1-Year Prevalence of Toxocariasis through Toxocara Antibody Presence Among Low-Income Children in the United States from 2011-2012: Cross-Sectional Study

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ABSTRACT

BACKGROUND

Toxocariasis is a disease caused by parasitic roundworms transmitted via fecal matter, generally from canine and feline domestic pets. It has been referred to as the "neglected disease of poverty" in the United States, given its presence in fecal matter-contaminated parks and playground areas.

METHODS

The NHANES Toxocariasis study is a cross-sectional study conducted from 2011-2012 to understand the relationship between multiple variables and Toxocariasis. This analysis examines the association between income levels and Toxocariasis in a subset of n=1,297 aged 6 to 19. A chi-square test was conducted with the prevalence difference, and a multivariable logistic regression analysis was used to obtain an adjusted odds ratio and 95% confidence interval.

RESULTS

Overall, there were 30 (2.3%) cases of Toxocariasis among 1,297 participants aged 6-19 years in 2011-2012. The prevalence of Toxocariasis in the lower-income group was 3.5%, while in the higher-income group, it was 1.4%. There was a significant statistical difference in the computed prevalence difference (0.02) from the chi-squared test (test statistic = 6.76, 1 df, p = 0.009). In the adjusted analysis, there was no statistically significant difference between lower and higher income groups, controlling for log-transformed blood lead levels, age, race/ethnicity, and home ownership status (OR=0.377, 95% CI: 0.607, 3.638, p=0.405).

CONCLUSION

There is no evidence that income affected the risk of Toxocariasis among children aged 6-19 years in the United States in 2011-2012.

BACKGROUND

Toxocariasis is caused by a parasitic roundworm found in the intestines of dogs and cats. It is transmitted from animals to humans via canine and feline feces from domestic pets. Infections are often asymptomatic but can cause severe central nervous system complications or vision loss. Toxocariasis is considered a "neglected disease of poverty" in the United States (U.S.) due to contamination in parks in urban areas with fecal material. In some cases, individuals may be exposed to Toxocariasis via their pets.

This cross-sectional study of 1,297 participants was conducted from the 2011 to 2012 NHANES survey dataset. Participants are U.S. residents from 15 selected areas, per NHANES selection strategy, aged 6-19 years (*NHANES - Participants - Why I Was Selected*, 2021). The primary exposure assessed is income. To assess the income difference effect on Toxocariasis antibody presence, 'income' was modified to be dichotomous by grouping income groups 1-6 as 'lower-income' ($0 to $34,999), and groups 7-11 as 'higher-income,' ($35,000 to $75,000+). Given the known association between poverty and Toxocariasis in the U.S., the null hypothesis is that income will not affect the prevalence of Toxocariasis in 2011-2012 NHANES participants aged 6 to 19 years (H0: $p1=p2$). The research hypothesis is that there will be a positive effect (increased prevalence) of Toxocariasis in the lower-income group from the 2011-2012 NHANES study (H_1: $p1 \neq p2$).

Methods

The primary outcome was the presence of the Toxocara antibody, which is a dichotomous variable. An individual is considered to have Toxocariasis if the Toxocara antibody is present. At baseline, data on several covariates was collected, such as age, number of children under age five, number of children between ages 6-19, sex, race, the total number of people in the household, income, Blood Lead Level (BLL), log transformed BLL, citizenship status, home status, and number of rooms in the home. The potential confounders were log-transformed BLL, age, race, and home status.

A chi-square test was used to determine if there was an association between lower-income status and Toxocariasis through the presence of the Toxocara antibody. Prevalence difference (95% confidence interval) was calculated for the crude relationship. A multivariable logistic regression analysis was used to obtain an adjusted odds ratio (95% confidence interval) that compared income status with the presence of the Toxocara antibody. RStudio was used for all analyses, and statistical significance was determined by the p-value being less than 0.05.

RESULTS

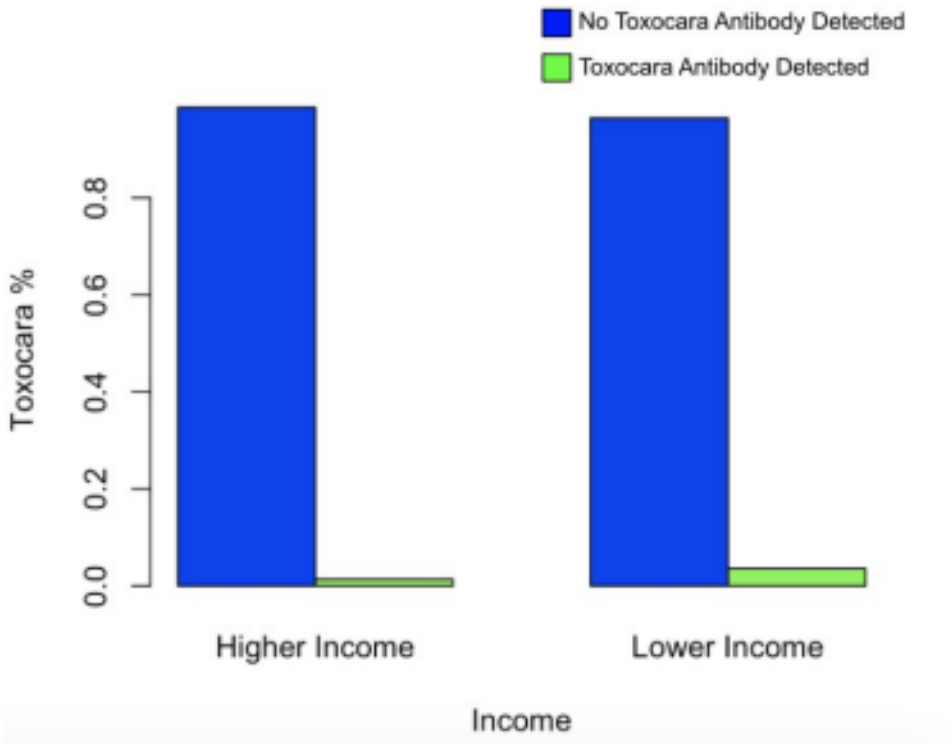
The baseline characteristics of the study participants were not similar across stratified income groups in the 2011-2012 NHANES survey of children 6-19 years old. Table 1 presents log transformed BLL, age, race, and home status characteristics. The lower-income group, compared to the higher-income group, were more likely to have heightened BLL (ug/dL), to rent their home (rather than own), were younger (months), and were unbalanced in race/ethnicity, with notable differences in every group.

Table 1. Baseline Characteristics by Income Group, NHANES Toxocariasis Survey 2011-2012

Participant Characteristics n(%) unless otherwise indicated	Lower-Income n=563 (<$34,999)	Higher-Income n=734 (>$35,000)
Log Transformed Blood Lead Level (ug/dL) Mean (SD)	-0.4358267 (0.6402797)	-0.6931144 (0.5141634)
Age in months Median (IQR)	130 (72.5)	134 (78)
Race		
1= Mexican American	148 (26.29%)	189 (25.75%)
2= Other Hispanic	72 (12.79%)	65 (8.86%)
3= Non-Hispanic white	140 (24.87%)	223 (30.38%)
4= Non-Hispanic black	154 (27.35%)	121 (16.49%)
5= Other race	49 (8.70%)	136 (18.53%)
Home Status		
1=Owner	173 (30.73%)	506 (68.94%)
2=Renter	385 (68.38%)	219 (29.84%)
3=Other	5 (0.89%)	9 (1.23%)

Overall, 20 (3.6%) lower-income individuals and 10 (1.4%) higher-income individuals aged 6-19 years contracted Toxocariasis in 2011-2012 (Figure 1). The computed prevalence ratio was 2.61, meaning children aged 6-19 in the lower-income group in 2011-2012 had 2.61 times the prevalence of Toxocara antibodies than those in the higher-income group. The figure shows that the prevalence of Toxocariasis was higher in the lower-income group than the higher-income group.

Figure 1. Prevalence of Toxocariasis Case by Income Group



We conducted a chi-square test on the association between income and risk of Toxocariasis and computed the prevalence difference (95% CI). The results are presented in Table 2.

Table 2. Association between Toxocariasis Infection and Income Group, NHANES SURVEY 2011-2012

Prevalence Difference (95% CI)	Test Statistic (df)	p-value
0.0219000007 (0.0045, 0.0393)	6.7629 (1)	.009307

In the lower-income group, children aged 6-19 experienced 2.19 more cases of Toxocariasis per 100 than those in the higher-income group in 2011-2012 (95% CI: 0.45 per 100 to 3.93 per 100). This association was statistically significant (X^2=6.7639, df=1, p=.009307). We conducted a multivariable logistic regression analysis to account for potential confounding and included log

transformed BLL, age, race, and home status as covariates (Table 3). A simple logistic regression model ran as a comparison to compute the magnitude of confounding.

Table 3. Crude and Adjusted Association between Toxocariasis and Income Group, NHANES Survey 2011-2012

Model	Measure of Effect	95% CI	p-value
Crude Odds Ratio	0.9808	(1.266, 5.984)	0.0122
*Adjusted Odds Ratio	0.377	(0.607, 3.638)	0.40546

*Adjusted for age, log-transformed blood lead level, race, and home status.

In the lower-income group, children aged 6-19 had 0.377 times the odds of Toxocariasis compared to those in the higher-income group in 2011-2012, adjusting for log-transformed BLL, age, race, and home status. This association was not statistically significant (p=0.405). The magnitude of confounding (0.9808-0.376653/0.376653) was 160.40%, which suggests confounding was present using the 10% rule.

DISCUSSION

Income level did not statistically significantly impact the prevalence of Toxocariasis among children aged 6-19 years old in 2011-2012 (aOR=0.377, 95% CI: 0.607, 3.638, p=0.40546), despite the disease's perceived relationship with poverty within the U.S.

The null results may be influenced by bias. First, selection bias based on income level among participants may impact results. The dataset includes more participants in the higher-income group than the lower-income group. The impact on the observed risk ratio would be a bias towards or away from the null if the participation differs by outcome status. Additionally, misclassification of exposure may have skewed results, given that income groupings are not stratified based on the Federal Poverty Line, resulting in more individuals classified as lower-

income. This may bias away from the null and underestimate the association between income and Toxocariasis.

These results could also be explained by a significant effect of confounding evidenced by the high degree of variability (Table 1). One potential source of confounding is log-transformed BLL, as its average in lower-income and higher-income groups was different. Since BLL is indicative of exposure to lead, prevalent in poorer urban areas, it may be associated with both exposure and outcome. Another potential confounder is homeownership status. Lower-income individuals, who are more likely to rent, may rent in lower-income areas with decreased economic mobility, influencing income. Furthermore, lower-income areas have higher rates of fecal contamination from pets due to poor maintenance, meaning higher rates of Toxocariasis.

Limitations of cross-sectional studies include temporal sequence being unclear. We cannot determine the directionality between income and Toxocariasis. Also, prevalent cases of long duration may bias results. Different results could have been observed if overall trends were observed over time. These cross-sectional study results may be generalizable to similar populations of children in North America and some European countries as they are similar regarding soil and animal contact opportunities (Abedi et al., 2021).

The results of this cross-sectional study show that Toxocariasis is present among lower-income populations, although not statistically significant. BLL and homeownership status are suggested as potential sources of confounding. Therefore, public health interventions are needed to prevent infection among children in lower-income households living in rental housing and with high BLL. These children may be more likely to be exposed to animal feces in parks in their environments, so policies targeting these environments are necessary (Chen et al., 2018).

REFERENCES

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Chen, J., Liu, Q., Liu, G.-H., Zheng, W.-B., Hong, S.-J., Sugiyama, H., Zhu, X.-Q., & Elsheikha, H. M. (2018). Toxocariasis: A silent threat with a progressive public health impact. *Infectious Diseases of Poverty*, *7*(1), 59. https://doi.org/10.1186/s40249-018-0437-0

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R CODE Appendix by Project Component

PC 2: 2x2 Table, 'lowincome'.

```
> table(income)
income
  1   2   3   4   5   6   7   8   9  10  11
 37  52  71  82 114 207 123  93  59  43 416

> median(income)
[1] 7

lowincome <- ifelse(income>6,0,1)
> table(lowincome)
lowincome
  0   1
734 563
> table(tox,lowincome)
   lowincome
tox   0   1
  0 724 543
  1  10  20
```

PC 3: Table 1

```
> tapply(log_lead, lowincome, mean)
        0         1
-0.6931144 -0.4358267

> tapply(log_lead, lowincome, sd)
        0         1
0.5141634 0.6402797
> tapply(age, lowincome, median)
  0   1
134 130
> tapply(age, lowincome, IQR)
   0    1
78.0 72.5


> table(race,lowincome)
    lowincome
race   0   1
   1 189 148
   2  65  72
   3 223 140
   4 121 154
   5 136  49
```

```
> prop.table(table(lowincome,race),1)
          race
lowincome         1         2
       0 0.25749319 0.08855586
       1 0.26287744 0.12788632
          race
lowincome         3         4
       0 0.30381471 0.16485014
       1 0.24866785 0.27353464
          race
lowincome         5
       0 0.18528610
       1 0.08703375


          home_status
              Lowincome 1     2     3
       0 506 219   9
       1 173 385   5
> prop.table(table(lowincome,home_status),1)
          home_status
lowincome         1         2           3
       0 0.689373297 0.298365123 0.012261580
       1 0.307282416 0.683836590 0.008880995
```

PC3: Figure 1

```
> prop.table(table(lowincome,tox))
                  tox
lowincome          0           1
       0          0.5582113   0.0077101
       1          0.4186584   0.0154202
```

```
barplot(prop.table(table(tox,lowincome),2),beside=TRUE,names=c("Higher Income", "Lower Income"),col=c("blue","green"),xlab="Income",ylab="Toxocara %")
```

PC4: Hypothesis Test

```
> table(lowincome,tox)
          tox
lowincome   0   1
                0 724  10
                1 543  20
```

```
> prop.test(c(20,10),c(563,734),correct=FALSE)

                2-sample test for equality of proportions
```

```
                without continuity correction

data:  c(20, 10) out of c(563, 734)
X-squared = 6.7629, df = 1, p-value = 0.009307
alternative hypothesis: two.sided
95 percent confidence interval:
 0.004461324 0.039338677
sample estimates:
   prop 1     prop 2
0.03552398 0.01362398
```

PC5: Logistic Regression

```
> tox_lead11.21 <- read.csv("~/Downloads/tox_lead11.21.csv")
>   View(tox_lead11.21)
> attach(tox_lead11.21)
> lowincome <- ifelse(income>6,0,1)
> LogitModel1<-glm(tox~lowincome, family=binomial(link=logit))
> summary(LogitModel1)

Call:
glm(formula = tox ~ lowincome, family = binomial(link = logit))

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -4.2822     0.3184 -13.449   <2e-16 ***
lowincome     0.9808     0.3914   2.506   0.0122 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 285.30  on 1296  degrees of freedom
Residual deviance: 278.56  on 1295  degrees of freedom
AIC: 282.56

Number of Fisher Scoring iterations: 7

> exp(LogitModel1$coefficients)
(Intercept)   lowincome
 0.01381215  2.66666667
> exp(confint(LogitModel1))
Waiting for profiling to be done...
                2.5 %     97.5 %
(Intercept) 0.00689684 0.02434917
lowincome   1.26643648 5.98418056
```

```
> LogitModel2<-glm(tox~lowincome+log_lead+age+relevel(factor(race),ref="3")
+factor(home_status), family = binomial(link = logit))
> summary(LogitModel2)

Call:
glm(formula = tox ~ lowincome + log_lead + age + relevel(factor(race),
    ref = "3") + factor(home_status), family = binomial(link = logit))

Coefficients:
                                  Estimate Std. Error z value Pr(>|z|)
(Intercept)                     -5.184614   0.807626  -6.420 1.37e-10 ***
lowincome                        0.376653   0.452760   0.832  0.40546
log_lead                         1.731263   0.280233   6.178 6.49e-10 ***
age                              0.012012   0.004102   2.928  0.00341 **
relevel(factor(race), ref = "3")1 -0.533970   0.607772  -0.879  0.37963
relevel(factor(race), ref = "3")2  1.022174   0.548208   1.865  0.06224 .
relevel(factor(race), ref = "3")4 -0.266381   0.571910  -0.466  0.64138
relevel(factor(race), ref = "3")5 -1.702497   1.098572  -1.550  0.12120
factor(home_status)2             0.014654   0.450853   0.033  0.97407
factor(home_status)3             1.599470   1.147354   1.394  0.16330
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 285.30  on 1296  degrees of freedom
Residual deviance: 221.92  on 1287  degrees of freedom
AIC: 241.92

Number of Fisher Scoring iterations: 8
```