Published in final edited form as:
Birth Defects Res A Clin Mol Teratol. 2009 October ; 85(10): 850–857. doi:10.1002/bdra.20614.

Socioeconomic Measures, Orofacial Clefts, and Conotruncal Heart Defects in California

Suzan L. Carmichael[1,*], **Chen Ma**[1], and **Gary M. Shaw**[1,2]

[1]California Research Division, March of Dimes Foundation, Oakland, California

[2]Stanford University School of Medicine, Palo Alto, California

Abstract

OBJECTIVE—To examine the association of multiple measures of socioeconomic status (SES) with risks of orofacial clefts and conotruncal heart defects.

DESIGN—Data were from a recent population-based case-control study conducted in California that included 608 patients with orofacial clefts, 277 patients with conotruncal heart defects, and 617 nonmalformed controls.

RESULTS—The odds ratio for the worst versus best score on a household-level SES index was strongest for cleft lip with or without palate, at 1.7 (95% confidence interval, 0.9–3.4); the odds ratios for this comparison were closer to 1 and less precise for the other defect groups. An index based on neighborhood-level SES was also not associated with increased risk of the studied defects.

CONCLUSIONS—This detailed analysis of SES and selected birth defects did not suggest worse SES was associated with increased risk of the studied defects, with the possible exception of cleft lip with or without cleft palate.

Keywords

socioeconomic status; neighborhood; birth defects; clefts; conotruncal; heart defect

INTRODUCTION

Numerous studies have shown that lower socioeconomic status (SES) is associated with increased risk of a variety of adverse perinatal and infant outcomes, such as low birthweight, preterm delivery, and mortality (Parker et al. 1994; Kramer et al. 2000). Studies have also shown that worse SES is associated with neural tube defects (NTDs; Elwood et al. 1992; Wasserman et al. 1998; Blatter et al. 2000; Vrijheid et al. 2000; Farley et al. 2002; Meyer and Siega-Riz, 2002; Blanco et al. 2005;Li et al. 2006; Yang et al. 2008). Few studies have investigated an association between SES and other birth defects. Understanding the association of SES with birth defects is important because it might provide etiologic clues, it might improve our understanding of SES as a potential confounder of other exposures, and it might help in effective planning of health services and design of prevention efforts.

Orofacial clefts represent one of the more common birth defects, with a combined prevalence of about 1.5 per 1000 live births in the U.S. (National Birth Defects Prevention Network

*Correspondence to: Suzan L. Carmichael, March of Dimes, California Research Division, Children's Hospital Oakland Research Institute, 5700 Martin Luther King, Jr. Way, Oakland, CA 94609. scarmichael@marchofdimes.com.

(NBDPN), 2005; Canfield et al. 2006). Conotruncal defects are less common, with a prevalence closer to 0.8 per 1000 live births (NBDPN, 2005; Canfield et al. 2006). Studies of clefts and SES tend to report no association with SES (Ericson et al. 1984; Clark et al. 2003). Studies of conotruncal heart defects have been less consistent, with some showing worse SES to have a positive, a negative, or no association (Adams et al. 1989; Correa-Villasenor et al. 1991; Vrijheid et al. 2000; Carmichael et al. 2003; Yang et al. 2008). However, few studies have provided detailed analyses regarding the association of SES with these defects. The current study examined the association of individual-, household- and neighborhood-level measures of SES with risks of orofacial clefts and conotruncal heart defects, using recent data from a population-based case-control study conducted in California.

METHODS

Study Design and Sample Selection

This case-control study included live born, stillborn (fetal deaths at ≥20 weeks' gestation), and prenatally diagnosed, electively terminated case fetuses that occurred to mothers residing in Los Angeles, San Francisco, and Santa Clara counties in the state of California (Carmichael et al., 2007a, 2007b). The study included data on deliveries that had estimated due dates (EDDs) of July 1999 to June 2004. Ascertainment of clefts ended with EDD June 30, 2003; ascertainment of conotruncal heart defects ended with EDD June 30, 2004, to accrue more cases for these less prevalent outcomes. Case information was abstracted from multiple hospital reports and medical records and then reviewed by a clinical geneticist. Information was abstracted at all regional hospitals at which the subjects may have received care, and diagnoses up to 1 year of age were abstracted using the BPA coding system. Based on information gathered from chart reviews, if infants were diagnosed with single gene disorders or chromosomal aneusomies, they were ineligible. Case groups included cleft palate (CP), cleft lip with or without cleft palate (CLP), and the conotruncal heart defects d-transposition of the great arteries (dTGA) and tetralogy of Fallot (TOF). For each conotruncal heart defect case, anatomic and physiologic features were confirmed by reviewing echocardiography, cardiac catheterization, surgery, or autopsy reports. Infants with dTGA associated with an endocardial cushion defect or with double outlet right ventricle were excluded, because we consider that transposition is not the primary or earliest defect in these combinations. Each case was classified as *isolated* if there was no concurrent major malformation or as *nonisolated* if there was at least one accompanying major malformation.

Nonmalformed, live born controls were selected randomly from birth hospitals to represent the population from which the cases were derived. Specifically, controls were selected from area hospitals in proportion to their contribution to the total population of live born infants. That is, we determined the number of eligible control infants from each hospital in proportion to that hospital's contribution to the most recent birth cohort for which vital statistics data were available, and then we randomly generated a set of birth dates from which we selected the controls from hospital logs. Ascertainment of controls ended with EDD June 30, 2004.

Mothers were eligible for interview if they were the biologic mother and carried the pregnancy of the selected study subject, they were not incarcerated, and their primary language was English or Spanish. Maternal interviews were conducted using a standardized, computer-based questionnaire, primarily by telephone, in English or Spanish, no earlier than 6 weeks after the infant's EDD. A variety of exposures were assessed, focusing on the periconceptional time period, which was defined as 2 months before through 2 months after conception.

In total, 81% of eligible case mothers (1255) and 77% of control mothers (700) were interviewed. Ten percent of eligible case mothers and 12% of control mothers were not locatable, and the remaining nonparticipants declined the interview. The median time between

EDD and interview completion was 12 months for cases and 8 months for controls. Overall, available for analyses were 700 controls (626 with EDD through June 30, 2003) and 1015 cases: 199 CP, 502 CLP, 142 dTGA and 176 TOF (several cases had a cleft and a heart defect).

Variable Construction

Individual- and household-level SES measures included maternal education (<high school, high school, some college, or ≥4 years of college), maternal and paternal employment (yes or no, for any paid, voluntary, or military part- or full-time job during the periconceptional period), and annual household income (<$10,000; $10,000-$20,000; $20,000-$30,000; $30,000-$40,000; $40,000-$50,000; and >$50,000). We created a household-level SES index to examine a potential gradient in risk across these measures. The index equals the number of measures scored as *low*. The measures were scored as follows: parental education (low if either parent's education was <high school), income (low if <$20,000), and employment (low if the father was not employed; Yang et al. 2008).

Respondents reported addresses for all residences at which they lived for at least 1 month during the periconceptional period. Addresses were geocoded to 2000 U.S. Census tracts and block groups using EZ-Locate (geocode.com), an online geocoding service. In case of multiple geocoded addresses for a single individual, one address was selected at random for analysis. The census information was linked with and incorporated into the analytical data set. Geocoding at the block group level was successful for 86.9% of the interviewed cases and 88.1% of the controls—that is, 617 controls (552 with EDD through June 30, 2003) and 882 cases: 174 CP, 434 CLP, 125 dTGA, and 152 TOF.

We examined six census measures to reflect neighborhood-level (i.e., block group) SES: (1) education—proportion of the population aged ≥25 who did not graduate from high school or its equivalent; (2) poverty—proportion of the noninstitutionalized population living below poverty level, which was $17,029 for a family of four in 1999; (3) unemployment—proportion of the population aged ≥16 that was not working; (4) operator/laborer occupation—proportion of the employed population aged at least 16 years in occupations that included operators, fabricators, and laborers; (5) crowding—proportion of occupied housing units with more than one person per room; and (6) rental occupancy—proportion of occupied housing units that were rental units (Wasserman et al. 1998). Each census measure was divided into quartiles based on the distribution among controls. Higher values reflect worse SES for each measure. We also created a neighborhood-level SES index. Each measure was scored as 1 if in the worst (highest) quartile or as 0 otherwise, and the values were summed such that a higher value on the index reflected worse SES (Carmichael et al. 2003; Grewal et al. 2009).

Analyses

We used logistic regression to generate maximum likelihood estimates of the odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) using SAS (version 9.1, SAS Institute, Cary, NC). We examined the association of each anomaly group with each SES measure. We also examined odds ratios after adjusting for the following potential confounders, which were selected a priori: maternal race-ethnicity (non-Hispanic white, U.S.-born Hispanic, foreign-born Hispanic, African-American, Asian, other), body mass index (weight [kg]/height $[m]^2$), and intake of folic acid-containing supplements, smoking, and binge drinking (defined as five or more drinks on a single occasion) during the two months before or first two months of pregnancy. We also examined final analyses after exclusion of nonisolated cleft cases, cases and controls with a family history of the studied defects in a parent or sibling, mothers who had type I or II diabetes, and mothers who took medications to prevent seizures (the latter three variables were based on maternal self-report during the interview).

All data collection and analyses for this study were approved by the California Health and Human Services Agency Committee for the Protection of Human Subjects.

RESULTS

A majority of mothers of cases and controls were Hispanic, approximately half were 25 to 34 years old, and approximately half had at least some college education (Table 1). Most of the fathers and approximately 60% of the mothers were employed. Approximately 30 to 40% of subjects had household income >$50,000 per year.

Mothers who did not have block group data and mothers who did have block group data differed in the following ways (i.e., the descriptive characteristics differed by >5%; Appendix 1) Mothers of patients with CLP with data were less likely to be foreign-born Hispanic and more likely to be Asian, mothers of patients with dTGA were less likely to be U.S.-born Hispanic, and mothers of patients with TOF were less likely to be white, relative to mothers without block group data. Control mothers with data were more likely than control mothers without data to be employed (61 vs. 54%, respectively), but CLP mothers with data were less likely than CLP mothers without data to be employed (61 vs. 71%, respectively). Mothers of patients with CP, CLP, and dTGA with data were more likely to have completed at least high school than mothers without data. Mothers of controls and patients with CP and TOF with data were more likely to take supplements, whereas mothers of patients with CLP and dTGA with data were less likely to take supplements.

Odds ratios for CP and individual- and household-level SES measures tended to be close to 1 and not significant (Table 2). Maternal unemployment was associated with decreased risk (OR, 0.7; 95% CI, 0.5–1.0). Odds ratios for CLP indicated that paternal education less than high school and some college, relative to high school education, were both associated with increased risk; paternal unemployment was associated with increased risk; income greater than $50,000 per year was associated with decreased risk; and a worse score on household-level index was associated with increased risk. Odds ratios for CP and neighborhood-level SES measures tended to suggest that worse SES was associated with decreased risk (i.e., most ORs were less than 1; Table 3). Odds ratios for CLP tended to be slightly greater than 1 (Table 3). In general, associations tended to be relatively modest (i.e., ORs tended to be between 0.7 and 1.4, and confidence intervals tended to include 1).

Odds ratios for dTGA and the individual- and household-level SES measures suggested that maternal education greater than high school, paternal education greater than or less than high school, and higher income tended to be associated with increased risk (Table 4). For TOF, increased income was associated with increased risk. However, the associations with income did not suggest a clear gradient across income categories for either outcome. For both of these outcomes, the worst (highest) value of the SES index was associated with the highest OR, but associations were modest and estimates imprecise. Odds ratios for these heart defects and the neighborhood-level SES measures tended to suggest that worse SES was associated with decreased risk, but most CIs included 1 and did not suggest a gradient of association (Table 5). Results for the index did not suggest a gradient of risk.

Results adjusted for the potential confounders (maternal race/ethnicity, body mass index, intake of folic acid-containing supplements, smoking, and binge drinking) were not substantially different from unadjusted results (data not shown). The pattern of results was also essentially unchanged after excluding cases and controls with a family history of the selected defects in a parent or sibling, mothers who had type I or II diabetes, mothers who took medications to prevent seizures, and nonisolated cleft cases (i.e., those with major accompanying malformations).

DISCUSSION

We examined whether multiple measures of SES were associated with specific orofacial clefts or conotruncal heart defects. Results did not suggest worse SES was associated with increased risk of the studied defects, with the possible exception of CLP. In fact, several observations for household- and neighborhood-level measures suggested better SES might be associated with slightly increased risk for the other defects. In general, associations were modest and chance could not be ruled out as an alternative explanation.

The current findings add to a relatively limited body of evidence. In general, previous studies of SES and the studied birth defects have tended to rely on one or two measures of SES. A few notable studies have provided a somewhat more in-depth examination of associations with SES. In a previous population-based study of births in selected California counties from 1987 to 1989, we reported that low SES, based on both individual- and neighborhood-level measures, was associated with increased risk of dTGA and reduced risk of TOF, and it was not associated with CLP or CP, after adjusting for several potential confounders (Carmichael et al. 2003). Individual-level measures were limited to maternal education and parental employment in that study. A more recent study that used data from the population-based, multistate National Birth Defects Prevention Study reported that subjects with the worst SES based on an index that combined five measures of individual-level SES had the greatest risks of CLP, CP, and dTGA, but TOF was not associated with the index (Yang et al. 2008). Results for one measure at a time tended to be more modest. An advantage of that study was its classification of parental occupations as operator/laborer or not, but a disadvantage was that it did not include neighborhood-level measures. A study of a variety of birth defects in several European countries, which used the Carstairs index to reflect SES, observed no association with CLP or CP, but they were limited to a small number of cases (<50 in each group; Vrijheid et al. 2000). A few other studies have included multiple measures of individual- or household-level SES, but their focus has tended to be on SES measures as confounders, and as such, detailed analyses of SES have not been presented (Correa-Villasenor et al., 1991; Loffredo et al., 2001).

An explanation for inconsistent findings across studies is not known. One potential explanation is that some of the earlier studies were before folic acid supplementation, and the current study was afterward, given that both of the defect groups studied here have been associated with folic acid supplementation (Botto et al. 2004). Another potential explanation is that SES might represent a differing set of risk factors in different regional populations. Certainly, the studies done thus far, including those conducted within California, have encompassed different geographic populations. Studies have also varied with respect to exclusion or inclusion of cases with syndromes and nonisolated cases (i.e., cases with other accompanying major malformations), especially for orofacial clefts. The current study excluded cases with known single-gene disorders and aneusomies, and its results were similar regardless of whether it included or excluded nonisolated cleft cases. In addition, previous studies have examined CLP as a single outcome, although some evidence supports differing etiologies for CLP (Harville et al. 2005). The overall conclusions regarding the association of SES with CLP were similar in the current study, regardless of whether cleft lip cases with or without cleft palate were analyzed separately or together (data are available from the authors upon request).

The strengths of our study include multiple, multi-level measures of SES; neighborhood-level SES based on addresses from early pregnancy; population-based controls; and adjustment for several potential confounders, including intake of folic acid-containing supplements. Limitations include that the study is region-specific and that sample size was limited for certain comparisons. Generalizability to the study population is likely to be good, given our thorough ascertainment of cases and population-based control selection; indeed, the distributions of

maternal race-ethnicity, age, education, and infant birthweight were similar among the interviewed control mothers and the study population (data not shown). However, generalizability beyond the study population, which was largely urban and Hispanic, is uncertain. Although this study is more detailed than most previous studies of SES and birth defects, the SES measures were still somewhat limited; for example, classification of occupation into social class and measures of social capital were not available. Data obtained from retrospective studies are always subject to recall bias; however, it is unlikely that reporting error would have been systematic for objective measures such as address and education level.

Another potential limitation of the study is selection bias. It is unknown whether women who did versus did not participate in the study were systematically different with respect to socioeconomic factors. In addition, some women had to be excluded from various aspects of the analysis because of missing data on the individual- and household-level SES measures; whether this incurred some bias in our results is unknown. Another potential contributor to selection bias is the lack of data on women who did not have census block group data. The pattern of association of maternal characteristics among women with and without block group data varied across the outcomes, so if there was selection bias, it is unlikely to have been consistent across the outcomes. In addition, given that SES is a broad indicator that might reflect a variety of exposure differences (e.g., low SES might be associated with increased exposure to harmful environmental contaminants), information regarding its association with outcomes tends to generate hypotheses rather than offer precise knowledge about biologic underpinnings. Information on other potentially harmful environmental exposures that can vary by SES, such as proximity to landfill sites, was not available. Information on other birth defects was also not available, although it would be useful to examine additional defects and SES.

Socioeconomic status tends to be associated rather consistently with other perinatal and infant outcomes, such as birthweight and mortality (Parker et al. 1994; Kramer et al. 2000). In contrast, the evidence thus far suggests that orofacial clefts and conotruncal defects may be weakly, if at all, associated with SES measures, and therefore other types of factors might be more important contributors to these defects. It is certainly useful to extend the limited existing literature on SES and birth defects with studies such as the current one that offer rigorous study designs and more comprehensive measures of SES. These improved studies, however, do not tend to suggest strong or consistent associations of SES with orofacial clefts or conotruncal heart anomalies.

Acknowledgments

We thank the California Department of Public Health, Maternal Child and Adolescent Health Division for providing surveillance data for this study. We thank Makinde Falade (California Department of Public Health, Richmond, CA) for his help with geocoding the data.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention, the National Institute of Child Health and Human Development, the National Institutes of Health, or the California Department of Public Health.

Supported by Award Number R01 HD 42538-03 from the National Institute of Child Health and Human Development and the Centers for Disease Control and Prevention, Centers of Excellence U50/CCU913241.

APPENDIX

Appendix table 1

Comparison of Maternal Characteristics among Women with and without Available Census Block Group Data

	Block group data					No block group data				
	Controls (n = 617)	**CP (n = 174)**	**CLP (n = 434)**	**dTGA (n = 125)**	**TOF (n = 152)**	**Controls (n = 83)**	**CP (n = 25)**	**CLP (n = 68)**	**dTGA (n = 17)**	**TOF (n = 24)**
Maternal race/ethnicity										
U.S.-born Hispanic	23	20	16	19	14	18	17	14	33	10
Foreign-born Hispanic	38	34	43	37	38	42	38	59	33	33
Non-Hispanic white	21	26	21	27	28	18	21	17	27	38
Black	8	6	3	5	5	8	8	3	0	5
Asian	9	13	15	9	12	11	17	6	7	14
Other[a]	1	1	3	3	3	3	0	0	0	0
Maternal employment	61	71	61	64	63	54	67	71	67	59
Maternal education										
<High school	29	21	33	24	27	32	42	44	31	29
High school	25	23	23	18	23	21	8	23	13	5
Some college	22	29	25	23	24	25	13	16	19	43
≥Bachelor's degree	25	27	20	35	26	23	38	17	38	24
Intake of folic acid containing supplements	62	59	58	61	63	52	48	40	71	42

CP, cleft palate; CLP, cleft lip with or without cleft palate; dTGA, d-transposition of the great arteries; TOF, tetralogy of Fallot.

[a] Primarily multiple races/ethnicities.

REFERENCES

Adams MM, Mulinare J, Dooley K. Risk factors for conotruncal cardiac defects in Atlanta. J Am Coll Cardiol 1989;14:432–442. [PubMed: 2787814]

Blanco Muñoz J, Lacasaña M, Borja Aburto VH, et al. Socioeconomic factors and the risk of anencephaly in a Mexican population: a case-control study. Public Health Rep 2005;120:39–45. [PubMed: 15736330]

Blatter BM, Roeleveld N, Bermejo E, et al. Spina bifida and parental occupation: results from three malformation monitoring programs in Europe. Eur J Epidemiol 2000;16:343–351. [PubMed: 10959942]

Botto LD, Olney RS, Erickson JD. Vitamin supplements and the risk for congenital anomalies other than neural tube defects. Am J Med Genet C Semin Med Genet 2004;125:12–21. [PubMed: 14755429]

Canfield MA, Honein MA, Yuskiv N, et al. National estimates and race/ethnic-specific variation of selected birth defects in the United States, 1999–2001. Birth Defects Res A Clin Mol Teratol 2006;76:747–756. [PubMed: 17051527]

Carmichael SL, Nelson V, Shaw GM, et al. Socio-economic status and risk of conotruncal heart defects and orofacial clefts. Paediatr Perinat Epidemiol 2003;17:264–271. [PubMed: 12839538]

Carmichael SL, Shaw GM, Yang W, et al. Maternal stressful life events and risks of birth defects. Epidemiology 2007a;18:356–361. [PubMed: 17435445]

Carmichael SL, Yang W, Herring A, et al. Food insecurity and risks of birth defects. J Nutr 2007b; 137:2087–2092. [PubMed: 17709447]

Clark JD, Mossey PA, Sharp L, Little J. Socioeconomic status and orofacial clefts in Scotland, 1989 to 1998. Cleft Palate Craniofac J 2003;40:481–485. [PubMed: 12943441]

Correa-Villasẽor A, McCarter R, Downing J, Ferencz C, The Baltimore-Washington Infant Study Group. White-black differences in cardiovascular malformations in infancy and socioeconomic factors. Am J Epidemiol 1991;134:393–402. [PubMed: 1877600]

Elwood, JM.; Little, J.; Elwood, JH. Epidemiology and control of neural tube defects. Oxford University Press; Oxford: 1992.

Ericson A, Eriksson M, Zetterstrom R. The incidence of congenital malformations in various socioeconomic groups in Sweden. Acta Paediatr Scand 1984;73:664–666. [PubMed: 6485786]

Farley TF, Hambidge SJ, Daley MF. Association of low maternal education with neural tube defects in Colorado, 1989–1998. Public Health 2002;116:89–94. [PubMed: 11961676]

Grewal J, Carmichael SL, Shaw GM, Song J. Risk of neural tube defects: an analysis of neighborhood and individual level socioeconomic characteristics. Paediatr Perinat Epidemiol 2009;23:116–124. [PubMed: 19159398]

Harville EW, Wilcox AJ, Lie RT, et al. Cleft lip and palate versus cleft lip only: are they distinct defects? Am J Epidemiol 2005;162:448–453. [PubMed: 16076837]

Kramer MS, Seguin L, Lydon J, Goulet L. Socio-economic disparities in pregnancy outcome: why do the poor fare so poorly? Paediatr Perinat Epidemiol 2000;14:194–210. [PubMed: 10949211]

Li Z, Ren A, Zhang L, et al. A population-based case-control study of risk factors for neural tube defects in four high-prevalence areas of Shanxi province, China. Paediatr Perinat Epidemiol 2006;20:43–53. [PubMed: 16420340]

Loffredo CA, Silbergeld EK, Ferencz C, Zhang J. Association of transposition of the great arteries in infants with maternal exposures to herbicides and rodenticides. Am J Epidemiol 2001;153:529–536. [PubMed: 11257060]

Meyer RE, Siega-Riz AM. Sociodemographic patterns in spina bifida prevalence trends--North Carolina, 1995–1999. MMWR Recomm Rep 2002;51:12–15. [PubMed: 12353507]

National Birth Defects Prevention Network (NBDPN). State Birth Defects Surveillance Program Directory. Birth Defects Res Part A Clin Mol Teratol 2005;73:700–757.

Parker JD, Schoendorf K, Kiely JL. Associations between measures of socioeconomic status and low birth weight, small for gestational age, and premature delivery in the United States. Ann Epidemiol 1994;4:271–278. [PubMed: 7921316]

Vrijheid M, Dolk H, Stone D, et al. Socioeconomic inequalities in risk of congenital anomaly. Arch Dis Child 2000;82:349–352. [PubMed: 10799420]

Wasserman CR, Shaw GM, Selvin S, et al. Socioeconomic status, neighborhood social conditions, and neural tube defects. Am J Public Health 1998;88:1674–1680. [PubMed: 9807535]

Yang J, Carmichael SL, Canfield M, et al. Socioeconomic status in relation to selected birth defects in a large multicentered US case-control study. Am J Epidemiol 2008;167:145–154. [PubMed: 17947220]

Birth Defects Res A Clin Mol Teratol. Author manuscript; available in PMC 2010 May 6.

Table 1

Characteristics of Parents of Cases and Controls

	Percent (n)				
	Cleft palate (n = 174)	**Cleft lip with or without cleft palate (n = 434)**	**d-Transposition of the great arteries (n = 125)**	**Tetralogy of Fallot (n = 152)**	**Controls (n = 617)**
Maternal race/ethnicity					
U.S.-born Hispanic	20 (34)	16 (69)	19 (24)	14 (21)	23 (141)
Foreign-born Hispanic	34 (59)	43 (184)	37 (46)	38 (58)	38 (232)
Non-Hispanic White	26 (46)	21 (91)	27 (34)	28 (43)	21 (130)
African-American	6 (11)	3 (14)	5 (6)	6 (7)	8 (48)
Asian	13 (23)	15 (63)	9 (11)	12 (18)	9 (55)
Other[a]	1 (1)	3 (12)	3 (4)	3 (5)	1 (8)
Maternal age (years)					
<20	2 (4)	6 (28)	5 (6)	5 (7)	8 (50)
20–24	17 (29)	25 (107)	20 (25)	22 (33)	22 (136)
25–29	26 (45)	24 (105)	22 (27)	22 (33)	22 (137)
30–34	34 (60)	25 (110)	31 (38)	27 (41)	29 (178)
35–39	16 (27)	14 (61)	18 (22)	17 (26)	14 (87)
≥39	5 (9)	5 (23)	5 (6)	8 (12)	4 (27)
Maternal education					
<High school	21 (36)	33 (141)	24 (30)	27 (41)	29 (177)
High school	23 (39)	23 (98)	18 (22)	23 (35)	25 (150)
Some college	29 (50)	25 (109)	24 (29)	24 (36)	22 (133)
≥Bachelor’s degree	27 (47)	20 (85)	35 (43)	26 (40)	25 (151)
Paternal education					
<High school	28 (46)	35 (138)	30 (36)	31 (44)	27 (154)
High school	26 (43)	24 (95)	24 (29)	26 (38)	32 (183)
Some college	17 (28)	20 (78)	16 (19)	15 (21)	17 (97)
≥Bachelor’s degree	30 (49)	22 (89)	31 (38)	29 (41)	25 (147)
Maternal employment					
Yes	71 (123)	61 (263)	64 (80)	62 (95)	61 (375)
No	29 (51)	39 (171)	36 (45)	38 (57)	39 (240)

	Percent (n)				
	Cleft palate (n = 174)	**Cleft lip with or without cleft palate (n = 434)**	**d-Transposition of the great arteries (n = 125)**	**Tetralogy of Fallot (n = 152)**	**Controls (n = 617)**
Paternal employment					
Yes	89 (148)	87 (365)	90 (112)	93 (139)	91 (544)
No	11 (18)	13 (56)	10 (12)	7 (10)	9 (51)
Household income					
<$10,000	21 (34)	27 (105)	18 (20)	20 (27)	25 (138)
$10,000–$20,000	12 (20)	16 (62)	16 (18)	21 (29)	17 (97)
$20,000–$30,000	14 (23)	17 (66)	10 (11)	10 (13)	12 (69)
$30,000–$40,000	8 (14)	7 (26)	9 (10)	4 (6)	7 (41)
$40,000–$50,000	4 (7)	5 (19)	7 (8)	7 (10)	4(23)
>$50,000	41 (67)	29 (113)	40 (44)	38 (51)	34 (187)

[a]Primarily multiple races/ethnicities.

Birth Defects Res A Clin Mol Teratol. Author manuscript; available in PMC 2010 May 6.

Table 2

Association of Orofacial Clefts with Individual- and Household-Level SES Measures[a]

		Cleft palate		Cleft lip with or without cleft palate	
	Number of controls (n = 552)	Number of cases (n = 174)	OR (95% CI)	Number of cases (n = 434)	OR (95% CI)
Maternal education					
<High school	157	36	0.8 (0.5–1.3)	141	1.2 (0.9–1.7)
High school	135	39	Reference	98	Reference
Some college	117	50	1.5 (0.9–2.4)	109	1.3 (0.9–1.9)
≥Bachelor's degree	137	47	1.2 (0.7–1.9)	85	0.9 (0.6–1.2)
Paternal education					
<High school	141	46	1.2 (0.8–2.0)	138	1.7 (1.2–2.4)
High school	163	43	Reference	95	Reference
Some college	83	28	1.3 (0.7–2.2)	78	1.6 (1.1–2.4)
≥Bachelor's degree	133	49	1.4 (0.9–2.2)	89	1.1 (0.8–1.7)
Maternal employment					
Yes	338	123	Reference	263	Reference
No	212	51	0.7 (0.5–1.0)	171	1.0 (0.8–1.3)
Paternal employment					
Yes	484	148	Reference	365	Reference
No	47	18	1.3 (0.7–2.2)	56	1.6 (1.0–2.4)
Household income					
<$10,000	122	34	0.7 (0.4–1.3)	105	0.8 (0.5–1.2)
$10,000–$20,000	86	20	0.6 (0.3–1.2)	62	0.7 (0.4–1.1)
$20,000–$30,000	60	23	Reference	66	Reference
$30,000–$40000	38	14	1.0 (0.4–2.1)	26	0.6 (0.3–1.1)
$40,000–$50,000	21	7	0.9 (0.3–2.3)	19	0.8 (0.4–1.7)
>$50,000	166	67	1.1 (0.6–1.8)	113	0.6 (0.4–0.9)
Household-level SES Index[b]					
0	226	81	Reference	167	Reference
1	117	43	1.0 (0.7–1.6)	75	0.9 (0.6–1.2)

		Cleft palate		Cleft lip with or without cleft palate	
	Number of controls (n = 552)	Number of cases (n = 174)	OR (95% CI)	Number of cases (n = 434)	OR (95% CI)
2	105	27	0.7 (0.4–1.2)	101	1.3 (0.9–1.8)
3	16	5	0.9 (0.3–2.5)	20	1.7 (0.9–3.4)

SES, socioeconomic status; OR, odds ratio; CI, confidence interval.

[a] A separate model was run for each SES measure.

[b] The index equals number of measures scored as *low*. Each measure was scored as follows: parental education (*low* if either parent's education was <high school), income (*low* if <$20,000), and employment (*low* if father was not employed).

Table 3

Association of Orofacial Clefts with Neighborhood-Level SES Measures[a]

		Cleft palate		Cleft lip with or without cleft palate	
	Number of controls(n = 552)	Number of cases (n = 174)	OR (95% CI)	Number of cases (n = 434)	OR (95% CI)
Education					
Q4	137	35	0.6 (0.4–1.0)	107	1.1 (0.8–1.6)
Q3	139	40	0.7 (0.4–1.1)	118	1.2 (0.8–1.7)
Q2	138	39	0.7 (0.4–1.0)	112	1.2 (0.8–1.7)
Q1	138	60	Reference	97	Reference
Poverty					
Q4	137	37	0.6 (0.4–1.0)	105	0.9 (0.6–1.3)
Q3	139	41	0.7 (0.4–1.1)	131	1.1 (0.8–1.6)
Q2	138	37	0.6 (0.4–1.0)	80	0.7 (0.5–1.0)
Q1	138	59	Reference	118	Reference
Unemployment					
Q4	138	28	0.5 (0.3–0.8)	104	1.0 (0.7–1.4)
Q3	138	48	0.8 (0.5–1.2)	104	1.0 (0.7–1.4)
Q2	134	36	0.6 (0.4–1.0)	115	1.1 (0.8–1.6)
Q1	142	62	Reference	111	Reference
Operator/laborer occupation					
Q4	138	45	0.7 (0.5–1.1)	107	1.1 (0.8–1.6)
Q3	138	35	0.6 (0.3–0.9)	112	1.2 (0.8–1.7)
Q2	138	31	0.5 (0.3–0.8)	118	1.2 (0.9–1.7)
Q1	138	63	Reference	97	Reference
Crowding					
Q4	136	36	0.7 (0.4–1.1)	105	1.2 (0.8–1.8)
Q3	139	41	0.8 (0.5–1.3)	117	1.3 (0.9–1.9)
Q2	139	45	0.9 (0.5–1.4)	124	1.4 (1.0–2.0)
Q1	138	52	Reference	88	Reference
Rental occupancy					
Q4	137	46	1.0 (0.6–1.6)	107	1.1 (0.8–1.5)

		Cleft palate		Cleft lip with or without cleft palate	
	Number of controls(n = 552)	**Number of cases (n = 174)**	**OR (95% CI)**	**Number of cases (n = 434)**	**OR (95% CI)**
Q3	138	34	0.7 (0.4–1.2)	108	1.1 (0.8–1.5)
Q2	139	47	1.0 (0.6–1.6)	119	1.2 (0.8–1.7)
Q1	138	47	Reference	100	Reference
Neighborhood-level SES index[b]					
0	260	89	Reference	206	Reference
1–3	185	56	0.9 (0.6–1.3)	153	1.0 (0.8–1.4)
4–6	107	29	0.8 (0.5–1.3)	75	0.9 (0.6, 1.3)

SES, socioeconomic status; OR, odds ratio; CI, confidence interval.

[a] See Methods for definitions of each measure. Higher quartile scores reflect worse SES. A separate model was run for each SES measure.

[b] To create the index, each measure was scored as 1 if in the highest quartile or as 0 otherwise. The values were then summed, such that a higher value on the index reflects worse SES.

Table 4

Association of Conotruncal Heart Defects with Individual- and Household-Level SES Measures[a]

		d-Transposition of the great arteries		Tetralogy of Fallot	
	Number of controls (n = 617)	Number of cases (n = 125)	OR (95% CI)	Number of cases (n = 152)	OR (95% CI)
Maternal education					
<High school	177	30	1.2 (0.6–2.1)	41	1.0 (0.6–1.6)
High school	150	22	Reference	35	Reference
Some college	133	29	1.5 (0.8–2.7)	36	1.2 (0.7–2.0)
≥Bachelor's degree	151	43	1.9 (1.1–3.4)	40	1.1 (0.7–1.9)
Paternal education					
<High school	154	36	1.5 (0.9–2.5)	44	1.4 (0.8–2.2)
High school	183	29	Reference	38	Reference
Some college	97	19	1.2 (0.7–2.3)	21	1.0 (0.6–1.9)
≥Bachelor's degree	147	38	1.6 (1.0–2.8)	41	1.3 (0.8–2.2)
Maternal employment					
Yes	375	80	Reference	95	Reference
No	240	45	0.9 (0.6–1.3)	57	0.9 (0.7–1.4)
Paternal employment					
Yes	544	112	Reference	139	Reference
No	51	12	1.1 (0.6–2.2)	10	0.8 (0.4–1.6)
Household income					
<$10,000	138	20	0.9 (0.4–2.0)	27	1.0 (0.5–2.1)
$10,000–$20,000	97	18	1.6 (0.5–2.6)	29	1.6 (0.8–3.3)
$20,000–$30,000	69	11	Reference	13	Reference
$30,000–$40000	41	10	1.5 (0.6–3.9)	6	0.8 (0.3–2.2)
$40,000–$50,000	23	8	2.2 (0.8–6.1)	10	2.3 (0.9–6.0)
>$50,000	187	44	1.5 (0.7–3.0)	51	1.5 (0.7–2.8)
Household-level SES index[b]					
0	253	54	Reference	69	Reference
1	132	25	0.9 (0.5–1.5)	24	0.7 (0.4–1.1)

		d-Transposition of the great arteries		Tetralogy of Fallot	
	Number of controls (n = 617)	Number of cases (n = 125)	OR (95% CI)	Number of cases (n = 152)	OR (95% CI)
2	120	25	1.0 (0.6–1.6)	30	0.9 (0.6–1.5)
3	17	5	1.4 (0.5–3.9)	7	1.5 (0.6–3.8)

SES, socioeconomic status; OR, odds ratio; CI, confidence interval.

[a] A separate model was run for each SES measure.

[b] The index equals number of measures scored as *low*. Each measure was scored as follows: parental education (low if either parent's education was < high school), income (*low* if <$20,000), and employment (*low* if father was not employed).

Table 5

Association of Conotruncal Heart Defects with Neighborhood-Level SES Measures[a]

		d-Transposition of the great arteries		Tetralogy of Fallot	
	Number of controls (n = 617)	Number of cases (n = 125)	OR (95% CI)	Number of cases (n = 152)	OR (95% CI)
Education					
Q4	154	25	0.7 (0.4–1.3)	33	0.7 (0.4–1.1)
Q3	154	37	1.1 (0.6–1.8)	37	0.8 (0.5–1.2)
Q2	154	28	0.8 (0.5–1.4)	33	0.7 (0.4–1.1)
Q1	155	35	Reference	49	Reference
Poverty					
Q4	152	29	0.7 (0.4–1.1)	38	0.8 (0.5–1.2)
Q3	155	22	0.5 (0.3–0.9)	27	0.5 (0.3–0.9)
Q2	155	30	0.7 (0.4–1.1)	35	0.7 (0.4–1.1)
Q1	155	44	Reference	51	Reference
Unemployment					
Q4	152	23	0.7 (0.4–1.3)	38	0.9 (0.6–1.5)
Q3	155	36	1.3 (0.7–1.9)	33	0.8 (0.5–1.3)
Q2	154	34	1.1 (0.6–1.8)	37	0.8 (0.5–1.4)
Q1	156	32	Reference	43	Reference
Operator/laborer occupation					
Q4	154	31	0.8 (0.6–1.6)	31	0.7 (0.4–1.1)
Q3	154	36	1.1 (0.7–1.9)	40	0.9 (0.5–1.5)
Q2	153	25	0.8 (0.4–1.4)	34	0.8 (0.5–1.2)
Q1	156	33	Reference	46	Reference
Crowding					
Q4	154	26	0.8 (0.5–1.4)	29	0.7 (0.4–1.2)
Q3	154	32	1.0 (0.6–1.7)	40	1.0 (0.6–1.6)
Q2	153	34	1.1 (0.6–1.8)	40	1.0 (0.7–1.6)
Q1	156	33	Reference	42	Reference
Rental occupancy					
Q4	153	26	0.7 (0.4–1.3)	50	1.2 (0.8–1.9)

		d-Transposition of the great arteries		Tetralogy of Fallot	
	Number of controls (n = 617)	Number of cases (n = 125)	OR (95% CI)	Number of cases (n = 152)	OR (95% CI)
Q3	155	29	0.8 (0.5–1.4)	25	0.6 (0.3–1.0)
Q2	153	34	1.0 (0.6–1.6)	34	0.8 (0.5–1.4)
Q1	156	36	Reference	42	Reference
Neighborhood-level SES index[b]					
0	297	68	Reference	69	Reference
1–3	200	40	0.9 (0.6–1.3)	57	1.2 (0.8–1.8)
4–6	120	17	0.6 (0.4–1.1)	26	0.9 (0.6–1.5)

SES, socioeconomic status; OR, odds ratio; CI, confidence interval.

[a] See Methods for definitions of each measure. Higher quartile scores reflect worse SES. A separate model was run for each SES measure.

[b] To create the index, each measure was scored as 1 if in the highest quartile or as 0 otherwise. The values were then summed, such that a higher value on the index reflects worse SES.