavioral	Autism Cerebral Palsy Mental retardation
Respiratory	Acute bronchitis Asthma

* Officially classified as a "Blood-related" condition; however, *due to its similar pathophysiology to lymphoma and other childhood cancers, we chose to include it in this section.*

Note: Although there is some evidence that particulate matter (e.g., airborne metals) is a risk factor for cardiovascular disease[9] and "long term" exposure to combustion-related fine particulate air pollution is an important environmental factor for cardiopulmonary and lung cancer mortality,[10] cardiovascular [circulatory]-related conditions were NOT included in this analysis because (1) the preceding conditions are generally classified as diseases attributed to *long term* exposure and (2) health care utilization and cost data for these conditions are not readily available for child and adolescent populations.

Target Population and Data Request

In 2006, there were approximately 2,119,135 children (0-18 years of age) in North Carolina with the following health insurance status:

Source	# of Children	Percentage*
Employer-sponsored	1,186,715	56%
Medicaid	529,783	25%
Uninsured	233,104	11%
Individual	105,956	5%
Other public	63,574	3%

** North Carolina: Health Insurance Coverage of Children, 0-18 years of age, 2004-2005.* [www.statehealthfacts.kff.org]

Due to (a) the variable status in children's health insurance coverage and (b) the many different types of health care providers rendering medical care to children in North Carolina, it was important to obtain medical claims data from prominent vendors. In doing so, we first re-classified the four *insured* entities into two general categories to determine appropriate vendors, as follows:

Category	Source	Primary Data Vendor
Commercial/Private	Commercial & Individual	Blue Cross Blue Shield of North Carolina
Non-commercial/Public	Medicaid & Other public	Division of Medical Assistance [N.C. Dept. of Health & Human Services]

The remaining category of uninsured children was excluded from the preceding re-classification since it was impossible to identify a vendor that tracks and/or retains accurate medical claims utilization and cost data on this particular population. Yet, since this group comprises approximately 11 percent of all North Carolina children, a *multiple of 1.1235* was applied to the combined *commercial and non-commercial* claims and costs to determine an approximate statewide estimate.

We chose to request claims and cost data from ***Blue Cross Blue Shield of North Carolina*** (BCBSNC) and the ***Division of Medical Assistance*** (DMA) because (1) BCBSNC is the state's largest health insurance – in terms of market share - and (2) DMA is the data analysis division of the North Carolina Department of Health & Human Services which administers the Medicaid program for poor children and poor adults throughout the state.

The specificity of our data request to each organization was as follows:

Data Vendor	Data Requested
BCBSNC	Outpatient ICD-9 codes claims and charges for targeted medical conditions on child members (0-18 years) enrolled in a commercial/individual plan from Jan. 1, 2006 to September 30, 2006.
DMA	Total ICD-9 coded claims and charges for targeted medical conditions on child members (0-18 years) enrolled in a Medicaid health plan from Jan. 1, 2006 to September 30, 2006.

Upon receiving data from each of the preceding vendors, we had to inflate utilization (number of claims) and financial costs (dollar charges) by a multiple of 1.33 to determine full-year (12 months) values for data supplied by BCBSNC and DMA. Essentially, this multiple was part of actual equations used to determine utilization and financial values at the state level, as follows:

Commercial/Individual Health Insurance

BCBSNC insureds as % of total statewide insureds: 17.31%*

Statewide extrapolation multiple:	**5.77
Actual ***outpatient*** BCBSNC claims/charges:	x _____
9 months conversion to full year:	x 1.33
State of North Carolina ***outpatient*** estimate:	_____
# of children with commercial insurance	1,292,671
National ***inpatient*** rate by condition:	x *** _____
Average DRG-specific cost per condition	x **** _____
State of North Carolina ***inpatient*** estimate:	$ _____

* Based on average monthly membership of 223,831 children (0-18 years of age) in managed care lines of business (HMO, POS, PPO) according to Blue Cross Blue Shield of North Carolina.
** [Statewide total (100%) –divided by- BCBSNC insureds (17.31) – equals- 5.77]
*** *Cancer (neoplasm) = .00077; neurobehavioral = .00238; respiratory = .0018; congenital birth defects = .00010; and burns = .0002713*. Based on **2001 National Hospital Discharge Survey**, Division of Health Care Statistics, reported in **Advance Data, Department of Health and Human Services,** Number 332, April 9, 2003, table 3, page 9.
**** Fee Schedule, Maximum Allowable Charges, Hospital Inpatient, 2006. *Workforce Safety & Insurance [www.workforcesafety.com]*

Non-Commercial/Public [Medicaid]

DMA provided **statewide** (100% of Medicaid insured) ICD-9 coded claims and payments. Thus, there was no need to incorporate the multiples previously used in the commercial/individual population. However, due to the aggregate (*inpatient and outpatient combined*) nature of claims and payment data provided by DMA, we had to compute a *representative cost per claim* via the following equation:

[Total Dollars Paid x 1.33] –divided by- [# of Claims x 1.33] –equals- Average Cost Per Claim

Data outcomes from the preceding equations were then inserted into customized *Proportionate Risk Factor Cost Appraisal*™ templates for each of the targeted conditions.

Methodology

To estimate the proportion of each condition attributable to **substandard housing conditions**, we used ***environmentally attributable fractions*** (EAFs) within a **Proportionate Risk Factor Cost Appraisal™** (PRFCA) framework. Specifically, an EAF is defined by Smith et al as "*the percentage of a particular disease category that would be eliminated if environmental risk factors were reduced to their lowest feasible levels*."[11] The EAF is a composite value and the product of the incidence of a risk factor multiplied by the relative risk of disease associated with that risk factor. Its calculation is a useful tool in developing strategies for resource allocation and prioritization in public health. The EAF model has been used previously to assess the costs of environmental and occupational disease and used by the Institute of Medicine to assess the "fractional contribution" of the environment to causation of illness in the United States. Using the modified Delphi technique,[13-14] EAFs have previously been established by several expert panels for lead poisoning, asthma, and childhood cancer.[5] This is noteworthy because data were previously not available on the fractions of diseases in children that may be caused by toxic exposures in the environment.[5]

When the field of ***prospective medicine*** was conceived in the early 1960s, there was virtually nothing to guide data analysts in calculating the cost of major risk factors. Eventually the traditional model of risk-factor influence was conceived and provided data analysts with a *relative* understanding of how lifestyle, environmental, genetic, and health care factors can influence a person's health status. Yet, in most cases, it was customary to link major risk factors to a **single** influence, such as obesity with lifestyle.

Eventually, this one-to-one unilateral concept gave way to a more contemporary concept known as **multi-risk factor causation**, which is based on the premise that many illnesses and diseases are often caused by *multiple* risk factors across the (a) lifestyle, (b) genetic, (c) environmental, and (d) health care spectrum.[20]

One simple way to calculate the cost of each risk factor is to use an ***Equitable Risk Factor Weight Method*** as shown below:

Total Cost of Condition **divided by** *# of risk factors* = **individual risk factor cost**

$ 200,000 / 12 = **$ 16,666**

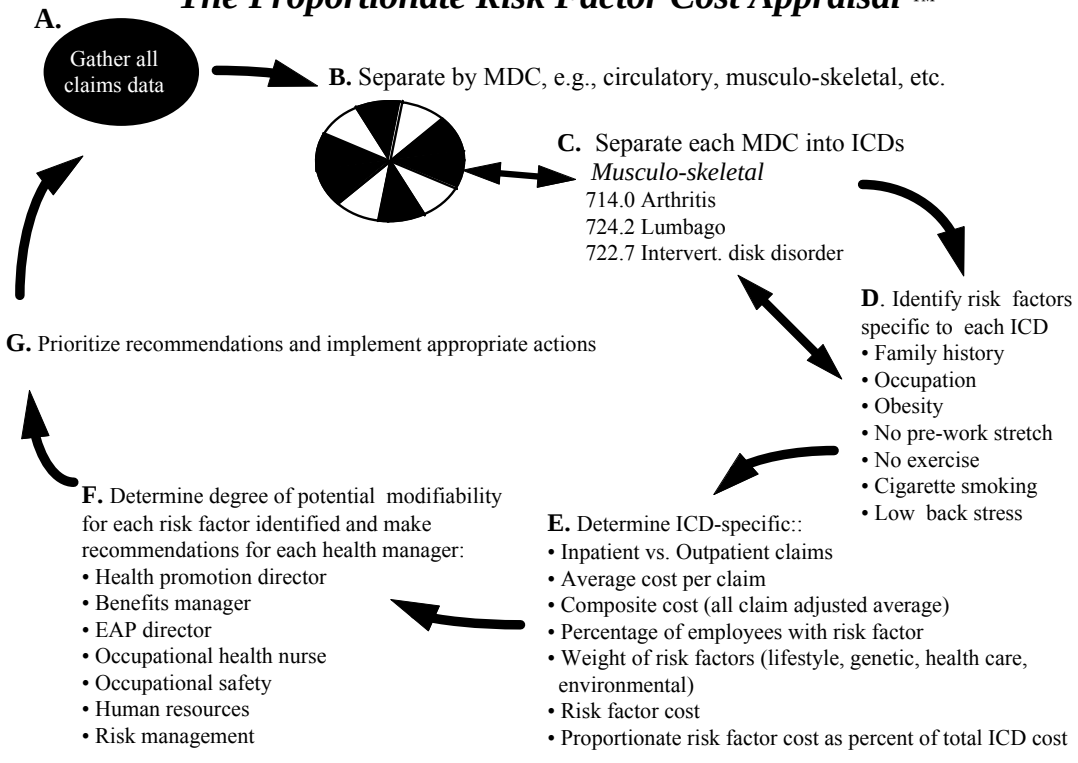
As you can see, the equitable risk factor weight method has ***limitations***, most notably it is based on the premise that each risk factor has an equal level of influence; yet research clearly shows that ***no two risk factors have the same influence*** on a person's predisposition for a specific illness, condition, or disability. Thus, to account for this influential difference, risk factor costing calculations should incorporate techniques such as **Proportionate Risk Factor Cost Appraisal™** (PRFCA) as illustrated in Figure 1.

Methodologically, PRFCA incorporates specific risk factors linked to (a) lifestyle, (b) environment, (c) genetic, and (d) health care variables (e.g., misdiagnoses, iatrogenic infection, non-compliant drug regimen, etc.). Moreover, PRFCA (1) accounts for the percentage of claimants with specific risk factors and (2) distinguishes between the volume of inpatient vs. outpatient claims and costs associated with a particular condition. These distinctions are essential because:

- Outpatient claims are far more common than inpatient claims
- An inpatient claim is significantly more expensive than an outpatient claim
- Some level of invalidity will occur if all claims and costs are bundled together – resulting in artificially inflating or deflating the **composite cost** [weighted claim cost] used in the PRFCA calculation.

Figure 1

The Proportionate Risk Factor Cost Appraisal ™



Source: HMA

SECTION I

Direct Medical Care Costs

This section focuses on the direct medical care costs associated with each of the targeted conditions described earlier. The scope of direct medical care cost units includes:

- Payments for outpatient medical care treatment, medications, and supplies used per encounter
- Payments for inpatient medical care treatment, medications, facilities, and supplies used per admission

Congenital (Birth Defects)

About 120,000 babies (1 in 33) in the United States are born each year with birth defects.[15] A birth defect is an abnormality of structure, function or metabolism (body chemistry) present at birth that results in physical or mental disabilities or death. Several thousand different birth defects have been identified.

Both genetic and environmental factors, or a combination of these factors, can cause birth defects. However, the causes of about 70 percent of birth defects are **unknown**.[15] While some birth defects are inherited, many are caused by factors such as nutritional deficiencies, maternal alcohol or drug use, and exposure to environmental toxins. Exposure to mercury, dioxins, PCBs, plasticizers, certain pesticides, organic solvents and air pollution have conclusively been linked with an increased risk of birth defects.[1,16] Some birth defects appear to be caused by a combination of one or more genes *and* environmental exposure. This is called "multi-factorial inheritance." In some cases, an individual may inherit one or more genes that make him more likely to have a birth defect if he is exposed to certain environmental substances (such as cigarette smoke). These individuals have a genetic predisposition to a birth defect. But if the individual is not exposed to the environmental substance before birth, he probably won't have the birth defect. Examples of multi-factorial birth defects include:

- Cleft lip/palate (opening in the lip and/or roof of the mouth)
- Neural tube defects (serious birth defects of the brain and spinal cord, including spina bifida and anencephaly)
- Heart defects (holes in walls of the heart, narrow valves, etc.)

Smith et al estimate that approximately 5 percent to 10 percent of all birth defects are associated with ***environmental and occupational exposures to chemicals during pregnancy***.[17] We used a risk factor weight of 7.5 percent (.075) as a mid-point in the range. Our decision was also based on the general belief that some types of birth defects are influenced more by environmental factors than other types. Moreover, we chose to limit the scope of birth defects in this analysis to those that are:

- influenced, to some degree, by environmental exposures that are more common in substandard housing settings (e.g., unsafe drinking water)
- influenced, to some degree, by human lifestyle (behavioral) factors that are more common in persons living in substandard housing (e.g., inadequate intake of folic acid)
- NOT considered to be *primarily* or *exclusively* due to genetic/chromosomal aberrations; thus, Down's Syndrome was *excluded* from this analysis

Based on the preceding criteria, we chose the following types of birth defects:

Condition	Frequency in N.C.*
Anencephaly	1:550
Cleft palate w/ cleft lip	1:890
Heart defects	1:520
Hypospadias	1:320
Limb reduction	1:2,620
Omphalocele	1:6,064
Spina bifida	1:1,160

* Source: ***North Carolina Birth Defects Monitoring Program, State Center for Health Statistics,*** 2003.

In order to estimate the direct medical care cost of birth defects attributed to substandard housing conditions in North Carolina, we implemented the following procedures:

(1) Requested medical claims and cost data on children 0-18 years of age from (a) the ***Division of Medical Assistance*** (DMA) within the North Carolina Department of Health & Human Services and (b) ***Blue Cross Blue Shield of North Carolina*** (BCBSNC), the state's largest health insurer; we received claims and cost data that corresponded to the targeted birth defects.
(2) Incorporated claims data into a *Proportionate Risk Factor Cost Appraisal*™ framework that was customized to account for:
    (a) an estimated percentage of all birth defects that are presumably borne by individuals living in ***substandard or unaffordable housing****
    (b) estimated risk factor weights (e.g., level of influence that environmental factors have on specific birth defects)
(3) Inserted appropriate prevalence, risk factor, and health care utilization data per targeted birth defect into the PRFCA™ framework.
(4) Tabulated the respective columns of data within the framework in order to compute the direct medical cost of each risk factor. Table 1 illustrates specific risk factors for targeted birth defects.

---

* *The estimated percentage used in this portion of the analysis is based on two key factors: (1) one of five North Carolina households being substandard; a value of 20% represents the* ***lowest percentage*** *provided by various sources: (a) North Carolina Smart Growth [www.ncsmartgrowth.org/archive/housingpaper _text.html], (b) North Carolina Data Center[census.state.nc.us/cps_ summary-2006.pdf], (c) North Carolina Housing Coalition [www.nchousing.org/research_publications/ facts_ stats/index_html] and (d) North Carolina Rural Economic Development Center, Inc. [www.ncruralcenter.org/databank/datasheet.asp?topic=housing] –and- (2) the higher probability that a poor child will incur a specific birth defect compared to a child who is not poor (40% higher); published research suggests a strong inverse relationship between socio-economic status and risk of congenital abnormalities for different ethnic populations.*[18-19]

TABLE 1

Proportionate Risk Factor Cost Appraisal™

Congenital Birth Defects

Group	# Claims	Total Charges	Ave Chrge	Ratio:Out/In	Net cost	Composite
Commercial	6,437	$14,410,473	2,238.69	0.16	357.99	
						673.03
Medicaid	247,208	$92,703,949	375.00	0.84	315.04	
Total	253,645	$107,114,422				

Composite	*Risk Factor*	Risk Fact.Wt.**	x% w/ RF	x#claims	EqlsRFCost	Directly tied Env. Housing
673	***Maternal Exp Toxins***	0.075	0.09	253,645	$1,152,246	$1,152,246
673	Genetics/unknown	0.7	0.00315	253,645	$376,400	
673	***Substandard housing***	0.045	0.2	253,645	$1,536,328	$1,536,328
673	Maternal Malnutrition	0.045	0.775	253,645	$5,953,270	
673	Matern Alc/drug use	0.045	0.131	253,645	$1,006,295	
673	Maternal obesity	0.045	0.471	253,645	$3,618,052	
673	Inadeq prenatal care	0.045	0.16	253,645	$1,229,062	
		1		**Total**	$14,871,653	$2,688,574

Collectively, **two risk factors** associated with ***substandard housing*** were calculated to cost more than $2.6 million in **direct medical care costs** among North Carolina children. This represents one of every 40 dollars (2.5%) spent on targeted birth defects.

NOTE: Risk factors highlighted in ***italic bold*** within each of the respective PRFCA™ templates represent precursors that (1) predominantly exist in substandard housing, (2) increase a child's risk of incurring the targeted condition(s) and/or (3) directly interact with other risk factors known to increase the child's risk of incurring the targeted condition(s).

Unintentional Falls

Falls remain a significant cause of morbidity and mortality. At most trauma centers, falls are the primary mechanism of injury resulting in admission for children.[21] Nearly three-quarters of falls from a height in children are unintentional and most frequently tend to occur in homes, followed by schoolyards, and playgrounds.[21]

Factors determining the probability of serious injury in a fall are the distance of the fall, the landing surface, orientation on falling, and whether the fall was broken. Moreover, unsafe housing conditions contribute to a child's risk of sustaining an accidental fall.[22]

> *"To reduce these injuries, there needs to be development of health-based standards for housing. The high rates of deaths among black children is probably due to* ***inferior housing****. It's probably a* ***proxy for lower socioeconomic status****, which is a direct marker for being exposed to older, substandard housing. There is greater window access, fire risks, and dilapidated stairways."*[22]
>
> Dr. Kieran J. Phelan
> Asst. Professor, Pediatrics
> Children's Hospital Medical Center
> Cincinnati, Ohio

Some research suggests that falls are likely to result in fractures of the femur (thigh bone) and related to a host of socio-demographic risk factors. For example, a three year long population-based study involving all Colorado children aged 0 to 17 years showed youngsters at the highest risk to be:[23]

- Male gender
- Hispanic ethnicity
- In single parent (mother) household
- In crowded households
- Of low socio-economic status

In another study of preschoolers in Columbia, South Carolina, researchers found Caucasian children whose mothers were unemployed and *whose homes needed repair* were at higher risk of injury than other children.[24] In particular, preschoolers whose homes needed repair had an estimated risk of injury nearly four times (3.92) the risk of injury of preschoolers, whose homes did not need repair.

In order to estimate the direct medical care cost of accidental falls attributed to substandard housing in North Carolina children, we followed the methodological protocol outlined on page 10. In particular, we requested medical claims data relevant to ICD-9 code E880 ("Accidental Falls"). However, "E Codes" are generally not used as the first listed diagnosis – always conjunctive. Thus, we used national accidental injury incidence norms and applied them to the demographic profile of North Carolina children, as follows:

# of households in North Carolina	3.409,840
% of households with children (33%)	x *.33
# of households with children	1,125,247
% of households reporting unintentional fall	x *.07
# of unintentional falls	78,767
% of residents who are children (25%)	x **.25
# of children sustaining unintentional falls	19,691
Average medical care cost per fall-related claim	x ***$396
Total estimated medical care cost of falls	$7,797,636

---

* Runyan, C. et al. (2005). "Unintentional Injuries in the Home in the United States: Part II: Morbidity." **American Journal of Preventive Medicine**, 28, 1, 80-87.
** *North Carolina Estimates from the Current Population Survey*.
[census.state.nc.us./cps/cps_summary_2006.pdf]
*** Bishai, D. et al (2002). "The Burden of Injury in Preschool Children in an Urban Medicaid Managed Care Organization." **Ambulatory Pediatrics**. July-August, 2, 279-283.

We incorporated claims data as well as data from the preceding equation into a customized PRFCA™ framework as illustrated in Table 2.

TABLE 2

Proportionate Risk Factor Cost Appraisal™

Accidental Falls

Group	**# Claims**	**Total Charges**	**Average Charge**
All	19,691	$7,797,636	$396

Composite	Risk Factor	x R.F. Wt.	x %wRF	x# claims	Equals R.F.Cost	**Associated with Substandard Housing**
396	Male	0.166	0.466	19,691	$603,194	
396	Hispanic/Afri-American	0.166	0.347	19,691	$449,159	
396	Single parent household	0.166	0.26	19,691	$336,546	
396	***Crowded household***	0.166	0.1043	19,691	$135,007	$135,007
396	***Low soc-econ status***	0.166	0.213	19,691	$275,709	$275,709
396	***Substandard housing***	0.166	0.2	19,691	$258,882	$258,882
		0.996			$2,058,496	$669,597

Collectively, **three risk factors** associated with ***substandard housing*** were calculated to cost $669,597 in **direct medical care costs** among North Carolina children. This represents about **one of every 11.6 dollars (8.5%)** paid for accidental falls.

Unintentional Burns

According to the National Center for Injury Prevention and Control, the groups at highest risk nationally for deaths due to fire and burns include *children under age five*, adults ages 65 and older, people living in poverty, African-Americans, Native Americans, people living in rural areas, and people living in manufactured homes or *substandard housing*.[25] In particular, children from low-income families are at greater risk for fire-related death and injury, due to factors such as a lack of working smoke alarms, substandard housing, use of alternative heating sources, and economic constraints on providing adequate adult supervision.

Most non-fatal burn injuries are from scalding water and other liquids. Scalds are the leading cause of burn hospitalizations among children under five years of age, followed by contact burns.[26] Risk factors for scalds involve kitchen-related injury from tipping very hot liquids and bathtub-related injuries often associated with lack of supervision or child abuse.[26]

Based on a review of fifteen residential fire risk factor studies, researchers found a range of relative risks (RR) for various risk factors, as follows:

Risk Factor	RR (Range) [27]
Young age	1.8 – 7.5
Old age	2.6 – 3.6
Male gender	1.4 – 2.9
Non-white race	1.3 – 15.0
Low income	3.4
Disability	2.5 – 6.5
Late night/early morning occurrence	4.1
Place of residence	2.1 – 4.2
Type of residence	1.7 – 10.5
Smoking residents	1.5 – 7.7
Alcohol use by residents	0.7 – 7.5

In order to estimate the direct medical care cost of accidental burns attributed to substandard/unhealthy housing in North Carolina children, we followed the methodological protocol outlined on page 10. In particular, we requested medical claims data relevant to ICD-9 940.0 – 949.5 ("Burns"). We incorporated claims data and other pertinent data into a customized PRFCA™ framework as illustrated in Table 3.

TABLE 3

Proportionate Risk Factor Cost Appraisal™

Unintentional Burns

GroupP	# Claims	Total Charges	Average Charge	Ratio: Com. to Medicaid	Net cost	Composite
Commercial	4,847	4,900,297	1,011.00	0.745	753.19	
						814
Medicaid	2,984	713,835	239.22	0.255	61.00	
Total	7,831	5,614,132				

Composite	Risk Factor	x R.F. Wt.	x %wRF	x# claims	R.F.Cost	Associated with Sub. Housing
814	***Substandard housing***	0.161	0.2	7,831	$205,257	$205,257
814	***Lack adult supervision***	0.124	0.596	7,831	**$471,096**	$471,096
814	Young age	0.122	0.122	7,831	$94,877	
814	Male	0.056	0.466	7,831	$166,347	
814	Non-caucasian	0.215	0.347	7,831	$475,565	
814	***Low socio-econ status***	0.089	0.213	7,831	$120,840	$120,840
814	***Smoking residents***	0.121	0.226	7,831	$174,315	$174,315
814	***Alcohol abuse residents***	0.108	0.105	7,831	$72,286	$72,286
		0.996		**Total**	$1,780,583	$1,043,794

Collectively, **five risk factors** associated with ***substandard housing*** were calculated to cost more than **$1 million in direct medical care costs** among North Carolina children. This represents about **1 of every 5.4 dollars (18.5%)** spent on accidental burns.

Hunger and Thirst

Unaffordable rent [e.g., poverty] is associated with substandard housing and inadequate childhood nutrition and growth, as well as the mother's childhood health status and mother's perception of her health.[28-29B] Considering that 18.3% to 21.3% of all North Carolina children live in households with incomes *at or below* the poverty level,[30] it is not surprising to find that their nutrient intakes were reportedly worse than the national norm on 22 of 23 nutritional indices.[31] Moreover, the rate of statewide hunger (for all North Carolina residents) was reportedly higher than the national norm.[31]

> *"Hunger is the uneasy or painful sensation caused by lack of food; the recurrent and involuntary lack of access to food."*

Considering there are approximately 1.79 children in a North Carolina household,[32] and approximately 76,000 households affected by hunger,[35] then approximately 136,451 children in North Carolina are currently victims of hunger.

In order to estimate the direct medical care cost of hunger and thirst attributed to substandard/unhealthy housing in North Carolina children, we followed the methodological protocol outlined on page 10. In particular, we requested medical claims data relevant to ICD-9 codes 994.2 – 994.3 ("Deprivation of Food/Water"). Surprisingly, we found **no reportable medical care claims or costs** tied primarily to these codes. Thus, we did **NOT** prepare a PRFCA™ framework for hunger and thirst.

Lead Poisoning

Lead is a naturally occurring metal that was found for many years in gasoline, paint and other products used in homes and businesses. While lead is still resent in the environment, the amounts continue to decrease since the Environmental Protection Agency (EPA) banned its use in these products in the 1970s.

Lead poses health risks for everyone, but young children and unborn babies are at greatest risk. Exposure to high levels of lead during pregnancy contributes to miscarriage, preterm delivery, low birth weight and developmental delays in infants.[34] Lead toxicity in children is characterized by behavioral and learning problems and anemia. Lead levels as low as 10 micrograms per deciliter are associated with lower intelligence (lower IQs), reduced physical stature, impaired hearing, and behavior issues.[34] Lead-poisoned children can be left behind before they even enter school, and often never catch up. More than 400,000 children in the United States have blood lead levels high enough to impair their ability to think, concentrate, and learn.[35]

While lead poisoning crosses all socioeconomic, geographic, and racial boundaries, the burden of this disease falls disproportionately on ***low-income families and families of color living in older, poorly maintained housing***.[35] For example, in the United States, African-

American children are at least two times more likely to incur lead poisoning than Caucasian children, according to the most recent data available on the disparities of the disease.[35] In particular, children who live in older homes may be exposed to higher levels of lead due to deteriorating lead-based paint. It is clear that children served by Medicaid and those living in older, dilapidated properties are at highest risk.[35] About 80 percent of homes built before 1978 were painted with lead-based paint. In fact, more than 38 million US homes and apartments are burdened by lead-based paint, and more than 24 million of them contain substantial lead hazards, according to the United States Department of Housing and Urban Development (HUD).[36]

While lead in drinking water is a serious threat to the health of children, the most common cause of childhood lead poisoning is lead paint in older housing and the contaminated dust and soil it generates. Lead-based paint, which is present in 40 percent of all U.S. housing, contains a very high concentration of lead – typically several million times greater than the EPA's 15 parts per billion "action level" for lead drinking water.[36]

While the lead poisoning problem in North Carolina has diminished since the North Carolina Childhood Lead Poisoning Prevention Program (NC CLPPP) was formed in 1994, lead poisoning is still a problem that impacts affected children for their entire lives. Surveillance data indicate a substantial decrease in the number of children with elevated blood lead levels since 1995 when 895 children were confirmed to have exposures at or about 10 micrograms per deciliter (μg/dL). In 2003, only 505 children were confirmed at the same exposure level, despite the fact that the total number of children tested has grown nearly 40% from 87,884 in 1995 to 121,971 in 2003. In 2004, there were 124,257 children under the age of 6 screened for lead poisoning in North Carolina; 1,489 (more than 1% of those screened) had elevated lead exposures.[37]

In order to estimate the direct medical care cost of lead poisoning attributed to substandard/unhealthy housing in North Carolina children, we followed the methodological protocol outlined on page 10. It is important to note that *all cases of lead poisoning are deemed to be of environmental origin*, based on the consensus of experts.[5] In particular, we requested medical claims data relevant to ICD-9 codes 984.0 – 987.8 ("Lead/Metal Poisoning"). We incorporated claims data and other pertinent data into a customized PRFCA™ framework as illustrated in Table 4.

TABLE 4

Proportionate Risk Factor Cost Appraisal™

Lead Poisoning

Group	# Claims	Total Charges	Average Charge	Ratio: Com to Medicaid	Net cost	Composite
Commercial	399	$157,595	394.97	0.6768	267.32	
						307.08
Medicaid	321	$39,488	123.02	0.3232	39.76	
Total	720	$197,083		1		

Composite	Risk Factor	x R.F. Wt.**	x %w/RF***	x# claims	equals R.F.Cost	Associated with Sub. Housing
307	***Environmental ****	1	1	720	$197,083	$197,083

** Includes all identifiable **substandard housing-related environmentally-based risk factors** (e.g., living in lead-painted, pre-1978 constructed housing; eating paint chips; having parents or guardians work in lead-based occupations, etc.)*
*** The listed risk factor weight of 1.00 (100%) is used since the expert panel of the National Academy of Sciences (NAS) attributes all lead poisoning to **environmentally-based risk factors** that are predominantly associated with poverty, substandard housing, etc.*[5]
**** The prevalence rate of 1.00 (100%) is used since the NAS expert panel judged all lead poisoning cases to **occur only** in persons subjected to the preceding environmental risk factors.*[5]

Neurobehavioral Conditions

In other economic cost studies of this type, researchers have selected three specific neurobehavioral conditions: (1) autism, (2) cerebral palsy, and (3) mental retardation. The National Academy of Sciences (NAS) estimates that 3 percent of neurobehavioral disorders in American children are caused directly by exposure to environmental toxins; an additional 25 percent are caused by interactions between environmental factors [defined broadly] ***and*** the individual's genetic susceptibility.[38]

Autism

Autism is a complex developmental disorder that appears in the first 3 years of life, although it is sometimes diagnosed much later. It affects the brain's normal development of social and communication skills. Autism is a spectrum that encompasses a wide range of behavior encompassing impaired social interactions, impaired verbal and nonverbal communication, and restricted and repetitive patterns of behavior.

Autism is a physical condition linked to abnormal biology and chemistry in the brain.[39] The exact causes of these abnormalities remain unknown, but this is a very active area of research. There are many factors that lead to autism. While most research points to the significance of genetic factors as a precursor to autism, one of the largest case-control studies

ever conducted found that *prenatal environmental factors* and *prenatal mental health* may be associated with this condition.[40] Parents with a history of certain types of psychoses or affective disorders were particularly at risk of having children with some form of autism.[40] Moreover, it can be argued that the prevalence of poor mental health among parents of behaviorally challenged children (e.g., autistic) is higher in poverty-stricken, substandard housing.[41] It is not currently known how many children living in North Carolina have autism.[42] However, it is estimated that one out of 166 people born today has some form of autism.[43]

Cerebral Palsy

Cerebral palsy is a condition caused by damage to the brain, occurring before, during or after birth. Cerebral palsy is characterized by an inability to fully control motor function. Cerebral palsy occurs in approximately 1.4 to 2.4 of every 1,000 people.[44] It occurs equally in males and females. It is estimated that 500,000 children and adults in the U.S., or about 16 out of every 5,000 people manifest one or more of the symptoms of cerebral palsy. Each year, approximately 5,000 infants are born with the condition and approximately 1,200 to 1,500 young children acquire cerebral palsy as a result of head injuries.[45]

Up to 50 percent of cerebral palsy cases have no known cause at present, though there are specific risk factors for infants and young children who develop cerebral palsy. In patients with cerebral palsy, parts of the brain areas receive lower levels of oxygen (hypoxia) at some point, but it is not known why this occurs. Premature infants have a slightly higher rate of cerebral palsy. Cerebral palsy may also occur during early infancy as a result of illnesses (encephalitis, meningitis, herpes simplex infections, and so on), head injury that results in subdural hematoma, blood vessel injuries, and many other conditions.[45]

Mental Retardation

Mental retardation is described as a condition that is diagnosed before age 18, and includes below-average general intellectual function, accompanied by impairment in the person's ability to acquire the skills necessary for daily living.[46] Mental retardation affects about 1% to 3% of the population. Causes of mental retardation are numerous, but a specific reason for mental retardation is determined in **only 25% of all cases**.

Risk factors are related to the causes, which can be broken down into several categories:

- Trauma
- Infections (present at birth or occurring after birth)
- Chromosomal Abnormalities
- Genetic abnormalities
- Genetic abnormalities and inherited metabolic disorders
- Metabolic
- Toxic
- Nutritional
- Environmental (e.g., poverty)

In order to estimate the direct medical cost of autism, cerebral palsy, and mental retardation attributed to substandard/unhealthy housing in North Carolina children, we followed the

methodological protocol outlined on page 10. One important task involved in this protocol involved requesting medical claims data relevant to each of the respective neurobehavioral disorders:

Disorder	ICD-9 Code
Autism	299
Cerebral Palsy	343.0 – 343.9
Mental Retardation	317.0 – 319

We incorporated claims data and other pertinent data into a customized PRFCA™ framework as illustrated in Table 5.

TABLE 5

Proportionate Risk Factor Cost Appraisal™

Neurobehavioral

GROUP	# Claims	Total Charges	Average Charge	Ratio: Com. to Medicaid	Net cost	Composite
Commercial	13,021	24,222,068	1,860.23	0.458	851.99	
						2,328.74
Medicaid	8,890	50,742,800	2,724.64	0.542	1,476.76	
Total	21,911	74,964,868				

Composite	Risk Factor	Risk Fact.Wt.	% w/R.F.	x# claims	R.F.Cost	Associated with Sub. Housing
2,329	***Prenatal lifestyle***	0.075	0.6	21,911	$2,296,382	$2,296,382
2,329	Genetics	0.03	0.03	21,911	$45,928	
2,329	Unknown	0.72	1	21,911	$36,742,118	
2,329	***Low soc. econ status***	0.0375	0.213	21,911	$407,608	$407,608
2,329	***Substandard housing***	0.0375	0.2	21,911	$382,730	$382,730
2,329	***Prenatal Exp. Toxins****	0.1	0.09	21,911	$459,276	$459,276
		1		**Total**	$40,334,042	$3,545,997

** Such as lead, mercury, dioxins, and PCBs; not including alcohol, tobacco, or drugs of abuse.*

Collectively, **four risk factors** associated with ***substandard housing*** were calculated to cost more than $3.5 million in **direct medical care costs** for targeted neurobehavioral conditions among North Carolina children. This represents about **one of every 21.1 dollars (4.6%)** paid for targeted neuro-behavioral conditions.

Respiratory

Two specific types of respiratory conditions were selected for inclusion in this analysis due to their commonality in substandard/unhealthy housing:[47-50]

- Asthma
- Acute bronchitis

Asthma

Asthma is a respiratory condition causing the airways in the bronchial tubes to be obstructed. The prevalence of asthma in children has increased significantly over the past two decades with associated increases in hospitalization, death, and restricted activity. Approximately 134,000 North Carolina children suffer from asthma which is one of the most common causes of emergency department visits and hospitalizations.[51] Unfortunately, this number may not fully represent the prevalence of the disease among children, since many children go undiagnosed or are misdiagnosed.

Asthma has no single cause. However, there is a strong inherited (genetic) component.[52] If one of the child's parents has asthma, there is at least a 1 chance in 3 that the child will have asthma. If both parents have asthma, the chances are even greater. Environment also plays an important role in determining whether a child will develop asthma. Landrigan and colleagues estimate that ***environmental factors are responsible for about 30 percent of all risk factors associated with asthma***.[5]

One of the strongest environmental precursors to asthma appears to be housing status. However, it is difficult to separate a person's housing status from their socio-economic status since there is usually a correlation between the two. Unquestionably, poverty forces families to live in substandard housing, whether urban, suburban, or rural.[49-50] Older homes, or those in crowded areas, give cockroaches and other asthmatic "triggers" a fertile breeding ground.[53] Roaches are particularly difficult to eradicate in multi-family dwellings; cleaning them out of one unit usually just drives them into another, and it is only a matter of time until they return. Low-income housing may have other qualities associated with high asthma rates such as uncontrollable heating systems, poor ventilation, and water damage that may lead to mold growth. Overcrowded conditions can also create more of the humid conditions (more showering and cooking) in which cockroaches thrive. And low-income housing may also be located in neighborhoods that contain high concentrations of other asthma triggers, like vehicle exhaust.

Acute Bronchitis

The same viruses that cause colds often cause acute bronchitis, a condition in which the bronchial tubes are inflamed.[54] People who smoke or who live with a smoker are at greatest risk of both acute and chronic bronchitis. Children whose parents or siblings smoke are especially susceptible to bronchitis, as well as asthma, pneumonia, colds and ear infections.[54]

Just as poverty and substandard/unhealthy housing conditions predispose children to asthma and acute bronchitis [and possibly chronic bronchitis], patterns are also higher among children living in disadvantaged settings.[48-50]

In order to estimate the direct medical care cost of asthma and acute bronchitis attributed to substandard/unhealthy housing in North Carolina children, we followed the methodological protocol outlined on page 10. In particular, we requested medical claims data relevant to ICD-9 codes 466.0 – 466.1 ("Acute Bronchitis") and 493.0 – 493.9 ("Asthma"). We incorporated claims data and other pertinent data into a customized PRFCA™ framework as illustrated in Table 6.

TABLE 6

Proportionate Risk Factor Cost Appraisal™

Respiratory

Group	# Claims	Total Charges	Average Charge	Ratio: Com. to Medicaid	Net cost	Composite
Commercial	37,926	25,537,940	673.36	0.636	428.26	
						493.65
Medicaid	39,425	7,082,210	179.64	0.364	65.39	
Total	77,351	32,620,150				

Composite	Risk Factor	R. Factor Wt.	% w/RF	# claims	RFCost	Associated with Sub. Housing
494	***Child's Expos. Toxins***	0.2	0.01	77,351	$76,423	$76,423
494	***Low soc econ status***	0.133	0.213	77,351	$1,082,491	$1,082,491
494	***Substandard housing***	0.133	0.2	77,351	$1,016,423	$1,016,423
494	Genetics	0.133	0.133	77,351	$675,921	
494	Non-caucasian	0.133	0.347	77,351	$1,763,494	
494	Current allergy	0.133	0.133	77,351	$675,921	
494	***Smoking residents***	0.133	0.226	77,351	$1,148,558	$1,148,558
		0.998		**Total**	$6,439,231	$3,323,895

Collectively, **four risk factors** associated with ***substandard housing*** were calculated to cost more than **$3.3 million in direct medical are costs** among North Carolina children. This represents about **one of every 9.8 dollars (10.1%)** paid for asthma and acute bronchitis.

Neoplasm (Cancer)

Cancer is a very rare childhood disease with 14.1 cases per 100,000 children. An estimated 240 new pediatric (under age 15) cancers are expected to occur in North Carolina each year.[56]

The cause of most childhood cancers is unknown. In fact, confirmed clinical and epidemiologic associations explain about 10 percent of disease incidence, leaving 90 percent of the cases with an unclear etiology.[57] Despite overwhelming evidence suggesting genetics (family history) is probably the predominant precursor to most childhood cancers,[56-59] environmental factors may also be partially responsible for the increase in some childhood cancers, especially lymphoma. For example, exposure to certain chemicals (dioxin, PCB, pesticides, solvents, fertilizers, etc.), ionizing radiation, and elevated nitrate levels in drinking water are believed to increase a child's risk of incurring lymphoma and related conditions such as leukemia.[58-60]

Childhood leukemia is the most common cause of malignancy in children under the age of 15, representing an annual incidence rate of 43 cases per million in the United States.[57] Various childhood leukemias* are also believed to have a strong genetic as well as a partial environmental etiology.[61] Although specific environmental factors associated with certain childhood cancers can exist in any type of household, some research suggests that childhood exposures to potentially dangerous chemicals and unsafe drinking water are more likely to occur in children living in substandard/unhealthy housing.[1,2,62-63]

In order to estimate the direct medical care cost of selected childhood cancers attributed to substandard housing in North Carolina children, we followed the methodological protocol outlined on page 10. In particular, we requested and obtained medical claims data on ICD-9 codes 982.0-983.9 ("Leukemias") and 200.0-208.9 ("Lymphoma"). We incorporated the claims data as well as other relevant data into a customized PRFCA™ template as shown in table 7.

** Biologically diverse malignancies resulting from an abnormal change in an early form of one or a few blood cells that arise in the bone marrow. Leukemia is actually considered a "blood-related" condition, not a neoplasm/cancer. However, due to its similar pathophysiology to lymphoma and other childhood cancers, we chose to include it in this section.*

TABLE 7

Proportionate Risk Factor Cost Appraisal™

Cancer

Group	# Claims	Total Charges	Average Charge	Ratio: Com to Medicaid	Net cost	Composite
Commercial	20,410	41,605,884	2,038.50	0.974	1,985.50	
						2,046.88
Medicaid	505	1,192,070	2,360.53	0.026	61.37	
Total	20,915	42,797,954				

Composite	Risk Factor	R.F. Wt.	% w/RF	# claims	R.F.Cost	Associated with Sub. Housing
2,047	Genetics	0.025	0.0001132	20,915	$121	
2,047	Caucasian male	0.025	0.304	20,915	$325,379	
2,047	***Child's Env. Exposures****	0.025	0.255	20,915	$272,933	272,933
2,047	***Substandard Housing***	0.025	0.2	20,915	$214,065	214,065
2,047	Unknown	0.9	1	20,915	$38,531,705	
		1		**Total**	$39,344,202	486,998

** Pesticides, ionizing radiation, contaminated drinking water, etc.*

Collectively, **two risk factors** associated with ***substandard housing*** cost $486,998 in **direct medical care dollars** among North Carolina children. This represents about **one of every 88 dollars (1.1%)** paid for lymphoma and leukemia.

Aggregate Medical Costs

Once all substandard housing-related risk factor costs have been quantified for ***each*** of the preceding PRFCA™ templates, they were converted into a single aggregate cost. This conversion yielded an **aggregate [total] direct medical care cost of approximately $13,432,496**. However, this cost only reflects direct medical care costs tied to North Carolina children who have some form of health insurance; it does not include any medical care costs presumably tied to **11%** of North Carolina children who do **NOT** have health insurance. Thus, a multiple of 1.1235 was applied to the insured population's cost in order to calculate a total statewide cost estimate. An itemized breakdown of this aggregate liability reveals a cost distribution in table 8 and figure 2.

TABLE 8

Risk-Factor Medical Care Cost Distribution by Condition

Risk Factor	Burns	Cancer	Congenital	Falls	Lead Poisoning	Neuro-behavioral	Respiratory
Prenatal Exp. Toxins			$1,152,246			$459,276	
Prenatal lifestyle						$2,296,382	
Substand. housing	$205,257	$214,065	$1,536,328	$258,882	$197,083*	$382,730	$1,016,423
Crowded household				$135,007			
Low soc-econ stat	$120,840			$275,709		$407,608	$1,082,491
Smoking residents	$174,315						$1,148,558
Alcohol abuse residents	$72,286						
Lack adult superv.	$471,096						
Child's envir. Expos.		$272,933					$76,423
Sub-Total	$1,043,794	$486,998	$2,688,574	$669,598	$197,083	$3,545,996	$3,323,895
Insured Total	$11,955,938						
Grand Total*	***$13,432,496***						

** Represents all relevant environmental risk factors such as living in lead-painted pre-1978 constructed housing; eating paint chips; having parents/guardians work in lead-based occupations, etc.)*

*** Represents the total costs among children with recordable medical claims – multiplied by 1.125 – to factor in eleven percent of North Carolina without health insurance.*

Figure 2.

Risk factor medical care cost distribution and condition by percentage.

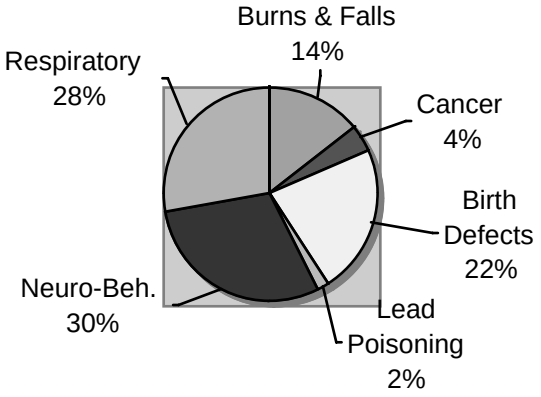


Figure 2 reveals that ***neuro-behavioral*** conditions comprise the largest portion of direct medical care costs followed by respiratory (asthma), birth defects, burns and falls, cancer, and lead poisoning.

SECTION II

Indirect Non-Medical Costs of Substandard Housing

The previous section of this analysis focused primarily on ***direct medical care*** costs tied to specific substandard housing-influenced conditions among North Carolina Children. Essentially, direct medical care cost items included in this analysis include:

- Physician (outpatient) care
- Laboratory services
- Long-term care
- Hospital (inpatient) services
- Prescription drugs

In contrast, Section II focuses on ***indirect non-medical costs*** that are typically borne before –or- after direct medical care services are rendered. Indirect cost units identified throughout the literature on unhealthy environmental housing are as follows:

- School days lost
- Lost parental wages
- Home and auto modifications
- Lifetime wages lost
- Premature death
- Assistive devices
- Special education
- Home care
- Developmental services

Indirect costs included in cost-of-illness (COI) estimates are based on the value of disease-related lost income and productivity, which are typically valued using age- and sex-adjusted average wages.[64] The total value of the lost income and productivity is estimated based on the distribution of disease-related outcomes across age and sex categories.***** Indirect morbidity costs value the lost income and productivity for nonfatal disease-related outcomes (e.g., lost work days, lost school days, and days spent in bed). Indirect mortality costs are based on the present value of expected future earnings that are lost because of disease-related death.

***** *To avoid omitting the value of productivity for those who are primarily homemakers and don't directly earn a wage, a "shadow" wage equal to that earned by domestic workers in the workforce, or some estimate of the foregone wage based on age and sex, is generally used*.

COI estimates can be prevalence-based –or- incidence-based. *Prevalence-based* estimates are the costs for all individuals who have a disease in a specified time period. For example, an estimate of the total number of individuals who currently have asthma, as diagnosed by a physician, reflects the current prevalence of physician-diagnosed asthma. Prevalence-based COI estimates for asthma generally include all direct and indirect costs associated with the treatment of and the mortality and morbidity effects of asthma within a given time period, such as a year. By and large, prevalence-based COI estimates are a measure of the full financial burden of a disease. However, since direct medical care costs for asthma have already been quantified in Section I, this analysis focuses on prevalence-based COI estimates relevant *only to indirect cost items*. In the final portion of this analysis, we have combined direct and indirect costs to compute an estimated aggregate total cost for asthma and other targeted conditions among North Carolina children.

Although we have attempted to include various types of indirect cost items [where applicable], we do ***not include the costs of some adverse social outcomes*** that have been associated with IQ reductions allegedly tied to specific birth defects, neurobehavioral conditions, and lead poisoning. Thus, the aggregate sum of indirect costs measured in this section represents a conservative estimate of the total economic impact of unhealthy environmental housing conditions on North Carolina society.

Respiratory (Asthma)

As was noted in Section I, direct medical care costs for asthma [and acute bronchitis] in North Carolina children **exceed $32 million** per year. This cost relates to approximately 134,000 children in North Carolina having asthma in any given year.

Indirect cost measurements on asthma have been constructed by Landrigan,[5] Davies[6] and Massey and Ackerman.[7] Yet, upon closer review, it appears the genesis of these efforts actually evolved from earlier efforts of Chestnut et al[64] and Weiss et al.[65] In particular, these researchers were primarily responsible for establishing quantification metrics to calculate indirect costs on (a) school days lost and (b) lost productivity due to premature death tied to childhood asthma.

In order to calculate indirect asthma-related costs among North Carolina children, we created the following equations comprised, in part, on computations and data from Chestnut and Weiss:[64-65]

Lost School Days

Cost of lost school days in USA:	$1,780,000,000 ($1.78 Billion)
Annual USA cost per child:	$ *252 (2006$)
# North Carolina children with asthma	x 134,000
Approximate cost of lost school days	$33,768,000

* Based on 1997 value of $176 multiplied by the following year-specific *employment cost index*: 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Lost Productivity due to Premature Death

Cost of premature deaths in USA:	$193,000,000
- divided by -	
# of USA childhood asthma deaths:	247
Average cost per childhood death:	$ 781,376
# of N.C. childhood asthma deaths	x **5
Cost of N.C. asthmatic child deaths	$ 3,906,882

** "Childhood Asthma in North Carolina" by Paul Buescher and Kathleen Jones-Vessey. *North Carolina State Center for Health Statistics,* No. 113, March 1999, page 2.

Overall, aggregate estimated indirect costs for asthmatic conditions among all North Carolina children amounted to more than $37 million in 2006. Although this cost estimate pertains to approximately 134,000 North Carolina children with asthmatic conditions presumably tied to *environmentally-attributed risk factors*, it does **not** reveal what portion of environmental influence is due ***specifically to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of asthmatic conditions tied to substandard housing:

All indirect asthmatic costs in N.C. children:	$37,674,882
% of N.C. children in substandard housing:	x .20*
Substandard housing-specific risk factor weight	x .599**
Excess asthmatic prevalence via Medicaid:	x 1.27***
Indirect asthma costs tied to substandard housing:	$ 5,732,082

Based on the preceding equation, indirect asthmatic costs tied due to substandard housing conditions are approximately $5.7 million in 2006.

---

* *The estimated percentage used in this portion of the analysis is based on two key factors: (1) one of five North Carolina households being substandard; a value of 20% represents the* ***lowest percentage*** *provided by various sources: (a) North Carolina Smart Growth [www.ncsmartgrowth.org/archive/housingpaper _text.html], (b) North Carolina Data Center[census.state.nc.us/cps_ summary-2006.pdf], (c) North Carolina Housing Coalition [www.nchousing.org/research_publications/ facts_ stats/index_html] and (d) North Carolina Rural Economic Development Center, Inc. [www.ncruralcenter.org/databank/datasheet.asp?topic=housing] –and- (2) the higher probability that a poor child will incur a specific birth defect compared to a child who is not poor (40% higher); published research suggests a strong inverse relationship between socio-economic status and risk of congenital abnormalities for different ethnic populations.*[18-19]

** This weight represents the portion of all risk factors attributed to *specific risk factors* strongly tied to *substandard housing conditions* (e.g., child's exposure toxins=.2; low socio-economic status=.133; substandard housing=.133; and smoking residents=.133; collectively, these risk factors equal 59.9% of all risk factors.)

*** 13.3% of all children enrolled in Medicaid have been diagnosed with asthma and/or are taking asthma medication compared to a statewide prevalence of 6.32% according to "Childhood Asthma in North Carolina" by Paul Buescher and Kathleen Jones-Vessey. *North Carolina State Center for Health Statistics,* No. 113, March 1999, page 3. The equation used to compute excess asthmatic prevalence in the Medicaid insured population is: [75 x .0632 = 4.74; 25 x .133 = 3.32; 4.74 + 3.32 = 8.04; 8.04 / 6.32 = 1.27]

Birth Defects

As was noted in Section I, direct medical care costs for selected birth defects in North Carolina children **exceed $107 million** per year. This cost relates to approximately 1 of every 320 children in North Carolina with *hypospadias* or *other selected birth defects.*

Indirect cost measurements on birth defects have been conducted by Davies,[6] Schuler[6B] and Waitzman.[66] In particular, these researchers are primarily responsible for establishing quantification metrics to calculate indirect costs on (a) special education, (b) developmental services, and (c) lost productivity tied to birth defects. For example, Waitzman estimated indirect costs for a cluster of birth defects at $5.9 billion in the USA; in contrast, they estimated direct medical care costs for the same cluster of birth defects at $2.1 billion (in 1992 $) –or- an overall **indirect-to-direct cost** ratio of **$2.8 to $1**. Inflated to 2004 dollars, the total cost rises to $10.8 billion. Since the bulk of indirect cost research on birth defects has focused primarily on **special education** and **developmental services**, we chose to limit the scope of the indirect portion of our cost analysis to these particular entities.

In order to calculate indirect birth defect-related costs among North Carolina children, we created the following equations comprised, in part, on cost accounting methods and data extracted from Waitzman et al:[66]

Special Education

Birth Defect	Frequency	# N.C. Children	[1996$] Per Capita Cost	Total Costs
• Hypospadias*	1: 320	----------	----------	----------
• Heart defects	1: 520	4,075	$ 4,196	**$ 17,098,700
• Anencephaly*	1: 550	----------	----------	----------
• Cleft lip & palate	1: 890	2,381	$ 5,218	$ 12,424,058
• Spina bifida	1:1,160	1,826	$50,719	$ 92,612,894
• Limb reduction	1:2,620	808	$28,352	**$ 22,908,416
• Omphalocele	*	1:6,064	----------	
				$145,044,068
				x ***ECIIR
			TOTAL	$180,344,882

* These birth defects were not cost quantified by Waitzman et al and, thus, were excluded from the aggregate cost estimate.
** Costs for special education and developmental services were combined into a single quantity.
*** Annual *employment cost index* inflation rate: 1997=2.8%; 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Developmental Services

Birth Defect	Frequency	# N.C. Children	[1996$] Per Capita Cost	Total Costs
Hypospadias*	1: 320	----------	----------	----------
Heart defects**	1: 520	----------	----------	----------
Anencephaly*	1: 550	----------	----------	----------
Cleft lip & palate	1: 890	2,381	$ 688	$ 1,638,128
Spina bifida	1:1,160	1,826	$ 2,694	$ 4,919,244
Limb reduction**	1:2,620	----------	----------	----------
Omphalocele*	1:6,064	----------	----------	----------
				$ 6,557,372
				x ***ECIIR
			TOTAL	$ 8,437,823

* These birth defects were not cost quantified by Waitzman and, thus, were excluded from the aggregate cost estmate.
** Costs for special education and developmental services were combined and listed in the "Special Education" framework on the preceding page.
*** Annual *employment cost index* inflation rate: 1997=2.8%; 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for birth defects among all North Carolina children amounted to approximately $188.7 million. Although this cost estimate relates to *all* North Carolina children with birth defects tied to *environmentally-attributed risk factors*, it does **not** reveal what portion of environmental influence is due ***specifically to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of birth defects attributed to unhealthy/substandard housing:

Special education costs for birth defects:	$180,344,882
Developmental services costs for birth defects:	$ 8,437,823
All indirect birth defect costs in N.C. children:	$188,782,705
% of N.C. children in substandard housing:	x *.20
Substandard housing-specific risk factor weight	x **.12
Indirect birth defect costs tied to substandard housing:	$ 4,530,785

Based on the preceding equation, indirect birth defect costs due to ***substandard housing*** conditions were estimated to be approximately **$ 4.5 million** in 2006.

* See footnote on page 34.
** This weight represents the portion of all risk factors that is attributed to *specific risk factors* strongly tied to *substandard housing conditions* (e.g., prenatal exposure to toxins = .075 and substandard housing = .045; collectively, these risk factors equal 12% of all risk factor weight)

Neoplasm (Cancer)

As was noted in Section I, direct medical care costs for lymphoma and leukemia in North Carolina children **exceed $42 million** per year. Indirect cost measurements on specific childhood cancers such as lymphoma and leukemia have been conducted by Landrigan,[5] Davies[6] and Schuler.[6B] In particular, these researchers are primarily responsible for establishing quantification metrics to calculate indirect costs on (a) lost parental wages and (b) loss of IQ and resulting lost future income among child victims. For example, Landrigan estimated indirect costs for pediatric cancer at $13,500 for lost parental wages (in 1998 $) and $60,500 for loss in IQ-induced lost future income. Since the bulk of indirect cost research on pediatric cancer has focused primarily on **lost parental wages –**and- **loss in IQ-induced lost future incomes**, we chose to limit the scope of the indirect portion of our cost analysis to these particular entities.

In order to calculate indirect neoplasm costs among North Carolina children, we created the following equation comprised, in part, on cost accounting methods and data extracted from Landrigan:[5]

		[1998$]	
Cost Entity	# N.C. Children	Per Capita Cost	Total Costs
• Lost parental wages	240	$13,500	$ 3,240,000
• IQ loss-induced lost income	240	$60,500	$ 14,520,000
			$ 17,760,000
			x *ECIIR
		TOTAL	$ 20,742,118

* Annual *employment cost index* inflation rate: 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for *newly-identified* cancers among all North Carolina children amounted to approximately $20.7 million. Although this cost estimate relates to *all* North Carolina children with selected cancers tied to *environmentally-attributed risk factors*, it does **not** reveal what portion of environmental influence is tied ***specifically substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of selected neoplasms attributed to unhealthy/substandard housing:

All indirect cancer costs in N.C. children:	$ 20,742,118
% of N.C. children in substandard housing:	x .20*
Substandard housing-specific risk factor weight	x .05**
Indirect neoplasm costs tied to substandard housing:	$ 207,421

Based on the preceding equation, indirect neoplasm costs due to **substandard housing** conditions were estimated to be approximately **$ 207,421** in 2006.

* See footnote on page 34.

** This weight represents the portion of all risk factors that is attributed to *specific risk factors* strongly tied to *substandard housing conditions* (e.g., child's environmental exposure = .025 and substandard housing = .025; collectively, these risk factors equal 5% of all risk factors.)

Neuro - Behavioral

As was noted in Section I, direct medical care costs for selected neurobehavioral conditions (autism, cerebral palsy, and mental retardation) in North Carolina children are **nearly $75 million** per year.

Indirect cost measurements on these particular conditions have been conducted by various researchers including Landrigan[5] and Honeycutt.[67] In particular, Landrigan and Honeycutt have established quantification metrics to calculate indirect costs on various neuro-behavioral variables outlined below. Due to the comprehensive and clearly delineated nature of their quantification efforts in this arena, we tailored the scope of the indirect portion of our cost analysis around their well-respected methodologies.

In order to calculate indirect neuro-behavioral costs among North Carolina children, we created the following equation comprised, in part, on cost accounting methods and data extracted from Landrigan[5] and Honeycutt:[67]

Autism

Cost Entity	# N.C. Children	[1997$] Lifetime Cost	Lifetime Total Costs
Home/auto modifications	12,765	$ 571	$ 7,288,815
Special education services	12,765	$ 72,399	$ 924,173,235
Home care	12,765	$1,024,237	$ 13,074,385,305
Productivity losses due to morbidity	12,765	$ 472,740	$ 6,034,526,100
		Subtotal	$ 20,040,373,455
		Lifetime divider	(75 years)
		Gross Annual cost	$ 267,204,979
		Comorbidity Deflator	x .66*
		Net annual cost	$ 176,355,286
			x ECIIR**
		Annual Total (2006$)	$ 215,228,760

* To avoid double-counting, a deflator is used to account for the fact that autism co-exists with mental retardation in approximately 34% of affected children.
** Annual *employment cost index* inflation rate: 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for autistic conditions among all North Carolina children amounted to approximately $215.2 million. Although this cost estimate relates to *all* North Carolina children with autistic conditions tied to *environmentally-attributed risk factors*, it does not reveal what portion of environmental influence is due ***specifically to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of autistic conditions tied to substandard housing:

All indirect autistic costs in N.C. children:	$ 215,228,760
% of N.C. children in substandard housing:	x .20*
Indirect autistic costs tied to substandard housing:	$ 43,045,752

* See footnote on page 34.

Cerebral Palsy

Cost Entity	# N.C. Children	[1997$] Lifetime Cost	Lifetime Total Costs
Home/auto modifications	6,781	$ 1,847	$ 12,524,507
Special education services	6,781	$ 51,182	$ 347,065,142
Home care	6,781	$ 882,932	$ 5,987,161,890
Productivity losses due to morbidity	6,781	$ 467,753	$ 3.171.833.093
		Subtotal	$ 9,518,584,634
		Lifetime divider	(75 years)
		Gross Annual cost	$ 126,914,461
		Comorbidity Deflator	x .85*
		Net annual cost	$ 107,877,292
			x ECIIR**
		Annual Total (2006$)	$ 131,786,740

* To avoid double-counting, a deflator is used to account for the fact that cerebral palsy co-exists with mental retardation in approximately 15% of affected children.
** Annual *employment cost index* inflation rate: 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for cerebral palsy among all North Carolina children amounted to approximately $131.7 million. Although this cost estimate relates to *all* North Carolina children with cerebral palsy tied to *environmentally-attributed risk factors*, it does not reveal what portion of environmental influence is due ***specifically to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of cerebral palsy tied to substandard housing:

All indirect cerebral palsy costs in N.C. children:	$ 131,786,740
% of N.C. children in substandard housing:	x .20*
Indirect cerebral palsy costs tied to substandard housing:	$ 26,357,348

* See footnote on page 34.

Mental Retardation

Cost Entity	# N.C. Children*	[1997$] Lifetime Cost	Lifetime Total Costs
Home/auto modifications	21,191	$ 810	$ 17,164,710
Special education services	21,191	$ 64,107	$ 1,358,491,437
Home care	21,191	$ 907,742	$ 19,235,960,722
Productivity losses due to morbidity	21,191	$ 563,869	$ 11,948,947,979
		Subtotal	$ 32,560,564,848
		Lifetime divider	(75 years)
		Gross Annual cost	$ 434,140,864
			x ECIIR**
		Annual Total (2006)	$ 530,362,160

* Based on the lowest end (1%) of the national range (1%-3%)
** Annual *employment cost index* inflation rate: 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for mental retardation among all North Carolina children amounted to approximately $530 million. Although this cost estimate relates to all North Carolina children with mental retardation tied to environmentally-attributed risk *factors*, it does **not** reveal what portion of environmental influence is due ***to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of mental retardation tied to substandard housing:

All indirect mental retardation costs in N.C. children:	$ 530,362,160
% of N.C. children in substandard housing:	x *.20
Indirect mental retardation costs tied to substandard housing:	$ 106,072,432

All Conditions (3) Costs

Autism	$ 43,045,752
Cerebral Palsy	$ 26,357,348
Mental Retardation	$ 106,072,432
Subtotal	$ 175,475,532
Substandard housing-specific risk factor weight	x **.25
Total	**$ 43,868,883**

* See footnote on page 34.
** This weight represents the portion of *all risk factors* attributed to *specific risk factors* strongly tied to *substandard housing conditions* (e.g., mother's prenatal lifestyle = .075; low socio-economic status = .0375; substandard housing = .0375; and, prenatal exposure to toxins = .10; collectively, these risk factors equal 25% of all risk factors.)

Lead Poisoning

Nationally, the mean blood lead level in a sampled birth cohort of 5 year-old children was reported in 1997 to be 2.7 micrograms per deciliter (ug/dL).[68] In North Carolina, surveillance data indicate a substantial decrease in the number of children with elevated blood lead levels since 1995 when 895 children were confirmed to have exposures at or about 10 μg/dL. In 2003, only 505 children were confirmed at the same exposure level, despite the fact that the total number of children tested had grown nearly 40% from 87,884 in 1995 to 121,971 in 2003. In 2004, there were 124,257 children under the age of 6 screened for lead poisoning in North Carolina; **1,489** (more than 1% of those screened) had **elevated lead exposures**.[37]

As was noted in Section I, the direct medical care cost for lead poisoning in North Carolina children is **approximately $197,083** per year.

Indirect cost measurements on childhood lead poisoning have been conducted by Schwartz,[69] Salkever[71] and Landrigan.[5] In particular, these researchers are primarily responsible for establishing quantification metrics to calculate indirect costs on the impact of lead poisoning on IQ and estimated lifetime lost earnings. Since the bulk of indirect cost research on childhood lead poisoning has focused primarily on **loss in IQ-induced lost future earnings** by affected persons, we chose to limit the scope of the indirect portion of our cost analysis to this particular area.

On the basis of Schwartz's analysis,[69] we considered each microgram per deciliter of blood lead concentration to be associated with a reduction in IQ of 0.25 points at these levels of lead exposure.[5] Application here of an IQ reduction of 0.25 IQ points per ug/dL assumes implicitly that there is ***no threshold blood lead level below which cognitive effects are seen***. This assumption appears reasonable, because to date, cognitive deficits have been associated with all ranges of blood lead concentration studied, and no evidence of a threshold has been found.[70] Moreover, Salkever has calculated that the loss of one IQ point is associated with an overall reduction in lifetime earnings of 2.39 percent.[71] This corresponds to a loss of 1.61% of earnings potential for an IQ deficit of 0.675 points.

In order to calculate **indirect** lead poisoning costs among North Carolina children, we used the following framework which closely resembles the one developed by Landrigan[5] and comprised largely of cost accounting methods and data from Schwartz[69] and Salkever.[71]

Factor		Quantitative Index
Environmental attributable fraction		100%
Mean blood lead level		2.7 ug/dL*
Blood lead level of 1 ug/dL	equals	Mean loss of 0.25 IQ points
Therefore, 2.7 ug/dL	equals	Mean loss of .675 IQ points
Loss of 1 IQ point	equals	Loss of lifetime earnings of 2.39%
Therefore, loss of .675 IQ points	equals	Loss of 1.61% of lifetime earnings

Group	# of Children**	[1997$] Lifetime Earnings	% Loss	Total Loss
Boys	3,559	$ 881,027	1.61 (.0161)	$50,482,758
Girls	3,674	$ 519,631	1.61 (.0161)	$30,736,901
			Subtotal	$81,219,659
				x ***ECIIR
			TOTAL	$ 99,220,873

* Since the blood lead levels have reportedly dropped substantially over the past decade, we chose to use the national norm of 2.7 ug/dl as an estimated mean for North Carolina children with elevated blood lead levels.
** Based on a 1.19% prevalence rate of 607,827 children <age 5 years ; 50.8% female vs. 49.2% male [quickfacts.census.gov]
*** Annual *employment cost index* inflation rate: 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for lead poisoning reported in 0-4 year-old North Carolina children amounted to approximately $99.2 million. Although this cost estimate relates to this particular group of North Carolina children with elevated blood lead levels tied to *environmentally-attributed risk factors*, it does **not** reveal what portion of environmental influence is due ***specifically to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of elevated blood lead levels attributed to unhealthy/substandard housing:

All indirect blood poisoning costs in N.C. children:	$ 99,220,873
% of N.C. children in substandard housing:	x *.20
Substandard housing-specific risk factor weight	x **1.00
Indirect blood poisoning costs due to substandard housing:	$ 19,844,174

Based on the preceding equation, ***indirect blood lead poisoning*** costs due to **substandard housing** conditions were estimated to be approximately **$ 19.8 million** in 2006.

* See footnote on page 34.
** This weight represents the portion of all risk factors that is attributed to *specific risk factors* strongly tied to *substandard housing conditions* (e.g., environmental = 1.00)

Unintentional Injuries: Falls & Burns

Injuries among children and adolescents impose a financial burden on many segments of society.[72] Parents and health insurers, for example, assume responsibility for a myriad of medically-related expenses due to injuries. Parents may be forced to stay home from work to care for an injured child, affecting both the family's income and the employers' profit. Children who are disabled from an injury [such as a fall or burn] may be unable to work in the future. Deciding which of these costs to include in cost-of-injury estimates is crucial, because the decision can influence the estimated monetary burden of injuries by orders of magnitude. As recommended by the Panel on Cost-Effectiveness in Health and Medicine,[73] a nonfederal panel convened by the U.S. Public Health Service, we adopted a societal perspective that attempts to

estimate all costs associated with unintentional falls and unintentional burns -- costs to victims, families, government, insurers, and taxpayers. Other perspectives would constrain the analysis to, for example, government expenditures for health care payer expenditures, which include only a subset of total injury costs.

Unintentional fall-related and burn-related injuries can be separated into *resource* and *productivity* costs.[72] **Resource** costs are broken down into medical costs and other resource costs. In contrast, **productivity** costs include immediate and future work losses due to a childhood injury. We have already documented ***direct medical care costs*** for childhood falls and burns in Section I. However, we have yet to quantify other direct resource costs (e.g., police and fire department costs) or productivity costs (e.g., work losses by family and friends who care for injured children; victims' future lost wages and value of lost household work, fringe benefits, and the administration costs of processing compensation for lost earnings through litigation, insurance, or public welfare programs such as food stamps and Supplemental Social Security Income). Thus, in order to calculate **indirect** costs of unintentional falls and unintentional burns among North Carolina children, we used the following framework:

Injury	Non-medical Resource*	Productivity**	[1997$] Total Indirect Cost
Falls	$ 530,560	$29,743,559	$ 30,274,119
Burns	$ 443,516	$21,389,842	$ 21,833,358
		Subtotal	$ 52,107,477
			x ***ECIIR
		TOTAL	$ 65,438,755

* Based on a nationwide "medical care"-to-"other resource" cost ratio of 1.00-to-.079 [74]

** Based on a nationwide "medical care"-to-"other resource" cost ratio of 1.00-to-3.81[74]

*** Annual *employment cost index* inflation rate: 1997=2.8%; 1998=4.6%; 1999=2.8%; 2000=3.6%; 2001=1.4%; 2002=2%; 2003=1.7%; 2004=1.1%; 2005=1%; 2006=2.1%. U.S. Dept. of Labor Statistics [www.bls.gov/news.release/prod2.nro.htm]

Overall, aggregate estimated indirect costs for unintentional falls and unintentional burns in all North Carolina children amounted to approximately $65 million. Although this cost estimate relates to all North Carolina children who incurred such injuries tied to *environmentally-attributed risk factors*, it does **not** reveal what portion of environmental influence is due ***specifically to substandard housing***. Thus, we used the following equation to determine the approximate indirect cost of these injuries attributed to substandard housing:

All indirect fall and burn costs in N.C. children:	$ 65,438,755
% of N.C. children in substandard housing:	x .20*
Substandard housing-specific risk factor weight	x .55**
Indirect fall/burn costs tied to substandard housing:	$ 7,198,263

Based on the preceding equation, ***indirect*** fall and burn-related costs due to **substandard housing** conditions were estimated to be nearly **$7.2 million** in 2006.

---

* *The estimated percentage used in this portion of the analysis is based on two key factors: (1) one of five North Carolina households being substandard; a value of 20% represents the* ***lowest percentage*** *provided by various sources: (a) North Carolina Smart Growth [www.ncsmartgrowth.org/archive/housingpaper _text.html], (b) North Carolina Data Center[census.state.nc.us/cps_ summary-2006.pdf], (c) North Carolina Housing Coalition [www.nchousing.org/research_publications/ facts_ stats/index_html] and (d) North Carolina Rural Economic Development Center, Inc. [www.ncruralcenter.org/databank/datasheet.asp?topic=housing] –and- (2) the higher probability that a poor child will incur a specific birth defect compared to a child who is not poor (40% higher); published research suggests a strong inverse relationship between socio-economic status and risk of congenital abnormalities for different ethnic populations.*[18-19]

** This weight represents the portion of all risk factors that is attributed to *specific risk factors* strongly tied to *substandard housing conditions* (five burn-specific and three fall-specific risk factors equaled 1.10; 1.10 –divided- by 2 = .55)

SECTION III

Combined Direct & Indirect Costs Due to Substandard Housing Conditions

In this third, and final, section of our analysis we combine direct medical care [Section I] and indirect non-medical costs [Section II]. Since all costs have previously been adjusted to reflect 2006 dollars, the figures listed in table 9 reflect a present day value of the estimated costs of substandard housing conditions among North Carolina children.

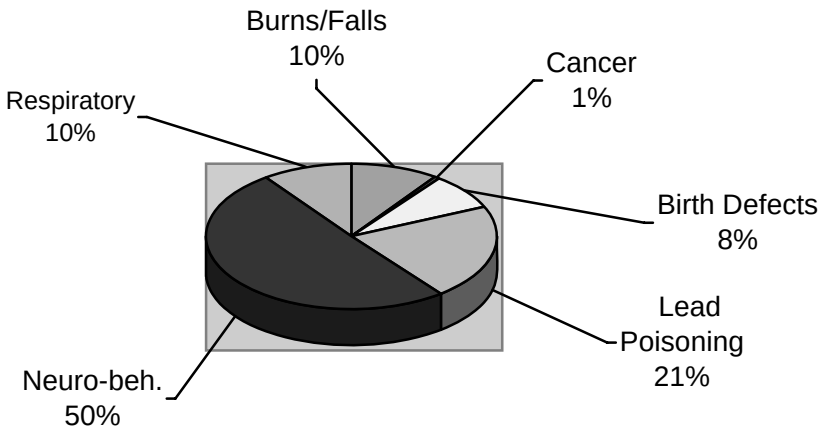
TABLE 9

Direct, Indirect, and Combined Costs

Condition	Direct Cost	Indirect Cost	Percentage of Direct:Indirect	Total Cost
Burns & Falls	$1,924,996	$7,198,263	26.74%	$9,123,259
Cancer	$547,142	$207,421	263.78%	$754,563
Congenital Birth Defects	$3,020,612	$4,530,785	66.67%	$7,551,397
Lead Poisoning	$221,422	$19,844,174	1.12%	$20,065,596
Neuro-behavioral	$3,983,926	$43,868,883	9.08%	$47,852,809
Respiratory (Asthma)	$3,734,396	$5,732,082	65.15%	$9,466,478
Sub-total	$13,432,494	$81,381,608	***Grand Total***	$94,814,102

Specifically, Table 9 reveals the total costs attributed to substandard housing conditions among all targeted conditions is nearly **$ 95 million** in 2006 dollars.

Figure 3.
Combined Direct & Indirect Costs Per Condition by Percentage.



Overall, **combined** costs for the 3 **neurobehavioral** conditions (autism, cerebral palsy, and mental retardation) comprise **approximately 50%** of all costs – following by **lead poisoning** commanding a distant second at 21%. This distribution is similar to the percentage breakdown of **direct medical care costs** in which **neurobehavioral** was the largest cost contributor (30%) followed by asthma (28%) and birth defects (22%). Several factors contributing to the consistently high ranking of neurobehavioral costs are:

(1) *Far more North Carolina children* have one or more of the targeted neurobehavioral conditions than children born with congenital birth defects;
(2) Children with any of the targeted neurobehavioral conditions are more likely to *live a longer lifespan* than children born with a congenital birth defect;
(3) Due, in part, to their longer lifespan, children with any of the targeted neurobehavioral conditions incur *cumulatively higher costs* associated with their daily care and functioning.

Lead poisoning and **respiratory (asthma)** were the second and third highest total cost entities. Their high rankings are due largely to the fact that children with either of these conditions are also more likely to live longer life spans than children with congenital birth defects and, thus, more likely to incur cumulatively higher costs throughout their lives.

SECTION IV

Conclusion, Limitation and References

Conclusion

Overall, this study was designed to address measurable economic impacts of environmental risk factors commonly-found within substandard housing on childhood illnesses and diseases. However, it **does not account for the significant human [emotional, psychological, social, and physical] toll**, as individuals and families grapple with developmental and lingering problems on a daily and, often, unrelenting basis.

Neurobehavioral conditions were the most expensive direct –and- indirect cost entity. Although these conditions had slightly higher direct costs than the second- and third-ranked conditions (asthma and birth defects), **indirect** cost differences showed (a) far greater cost variance among the targeted conditions and (b) that ***lead poisoning***, in particular, commanded a much higher indirect cost than four of remaining five conditions. **Neurobehavioral** conditions generate high costs because they typically require extensive life maintenance services over a long period of time (e.g., lifetime). Moreover, **neurobehavioral** conditions [as well as ***lead poisoning***] often result in significant intellectual deficits that compromise a person's employment prospects and lifetime income capabilities.

By and large, **everyone pays** – sooner or later – for the pernicious effects of substandard housing on the health, education, and welfare of North Carolina's children. North Carolina's taxpayers [and employers] essentially fund much of the direct health care costs for childhood illnesses and disabilities due to substandard housing conditions. Moreover, North Carolina's prospects for new and sustained economic growth are threatened when today' children (tomorrow's workers) are physically, mentally and/or intellectually handicapped by the damaging effects of their childhood environment. Such impacts have additional and sometimes multiplicative consequences on family members if parents or guardians cannot make a living due to caring for their affected children.

Since all levels of government have a stake in the health of all children, it is incumbent for local, state and federal government officials work to work together to reduce, if not eliminate, the impact of substandard housing in North Carolina. By solving this dilemma, a large portion of future direct and indirect costs could be avoided and slow down today's health care cost spiral. In any public policy discussion, the health of ***all*** our children should be of paramount concern and priority. We hope that this analysis will help inform future policy discussions to insure that all North Carolina children have a healthy and productive future.

Limitations

Like cost estimates reported by other researchers who focused their attention on *environmentally attributable* factors and childhood health, our cost estimates on the impact of *substandard housing conditions* are also conservative. Most important, they are low because we considered only six categories of childhood morbidity and only certain categories of neurobehavioral dysfunction. Additionally, we avoided double-counting costs for children with co-existing conditions such as autism, mental retardation, cerebral palsy, or lead poisoning - although we recognize that the costs of caring for such children are certainly greater than the costs of caring for children with only one such disorder.

Another similar experience we share with our predecessors is being hampered in our modeling by the lack of etiologic research quantifying the possible contribution of substandard housing conditions to the causation of many pediatric diseases; and moreover, by the lack of knowledge of the possibly toxic effects of most chemicals to which American (North Carolina) children may be exposed. In future years, as more etiologic research is undertaken and as better information becomes available on possible associations between environmental [substandard housing] exposures and additional pediatric diseases, the model can be expanded. Our estimates are low additionally because we did not consider late complications of toxic exposures that could not reliably be attributed to exposures sustained during childhood. Thus, we did not examine the possible late cardiovascular consequences of childhood lead poisoning, nor did we consider the costs of adult asthma that might be the direct consequence and/or continuation of asthma that began in childhood. Moreover, our estimates are low because lifetime costs assigned to certain conditions were based on inflation and discount rates constricted to the [lower] monetary value of dollars spent over the past decade.

Although we made extensive efforts to acquire specific types of data, some data do not exist in the desired format, at the level of precision/accuracy desired, or the degree of completeness needed to ensure maximum reliability. Thus, the cost figures cited in this economic cost analysis should be viewed as estimates considering the following limitations and precautions:

- Since it is quite likely that co-existing environmental factors reside in substandard housing settings, it is difficult to determine the *exact [exclusive] influence of a particular environmental factor* on a child's predisposition for sustaining a specific illness, injury, or disease.

- Since eleven (11) percent of all North Carolina children are reportedly uninsured, we applied a multiple of 1.1235 to the insured population's cost in an effort to calculate a statewide cost estimate; however, considering the strong evidence linking uninsured status with poverty and poverty with poor risk factor status – it is possible that a multiple *higher* than 1.1235 is warranted to account for the prospects that this population might, in fact, incur *more severe conditions* due to postponing medical care due to their uninsured status.

- Prevalence rate and medical cost data relevant to unintentional falls was obtained on a combination of North Carolina –and- out-of-state pediatric populations.

- Percentage weight values assigned to most of the risk factors listed in each of the respective PRFCA™ templates were based on our interpretation of significance levels reported in selected research studies highlighted throughout this analysis.

- National *inpatient* [hospital discharge] frequency and cost norms were applied to the *Commercial and Individual* insured population; thus, it is possible that national norms may be higher or lower than North Carolina norms.

- Environmental attributable fractions (EAFs) used in this analysis were based, in large part, on the opinions of several expert panels convened by Landrigan and colleagues[5] as well as the U.S. National Academy of Sciences.

- Indirect cost estimates applied to each of the targeted conditions were based, in part, on cost measurements reported by other researchers highlighted throughout this analysis.

References

1. United States Environmental Protection Agency. (2003). America's children and the environment: measures of contaminants, body burdens, and illnesses. Washington, DC: EPA.
2. Schettler, T., Stein, J., Reich, F., Velenti, M., and Wallinga, D. (2000). In harm's way: toxic threats to child development. *Greater Boston Physicians for Social Responsibility*.
3. Abstracts of several housing status reports; Greensboro Housing Coalition, 2005.
4. [http://www.cdc.gov/healthyplaces/healthyhomes.htm.]
5. Landrigan, PJ, Schechter, CB, Lipton, JM, Fahs, MC, and Schwartz J. (2002). Environmental pollutants and disease in American children: estimates of morbidity, mortality, and costs for lead poisoning asthma, cancer, and developmental disabilities. *Environmental Health Perspectives* 100(7): 721-8.

6a. Schuler, K, et al. (2006) The price of pollution: cost estimates of environmental-related childhood disease in Minnesota. *Minnesota Center for Environmental Advocacy. Institute for Agriculture and Trade Policy: Food and Health Program*.

6b. Davies, K, and Hauge, D. (2005) Economic costs of diseases and disabilities attributable to environmental contaminants in Washington state. Collaborative on Health and Environment-Washington Research and Information Working Group, Seattle, WA.

7. Massey, R., and Ackerman, F. (2003) Costs of preventable childhood illness: the price we pay for pollution. *Global Development and Environment Institute, Tufts University*, Medford, MA.
8. Seninger, S. (2005). Cost estimates of environmentally related diseases in Montana. Montana Kids Count, *University of Montana-Missoula*, Missoula, MT.
9. Brook, R.D., et al. (2004). Air pollution and cardiovascular disease: a statement for healthcare professional from the expert panel on population and prevention science of the American Heart Association. *Circulation,* 109: 2655-2672.
10. Pope, C.A., et al. (2002). Lung caner, cardiopulmonary mortality, and long term exposure to fine particulate air pollution. *JAMA*, 287 (9), 1132-41.
11. Smith, K.R., Corvalin, C.F., and Kjellstrom, T. (1999). How much global ill health is attributable to environmental factors? *Epidemiology*, 10, 573-584.
12. *Institute of Medicine* (1981). Costs of environment-related health effects: a plan for continuing study. Washington, DC: National Academy Press.
13. Fink, A., Koscoff, J., Chassin, M.R., and Brook, R.H. (1984) Consensus methods: characteristics and guidelines for use. *Am J Public Health*, 74, 979-983.
14. Brook, R.H., Chassin, M.R., Fink, A., Soloman, D.H., Kosecoff, J., and Park, R.E. (1986). A method for the detailed assessment of the appropriateness of medical terminologies. *Int J Technol Assess Health Care*, 2, 53-63.
15. Centers for Disease Control and Prevention (CDC). (2006). Birth defects: frequently asked questions. March 21, 2006.
16. Ritz, B., Yu, F., Fruin, S., Chaa, G., Shaw, G.M., and Harris, J.A. (2002). Ambient air pollution and risk of birth defects in southern California. *Am J Epidemiology*, 155(1), 17-25.
17. Smith, M., Corvalan, C., and Kjellstrom, T. (1999). How much global ill health is attributed to environmental factors? *Epidemiology*, 10, 573-584.

18. Vrijheid, M., et al. (2000). Socioeconomic inequalities in risk of congenital anomaly. *Archives of Disease in Childhood*, 82(5), 349-352.
19. Blatter, B.M., van der Star, M., and Roeleveid, N. (1994). Review of neural tube defects: risk factors in parental occupation and the environment. *Env Health Perspectives*, 102(2), 140-145.
20. Hall, J., and Zwemer, J. (1979). *Prospective Medicine*. Indianapolis: Dept. of Medical Education, Methodist Hospital of Indiana.
21. Subcommittee on Injury Prevention and Control. Injuries due to falls from heights. American College of Surgeons. http://www.facs.org/trauma/falls.html
22. Nagaraja, J., et al. (2005). Deaths from residential injuries in US children and adolescents, 1985-1997. *Pediatrics*, 116(2), 454-461.
23. Rewers, A., et al. (2005). Childhood femur fractures, associated injuries, and sociodemographic risk factors: a population based study. *Pediatrics*, 115(5), e543-e552.
24. Dal Santo, J.A., et al. (2004). Childhood unintentional injuries: factors predicting injury risk among preschoolers. *J Pediatric Psychology*, 29(4), 273-283.
25. Centers for Disease Control and Prevention, National Center for Injury and Prevention Control. (2002). *Injury Fact Book 2001-2002: Residential Fires*. [http://www.cdc.gov/ncipc/fact_book/22/Residentia_Fires.htm.]
26. Common childhood injuries and poisonings facts about burn injury. [http://www.musckids.com/healthy/library/poison/burns.htm.]
27. Warda, L., Tenenbein, M., and Moffatt, M. (1999). House fire injury prevention update. Part I. A review of risk factors for fatal and non-fatal house fire injury. *Injury Prevention*, 5, 145-150.
28. Wehler, C., et al. (2004). Risk and protective factors for adult and child hunger among low-income housed and homeless female headed families. *Am J Public Health*, 94(1), 109-115.
29a. Housing America. Affordable housing shortage threatens children's health. [http://www.housingamerica.net/brief.html.]
29b. Wehler, C., et al. (2004). Risk and protective factors for adult and child hunger among low-income housed and homeless female-headed families. *Am J Public Health*, 94, 109-115.
30. North Carolina estimates from The Current Population Survey. [http://www.census.state.nc.us/cps/cps_summary_2006.pdf.]
31. United States Department of Agriculture. Agricultural Research Service. North Carolina. [http://www.ars.usda.gov/services/docs.htm?docid=11198.]
32. North Carolina demographics for relationships and households. [http://www.maps-n-stats.com/us_nc_h.html.]
33. North Carolina Hunger Network. [http://www.endhunger.com/assets/States/North%20Carolina.html.]
34. March of Dimes. Environmental risks and pregnancy. [http://www.marchofdimes.com/professionals/14332_9146.asp.]
35. Brown, M.J., Shenessa, E., and Tips, N. (2001). Small area analysis of risk for childhood lead poisoning. [http://www.afhh.org/res/res_pubs/saa.pdf.[
36. Centers for Disease Control and Prevention (CDC). (2005). Understanding new national data on lead poisoning. *MMWR*, 54(20), 513-516, [www.afhh.org/chil_ar_lead_poisoning_BLLdata_factsheet.htm]
37. Leonard, L. Preventing lead poisoning among young children: October is lead awareness month in North Carolina. [http://www.enr.state.nc.us/upclose/pages/leadposisoning.html.]

38. National Academy of Sciences, Committee on Developmental Toxicology. (2000). *Scientific frontiers in developmental toxicology and risk assessment*. Washington, DC: National Academy Press.
39. Autism. *Medline Plus*. Medical Encyclopedia. [http://www.nlm.nih.gov/medlineplus/ency/article/001526.htm.]
40. Larsson, H.J., et al. (2005). Risk factors for autism: perinatal factors, parental psychiatric history, and socioeconomic status. *Am J Epidemiology*, 161(10), 916-925.
41. Critical Issues for Parents with Mental Illness and their Families. Executive Summary. *SAMHSA's National Mental Health Information Center: Center for Mental Health Services.*
42. The North Carolina Center for Autism and Developmental Disabilities Epidemiology. Autism information center – state activities. [http://www.cdc.gov/nchddd/dd/aic/states.nc.htm.]
43. Autism society of North Carolina. What is Autism? [http://www.autismsociety-nc.org/html/what_is_autism_.html.]
44. Pellegrino, L. (2002). Cerebral palsy. In M Batshaw, ed., *Children With Disabilities*, 5th ed, Baltimore: Paul H. Brooks, 443-466.
45. *Medline Plus*. Medical Encyclopedia. Cerebral palsy. [http://www.nlm.nih.gov/medline/ency/article/000716.htm.]
46. *Medline Plus*. Medical Encyclopedia. Mental retardation. [http://www.nlm.nih.gov/medlineplus/ency/article/001523.htm.]
47. Holman, J.R. New study underscores particular risk factors for childhood asthma. *Medscape Medical News*. [http://www.medscape.com/viewarticle/520770?rss]
48. Malveaux, F.J., and Fletcher-Vincent, S.A. (1995). Environmental health issues. *Environmental Health Perspectives Supplements*, 103, 59-62.
49. U.S. Department of Health and Human Services. (2006) *Health status of minorities and low- income groups.* 3rd ed. Washington, DC: U.S. Government Printing Office.
50. Haan, M., and Kaplan, G. (1986). The contribution of socioeconomic position to minority health. In *Report of the Secretary's Task Force on Black and Minority Health*, 2, Washington, DC: U.S. Department of Health and Human Services, 29-103.
51. [http://www.healthycarolinians.org/2010objs/asthma.htm]
52. Widome, M.D. (2000). Childhood asthma. [http://healthandenergy.com/childhood_asthma.htm]
53. Spigel, S. (2002). Childhood asthma. OLR Research Report. [http://www.cga.ct.gov/2002/olrdata/ph/rpt/2002-R-0375.htm.]
54. Bronchitis. Mayoclinic.com: Tools for healthier lives. [http://www.mayoclinic.com/health/bronchitis/DS00031/DSECTION=1.]
55. Watkins, M.L., et al. (2003). Maternal obesity and risk for birth defects. *Pediatrics*, 111, 1152-1158.
56. Cancer in children. *N.C. Cancer Facts and Figures 2004*, 57.
57. Buffler, P.A., and Kwan, M.L. (2005) Environmental and genetic risk factors for childhood leukemia: appraising the evidence. *Cancer Investigation*, 1. Taylor and Francis, 60-75.
58. Risk Factors for Lymphoma. Lymphomation.org. [http://www.Lymphomation.org/risk-factors.htm#about.]
59. Belson, M., Kingsley, B., and Holmes, A. Risk factors for acute leukemia in children: a review. [http://www.ehponline.org/docs/2006/9023/abstract.html.]

60. Buckley, J.D., et al. (2000). Pesticide exposures in children with non-Hodgkin lymphoma. *Cancer*, 89(11), 2315-2321.
61. Liner, M.S. Leukemias. Risk Factors. [http://rex.nci.nih.gov/NCI_Pub_Interface/raterisk/risks148.html.]
62. Kwan, M.L. (2004). Breastfeeding and the risk of childhood leukemia: a meta analysis. *Public Health Reports*, 119, 521-535.
63. Faber, D.R., and Krieg, E.J. (2002). Unequal exposure to ecological hazards: environmental injustices in the commonwealth of Massachusetts. *Environmental Health Perspectives Supplement*, 110. [http://www.ehponline.org/members/2002/suppl-2/277-288faber/faber-full.html.]
64. Chestnut, L., Mills, D., and Agras, J. (2002) *National Costs of Asthma for 1997*. EPA Contract 68-W6-0055. Boulder, CO: Stratus Consulting, Inc.
65. Weiss, K., Sullivan, S., and Lyttle, C. (2000). Trends in the cost of illness for asthma in the United States, 1985-1994. *J of Allergy Clin. Immunology*, 106, 493-499.
66. Waitzman, N.J., Romano, P.S., Scheffler, R.M., and Harris, J.A. (1995). Economic costs of birth defects and cerebral palsy-United States 1992. *Morbidity and Mortality Weekly Report*, 44(37), 694-699.
67. Honeycutt, A., Dunlap, L., Chen, H., and al Hamsi, G. (2000). The cost of developmental disabilities. Task Order No. 0621-09. Revised Final Report. Research Triangle Park, NC: Research Triangle Institute.
68. Centers for Disease Control and Prevention. (1997). Update: Blood lead levels—United States, 1991-1994. *Morb Mortality Wkly Rep*, 46, 141-146.
69. Schwartz, J., Pitcher, H., Levin, R., Ostro, B., and Nichols, A.L. (1985). Costs and benefits of reducing lead in gasoline: final regulatory impact analysis. EPA-230/05-85/006. Washington, DC:U.S. Environmental Protection Agency.
70. Lanphear, B.P., Dietrich, K., Auinger, P., Cox, C. (2000). Cognitive deficits associated with blood lead concentaations < 10 µg/dl in US children and adolescents. *Public Health Report*, 115, 521-529.
71. Salkever, D.S. (1995). Updated estimates of earnings benefits from reduced exposure of children to environmental lead. *Environmental Res*, 70, 1-6.
72. The future of children: unintentional injuries in childhood. (2000). *The David and Lucile Packard Foundation. Executive Summary*, 10 (1).
73. Gold, M.R., Siegel, J.E., Russell, L.B., and Weinstein, M.C., eds. (1996). *Cost-effectiveness in health and medicine*. New York: Oxford Univ Press.