HHS Public Access
Author manuscript
Am J Ind Med. Author manuscript; available in PMC 2022 March 16.

Published in final edited form as:
Am J Ind Med. 2017 July ; 60(7): 627–634. doi:10.1002/ajim.22731.

Maternal occupational physical activity and risk for orofacial clefts

A. J. Agopian, PhD[1], **Jihye Kim, PhD**[1], **Peter H. Langlois, PhD**[2], **Laura Lee, PhD**[1], **Lawrence W. Whitehead, PhD**[1], **Elaine Symanski, PhD**[1], **Michele L. Herdt, PhD**[3], **George L. Delclos, PhD**[1]

[1]Department of Epidemiology, Human Genetics and Environmental Sciences, UTHealth School of Public Health, Houston, Texas

[2]Birth Defects Epidemiology and Surveillance Branch, Texas Department of State Health Services, Austin, Texas

[3]Center for Environmental Health, New York State Department of Health, Albany, New York

Abstract

Objectives: To perform a case-control study of maternal occupational physical activity and risk for orofacial clefts in Texas during 1999–2009.

Methods: We used logistic regression to assess 14 measures of physical activity estimated from a job exposure matrix, using the maternal occupational reported on the birth certificate, among 887 children with cleft lip with or without cleft palate (CLP), 436 children with cleft palate only (CP), and 1932 controls.

Results: After adjusting for several potential confounders, seven measures of physical activity (as a categorical and/or continuous variable) were significantly associated with CLP, CP, or both. Positive associations were seen for keeping balance, kneeling, standing, and walking/running (odds ratio 95% confidence interval range 1.0–1.9 for fourth versus first quartile). A significant

Correspondence: A. J. Agopian, PhD, University of Texas Health Science Center at Houston (UTHealth) School of Public Health, 1200 Herman Pressler, Houston, TX 77030. a.j.agopian@uth.tmc.edu.

AUTHORS' CONTRIBUTIONS
A. J. Agopian designed the study, performed the analysis, and drafted the first proof of the manuscript. Jihye Kim conducted the occupational assignment. All the authors provided input on the analysis and interpretation of results. All the authors contributed to the further writing of the manuscript, approved the final manuscript, and agree to be responsible for all aspects of the work.

DISCLOSURE (AUTHORS)
The authors report no conflicts of interest.

Institution at which the work was performed: UTHealth School of Public Health.
ETHICS APPROVAL AND INFORMED CONSENT
The study was approved by Institutional review boards at the University of Texas Health Science Center at Houston and the Texas Department of State Health Services.
DISCLOSURE BY AJIM EDITOR OF RECORD
Steven Markowitz declares that he has no conflict of interest in the review and publication decision regarding this article.
DISCLAIMER
The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.
SUPPORTING INFORMATION
Additional Supporting Information may be found online in the supporting information tab for this article.

positive trend was also seen for bending/twisting. Negative associations were seen for repetitive motion and sitting.

Conclusions: Maternal occupational physical activity may be related to the etiology of orofacial clefts.

Keywords

cleft lip with or without cleft palate; occupation; physical activity

1 | BACKGROUND

Orofacial clefts are congenital malformations involving a failure of fusion in the lip and/or palate during early pregnancy. Cleft lip with or without cleft palate (CLP) occurs in approximately 11 in 10000 live births, whereas cleft palate only (CP) occurs in approximately 6 in 10 000 live births.[1] These conditions are linked to increased morbidity (especially problems with feeding and language)[2] and mortality,[3] as well as substantial medical costs[4] and psychosocial difficulties for both the infant and their family.[5]

Recognized risk factors for CLP and/or CP include infant sex[6] and family history of orofacial clefts,[7] as well as maternal smoking,[8] pregestational diabetes,[9] and age >35 years.[10] Further, multiple studies have reported increased risk for CLP and/or CP in offspring among women in certain occupations, particularly occupations related to cleaning.[11–14] A number of studies have assessed occupational chemical exposures (eg, associations between oral clefts and organic solvents have been reported[12,15,16]), but few studies have assessed occupationa behaviors and activities, and janitors and maids represent occupations with substantial physical activity.[17] Further, it has been suggested that occupational and non-occupational physical activity may be associated with some nonsyndromic birth defects,[18] though the biologic mechanisms involved are not clear and few studies have specifically assessed physical activities and CLP and/or CP. We evaluated the relationship between several domains of maternal occupational physical activity and risk for CLP and/or CP in liveborn children in Texas.

2 | MATERIALS AND METHODS

2.1 | Study subjects

Our analyses for this case-control study are based on data from the Texas Birth Defects Registry. The Registry is a statewide, ongoing population-based birth defects surveillance system maintained by the Texas Department of State Health Services Birth Defects Epidemiology and Surveillance Branch. The details of case ascertainment and data collection have been previously detailed.[19] In brief, trained Registry staff conduct ongoing active surveillance of medical records at all hospitals, birthing centers, and midwife facilities in Texas. Cases are identified based on the presence of a documented structural birth defect or chromosomal abnormality diagnosed within 1 year of delivery. Each birth defect and chromosomal abnormality diagnosis is assigned a standard 6-digit modified British Pediatric Association (BPA) code.[20] For the present analyses, we included cases with CLP (BPA codes: 749.100–749.220) or CP (BPA codes: 749.000–749.090) delivered between January

1, 1999 and December 31, 2009. Some cases from the Registry are also represented in national studies of birth defects (eg, National Birth Defects Prevention Study, National Birth Defects Prevention Network).[21,22]

The Registry routinely links liveborn cases to their corresponding birth certificates (maintained by the Center for Health Statistics of the Texas Department of State Health Services). These records include sociodemographic data and self-reported maternal occupation. Because maternal occupation is not reported on Texas fetal death certificates, our case group was restricted to live births. To limit etiologic heterogeneity, our analyses were restricted to “isolated” cases. Isolated cases were defined based on not having an additional major birth defect (as defined by the National Birth Defects Prevention Study[23]), malformation syndrome, or chromosome abnormality. We randomly selected 6000 unmatched liveborn controls without birth defects (ie, not present in the Registry) during the same delivery period, among statewide Texas birth certificates. Our protocol was approved by the University of Texas Health Science Center at Houston and the Texas Department of State Health Services.

2.2 | Occupation classification

The process for maternal occupational assignment for these cases and controls, based on our previous linkage, has been recently described.[14] Briefly, a 2010 Standard Occupation Classification (SOC) code was assigned to each mother. Given the large dataset, we used software from the National Institute for Occupational Safety and Health (NIOSH) (www.cdc.gov/niosh/topics/coding/overview.html) to automatically perform this assignment for most subjects, based on the free-text for maternal occupation and industry from the birth certificate, as well as age and education. In a minority of subjects (15.3%), automated coding did not produce an SOC code match, and manual assignment was performed.[14] We and others have reported good agreement between manual coding and automated coding using this software (eg, kappa: 0.96).[14,24] For a minority (<1%) of subjects with more than one occupation listed on the birth certificate, the first eligible occupation was arbitrarily used, based on suggestions from NIOSH.[25] Subjects with non-working mothers (62.1%) were excluded from our analyses, including those coded as housewives, students, or unemployed.

2.3 | Exposure assessment

We obtained data from the U.S. Department of Labor’s occupational information database, O*NET (http://www.onetonline.org),[26] to use as a job-exposure matrix to estimate occupational physical activity. This database includes information from ongoing surveys of working subjects’ self-report of their occupational activities, including physical activities (eg, lifting, climbing, kneeling, standing, sitting) and other aspects of their job. These data have been used to estimate occupational physical activities in multiple prior studies of other outcomes,[27–29] and such estimates have been shown to agree with self-reported exposure.[30] We used O*NET version 20.1, which includes data from over 900 different occupations. Job-exposure matrixes (JEMs) were used for the amount of time spent in the occupation conducting nine different domains of occupational physical activity. These domains included bending/twisting, climbing ladders/scaffolds/poles, exposure to whole body vibration, keeping/regaining balance, kneeling/crouching/stooping, making repetitive motions, sitting (an inverse measure of physical activity), standing, and walking/running. These data included the reported mean time spent performing the activity for each occupation (originally based on a 1 [never] to 5 [every day] scale).

JEMs were also available for the level of handling/moving objects needed for the occupation, as well as the level of overall general physical activity needed for the occupation. General physical activity was defined as “performing physical activities that require considerable use of your arms and legs and moving your whole body, such as climbing, lifting, balancing, walking, stooping, and handling materials.”[31] For these two variables, the data included the mean reported level, originally scored on a scale ranging from 0 to 7 (eg, for general physical activity, 1 corresponded to “walk between work stations in a small office” and 6 corresponded to “climb up and down poles to install electricity”). JEMs were also available for the reported importance to the occupation of both handling/moving objects and overall general physical activity. For these two variables, the data included the mean reported importance, originally scored on a scale ranging from 1 (“Not Important”) to 5 (“Extremely Important”).

Because two different scales were used for the variables in the survey (1–5 scale versus 0–7 scale), we converted these values to standardized 0–100 scale, as recommended by O*NET (http://www.onetonline.org/help/online/scales). For each subject, we used the distribution of quartiles of this standardized variable for each domain in controls to assign a four-level categorical exposure variable.

2.4 | Statistical analysis

All analyses were conducted separately for CLP and CP. We tabulated counts and frequencies for characteristics of cases and controls, based on data from the birth certificate, using Chi-square tests (or Fisher’s exact test when any expected cell count was <5). Using unconditional logistic regression, we estimated crude and adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for the relationship between the JEM-based estimated time spent performing each of the nine physical activity domains and risk for each cleft phenotype. In other words, subjects with the same occupation had the same exposure values for a given physical activity (based on four possible exposure levels). The adjusted models included co-variables selected a priori, based on previous literature: maternal age, race/ethnicity, education, diabetes, previous livebirths, and smoking. To assess P for trend, these adjusted analyses were repeated, modeling the time spent performing each physical activity domain as a continuous variable. All of the association analyses were repeated to also assess the relationship between the importance of handling/moving objects, as well as overall general physical activity, and risk for each cleft phenotype. To address potential correlation between exposures, given similar results observed for some variables (see Results section), we also computed Pearson’s correlation coefficients post-hoc for each unique pairwise combination of the 13 exposure variables assessed among controls. All analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC).

3 | RESULTS

As previously described,[14] the NIOCCS software assigned maternal occupation status/category to 8646 subjects out of 10 207 potential total subjects. This included 6000 liveborn controls without birth defects and 4207 liveborn cases (2939 with CLP and 1268 with CP, after excluding 2782 non-isolated cases and 42 additional fetal deaths).[14] We manually assigned the occupation status/category for the remaining 15.3% of subjects. Maternal occupation data were missing for <5% of birth certificates. Women who were classified as non-working women (N = 6,342; 62.1%) and working women that did not have SOC codes present in the O*NET database (N = 610; 6.0%) were excluded, leaving a total of 3255 subjects analyzed (N = 887 cases with isolated CLP, 436 cases with isolated CP, and 1932 controls). The frequency of maternal smoking was significantly higher ($P < 0.05$) in cases with CLP and CP than in controls and the distribution of maternal race/ethnicity also significantly differed ($P < 0.05$) between cases with CLP compared to controls (Table 1 and Supplemental Table S1).

We observed statistically significant associations between estimated time spent performing seven of nine domains of occupational physical activity and CLP, CP, or both (Table 2), adjusted for potential confounders (crude results were similar and are not shown). Specifically, more versus less time kneeling/crouching/stooping was associated with both CLP (P for trend: 0.03) and CP (adjusted OR for quartile 4: 1.4, 95%CI: 1.1–1.9, P for trend: 0.01). There were associations between CLP and more versus less time bending/twisting, keeping/regaining balance, standing, and walking/running (range of adjusted ORs for quartile 4: 1.2–1.3, range of P for trend 0.02–0.04). These domains were not associated with CP, with the exception of an association between the second versus first quartile of time spent walking/running (adjusted OR: 1.4, 95%CI: 1.0–1.9). (Due to whole body vibrations being a relatively rare exposure,[29] more than 25% of women were represented in the lowest quartile group.)

Conversely, more versus less time sitting was inversely associated with CLP (adjusted OR for quartile 4: 0.7, 95%CI: 0.6–1.0, P for trend: 0.01) as well as CP (adjusted OR for quartile 4: 0.7, 95%CI: 0.5–0.9). We also observed a protective association between CP and the second and third versus first quartile of time spent making repetitive motions. There were no associations observed between either CLP or CP and occupational time spent exposed to whole body vibrations or climbing.

We also conducted analyses to assess the effect of the level and importance of handling and moving objects and general physical activities to the occupation (Tables 3 and 4). These domains were not associated with CLP or CP.

Given similar results observed for some of the exposures assessed, we also computed Pearson's correlation coefficients post-hoc for each unique pairwise combination among controls. Time spent sitting, standing, and walking/running were all correlated (correlation coefficient >0.8 or <-0.8), as were level and importance of handling and moving objects and general physical activities to the occupation.

4 | DISCUSSION

We effectively used a JEM to estimate maternal occupational physical activities for the occupations reported. We observed weak associations between estimated time spent performing seven out of nine domains of occupational physical activity and CLP (bending/twisting, keeping/regaining balance, standing), CP (making repetitive motions), or both (kneeling/crouching/stooping, walking/running, sitting). The majority of these associations involved significant trend tests and/or associations with the fourth versus first quartile of time spent on the activity. The protective association with more time spent sitting (an inverse measure of physical activity) is also consistent with the notion of increased risk with more time spent conducting occupational physical activity.

The similar observed associations of sitting, standing, and walking/running and CLP risk may be related to the correlation between these variables, though the different associations of these activities in relation to CP were not consistent with this notion.

The effect trends (eg, direction and magnitude) for some of these measures of estimated time spent conducting physical activities were similar for both CLP and CP (eg, kneeling/crouching/stooping, sitting), whereas others were different between the two phenotypes (eg, bending/twisting). These findings may be consistent with previous reports of both etiologic similarities (eg, effects of smoking) and differences (eg, by infant sex) between CLP and CP.[32–34]

Both measures of the estimated level and importance of physical activities to the occupation (handling/moving objects and general physical activities) were not associated with either CLP or CP. These measures might reflect broad estimates of the intensity of occupational physical activity, though, given the observed correlation between all of these exposures, it may be difficult to make any inferences about intensity versus frequency and duration of occupational physical activities from the limited data that are available. For example, there were no available physical activities with data on all three characteristics (estimated time spent performing the activity, level, and importance).

Two previous studies have assessed maternal occupational physical activity (based on self-report) and risk for CLP and/or CP,[35,36] though both of these studies included non-isolated cases and had relatively small samples ($N < 350$ total cases, whereas the total number of cases in our study was nearly four times larger). Similar to our results, one study (that used expert rating of physical activity based on occupations assigned from responses on a self-administered questionnaire) reported an association between maternal occupational standing >75% of working hours and risk of orofacial clefts (OR: 1.8, 95%CI: 1.1–2.9),[35] but another study (based on expert review of occupational activities reported during an interview) did not find an association between work involving standing or walking.[36] We cannot rule out the possibility that some of our results might differ due to exposure misclassification introduced by the use of job ratings and reported occupational titles from birth certificates. Though we did not directly assess similar activities, one study reported an association between maternal occupational work involving a moderate physical load and risk for orofacial clefts (OR: 1.8, 95%CI: 1.1–3.0),[36] but an other study did not observe an association between orofacial clefts and active strenuous work, including lifting.[35]

When considered together, our findings and these previous results suggest that there may be a connection between maternal physical activity, including occupational physical activities, and the etiology of CLP and CP. It may be that certain activities are more involved than others and there is some suggestion that certain activities may have adverse effects while other activities have protective effects. The exact biologic mechanisms involved are unclear. In fact, as these physical activities are heterogeneous, it may be that each activity may involve unique, complex biologic mechanisms (eg, hemodynamic changes, changes in glucose homeostasis, physical compression, gravity changes, oxidative stress, thermal changes, and changes in hormones/analytes such as adrenaline). Thus, a better understanding of the relationships between physical activities and birth defects may require a stronger understanding of the basic biologic mechanisms involved in physical activities during pregnancy. It is also possible that observed associations with occupational physical activity may be influenced by unmeasured confounders, such as factors related to occupational exposures, behavioral differences between occupations with high versus low physical demands (eg, folic acid use), or occupational stress.

The strengths of this study include use of a large, population-based registry and restriction to two very homogeneous case groups (isolated CLP and CP). However, until confirmed by future studies, our findings should be interpreted cautiously, in light of the limitations of the study. Because of the relative rarity of birth defects, using a cohort to prospectively assess individual level maternal exposures is prohibitive, so retrospective approaches are typically used instead. Similar to previous studies,[27,29] our available exposure data were limited in the characteristics of each physical activity (ie, timing, level/importance). The occupational physical activity was estimated based on a JEM, and our results are based on the accuracy of not only this JEM, but also on the accurate report of occupation on birth certificates and accurate classification of occupational categories. Further, typical limitations of JEM-based exposure assessment include the assumption that all subjects in the same occupation have the same exposure level. However, our use of a JEM likely limited the potential for recall bias,[37] as we believe self-report of occupational physical activity is more likely to be subject to recall bias than self-report of occupation. In fact, our exposure assessment approach has been previously used for studies of other outcomes, including pregnancy outcomes.[27–29] While previous studies suggest that some occupations may be under-reported on birth certificates,[38–40] the distributions of major occupational groups among the controls in our study were similar to those among the National Birth Defects Prevention Study (ie, interview-based assessment),[14,29] and potential occupational misclassification on birth certificates is thought to be non-differential by case status.[38–40] Our findings should be interpreted with regard to the multiple comparisons conducted, which included four comparisons (three based on categorical exposure and one based on continuous exposure) for each of 13 measurements of physical activity domains; however, these comparisons were not independent of one another, and the consistency among our results supports the notion that at least some of our findings were not due to chance alone. Our analyses were restricted to occupational physical activity, given the available data, but future studies could also integrate information on non-occupational physical activity.

In summary, these findings support a weak association between estimated occupational physical activity and risk for CLP and CP. More research is needed to confirm and better understand these results.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding information

Texas Center for Birth Defects Prevention and Research, Grant number: U01DD000494; Texas General Revenue and the Title V Maternal and Child Health Program

FUNDING

This publication was supported in part by the Texas Center for Birth Defects Prevention and Research through a cooperative agreement (U01DD000494) between the Centers for Disease Control and Prevention and the Texas Department of State Health Services (DSHS). Data collection and provision by the Texas Birth Defects Registry were supported by Texas General Revenue and the Title V Maternal and Child Health Program.

REFERENCES

1. Parker SE, Mai CT, Canfield MA, et al. Updated National Birth Prevalence estimates for selected birth defects in the United States, 2004–2006. Birth Defects Res A Clin Mol Teratol. 2010;88:1008–1016. [PubMed: 20878909]
2. Williams J The recognition and management of isolated cleft palate. Community Pract. 2012;85:28–31.
3. Christensen K, Juel K, Herskind AM, Murray JC. Long term follow up study of survival associated with cleft lip and palate at birth. BMJ. 2004;328:1405. [PubMed: 15145797]
4. Boulet SL, Grosse SD, Honein MA, Correa-Villasenor A. Children with orofacial clefts: health-care use and costs among a privately insured population. Public Health Rep. 2009;124:447–453. [PubMed: 19445422]
5. Endriga MC, Kapp-Simon KA. Psychological issues in craniofacial care: state of the art. Cleft Palate Craniofac J. 1999;36:3–11. [PubMed: 10067755]
6. Michalski AM, Richardson SD, Browne ML, et al. Sex ratios among infants with birth defects, National Birth Defects Prevention Study, 1997–2009. Am J Med Genet Part A. 2015;167A:1071–1081. [PubMed: 25711982]
7. Kot M, Kruk-Jeromini J. Analysis of family incidence of cleft lip and/or palate. Med Sci Monit. 2007;13:CR231–CR234. [PubMed: 17476195]
8. Little J, Cardy A, Munger RG. Tobacco smoking and oral clefts: a metaanalysis. Bull World Health Organ. 2004;82:213–218. [PubMed: 15112010]
9. Correa A, Gilboa SM, Besser LM, et al. Diabetes mellitus and birth defects. Am J Obstet Gynecol. 2008;199:237.e1–237.e9. [PubMed: 18674752]
10. Bille C, Skytthe A, Vach W, et al. Parent’s age and the risk of oral clefts. Epidemiology. 2005;16:311–316. [PubMed: 15824545]
11. Lin S, Herdt-Losavio ML, Chapman BR, Munsie JP, Olshan AF, Druschel CM. Maternal occupation and the risk of major birth defects: a follow-up analysis from the National Birth Defects Prevention Study. Int J Hyg Environ Health. 2013;216:317–323. [PubMed: 22695106]
12. Lorente C, Cordier S, Bergeret A, et al. Maternal occupational risk factors for oral clefts. Occupational Exposure and Congenital Malformation Working Group. Scand J Work Environ Health. 2000;26:137–145. [PubMed: 10817379]

13. Herdt-Losavio ML, Lin S, Chapman BR, et al. Maternal occupation and the risk of birth defects: an overview from the National Birth Defects Prevention Study. Occup Environ Med. 2010;67:58–66. [PubMed: 20029025]
14. Kim J, Langlois PH, Herdt-Losavio ML, Agopian AJ. A case-control study of maternal occupation and the risk of orofacial clefts. J Occup Environ Med. 2016;58:833–839. [PubMed: 27414011]
15. Chevrier C, Dananche B, Bahuau M, et al. Occupational exposure to organic solvent mixtures during pregnancy and the risk of nonsyndromic oral clefts. Occup Environ Med. 2006;63:617–623. [PubMed: 16644895]
16. Cordier S, Bergeret A, Goujard J, et al. Congenital malformation and maternal occupational exposure to glycol ethers. Occupational Exposure and Congenital Malformations Working Group. Epidemiology. 1997;8:355–363. [PubMed: 9209847]
17. Korshoj M, Krustrup P, Jespersen T, Sogaard K, Skotte JH, Holtermann A. A 24-h assessment of physical activity and cardio-respiratory fitness among female hospital cleaners: a pilot study. Ergonomics. 2013;56:935–943. [PubMed: 23586528]
18. Flak AL, Yun Tark J, Tinker SC, Correa A, Cogswell ME. Major, nonchromosomal, birth defects and maternal physical activity: a systematic review. Birth Defects Res A Clin Mol Teratol. 2012;94:521–531. [PubMed: 22628185]
19. Miller E Evaluation of the Texas Birth Defects Registry: an active surveillance system. Birth Defects Res A Clin Mol Teratol. 2006;76:787–792. [PubMed: 17094140]
20. National Center on Birth Defects and Developmental Disabilities. Appendix A: ICD-9 and CDC/BPA codes. Teratology. 2002;66: S218–S219. [PubMed: 12239749]
21. Yoon PW, Rasmussen SA, Lynberg MC, et al. The National Birth Defects Prevention Study. Public Health Rep. 2001;116:32–40.
22. Mai CT, Cassell CH, Meyer RE, et al. Birth defects data from population-based birth defects surveillance programs in the United States, 2007 to 2011: highlighting orofacial clefts. Birth Defects Res A Clin Mol Teratol. 2014;100:895–904. [PubMed: 25399767]
23. Rasmussen SA, Olney RS, Holmes LB, Lin AE, Keppler-Noreuil KM, Moore CA. Guidelines for case classification for the National Birth Defects Prevention Study. Birth Defects Res A Clin Mol Teratol. 2003;67:193–201. [PubMed: 12797461]
24. Patel MD, Rose KM, Owens CR, Bang H, Kaufman JS. Performance of automated and manual coding systems for occupational data: a case study of historical records. Am J Ind Med. 2012;55:228–231. [PubMed: 22420026]
25. National Institute for Occupational Safety and Health. Instructions for industry and occupation coding for death certificates. Available at: http://www.cdc.gov/niosh/topics/coding/pdfs/iandocodingmanual2002.pdf. Accessed August 1, 2015.
26. O*NET Resource Center. The O*NET content model. US Department of Labor Available at: http://www.onetcenter.org/content.html. 2017 Accessed March 12.
27. Fujishiro K, Diez Roux AV, Landsbergis P, Kaufman JD, Korcarz CE, Stein JH. Occupational characteristics and the progression of carotid artery intima-media thickness andplaque over9 years: the Multi-EthnicStudy of Atherosclerosis (MESA). Occup Environ Med. 2015;72:690–698. [PubMed: 25217203]
28. Fujishiro K, Diez-Roux AV, Landsbergis PA, Jenny NS, Seeman T. Current employment status, occupational category, occupational hazard exposure and job stress in relation to telomere length: the Multiethnic Study of Atherosclerosis (MESA). Occup Environ Med. 2013;70:552–560. [PubMed: 23686115]
29. Lee LJ, Symanski E, Lupo PJ, et al. Data linkage between the National Birth Defects Prevention Study and the Occupational Information Network (O*NET) to assess workplace physical activity, sedentary behaviors, and emotional stressors during pregnancy. Am J Ind Med. 2016;59:137–149. [PubMed: 26681357]
30. Gardner BT, Lombardi DA, Dale AM, Franzblau A, Evanoff BA. Reliability of job-title based physical work exposures for the upper extremity: comparison to self-reported and observed exposure estimates. Occup Environ Med. 2010;67:538–547. [PubMed: 20410076]
31. O*NET. O*NET generalized work activities questionaire. Available at: https://www.onetcenter.org/dl_files/MS_Word/Generalized_Work_Activities.pdf. Accessed November 22, 2016.

32. Matuleviciene A, Preiksaitiene E, Linkeviciene L, et al. Heterogeneity of oral clefts in relation to associated congenital anomalies. Medicina (Kaunas). 2013;49:61–66. [PubMed: 23888340]
33. Harville EW, Wilcox AJ, Lie RT, Vindenes H, Abyholm F. Cleft lip and palate versus cleft lip only: are they distinct defects? Am J Epidemiol. 2005;162:448–453. [PubMed: 16076837]
34. Forrester MB, Merz RD. Descriptive epidemiology of oral clefts in a multiethnic population, Hawaii, 1986–2000. Cleft Palate Craniofac J. 2004;41:622–628. [PubMed: 15516165]
35. Lin S, Gensburg L, Marshall EG, Roth GB, Dlugosz L. Effects of maternal work activity during pregnancy on infant malformations. J Occup Environ Med. 1998;40:829–834. [PubMed: 9777568]
36. Nurminen T, Lusa S, Ilmarinen J, Kurppa K. Physical work load, fetal development and course of pregnancy. Scand J Work Environ Health. 1989;15:404–414. [PubMed: 2617257]
37. Burstyn I, Slutsky A, Lee DG, Singer AB, An Y, Michael YL. Beyond crosswalks: reliability of exposure assessment following automated coding of free-text job descriptions for occupational epidemiology. Ann Occup Hyg. 2014;58:482–492. [PubMed: 24504175]
38. Brender JD, Suarez L, Langlois PH. Validity of parental work information on the birth certificate. BMC Public Health. 2008;8:95. [PubMed: 18366739]
39. Shaw GM, Malcoe LH, Croen LA, Smith DF. An assessment of error in parental occupation from the birth certificate. Am J Epidemiol. 1990;131:1072–1079. [PubMed: 2188499]
40. Marshall EG, Gensburg LJ, Roth GB, Davidson GK, Dlugosz LJ. Comparison of mother's occupation and industry from the birth certificate and a self-administered questionnaire. J Occup Med. 1992;34:1090–1096. [PubMed: 1432299]

TABLE 1

Characteristics of employed mothers of children with isolated orofacial clefts and controls, Texas, 1999–2009

	Controls (*n* = 1932)	CLP cases (*n* = 887)	CP cases (*n* = 436)
Covariates	***n* (%)**	***n* (%)**	***n* (%)**
Maternal age at delivery			
<20	115 (6.0)	49 (5.5)	20 (4.6)
20–34	1563 (80.9)	708 (80.0)	352 (80.7)
≥35	254 (13.2)	130 (14.7)	64 (14.7)
Missing	0 (0.0)	0 (0.0)	0 (0.0)
Maternal BMI (kg/m^2)[a]			
Underweight (<18.5)	24 (3.0)	14 (3.6)	11 (5.4)
Normal (18.5–<25)	352 (44.1)	181 (46.8)	78 (38.4)
Overweight (25–<30)	226 (28.3)	94 (24.3)	55 (27.1)
Obese (30+)	194 (24.3)	97 (25.1)	58 (28.6)
Missing	2 (0.3)	1 (0.3)	1 (0.5)
Maternal education			
<High school	221 (11.4)	111 (12.5)	60 (13.8)
High school	603 (31.2)	280 (31.6)	135 (31.0)
≥College	1095 (56.7)	491 (55.4)	241 (55.3)
Missing	13 (0.7)	5 (0.6)	0 (0.0)
Maternal race/ethnicity			
White	924 (47.8)	474 (53.4)[c]	233 (53.4)
Black	253 (13.1)	72 (8.1)	52 (11.9)
Hispanic	657 (34.0)	307 (34.6)	128 (29.4)
Others	93 (4.8)	32 (3.6)	23 (5.3)
Missing	5 (0.3)	2 (0.2)	0 (0.0)
Mother married			
Yes	1320 (68.3)	623 (70.3)	296 (67.9)
No	612 (31.7)	263 (29.7)	140 (32.1)
Missing	0 (0.0)	0 (0.0)	1 (0.0)
Parity			

	Controls (n = 1932)	CLP cases (n = 887)	CP cases (n = 436)
Covariates	***n* (%)**	***n* (%)**	***n* (%)**
0	791 (40.9)	341 (38.4)	166 (38.1)
≥1	1104 (57.1)	530 (59.8)	257 (58.9)
Missing	37 (1.9)	16 (1.8)	13 (3.0)
Any diabetes			
Yes	71 (3.7)	45 (5.1)	19 (4.4)
No	1861 (96.3)	842 (94.9)	417 (95.6)
Missing	0 (0.0)	0 (0.0)	0 (0.0)
Smoking during pregnancy			
Yes	133 (6.9)	81 (9.1)[c]	47 (10.8)[c]
No	1786 (92.4)	797 (89.9)	388 (89.0)
Missing	13 (0.7)	9 (1.0)	1 (0.2)
Alcohol use during pregnancy[b]			
Yes	11 (1.0)	10 (2.0)	3 (1.3)
No	1110 (97.9)	482 (96.4)	229 (98.3)
Missing	13 (1.2)	8 (1.6)	1 (0.4)

BMI, body mass index; CLP, cleft lip with or without cleft palate; CP, cleft palate only.

[a] Only available during 2005–2009.

[b] Only available during 1999–2004.

[c] Chi-square $P < 0.05$.

TABLE 2

Association between time performing maternal occupational physical activity and orofacial clefts, Texas, 1999–2009

	Controls *N* (%)	CLP *N* (%)	Adjusted OR (95%CI)[a]	CP *N* (%)	Adjusted OR (95%CI)[a]
Bending or twisting the body			P^b = **0.04**		P^b = 0.80
Quartile 1	491 (25.4)	213 (24.0)	1.00	115 (26.4)	1.00
Quartile 2	536 (27.7)	210 (23.7)	0.88 (0.70–1.12)	111 (25.5)	0.88 (0.66–1.19)
Quartile 3	432 (22.4)	211 (23.8)	1.10 (0.86–1.40)	102 (23.4)	0.98 (0.72–1.35)
Quartile 4	473 (24.5)	253 (28.5)	1.22 (0.97–1.53)	108 (24.8)	0.93 (0.69–1.27)
Climbing ladders, scaffolds, poles			P^b = 0.84		P^b = 0.39
Quartile 1	453 (23.5)	221 (24.9)	1.00	100 (22.9)	1.00
Quartile 2	499 (25.8)	201 (22.7)	0.85 (0.67–1.07)	97 (22.3)	0.95 (0.69–1.30)
Quartile 3	504 (26.1)	254 (28.6)	1.03 (0.82–1.29)	132 (30.3)	1.25 (0.93–1.68)
Quartile 4	476 (24.6)	211 (23.8)	0.91 (0.71–1.15)	107 (24.5)	1.04 (0.76–1.43)
Exposure to whole body vibration			P^b = 0.99		P^b = 0.56
Quartile 1[c]	587 (34.9)	283 (36.6)	1.00	131 (33.2)	1.00
Quartile 2[c]	120 (7.1)	45 (5.8)	0.76 (0.52–1.12)	26 (6.6)	1.00 (0.62–1.61)
Quartile 3[c]	526 (31.3)	217 (28.1)	0.88 (0.71–1.10)	131 (33.2)	1.17 (0.89–1.54)
Quartile 4	447 (26.6)	228 (29.5)	1.03 (0.82–1.28)	107 (27.1)	1.04 (0.78–1.34)
Keeping or regaining balance			P^b = **0.03**		P^b = 0.47
Quartile 1	431 (22.3)	168 (18.9)	1.00	85 (19.5)	1.00
Quartile 2	426 (22.1)	187 (21.1)	1.14 (0.88–1.47)	96 (22.0)	1.11 (0.80–1.54)
Quartile 3	592 (30.6)	275 (31.0)	1.16 (0.92–1.47)	142 (32.6)	1.20 (0.89–1.63)
Quartile 4	483 (25.0)	257 (29.0)	**1.32 (1.03–1.68)**	113 (25.9)	1.10 (0.80–1.52)
Kneeling, crouching, stooping			P^b = **0.03**		P^b = **0.01**
Quartile 1	496 (25.7)	199 (22.4)	1.00	102 (23.4)	1.00
Quartile 2	535 (27.7)	231 (26.0)	1.06 (0.84–1.33)	95 (21.8)	0.90 (0.66–1.24)
Quartile 3	420 (21.7)	209 (23.6)	1.22 (0.96–1.55)	102 (23.4)	1.14 (0.84–1.56)
Quartile 4	481 (24.9)	248 (28.0)	1.25 (0.99–1.58)	137 (31.4)	**1.41 (1.05–1.89)**

	Controls *N* (%)	CLP *N* (%)	Adjusted OR (95%CI)[a]	CP *N* (%)	Adjusted OR (95%CI)[a]
Making repetitive motions			$P^b = 0.47$		$P^b = 0.73$
Quartile 1	540 (28.0)	253 (28.5)	1.00	142 (32.6)	1.00
Quartile 2	456 (23.6)	229 (25.8)	1.05 (0.84–1.32)	81 (18.6)	**0.65 (0.48–0.88)**
Quartile 3	454 (23.5)	181 (20.4)	0.85 (0.66–1.08)	81 (18.6)	**0.65 (0.47–0.90)**
Quartile 4	482 (25.0)	224 (25.3)	0.97 (0.77–1.23)	132 (30.3)	1.06 (0.79–1.41)
Sitting			$P^b =$ **0.01**		$P^b = 0.08$
Quartile 1	451 (23.3)	240 (27.1)	1.00	119 (27.3)	1.00
Quartile 2	529 (27.4)	254 (28.6)	0.88 (0.69–1.12)	111 (25.5)	0.75 (0.54–1.02)
Quartile 3	495 (25.6)	209 (23.6)	0.81 (0.64–1.04)	122 (28.0)	0.93 (0.68–1.26)
Quartile 4	457 (23.7)	184 (20.7)	**0.74 (0.58–0.95)**	84 (19.3)	**0.67 (0.48–0.93)**
Standing			$P^b =$ **0.02**		$P^b = 0.27$
Quartile 1	547 (28.3)	208 (23.5)	1.00	109 (25.0)	1.00
Quartile 2	423 (21.9)	201 (22.7)	1.25 (0.99–1.58)	105 (24.1)	1.27 (0.94–1.72)
Quartile 3	531 (27.5)	261 (29.4)	**1.27 (1.02–1.59)**	111 (25.5)	1.03 (0.77–1.39)
Quartile 4	431 (22.3)	217 (24.5)	**1.33 (1.04–1.69)**	111 (25.5)	1.29 (0.95–1.77)
Walking and running			$P^b =$ **0.04**		$P^b = 0.82$
Quartile 1	552 (28.6)	216 (24.4)	1.00	112 (25.7)	1.00
Quartile 2	384 (19.9)	187 (21.1)	1.27 (1.00–1.62)	107 (24.5)	**1.39 (1.03–1.88)**
Quartile 3	495 (25.6)	221 (24.9)	1.11 (0.88–1.40)	106 (24.3)	1.07 (0.79–1.44)
Quartile 4	501 (25.9)	263 (29.7)	**1.32 (1.05–1.65)**	111 (25.5)	1.03 (0.76–1.39)

[a] Adjusted for maternal age, race/ethnicity, education, diabetes, previous livebirths, and smoking.

[b] *P* for trend.

[c] The percentage of control subjects differs from ~25% due to a large number of repeated values that spanned across percentiles.

Bold values are significant $P < 0.05$.

TABLE 3

Association between level of maternal occupational activity and orofacial clefts, Texas, 1999–2009

	Controls *N* (%)	**CLP *N* (%)**	**Adjusted OR (95%CI)**[a]	**CP *N* (%)**	**Adjusted OR (95%CI)**[a]
Performing general physical activities			$P^{b} = 0.11$		$P^{b} = 0.24$
Quartile 1	483 (25.0)	198 (22.3)	1.00	103 (23.6)	1.00
Quartile 2	549 (28.4)	241 (27.2)	1.07 (0.85–1.34)	140 (32.1)	1.23 (0.92–1.64)
Quartile 3	446 (23.1)	220 (24.8)	1.20 (0.94–1.53)	103 (23.6)	1.03 (0.75–1.41)
Quartile 4	454 (23.5)	228 (25.7)	1.19 (0.93–1.51)	90 (20.6)	0.86 (0.62–1.20)
Handling and moving objects			$P^{b} = 0.12$		$P^{b} = 0.97$
Quartile 1	508 (26.3)	213 (24.0)	1.00	110 (25.2)	1.00
Quartile 2	494 (25.6)	209 (23.6)	1.01 (0.80–1.28)	107 (24.5)	1.01 (0.75–1.37)
Quartile 3	447 (23.1)	226 (25.5)	1.21 (0.96–1.54)	114 (26.2)	1.18 (0.87–1.60)
Quartile 4	483 (25.0)	239 (26.9)	1.16 (0.91–1.46)	105 (24.1)	0.96 (0.70–1.31)

[a]Adjusted for maternal age, race/ethnicity, education, diabetes, previous livebirths, and smoking.

[b]*P* for trend.

TABLE 4

Association between importance of maternal physical activity and orofacial clefts, Texas, 1999–2009

	Controls *N* (%)	CLP *N* (%)	Adjusted OR (95%CI)[a]	CP *N* (%)	Adjusted OR (95%CI)[a]
Performing general physical activities			$P^{b} = 0.09$		$P^{b} = 0.97$
Quartile 1	484 (25.1)	211 (23.8)	1.00	103 (23.6)	1.00
Quartile 2	411 (21.3)	171 (19.3)	0.96 (0.75–1.23)	94 (21.6)	1.10 (0.80–1.50)
Quartile 3	555 (28.7)	252 (28.4)	1.04 (0.82–1.31)	137 (31.4)	1.15 (0.85–1.54)
Quartile 4	482 (25.0)	253 (28.5)	1.22 (0.97–1.54)	102 (23.4)	0.97 (0.71–1.34)
Handling and moving objects			$P^{b} = 0.13$		$P^{b} = 0.45$
Quartile 1	509 (26.4)	219 (24.7)	1.00	121 (27.8)	1.00
Quartile 2	398 (20.6)	175 (19.7)	1.03 (0.81–1.31)	84 (19.3)	0.88 (0.64–1.20)
Quartile 3	548 (28.4)	245 (27.6)	1.02 (0.81–1.29)	130 (29.8)	0.98 (0.73–1.31)
Quartile 4	477 (24.7)	248 (28.0)	1.22 (0.96–1.54)	101 (23.2)	0.86 (0.63–1.17)

[a]Adjusted for maternal age, race/ethnicity, education, diabetes, previous livebirths, and smoking.

[b]*P* for trend.