The Association Between Lead Exposure and Respiratory Health in Children

Colleen Coleman
Virginia Commonwealth University
Master of Public Health Research Project

The Association between Lead Exposure and Respiratory Health in Children

By

Colleen Coleman

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Preceptor: Roy T. Sabo, Ph.D.

Department of Epidemiology and Community Health
Master of Public Health Program
MPH Research Project: EPID 691

Virginia Commonwealth University
Richmond, Virginia

December 2009
Submission Statement
Master of Public Health Research Project

This MPH Research Project report is submitted in partial fulfillment of the requirements for a Master of Public Health degree from Virginia Commonwealth University’s School of Medicine. I agree that this research project report be made available for circulation in accordance with the program’s policies and regulations pertaining to documents of this type. I also understand that I must receive approval from my Faculty Advisor in order to copy from or publish this document, or submit to a funding agency. I understand that any copying from or publication of this document for potential financial gain is not allowed unless permission is granted by my Faculty Advisor or (in the absence of my Faculty Advisor) the Director of the MPH Program.

____________________________________________________
Student Signature

________________________________
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Semester: Fall  
Year: 2009

Please complete the following outline. **Do not exceed 2 pages (A-H).**

**A. PROJECT TITLE:**

The Association Between Lead Exposure and Respiratory Health in Children

**PURPOSE** (state hypothesis/research question):

The objective of this study is to examine the extent to which children testing positive for blood lead exposure are at an increased risk for having poor respiratory.

**C. SPECIFIC OBJECTIVES** (list major aims of the study):

- To identify a possible need for a more multi-targeted approach when dealing with a child that is lead poisoned
- To determine if a relationship exists between lead exposure and respiratory health in children ages 1-6yrs
- To determine if there are demographic differences in both exposure and outcome groups

**D. DESCRIPTION OF METHODS**

**D.1. Identify source(s) of data (eg, existing data set, data collection plans, etc):**

- Existing data set: NHANES 2005-2006

**D.2. State the type of study design (eg, cross-sectional, cohort, case-control, intervention, etc):**

- Cross-sectional

**D.3. Describe the study population and sample size:**
• Sample size: 997 children
• Study population:
  o Children ages 1-6 years
  o Blood lead tested
  o Completed respiratory health questionnaire

D.4. List variables to be included (If a qualitative study, describe types of information to be collected)

• Exposure variable: Assessed at varying blood lead levels
  o Positive blood lead exposure: ≥1, 2, 3, 4, 5, 10 ug/dL
  o Negative blood lead exposure: <1, 2, 3, 4, 5, 10 ug/dL
**Positive blood lead exposure level set at 1ug/dL due to recent findings that there is no safe blood lead level. Unable to choose a value of zero due to laboratory detection limit of 0.25ug/dL and small sample size (N=34) of study participants with levels <0.25ug/dL.**

• Outcome variable: Respiratory health status (questionnaire)
  o The following three questions from the respiratory health and disease questionnaire will be used to assess respiratory health status:
    ▪ 1. In the past 12 months, has your child had wheezing or whistling in your chest?
    ▪ 2. In the past 12 months, how many attacks of wheezing or whistling has your child had?
    ▪ 3. In the past 12 months, how many times has your child gone to the doctor’s office or the hospital emergency room for one or more of these attacks of wheezing or whistling?

  o I will dichotomize the outcome variable: poor vs. good respiratory health
    o Poor respiratory health will be defined as:
      ▪ Answer Q1: Yes response, the child is wheezing
      ▪ Answer Q2: >1 wheezing attacks
      ▪ Answer Q3: ≥1 visit to the doctor for wheezing attack

  o Good respiratory health will be defined as:
    ▪ Answer Q1: No response, the child is not wheezing
      OR
    Yes response, the child is wheezing
    ▪ Answer Q2: 1 wheezing attack reported
    ▪ Answer Q3: No visits to the doctor for wheezing attack

• Demographics:
  o Gender
  o Race
  o Age
  o Annual family income
D.5. Describe methods to be used for data analysis (If a qualitative study, describe general approach to compiling the information collected)

- Logistic regression

E. ANTICIPATED RESULTS:

I anticipate there is a positive association between lead exposure and poor respiratory health – as exposure to lead increases, the likelihood of poor respiratory health increases.

F. SIGNIFICANCE OF PROJECT TO PUBLIC HEALTH:

Addresses vulnerable populations

G. IRB Status:

1) Do you plan to collect data through direct intervention or interaction with human subjects? ___yes ___x_no

2) Will you have access to any existing identifiable private information? ___yes ___x_no

If you answered “no” to both of the questions above, IRB review is not required. If you answered “yes” to either one of these questions, your proposed study must be reviewed by the VCU Institutional Review Board (IRB). Please contact Dr. Vance or Dr. Sridhar for assistance with this procedure.

Please indicate your IRB status:
___ to be submitted (____) __ submitted (date of submission _____________; VCU IRB # __________) ___ IRB exempt review approved (date__________) ___ IRB expedited review approved (date__________) ___ IRB approval not required

H. PROPOSED SCHEDULE:

Start Date: __September 2009__
Anticipated End Date: __December 2009__

I. INDICATE WHICH OF THE FOLLOWING AREAS OF PUBLIC HEALTH KNOWLEDGE WILL BE DEMONSTRATED:

1. Biostatistics – collection, storage, retrieval, analysis and interpretation of health data; design and analysis of health-related surveys and experiments; and concepts and practice of statistical data analysis. ___x_ yes ___no (if yes, briefly describe): SAS

2. Epidemiology – distributions and determinants of disease, disabilities and death in human populations; the characteristics and dynamics of human populations; and the natural history of disease and the biologic basis of health. ___x_ yes ___no (if yes, briefly describe): examining relationship between lead exposure and respiratory health
3. **Environmental Health Sciences** – environmental factors including biological, physical and chemical factors which affect the health of a community.  x__yes ___no (if yes, briefly describe): lead exposure

4. **Health Services Administration** – planning, organization, administration, management, evaluation and policy analysis of health programs.  ___yes ___no (if yes, briefly describe): Evaluation of screening program

5. **Social/Behavioral Sciences** – concepts and methods of social and behavioral sciences relevant to the identification and the solution of public health problems.  ___yes ___no (if yes, briefly describe):
SIGNATURE PAGE
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SIGNATURES:

Student: ___________________________ Date: _________________________

Preceptor: __________________________ Date: _________________________

Faculty Advisor: ____________________ Date: _________________________

MPH Program Director: ______________ Date: _________________________

MPH Program Coordinator: __________ Date: _________________________
MPH Research Project Approval Form

(Type TITLE of Project here)

Submitted to the Graduate Faculty of the
Department of Epidemiology and Community Health
Virginia Commonwealth University

In partial fulfillment of the requirements for the degree of
Master of Public Health

(by: Type STUDENT NAME here)

Comments:

Approval signatures:
Table of Contents

Acknowledgements.................................................................................................................. ii
Abstract......................................................................................................................................... iii
Introduction..................................................................................................................................... 1
Objective......................................................................................................................................... 3
Methods.......................................................................................................................................... 4
Results............................................................................................................................................ 6
Discussion....................................................................................................................................... 7
Conclusion....................................................................................................................................... 9
References.......................................................................................................................................10
Tables............................................................................................................................................15
   Table 1: Study Population Characteristics.............................................................................16
   Table 2: Crude & Adjusted OR.................................................................................................17
Figures...........................................................................................................................................18
   Figure 1: Diagram of Respiratory Health Outcomes..............................................................19
Appendix.......................................................................................................................................20
   NHANES Respiratory Health Questionnaire...........................................................................21
   10% change-in-estimate model...............................................................................................22
   SAS Output..............................................................................................................................23
Acknowledgements

I would like to thank my advisor, Dr. Leonard Vance and my preceptor, Dr. Roy Sabo whose encouragement, guidance and statistical support allowed me to complete this project and enabled me to develop a stronger understanding of the subject.

Colleen Coleman
Abstract

Purpose: The substantial impact of indoor air quality and environmental hazards in the home on one’s health has long been recognized in the field of public health. This cross-sectional study investigates the risk between home based hazards, specifically lead, and respiratory health in children. The objective of this study is to examine the extent to which children testing positive for blood lead exposure are at an increased risk for having poor respiratory health.

Methods: A nationally representative sample of 977 children ages 1-6 years was obtained from the 2005-2006 National Health and Nutrition Examination Survey (NHANES). Information from the demographic, blood lead level, and respiratory health questionnaire databases were combined to assess the impact of lead exposure on respiratory health. Blood lead exposure (BLL) was assessed at the following cut-off values: 1, 2, 3, 4, 5 and 10ug/dL. Respiratory health status was dichotomized as good and poor respiratory health based on the study participant’s answers to the questionnaire. Logistic regression was used to determine the relationship between blood lead levels and respiratory health status while controlling for the following potential confounders: race, age, sex, and annual family income.

Results: This study was unable to establish a relationship between lead exposure and poor respiratory health in children ages 1-6 years, and the lack of relationship held for increasing levels of lead exposure. However, this study did reveal the significant impact of low level lead exposure in children with approximately 77% exposed at BLL ≥ 1ug/dL and 39% at BLL ≥ 2ug/dL. It is important to note that this is only a snapshot of the amount of lead exposure within this population; it is very likely that the levels fluctuate.

Conclusion: While the percentage of study population decreases as the lead exposure increases, it is still alarming at the number of children exposed to low levels of lead. A large and growing body of literature documents the adverse health effects associated with low levels of lead exposure in children. This finding further supports the need for continuing research in examining the true impact of low level lead exposure and in determining a threshold dose level. In addition, a stronger study with a larger sample size and a more clearly defined respiratory health variable would allow for the relationship to be more closely examined before a definitive “no association” result can be made.
INTRODUCTION

The substantial impact of indoor air quality and environmental hazards in the home on one’s health has long been recognized in the field of public health. Florence Nightingale suggested the link between housing and health in the mid 1800’s, noting that “the connection between health and the dwelling of the population is one of the most important that exists” (Jacobs et al. 2007). Research has shown that “the condition of an individual’s home appears to serve as a marker for some important underlying factors beyond those of diet and heredity” (Krieger and Higgins, 2002) and the CDC recently adopted a “Healthy Housing” holistic approach to preventing illnesses in the home. Because young children spend nearly 90% of their time inside their home, they are among the most susceptible to indoor toxins (Cummins and Jackson, 2001; Jacobs et al. 2009). This study investigates the risk between home based hazards, specifically lead, and respiratory health in children ages 1-6 years old.

Lead poisoning is a serious environmental health hazard for U.S. children (Ryan et al. 1999; Joseph et al., 2005; Boreland et al. 2002, 2007). Two major sources of lead poisoning in children are caused by exposure to deteriorated lead-based paint and lead contamination of house dust and soil around the home. Children can ingest lead based paint or lead dust by putting their hands or other objects in their mouths, by eating paint chips or by playing in lead-contaminated soil. It is estimated that there are almost 4 million homes in the U.S. that have peeling or chipping lead-based paint or high levels of lead dust in the home. Lead based paint deterioration is exacerbated by the presence of moisture from plumbing leaks, condensation on surfaces, roof leaks, or high humidity in the home. The effects of lead poisoning include delayed cognitive development, permanent learning disabilities, and behavioral problems (Lanphear et al. 2002, 2005; Needleman 1998). Although federal guidelines recommend intervention at a blood lead level
(BLL) greater than or equal to 10ug/dL, adverse outcomes have been demonstrated at lower levels (Bernard and McGeehin, 2003; Brown and Meehan, 2004; Canfield et al. 2003).

The same moisture that exasperates the deterioration of lead based paints also has a significant effect on respiratory health by contributing to the growth of mold and mildew in the home. Asthma, a chronic respiratory disease characterized by attacks of difficulty breathing, currently affects more than 6 million children in the U.S. (Lanphear, 2001). According to the CDC, asthma annually leads to more than 3 million clinic visits, 550,000 emergency visits, 150,000 hospitalizations, and in excess of 150 deaths in children less than 15 years old (CDC MMWR, 2002). Asthma and other respiratory illnesses are frequently triggered and exacerbated by dusts and mold in the home (Martinez et al. 1995; IOM National Academies Press 2000, 2004). Molds are ubiquitous spore producing organisms, prevalent in warm, damp environments (American Academy of Pediatrics 1998; IOM 2004). According to the EPA, respirable dust particles, especially <10 microns in size, can pose health risks if inhaled, due to its ability to penetrate the nose and upper respiratory system and deep into the lungs. Despite advances in therapy and in our understanding of the pathophysiology of this disease, there has been an increase in the prevalence, morbidity and mortality of children with asthma during the past two decades (Lanphear 2001).

It has been shown that disparities exist in both poor respiratory health and lead poisoning in children (Joseph et al. 2005). Both are prevalent among minorities and subjects with low socio-economic status and certain elements in the environment are associated with increased risk for both conditions (Hartert and Peebles, 2000; Lanphear et al. 1998; Bernard and McGeehin, 2003; Joseph et al. 2005). Although other risk factors are also likely to be important, the large health differences among lower-income and minority families compared with other populations suggest
housing conditions may contribute to chronic disease in some populations (Rosenbaum and Wilson 2001; Kawichi et al. 2005). In the U.S., children from low income families are eight times more likely to get lead poisoned and African-American children were found to have blood lead levels four times higher than Caucasians (Joseph et al. 2005). Previous research has shown that asthma rates are higher among children living in urban, low-income communities (Mannino et al. 2002; IOM 2004). Racial disparities also exist in respiratory illnesses. An Institute of Medicine report noted that African-American children living in low-income families tend to have more severe asthma and are at greater risk of death (IOM 2004).

**Objective**

The objective of this study was to examine the extent to which children testing positive for blood lead exposure are at an increased risk for having poor respiratory health. Three main goals of this study are to determine if a relationship exists between lead exposure and poor respiratory health in children ages 1-6 years of age, to determine if there are demographic differences between children with lead exposure and without lead exposure, and to identify a possible need for a more multi-targeted approach when dealing with a child that is lead poisoned. Secondary analyses examined if changes in the cut-off level that categorizes subjects with varying levels of lead exposure (2, 3, 4, 5, and 10ug/dL) change the relationship between lead exposure and respiratory health in children 1-6 years old.

**METHODS**

**Study design**

The National Health and Nutrition Examination Survey (NHANES) conducted in 2005-2006, was the source of data for this study. NHANES is a cross-sectional, random household
survey of a civilian, non-institutionalized population that used a complex, multistage probability sampling design. Three NHANES datasets (demographics, blood lead levels, and respiratory health questionnaire) were merged into one dataset.

The population inclusion criteria for this study included children 1-6 years of age who were blood lead tested and who completed the respiratory health questionnaire. The following demographics and potential confounders were included in this cross-sectional study: age, race, gender, and annual family income. The analytic sample consisted of 997 children out of a sample of 10,348 study participants aged 1-85 years.

Since recent research findings suggest that there may not be a safe blood lead level, the blood lead exposure variable was dichotomized as children testing positive for blood lead (BLL ≥1ug/dL) and children without exposure to lead (BLL <1ug/dL). A BLL value of 0ug/dL was not used to represent no exposure because the blood lead testing detection limit was 0.25ug/dL. A value of 1ug/dL was chosen due to a small unexposed sample size using (<0.25ug/dL). Secondary analyses were performed which tested the relationship between lead exposure and respiratory health using higher lead exposure categorization levels. The following additional BLLs were tested: 2ug/dL, 3ug/dL, 4ug/dL, 5ug/dL and 10ug/dL. Blood samples were collected from each study participant via venipuncture and lead level analysis was performed using inductively coupled plasma mass spectrometry (ICP-MS). NHANES chose this multi-analytic technique because it enhances productivity by simultaneously detecting the presence of lead, mercury, and cadmium.

The outcome variable, respiratory health status was determined from data found in the Respiratory Disease Questionnaire which was collected as part of the NHANES Household Questionnaire Interview. The questions were asked in the home, prior to physical examination,
using the Computer-Assisted Personal Interviewing (CAPI) system. The following three questions regarding a history of wheezing were administered to survey participants ages ≥1 years and was used as the criteria to assess respiratory health status:

- In the past 12 months, has your child had wheezing or whistling in his/her chest?
  - Yes or No
- In the past 12 months, how many attacks of wheezing or whistling has your child had?
  - Range of 1-12 attacks
- In the past 12 months, how many times has your child gone to the doctor’s office or the hospital emergency room for one or more of these attacks of wheezing or whistling?
  - None or a range of 1-20+ visits

Based on the answers to these three questions, respiratory health was dichotomized as good and poor respiratory health. The following criteria define good respiratory health: Any child that has never had wheezing or whistling in their chest or may have had wheezing/whistling in their chest and had one wheezing attack within the past year but has had no visits to the doctor or ER due to a wheezing attack. The following criteria define poor respiratory health: Any child that has had wheezing/whistling in their chest, has had one or more wheezing attacks, and has gone to the doctor or ER at least once due to a wheezing attack (See Fig. 1).

**Data Analysis**

The Statistical Analysis System (SAS) 9.1 was used for data management and all analyses. SAS survey procedures were used to perform weighted analyses that adjusted for the design effects of the complex sampling used by NHANES. The percentages shown in Table 1 were computed using PROC SURVEYFREQ. The logistic regression models which provided both crude and adjusted estimates of the association between lead exposure and respiratory health
status were computed using PROC SURVEYLOGISTIC. Potential confounders were retained in this model using 10% change-in-estimate strategy.

RESULTS

Table 1 shows the characteristics of the study population by low exposures to lead (BLL ≤ 1µg/dL). Overall, nearly 77% of 997 children surveyed tested positive for blood lead exposure at a level ≥ 1µg/dL. It is very interesting to see that a significant portion of the population is exposed to low levels of lead. This number represents only a “snapshot” of lead exposure within a population; it is very likely that these levels fluctuate. To examine the impact of lead exposure more closely, Table 2 compares lead exposure at levels 1, 2, and 3µg/dL. While the percentage of study population decreases as lead exposure increases, it is still alarming at the number of children exposed to low levels of lead. Almost 32% of the study population has a lead exposure of at least 2µg/dL and 13% at least 3µg/dL. Males and females are equally likely to be exposed to lead (see Table 1). Looking at the study population, 2 year olds are the most likely to be exposed: 84% of all 2 year olds tested were exposed to at least 1 ug/dL, 39% at least 2ug/dL, and 15% at least 3ug/dL. This is pertinent with the literature which has shown this age group is most likely to be exposed because they tend to put objects and their hands in their mouths. As age increases, the percentage of subjects highly exposed declines. Except in this study population, an equal percentage (80%) of both 1 year olds and 4 year olds were exposed at 1ug/dL. Across all levels of lead exposure, African American children were more likely to be exposed (92% of all African American exposed at 1ug/dL) than compared to Caucasian children (74% of all Caucasian exposed at 1ug/dL). Looking at Table 1, lower socio-economic families experienced an increase in lead exposure. Almost 85% of families with an annual family income of <$24,999 and nearly
80% of families with an annual family income of $25,000-$54,999 were exposed to lead as compared to only 37% of families with an annual family income of >$55,000. Both of these observations have been previously reported in literature.

Table 2 shows both crude and adjusted odds ratios examining the association between several lead exposure levels and respiratory health. Based on the results of the 10% change-in-estimate, all analyses were adjusted for race, age, gender and annual family income. It appears that no relationship exists in both crude and adjusted OR analyses for lead exposure at ≥1ug/dL (Crude OR= 1.179 (0.563, 2.466) and Adjusted OR=1.011 (0.439, 2.327)). To examine if any relationship exists among increasing lead exposure levels, additional logistic regression analyses were performed (Table 2). However, no relationship continues to exist as the lead exposure level is increased. Cut-off values greater than 3ug/dL were considered for high lead exposure, but there were no subjects with poor respiratory health in the high exposure groups with this categorization; thus they were not included in this analysis.

**DISCUSSION**

Lead exposure and respiratory diseases were found to jeopardize the health and quality of life of urban minority children in the United States (Bernard and McGeehin, 2003; Lanphear et al. 2002). This study sought to evaluate the strength of association between low level lead exposure and uni-dimensional scaling of respiratory health in children ages 1-6 years.

This study was unable to establish a relationship between lead exposure and poor respiratory health in children ages 1-6 years, and the lack of relationship held for various definitions of “high” lead exposure. However, these findings may not be completely accurate possibly due to the small sample size and/or the calculated respiratory health variable may not be accurately
representative. According to the CDC and other sources, African Americans and lower socio-economic children in the U.S. are at a higher risk of lead poisoning when compared with Caucasian and affluent children (Bernard and McGeehin 2003). This same association was seen within this study population.

Certain limitations of this analysis should be acknowledged. Respiratory health status was based on interviewer responses from the Respiratory Health Questionnaire which is not as accurate as a medical examination by a physician. The 2005-2006 NHANES did assess respiratory health by medical examinations utilizing pulmonary function tests but these were not performed on children less than 13 years of age. Self-reported data is subject to validity concerns, recall bias and misclassification is likely to occur when conducting interviews. This study did not assess the impacts of other confounders associated with respiratory diseases such as pets, allergens, environmental tobacco smoke or heredity. The small sample size was a major limitation because although NHANES has the capacity of providing large sample sizes, this study restricted the study population to 1-6 year olds. Also, NHANES 2005-2006 cannot be merged with other NHANES samples to increase the study population size because 4-year population weights are not currently available.

A major strength of this study is the use of NHANES data due its representativeness to the U.S. population. The CAPI system allows for a standardized, unbiased interviewing system. Lead levels in the NHANES laboratory database are obtained by venipuncture which is considered more reliable than other methods (e.g. finger or heel stick). This was a major strength in that it permitted assessment of all levels of lead exposure.
CONCLUSION

A large and growing body of literature documents the adverse health effects associated with low levels of lead exposure in children (Brown and Meehan 2004). Additionally, a growing number of studies have linked respiratory diseases with the condition of the home (Lanphear et al. 2001). This study attempts to provide additional impetus to the development of holistic strategies to reduce health hazards in the home.

Although the results of this cross-sectional study depicted no association between varying levels of lead exposure and respiratory health; this study did reveal the significant impact of low level lead exposure in children - approximately 77% of children ages 1-6 years exposed at BLL ≥ 1ug/dL and 39% at BLL ≥ 2ug/dL. It is also important to note that this is only a snapshot of the amount of lead exposure within this population; it is very likely that the levels fluctuate which may overestimate or underestimate the true exposure in children. This finding further supports the need for continuing research in examining the true impact of low level lead exposure and in determining a threshold dose level. Coherence exists with previous research when comparing study population demographics between children exposed and unexposed to lead, the same disparities can be seen.

A stronger study with a larger sample size and a more clearly defined respiratory health variable would allow for the relationship to be more closely examined before a definitive “no association” result can be made.
References


Tables
Table 1. Population Characteristics of Lead Exposure & No Lead Exposure

<table>
<thead>
<tr>
<th>Potential Confounders</th>
<th>Lead exposure (≥1ug/dL)</th>
<th>No lead exposure (&lt;1ug/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>% (Wt. %)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>375</td>
<td>48.9% (51.8%)</td>
</tr>
<tr>
<td>Female</td>
<td>392</td>
<td>51.1% (48.2%)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>158</td>
<td>21.0% (16.6%)</td>
</tr>
<tr>
<td>2 years</td>
<td>174</td>
<td>22.7% (18.8%)</td>
</tr>
<tr>
<td>3 years</td>
<td>112</td>
<td>14.6% (15.8%)</td>
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<tr>
<td>4 years</td>
<td>126</td>
<td>16.4% (17.7%)</td>
</tr>
<tr>
<td>5 years</td>
<td>106</td>
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<tr>
<td>6 years</td>
<td>91</td>
<td>11.9% (16.2%)</td>
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<tr>
<td><strong>Race</strong></td>
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<tr>
<td>Mexican</td>
<td>250</td>
<td>32.6% (15.4%)</td>
</tr>
<tr>
<td>Other Hispanic</td>
<td>40</td>
<td>5.2% (5.8%)</td>
</tr>
<tr>
<td>Caucasian</td>
<td>209</td>
<td>27.2% (55.9%)</td>
</tr>
<tr>
<td>African American</td>
<td>228</td>
<td>29.8% (16.1%)</td>
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<tr>
<td>Other/multi-racial</td>
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<td><strong>Annual family income</strong></td>
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<tr>
<td>$24,999</td>
<td>333</td>
<td>43.4% (30.8%)</td>
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<tr>
<td>$25,000 - $54,999</td>
<td>260</td>
<td>33.9% (34.0%)</td>
</tr>
<tr>
<td>≥ $55,000</td>
<td>104</td>
<td>22.7% (35.2%)</td>
</tr>
</tbody>
</table>
Table 2. Crude and Adjusted Analyses

<table>
<thead>
<tr>
<th>Lead Exposure</th>
<th>Good Respiratory Health</th>
<th>Poor Respiratory Health</th>
<th>Crude OR (95% CI)</th>
<th>Adjusted OR* (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N = 924</td>
<td>N = 73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>% (Wt. %)</td>
<td>N % (Wt. %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wt. N</td>
<td></td>
<td>Wt. N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BLL ≥ 1ug/dL</td>
<td>713</td>
<td>54</td>
<td>1.179 (0.56, 2.47)</td>
<td>1.011 (0.44, 2.33)</td>
</tr>
<tr>
<td>BLL &lt; 1ug/dL</td>
<td>211</td>
<td>19</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>BLL ≥ 2ug/dL</td>
<td>293</td>
<td>24</td>
<td>1.164 (0.59, 2.30)</td>
<td>1.032 (0.49, 2.16)</td>
</tr>
<tr>
<td>BLL &lt; 2ug/dL</td>
<td>631</td>
<td>49</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>BLL ≥ 3ug/dL</td>
<td>121</td>
<td>5</td>
<td>0.544 (0.17, 1.70)</td>
<td>0.436 (0.14, 1.37)</td>
</tr>
<tr>
<td>BLL &lt; 3ug/dL</td>
<td>803</td>
<td>68</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

* Adjusted for race, income, age, gender
Figures
Figure 1: Respiratory Health calculated outcomes (Good vs. Poor Respiratory Health)

- **Respiratory Health**
  - **Good Respiratory Health**
    - Child has not been wheezing within past year (Q1: No)
  - **Poor Respiratory Health**
    - Child has been wheezy, had one wheezing attack in past year but has not gone to the doctor (Q1: Yes, Q2: 1, Q3: No)
    - Child has been wheezing within past year (Q1: Yes)
    - Child has had more than one wheezing attack within past year (Q2: >1)
    - Child has gone to the doctor for a wheezing attack within past year (Q3: yes)
Appendix
NHANES Respiratory Health Questionnaire
(modified to include only questions selected for use in this study)

RDQ.070 In the past 12 months, {have you/has SP} had wheezing or whistling in {your/his/her} chest?

YES ......................................................... 1
NO........................................................... 2
(RDQ.140)
REFUSED ...............................................7
(RDQ.140)
DON’T KNOW ........................................ 9
(RDQ.140)

RDQ.080 In the past 12 months, how many attacks of wheezing or whistling {have you/has SP} had? IF 12 OR MORE EPISODES ENTER 12

CAPI INSTRUCTION: HARD EDIT: RANGE EQUALS 1 TO 12

_________ ENTER NUMBER OF EPISODES

REFUSED .........................77
DON’T KNOW .......................99

RDQ.120 (In the past 12 months), how many times {have you/has SP} gone to the doctor’s office or the hospital emergency room for one or more of these attacks of wheezing or whistling?

IF NEVER, ENTER 0

__________ (ENTER NUMBER)

CAPI INSTRUCTION:
SOFTWARE EDIT: IF RESPONSE >20, THEN DISPLAY “UNLIKELY RESPONSE. PLEASE VERIFY. (RDQ. 150).”


REFUSED .........................77
DON’T KNOW .......................99
10% change-in-estimate model

<table>
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<tr>
<th>Potential Confounders</th>
<th>Crude OR = 1.179</th>
<th>Crude weighted OR</th>
<th>% change</th>
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<td>income</td>
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**Calculate % change = (crude - adj) / crude**

**If the % change is greater than 10% than it is a confounder and will need to be adjusted for**

Crude OR = 1.179  
Full Model OR = 1.011

% change (crude OR vs. full model OR)

\[
\frac{(1.179-1.011)}{1.179} = 0.14*100=14%
\]
SAS Output
Potential confounders weighted Ns

The SURVEYFREQ Procedure

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<td>1 - Postive lead exposure (&gt;=1ug/dL)</td>
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## Table of race by lead

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## Table of race by lead

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**Crude Weighted OR for the E-D relationship**

*The SURVEYLOGISTIC Procedure*

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*Probability modeled is RH='1 - Poor respiratory health'.

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Crude Weighted OR for the E-D relationship

The SURVEYLOGISTIC Procedure

Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics

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Testing Global Null Hypothesis: BETA=0

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Type 3 Analysis of Effects

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Analysis of Maximum Likelihood Estimates

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### Odds Ratio Estimates

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### Association of Predicted Probabilities and Observed Responses

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Age, gender, race, and income adjusted OR

The SURVEYLOGISTIC Procedure

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*Probability modeled is RH='1 - Poor respiratory health'.
Age, gender, race, and income adjusted OR

The SURVEYLOGISTIC Procedure

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Model Convergence Status
Convergence criterion (GCONV=1E-8) satisfied.
Age, gender, race, and income adjusted OR

The SURVEYLOGISTIC Procedure

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Age, gender, race, and income adjusted OR

The SURVEYLOGISTIC Procedure

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### Odds Ratio Estimates

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### Odds Ratio Estimates

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<td>race 2 - other Hispanic vs 1 - Mexican Americans</td>
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### Association of Predicted Probabilities and Observed Responses

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Age, gender, race, and income adjusted OR

The SURVEYLOGISTIC Procedure
**Crude Weighted OR for the E-D relationship**

_The SURVEYLOGISTIC Procedure_

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_Probability modeled is RH='1 - Poor respiratory health'._

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<tr>
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</table>
**Crude Weighted OR for the E-D relationship**

*The SURVEYLOGISTIC Procedure*

<table>
<thead>
<tr>
<th>Model Convergence Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Convergence criterion (GCONV=1E-8) satisfied.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model Fit Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
</tr>
<tr>
<td>AIC</td>
</tr>
<tr>
<td>SC</td>
</tr>
<tr>
<td>-2 Log L</td>
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</table>

<table>
<thead>
<tr>
<th>Testing Global Null Hypothesis: BETA=0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test</strong></td>
</tr>
<tr>
<td>Likelihood Ratio</td>
</tr>
<tr>
<td>Score</td>
</tr>
<tr>
<td>Wald</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type 3 Analysis of Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effect</strong></td>
</tr>
<tr>
<td>lead</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th>Analysis of Maximum Likelihood Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>Intercept</td>
</tr>
<tr>
<td>lead</td>
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</tbody>
</table>

36
### Crude Weighted OR for the E-D relationship

**The SURVEYLOGISTIC Procedure**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Point Estimate</th>
<th>95% Wald Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead 1 - Positive lead exposure (&gt;=2ug/dL) vs 0 - Negative lead exposure (&lt;2ug/dL)</td>
<td>1.164</td>
<td>0.590</td>
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<table>
<thead>
<tr>
<th>Association of Predicted Probabilities and Observed Responses</th>
<th>Percent Concordant</th>
<th>Somers' D</th>
<th>0.012</th>
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</thead>
<tbody>
<tr>
<td>Percent Discordant</td>
<td>21.3</td>
<td>Gamma</td>
<td>0.027</td>
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<tr>
<td>Percent Tied</td>
<td>56.3</td>
<td>Tau-a</td>
<td>0.002</td>
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<tr>
<td>Pairs</td>
<td>67452</td>
<td>c</td>
<td>0.506</td>
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</table>
### Age, race, gender and income adjusted OR

**The SURVEYLOGISTIC Procedure**

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<thead>
<tr>
<th>Model Information</th>
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</thead>
<tbody>
<tr>
<td><strong>Data Set</strong></td>
</tr>
<tr>
<td><strong>Response Variable</strong></td>
</tr>
<tr>
<td><strong>Number of Response Levels</strong></td>
</tr>
<tr>
<td><strong>Weight Variable</strong></td>
</tr>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td><strong>Optimization Technique</strong></td>
</tr>
<tr>
<td><strong>Variance Adjustment</strong></td>
</tr>
</tbody>
</table>

| Number of Observations Read | 997 |
| Number of Observations Used | 997 |
| Sum of Weights Read | 15587949 |
| Sum of Weights Used | 15587949 |

<table>
<thead>
<tr>
<th>Response Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ordered Value</strong></td>
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<tr>
<td>1</td>
</tr>
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<td>2</td>
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**Probability modeled is RH='1 - Poor respiratory health'.**
### Class Level Information

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<td>1 - Positive lead exposure (&gt;=2ug/dL)</td>
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</tr>
<tr>
<td></td>
<td>0 - Negative lead exposure (&lt;2ug/dL)</td>
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</tr>
<tr>
<td></td>
<td>5 - Target population age, 5yrs</td>
<td>0 1 0 0 0</td>
</tr>
<tr>
<td></td>
<td>4 - Target population age, 4yrs</td>
<td>0 0 1 0 0</td>
</tr>
<tr>
<td></td>
<td>3 - Target population age, 3yrs</td>
<td>0 0 0 1 0</td>
</tr>
<tr>
<td></td>
<td>2 - Target population age, 2yrs</td>
<td>0 0 0 0 1</td>
</tr>
<tr>
<td></td>
<td>1 - Target population age, 1yr</td>
<td>- - - - -1</td>
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<tr>
<td></td>
<td></td>
<td>1 1 1 1 1</td>
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<tr>
<td>race</td>
<td>5 - other, multi-racial</td>
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<tr>
<td></td>
<td>4 - non-Hispanic black</td>
<td>0 1 0 0</td>
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<tr>
<td></td>
<td>3 - non-Hispanic white</td>
<td>0 0 1 0</td>
</tr>
<tr>
<td></td>
<td>2 - other Hispanic</td>
<td>0 0 0 1</td>
</tr>
<tr>
<td></td>
<td>1 - Mexican Americans</td>
<td>- - - -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>income</td>
<td>3 - Annual family income of greater than $55,000</td>
<td>1 0</td>
</tr>
<tr>
<td></td>
<td>2 - Annual family income between $25,000 and $54,999</td>
<td>0 1</td>
</tr>
<tr>
<td></td>
<td>1 - Annual family income of less than $24,999</td>
<td>- -</td>
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<tr>
<td></td>
<td></td>
<td>1 1</td>
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<tr>
<td>gender</td>
<td>2 - female</td>
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<tr>
<td></td>
<td>1 - male</td>
<td>- 1</td>
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### Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.
**Age, race, gender and income adjusted OR**

*The SURVEYLOGISTIC Procedure*

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Intercept Only</th>
<th>Intercept and Covariates</th>
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<tr>
<td>AIC</td>
<td>8414339.4</td>
<td>8058799.0</td>
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<td>SC</td>
<td>8414344.3</td>
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<table>
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<th>Pr &gt; ChiSq</th>
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<td>&lt;.0001</td>
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<table>
<thead>
<tr>
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<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
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</thead>
<tbody>
<tr>
<td>lead</td>
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<td>0.9337</td>
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<td>8.9710</td>
<td>0.1102</td>
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<tr>
<td>race</td>
<td>4</td>
<td>6.8243</td>
<td>0.1455</td>
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<tr>
<td>income</td>
<td>2</td>
<td>0.1842</td>
<td>0.9120</td>
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<tr>
<td>gender</td>
<td>1</td>
<td>3.1530</td>
<td>0.0758</td>
</tr>
</tbody>
</table>
Age, race, gender and income adjusted OR

The SURVEYLOGISTIC Procedure

### Analysis of Maximum Likelihood Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
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<tr>
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<td>0.3978</td>
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<td>age 2</td>
<td>1</td>
<td>0.2904</td>
<td>0.3314</td>
<td>0.7677</td>
<td>0.3809</td>
</tr>
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<td>race 5</td>
<td>1</td>
<td>0.3806</td>
<td>0.4863</td>
<td>0.6127</td>
<td>0.4338</td>
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<tr>
<td>race 4</td>
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<td>0.2676</td>
<td>0.2809</td>
<td>0.9080</td>
<td>0.3407</td>
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<td>0.2962</td>
<td>0.0112</td>
<td>0.9158</td>
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<td>-0.0746</td>
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<td>0.9032</td>
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<td>0.2593</td>
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<td>income 2</td>
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<td>0.2401</td>
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<td>0.6924</td>
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<td>gender 2</td>
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<td>0.1727</td>
<td>3.1530</td>
<td>0.0758</td>
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### Odds Ratio Estimates

<table>
<thead>
<tr>
<th>Effect</th>
<th>Point Estimate</th>
<th>95% Wald Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead 1 - Positive lead exposure (&gt;=2ug/dL) vs 0 - Negative lead exposure (&lt;2ug/dL)</td>
<td>1.032</td>
<td>0.494 2.156</td>
</tr>
<tr>
<td>age 6 - Target population age, 6yrs vs 1 - Target population age, 1yr</td>
<td>0.585</td>
<td>0.189 1.817</td>
</tr>
<tr>
<td>age 5 - Target population age, 5yrs vs 1 - Target population age, 1yr</td>
<td>0.714</td>
<td>0.257 1.981</td>
</tr>
<tr>
<td>age 4 - Target population age, 4yrs vs 1 - Target population age, 1yr</td>
<td>0.361</td>
<td>0.134 0.968</td>
</tr>
<tr>
<td>age 3 - Target population age, 3yrs vs 1 - Target population age, 1yr</td>
<td>0.239</td>
<td>0.080 0.717</td>
</tr>
<tr>
<td>age 2 - Target population age, 2yrs vs 1 - Target population age, 1yr</td>
<td>0.729</td>
<td>0.304 1.749</td>
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<tr>
<td>race 5 - other, multi-racial vs 1 - Mexican Americans</td>
<td>2.680</td>
<td>0.806 8.907</td>
</tr>
<tr>
<td>race 4 - non-Hispanic black vs 1 - Mexican Americans</td>
<td>2.393</td>
<td>1.169 4.899</td>
</tr>
<tr>
<td>race 3 - non-Hispanic white vs 1 - Mexican Americans</td>
<td>1.889</td>
<td>0.915 3.903</td>
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<tr>
<td>race 2 - other Hispanic vs 1 - Mexican Americans</td>
<td>1.700</td>
<td>0.363 7.955</td>
</tr>
</tbody>
</table>
Age, race, gender and income adjusted OR

The SURVEYLOGISTIC Procedure

<table>
<thead>
<tr>
<th>Effect</th>
<th>Effect Definition</th>
<th>Point Estimate</th>
<th>95% Wald Confidence Limits</th>
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<tbody>
<tr>
<td>income 3 - Annual family income of greater than $55,000 vs 1 - Annual</td>
<td>Annual family income of less than $24,999</td>
<td>0.903</td>
<td>0.404</td>
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<tr>
<td>income 2 - Annual family income between $25,000 and $54,999 vs 1 -</td>
<td>Annual family income of less than $24,999</td>
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<td>0.527</td>
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<td>gender 2 - female vs 1 - male</td>
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<td>0.542</td>
<td>0.275</td>
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</table>

Association of Predicted Probabilities and Observed Responses

| Percent Concordant | Somers' D | 0.308 |
| Percent Discordant | Gamma     | 0.313 |
| Percent Tied      | Tau-a     | 0.042 |
| Pairs             | 67452     | 0.654 |
**Crude Weighted OR for the E-D relationship**

*The SURVEYLOGISTIC Procedure*

<table>
<thead>
<tr>
<th>Model Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Set</strong></td>
</tr>
<tr>
<td><strong>Response Variable</strong></td>
</tr>
<tr>
<td><strong>Number of Response Levels</strong></td>
</tr>
<tr>
<td><strong>Weight Variable</strong></td>
</tr>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td><strong>Optimization Technique</strong></td>
</tr>
<tr>
<td><strong>Variance Adjustment</strong></td>
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<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of Observations Read</strong></td>
<td>997</td>
</tr>
<tr>
<td><strong>Number of Observations Used</strong></td>
<td>997</td>
</tr>
<tr>
<td><strong>Sum of Weights Read</strong></td>
<td>15587949</td>
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<tr>
<td><strong>Sum of Weights Used</strong></td>
<td>15587949</td>
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<table>
<thead>
<tr>
<th>Response Profile</th>
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<tbody>
<tr>
<td><strong>Ordered Value</strong></td>
<td><strong>Total Frequency</strong></td>
</tr>
<tr>
<td><strong>Total Weight</strong></td>
<td></td>
</tr>
<tr>
<td>1 1 - Poor respiratory health</td>
<td>73</td>
</tr>
<tr>
<td>2 0 - Good respiratory health</td>
<td>924</td>
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</table>

*Probability modeled is RH='1 - Poor respiratory health'.*

<table>
<thead>
<tr>
<th>Class Level Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Class</strong></td>
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<tr>
<td>lead</td>
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**Crude Weighted OR for the E-D relationship**

*The SURVEYLOGISTIC Procedure*

<table>
<thead>
<tr>
<th>Model Convergence Status</th>
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<tbody>
<tr>
<td>Convergence criterion (GCONV=1E-8) satisfied.</td>
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</table>

**Model Fit Statistics**

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Intercept Only</th>
<th>Intercept and Covariates</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIC</td>
<td>8414339.4</td>
<td>8388719.9</td>
</tr>
<tr>
<td>SC</td>
<td>8414344.3</td>
<td>8388729.7</td>
</tr>
<tr>
<td>-2 Log L</td>
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<td>8388715.9</td>
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**Testing Global Null Hypothesis: BETA=0**

<table>
<thead>
<tr>
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<th>Chi-Square</th>
<th>DF</th>
<th>Pr &gt; ChiSq</th>
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<tr>
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<td>Wald</td>
<td>1.0913</td>
<td>1</td>
<td>0.2962</td>
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</table>

**Type 3 Analysis of Effects**

<table>
<thead>
<tr>
<th>Effect</th>
<th>DF</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead</td>
<td>1</td>
<td>1.0913</td>
<td>0.2962</td>
</tr>
</tbody>
</table>

**Analysis of Maximum Likelihood Estimates**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
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<td>1.0913</td>
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### Odds Ratio Estimates

<table>
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<th>Effect</th>
<th>Point Estimate</th>
<th>95% Wald Confidence Limits</th>
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<tr>
<td>lead 1 - Positive lead exposure (&gt;=3ug/dL) vs 0 - Negative lead exposure (&lt;3ug/dL)</td>
<td>0.544</td>
<td>0.174 1.704</td>
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</table>

### Association of Predicted Probabilities and Observed Responses

<table>
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<th>Percentage</th>
<th>Value</th>
<th>Measure</th>
<th>Value</th>
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<tbody>
<tr>
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<tr>
<td>Percent Discordant</td>
<td>6.0</td>
<td>Gamma</td>
<td>0.344</td>
</tr>
<tr>
<td>Percent Tied</td>
<td>81.8</td>
<td>Tau-a</td>
<td>0.008</td>
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<td>Pairs</td>
<td>6745</td>
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**Model Information**

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<th>WORK.CLEANDATA</th>
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<td>Model</td>
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<td>Optimization Technique</td>
<td>Fisher's Scoring</td>
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<td>Variance Adjustment</td>
<td>Degrees of Freedom (DF)</td>
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<table>
<thead>
<tr>
<th>Number of Observations Read</th>
<th>997</th>
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</thead>
<tbody>
<tr>
<td>Number of Observations Used</td>
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<td>Sum of Weights Read</td>
<td>15587949</td>
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<td>Sum of Weights Used</td>
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**Response Profile**

<table>
<thead>
<tr>
<th>Ordered Value</th>
<th>RH</th>
<th>Total Frequency</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 - Poor respiratory health</td>
<td>73</td>
<td>1190989</td>
</tr>
<tr>
<td>2</td>
<td>0 - Good respiratory health</td>
<td>924</td>
<td>14396960</td>
</tr>
</tbody>
</table>

*Probability modeled is RH='1 - Poor respiratory health'.*

**Class Level Information**

<table>
<thead>
<tr>
<th>Class</th>
<th>Value</th>
<th>Design Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead</td>
<td>1 - Positive lead exposure (&gt;=3ug/dL)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0 - Negative lead exposure (&lt;3ug/dL)</td>
<td>-</td>
</tr>
<tr>
<td>age</td>
<td>6 - Target population age, 6yrs</td>
<td>1 0 0 0 0</td>
</tr>
</tbody>
</table>
**Age, race, gender and income adjusted OR**

*The SURVEYLOGISTIC Procedure*

### Class Level Information

<table>
<thead>
<tr>
<th>Class</th>
<th>Value</th>
<th>Design Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - Target population age, 5yrs</td>
<td>0 1 0 0 0</td>
<td></td>
</tr>
<tr>
<td>4 - Target population age, 4yrs</td>
<td>0 0 1 0 0</td>
<td></td>
</tr>
<tr>
<td>3 - Target population age, 3yrs</td>
<td>0 0 0 1 0</td>
<td></td>
</tr>
<tr>
<td>2 - Target population age, 2yrs</td>
<td>0 0 0 0 1</td>
<td></td>
</tr>
<tr>
<td>1 - Target population age, 1yr</td>
<td>- - - - -1</td>
<td>1 1 1 1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>race</th>
<th>Value</th>
<th>Design Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 - other, multi-racial</td>
<td>1 0 0 0</td>
<td></td>
</tr>
<tr>
<td>4 - non-Hispanic black</td>
<td>0 1 0 0</td>
<td></td>
</tr>
<tr>
<td>3 - non-Hispanic white</td>
<td>0 0 1 0</td>
<td></td>
</tr>
<tr>
<td>2 - other Hispanic</td>
<td>0 0 0 1</td>
<td></td>
</tr>
<tr>
<td>1 - Mexican Americans</td>
<td>- - - -</td>
<td>1 1 1 1</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>income</th>
<th>Value</th>
<th>Design Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - Annual family income of greater than $55,000</td>
<td>1 0</td>
<td></td>
</tr>
<tr>
<td>2 - Annual family income between $25,000 and $54,999</td>
<td>0 1</td>
<td></td>
</tr>
<tr>
<td>1 - Annual family income of less than $24,999</td>
<td>- -</td>
<td>1 1</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>gender</th>
<th>Value</th>
<th>Design Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - female</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1 - male</td>
<td>-</td>
<td>1</td>
</tr>
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</table>

### Model Convergence Status

Convergence criterion (GCONV=1E-8) satisfied.
Age, race, gender and income adjusted OR

The SURVEYLOGISTIC Procedure

<table>
<thead>
<tr>
<th>Model Fit Statistics</th>
<th>Intercept Only</th>
<th>Intercept and Covariates</th>
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<tbody>
<tr>
<td>Criterion</td>
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<tr>
<td>AIC</td>
<td>8414339.4</td>
<td>8011899.3</td>
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<td>SC</td>
<td>8414344.3</td>
<td>8011967.9</td>
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<td>-2 Log L</td>
<td>8414337.4</td>
<td>8011871.3</td>
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Testing Global Null Hypothesis: BETA=0

<table>
<thead>
<tr>
<th>Test</th>
<th>Chi-Square</th>
<th>DF</th>
<th>Pr &gt; ChiSq</th>
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<tbody>
<tr>
<td>Likelihood Ratio</td>
<td>402466.100</td>
<td>13</td>
<td>&lt;.0001</td>
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<tr>
<td>Score</td>
<td>376072.582</td>
<td>13</td>
<td>&lt;.0001</td>
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<tr>
<td>Wald</td>
<td>31.2562</td>
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Type 3 Analysis of Effects

<table>
<thead>
<tr>
<th>Effect</th>
<th>DF</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead</td>
<td>1</td>
<td>2.0237</td>
<td>0.1549</td>
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<tr>
<td>age</td>
<td>5</td>
<td>9.6387</td>
<td>0.0861</td>
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<tr>
<td>race</td>
<td>4</td>
<td>8.0351</td>
<td>0.0903</td>
</tr>
<tr>
<td>income</td>
<td>2</td>
<td>0.2317</td>
<td>0.8906</td>
</tr>
<tr>
<td>gender</td>
<td>1</td>
<td>3.4437</td>
<td>0.0635</td>
</tr>
</tbody>
</table>
### Age, race, gender and income adjusted OR

*The SURVEYLOGISTIC Procedure*

#### Analysis of Maximum Likelihood Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DF</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>Pr &gt; ChiSq</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1</td>
<td>-2.9455</td>
<td>0.3354</td>
<td>77.1129</td>
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<tr>
<td>lead 1 - Positive lead exposure (&gt;=3ug/dL) vs 0 - Negative lead exposure (&lt;3ug/dL)</td>
<td>1</td>
<td>-0.4150</td>
<td>0.2918</td>
<td>2.0237</td>
<td>0.1549</td>
</tr>
<tr>
<td>age 6 - Target population age, 6yrs vs 1 - Target population age, 1yr</td>
<td>1</td>
<td>0.0675</td>
<td>0.4576</td>
<td>0.0218</td>
<td>0.8827</td>
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<tr>
<td>age 5 - Target population age, 5yrs vs 1 - Target population age, 1yr</td>
<td>1</td>
<td>0.2502</td>
<td>0.4036</td>
<td>0.3842</td>
<td>0.5354</td>
</tr>
<tr>
<td>age 4 - Target population age, 4yrs vs 1 - Target population age, 1yr</td>
<td>1</td>
<td>-0.4233</td>
<td>0.3742</td>
<td>1.2799</td>
<td>0.2579</td>
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<tr>
<td>age 3 - Target population age, 3yrs vs 1 - Target population age, 1yr</td>
<td>1</td>
<td>-0.8361</td>
<td>0.4352</td>
<td>3.6913</td>
<td>0.0547</td>
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<tr>
<td>age 2 - Target population age, 2yrs vs 1 - Target population age, 1yr</td>
<td>1</td>
<td>0.3117</td>
<td>0.3250</td>
<td>0.9199</td>
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<tr>
<td>race 5 - other, multi-racial vs 1 - Mexican Americans</td>
<td>1</td>
<td>0.3596</td>
<td>0.4977</td>
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<td>0.4700</td>
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<tr>
<td>race 4 - non-Hispanic black vs 1 - Mexican Americans</td>
<td>1</td>
<td>0.3071</td>
<td>0.2795</td>
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<tr>
<td>race 3 - non-Hispanic white vs 1 - Mexican Americans</td>
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<td>0.9744</td>
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<tr>
<td>race 2 - other Hispanic vs 1 - Mexican Americans</td>
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<td>-0.0241</td>
<td>0.6085</td>
<td>0.0016</td>
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<tr>
<td>income 3 - Annual family income of greater than $55,000 vs 1 - Annual family income of less than or equal to $25,000</td>
<td>1</td>
<td>-0.1254</td>
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<td>0.2316</td>
<td>0.6303</td>
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<tr>
<td>income 2 - Annual family income between $25,000 and $54,999 vs 1 - Annual family income of less than or equal to $25,000</td>
<td>1</td>
<td>0.0728</td>
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<td>0.7606</td>
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<tr>
<td>gender 2 - female vs 1 - male</td>
<td>1</td>
<td>-0.3222</td>
<td>0.1736</td>
<td>3.4437</td>
<td>0.0635</td>
</tr>
</tbody>
</table>

#### Odds Ratio Estimates

<table>
<thead>
<tr>
<th>Effect</th>
<th>Point Estimate</th>
<th>95% Wald Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>lead 1 - Positive lead exposure (&gt;=3ug/dL) vs 0 - Negative lead exposure (&lt;3ug/dL)</td>
<td>0.436</td>
<td>0.139 - 1.368</td>
</tr>
<tr>
<td>age 6 - Target population age, 6yrs vs 1 - Target population age, 1yr</td>
<td>0.570</td>
<td>0.180 - 1.802</td>
</tr>
<tr>
<td>age 5 - Target population age, 5yrs vs 1 - Target population age, 1yr</td>
<td>0.684</td>
<td>0.242 - 1.934</td>
</tr>
<tr>
<td>age 4 - Target population age, 4yrs vs 1 - Target population age, 1yr</td>
<td>0.349</td>
<td>0.131 - 0.929</td>
</tr>
<tr>
<td>age 3 - Target population age, 3yrs vs 1 - Target population age, 1yr</td>
<td>0.231</td>
<td>0.077 - 0.693</td>
</tr>
<tr>
<td>age 2 - Target population age, 2yrs vs 1 - Target population age, 1yr</td>
<td>0.727</td>
<td>0.305 - 1.735</td>
</tr>
<tr>
<td>race 5 - other, multi-racial vs 1 - Mexican Americans</td>
<td>2.750</td>
<td>0.809 - 9.345</td>
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<tr>
<td>race 4 - non-Hispanic black vs 1 - Mexican Americans</td>
<td>2.610</td>
<td>1.289 - 5.282</td>
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<td>race 3 - non-Hispanic white vs 1 - Mexican Americans</td>
<td>1.938</td>
<td>0.933 - 4.026</td>
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<tr>
<td>race 2 - other Hispanic vs 1 - Mexican Americans</td>
<td>1.874</td>
<td>0.407 - 8.638</td>
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</tbody>
</table>
## Crude Weighted OR

*The SURVEYLOGISTIC Procedure*

<table>
<thead>
<tr>
<th>Effect</th>
<th>Point Estimate</th>
<th>95% Wald Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>income 3 - Annual family income of greater than $55,000 vs 1 - Annual family income of less than $24,999</td>
<td>0.837</td>
<td>0.376 - 1.864</td>
</tr>
<tr>
<td>income 2 - Annual family income between $25,000 and $54,999 vs 1 - Annual family income of less than $24,999</td>
<td>1.020</td>
<td>0.497 - 2.094</td>
</tr>
<tr>
<td>gender 2 - female vs 1 - male</td>
<td>0.525</td>
<td>0.266 - 1.037</td>
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### Association of Predicted Probabilities and Observed Responses

<table>
<thead>
<tr>
<th>Percent Concordant</th>
<th>66.3</th>
<th>Somers' D</th>
<th>0.345</th>
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<tbody>
<tr>
<td>Percent Discordant</td>
<td>31.8</td>
<td>Gamma</td>
<td>0.352</td>
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<tr>
<td>Percent Tied</td>
<td>1.9</td>
<td>Tau-a</td>
<td>0.047</td>
</tr>
<tr>
<td>Pairs</td>
<td>67452</td>
<td>c</td>
<td>0.672</td>
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</table>