Published in final edited form as:
Matern Child Health J. 2019 February ; 23(2): 228–239. doi:10.1007/s10995-018-2641-8.

Association Between Breastfeeding and Childhood Cardiovascular Disease Risk Factors

Amna Umer[1], **Candice Hamilton**[1], **Roger A. Edwards**[2], **Lesley Cottrell**[1], **Peter Giacobbi Jr.**[3], **Kim Innes**[4], **Collin John**[1], **George A. Kelley**[5], **William Neal**[1], and **Christa Lilly**[5]

[1]Department of Pediatrics, School of Medicine, West Virginia University, Morgantown, WV 26506, USA

[2]Department Health Professions Education Program, Center for Interprofessional Studies and Innovation, MGH Institute of Health Professions, Boston, MA, USA

[3]Department of Social and Behavioral Sciences, School of Public Health, Robert C. Byrd Health Sciences Center, West Virginia University, Morgantown, WV 26506, USA

[4]Department of Epidemiology, School of Public Health, Robert C. Byrd Health Sciences Center, West Virginia University, Morgantown, WV 26506, USA

[5]Department of Biostatistics, School of Public Health, Robert C. Byrd Health Sciences Center, West Virginia University, Morgantown, WV 26506, USA

Abstract

Introduction—The immediate benefits of breastfeeding are well-established but the long-term health benefits are less well-known. West Virginia (WV) has a higher prevalence of cardiovascular disease (CVD) and lower breastfeeding rates compared to national averages. There is a paucity of research examining the relationship between breastfeeding and subsequent childhood CVD risk factors, an issue of particular relevance in WV.

Methods—This study used longitudinally linked data from three cross-sectional datasets in WV (N = 11,980). The information on breastfeeding was obtained retrospectively via parental recall when the child was in the fifth grade. The outcome variables included blood pressure measures [systolic blood pressure (SBP), diastolic blood pressure (DBP)] and lipid profile [total cholesterol (TC), low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), non-HDL, and triglycerides (TG)]. Multiple regression analyses were performed, adjusting for childhood body mass index (BMI) and additional covariates.

Results—Only 43% of mothers selfreported ever breastfeeding. The unadjusted analysis showed that children who were ever vs. never breastfed had significantly lower SBP (b = − 1.39 mmHg; 95% CI − 1.97, − 0.81), DBP (b = − 0.79 mmHg; 95% CI − 1.26, − 0.33), log-TG (b = − 0.08; 95% CI − 0.1, − 0.05), and higher HDL (b = 0.95 mg/dL; 95% CI 0.33, 1.56). After adjustment for

Amna Umer, amumer@hsc.wvu.edu.

Compliance with Ethical Standards
Conflict of interest The authors declare that they have no competing interests.

the child's BMI, socio-demographic and lifestyle factors, log-TG remained significantly associated with breastfeeding (b = − 0.04; 95% CI − 0.06, − 0.01; p = 0.01).

Conclusion—The observed protective effect of any breastfeeding on childhood TG level was small but significant. This finding provides some support for a protective effect of breastfeeding on later CVD risk.

Keywords

Breastfeeding; Cardiovascular disease; Childhood; Blood pressure; Lipid(s); Triglycerides; Rural

Introduction

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in the United States (U.S.) (Mensah and Brown 2007). Importantly, CVD mortality rates are approximately 20% higher in the rural Appalachian population compared to the rest of the nation (Liburd et al. 2006). West Virginia (WV), a state entirely within the Appalachian region, has some of the highest rates of CVD mortality in the nation, ranking 45th, and CVD risk factors, ranking 50th in high blood pressure and 48th in high total cholesterol (TC) levels in the nation (UHF 2014). Although CVD typically develops in adulthood, the risk factors for CVD may be present in children and adolescents as well (Rodrigues et al. 2013). These risk factors have the propensity to persist from childhood into adulthood, and the association between childhood and adult CVD risk has been shown to rise in magnitude with increasing age (Chen and Wang 2008; Juhola et al. 2011). Data on early life determinants of CVD risk suggests that breastfeeding is protective for cardiovascular health (Gartner et al. 2005; Martin et al. 2005).

The American Academy of Pediatrics recommends 6 months of exclusive breastfeeding and continuation of breastfeeding until the infant is 1 year old while gradually introducing solid foods after 6 months (AAP 2012). Unfortunately, results from the 2013 National Immunization Survey show that only 22.3% of U.S. mothers exclusively breastfeed for the first 6 months while in WV, the prevalence is even lower (14.1%) (CDC 2016). Bartick and colleagues performed a pediatric cost analysis and concluded that the annual cost of morbidity and mortality associated with suboptimal breastfeeding in the U.S. was approximately $13 billion (Bartick and Reinhold 2010).

Breastfeeding has been shown to be protective against childhood obesity (Umer et al. 2015). Results from a recent meta-analysis found a 15% decrease in the odds of childhood obesity in children who were ever vs. never breastfed (Weng et al. 2012). In addition to childhood adiposity, breastfeeding has been shown to have protective effects on other childhood CVD risk factors as well (Plagemann and Harder 2005).

Previous research examining the associations between breastfeeding and later childhood CVD risk factors has yielded conflicting results. For example, while some studies have found a significant protective effect of breastfeeding on child CVD risk factors such as systolic blood pressure (SBP) (Amorim Rde et al. 2014; Hosaka et al. 2013; Lawlor et al. 2004), diastolic blood pressure (DBP) (Martin et al. 2005, 2004; Owen et al. 2003), and lipid levels in childhood (Plagemann and Harder 2005; Plancoulaine et al. 2000; Thorsdottir et al. 2003), others have not (Bekkers et al. 2011; de Jonge et al. 2010; Fall et al. 2011; Horta et al. 2006, 2015; Izadi et al. 2013; Kramer 2010; Kramer et al. 2007; Kwok et al. 2013; Owen et al. 2002, 2008; Rudnicka et al. 2007). These discrepancies may in part reflect the role of childhood adiposity, a factor associated with blood pressure and cholesterol (McMurray et al. 1995). Some studies that did adjust for childhood obesity found that the association between breastfeeding and childhood CVD risk factors became non-significant in the adjusted models (Bekkers et al. 2011), whereas others found that even after controlling for body mass index (BMI) the association attenuated but remained statistically significant (Amorim Rde et al. 2014; Lawlor et al. 2004; Martin et al. 2004). These conflicting results suggest that childhood obesity could potentially be a partial or full mediator between the observed effects. Furthermore, some studies have found this association to be gender specific (Kolacek et al. 1993; Plancoulaine et al. 2000; Thorsdottir et al. 2003), or specific to one or two components of CVD risk factors (Kolacek et al. 1993; Victora et al. 2006). Moreover, studies examining this association use varying definitions of breastfeeding, with very few studies examining the association of ever breastfeeding compared to never breastfeeding (Horta et al. 2015). Given the former, the purpose of this study was to examine the association between ever breastfeeding and SBP, DBP, TC, low-density lipoprotein cholesterol (LDL), high-density lipoprotein cholesterol (HDL), non-HDL, and triglycerides (TG) after controlling for childhood BMI.

Methods and Materials

Data Sources

The current study utilized data from three sources: (1) WV Birth Certificates (WVDHHR), (2) the Working in Appalachia to Track High Birth Score, Critical Congenital Heart Disease and Hearing Loss (WATCH)/Birth Score project (WATCH 2013), and (3) the Coronary Artery Risk Detection in Appalachian Communities (CARDIAC) project (Muratova et al. 2002). The Birth Score project collects data on every newborn in WV prior to discharge in order to identify infants who are at a high risk of poor health outcomes in the first year of life. The CARDIAC project collects data using an active-consent process in fifth grade children in all 55 counties in WV. Area coordinators employed by the project, along with health science student volunteers, school nurses, and volunteer phlebotomists conducted blood pressure, anthropometric measurements, and blood lipid testing in local schools. Blood samples were analyzed by local area hospitals or by LabCorp Inc. (Burlington, NC). Further details of the data collection procedure are described elsewhere (Muratova et al. 2002). For the current study, children participating in the CARDIAC Project from 2008 to 2014 (N = 20,531) were matched with Birth Score project participants (merged with Birth Certificate data) born between 1997 and 2004. Overall, a nearly 60% data match was achieved (N = 11,980, 58.4%). Reasons for non-matches included CARDIAC participants born out of state, BirthScore participants who were not named at the time the BirthScore was filled out, CARDIAC participants who use a different name than that given at birth (e.g., middle names as first name, nicknames), CARDIAC participants who were legally adopted, and lastly use of out-of-state hospital by the rural populations living hear state borders. The WVU IRB approved the data merging and subsequent analyses of the de-identified dataset.

The final analyses excluded infants born preterm, i.e., < 37 weeks of gestation (N = 1190, 10.2%) because preterm and term infants are considered two separate populations with different morbidity and mortality risk profiles in later life (Wilcox 2001).

Variables

Dependent Variables—The main outcome variables included blood pressure and lipid profile (SBP, DBP, TC, LDL, HDL, non-HDL, and TG) for the child in fifth grade. Blood pressure was taken in a sitting position with the arm resting on a table at the level of the heart after the child had rested for 5 min. The first and fifth Korotkoff sound was used to record SBP and DBP in mmHg respectively. Lipids were mostly fasting values, although when the student forgot to fast the non-fasting values were used. All lipid valus were measured in mg/dl. LabCorp Inc. (Burlington, NC) estimated LDL using the Friedewald equation (Friedewald et al. 1972).

Independent Variable—The main exposure variable was the one question on reported history of breastfeeding. Information related to breastfeeding was obtained using the CARDIAC questionnaire retrospectively via parental recall when the child was in fifth grade, and stated as, "Was your child breastfed?"

Mediator (BMI Percentile)—The children's height and weight were measured using SECA Road Rod stadiometers (78"/200 cm) and the SECA 840 Personal Digital Scales (Seca Corp, Hanover, MD, USA). The current study used BMI percentile as a measure of the child's adiposity status. BMI percentiles represent a measure of relative weight adjusted for the child's height, age and sex corresponding to the 2000 CDC growth charts (Kuczmarski et al. 2002).

Covariates

Socio-demographic Variables: Socio-demographic variables included the child's age, sex, race, maternal age, education, and health insurance status at time of delivery. The child's age, sex, and race was recorded by the CARDIAC project in fifth grade. For this study, race was dichotomized as white and other based on the population distribution of WV, i.e., 94% white (US-Census-Bureau 2011). Though not conclusive, several studies have suggested a link between advanced maternal age and children's negative health outcomes in later life (Myrskyla and Fenelon 2012). Thus, maternal age at the time of birth was included. Maternal socio-economic status (SES) has also been shown to be associated with CVD risk factors in childhood (van den Berg et al. 2013) and also a predictor of maternal breastfeeding practices (van Rossem et al. 2009). Two proxy assessments of maternal SES were included: (1) maternal education at the time of delivery, recorded as a continuous variable (number of years of education ranging from 1 to 17), and (2) maternal health insurance at the time of delivery, categorized as a binary variable (Medicaid and non-Medicaid).

Family History of CVD and Dyslipidemia: The CARDIAC project collects parent-reported information on family history (parent or grandparent) of heart disease, coronary heart disease, heart attack, open-heart surgery, angioplasty, and death from heart diseases.

For the current study, we created one variable for family history of CVD (yes or no) based on having a family history of any one of these six outcomes. The CARDIAC project also collects information on family history of high cholesterol (yes or no) that we included.

Other Infant and Maternal Characteristics: Additional covariates based on the literature included (1) number of previous pregnancies (0 or ≥ 1) (Gaillard et al. 2014), (2) smoking during pregnancy (yes or no) (Huang et al. 2012), (3) self-reported weight gain during pregnancy (measured in pounds) (Mamun et al. 2009), and (4) birth weight of the child (measured in grams) (Huang et al. 2012).

Statistical Analysis

All statistical analyses were conducted using SAS, version 9.3 (SAS Institute, Cary NC). Frequency and percentage were reported for categorical variables and mean ± standard deviation for the continuous data. If any of the continuous CVD risk factors had a skewed distribution they were log transformed for all analyses. Independent sample t-tests were used to compare the means of dependent variables (DV) for women who responded 'yes' vs. 'no' to the question about breastfeeding their index child. The magnitude of this association was calculated using Cohen's effect size (d). Seven separate multiple-regression analyses were performed for the seven continuous DVs (SBP, DBP, TC, LDL, HDL, non-HDL, and TG). All CVD outcomes were first regressed on reported breastfeeding (model 1) and then BMI percentile was included (model 2). For the outcomes where the association was statistically significant between breastfeeding and CVD outcomes independent of obesity, additional covariates were added to the model (model 3). The covariates were removed one at a time from the regression model if they were not statistically significant (highest p-value greater than $p > 0.05$). We also performed the regression analysis with and without breastfeeding to calculate the amount of variance shared between breastfeeding and CVD risk factors (change in R^2, model 3).

Sensitivity Analyses—To explore whether there were gender differences, we performed Chi square tests on breastfeeding groups in addition to including the interaction term between gender and reported breastfeeding in the linear regression analysis.

Results

A total of 11,980 participants were available for analysis after merging the data. After excluding the infants born preterm the final number of participants included for analysis was 10,457 (Table 1). The percentage of children who were parent-reported as having been ever been breastfed was 43.2% in children who had been born full-term. The mean age of the children in fifth grade was 11.0 ± 0.5 years. 55% were female and 94% were white. The mean BMI percentile of fifth graders was 72.6 ± 28.0. Only serum TG measurements had a skewed distribution and were log transformed (log-TG) for all analyses.

Children who were ever vs. never breastfed had significantly lower mean SBP, DBP, and log-TG levels, and significantly higher HDL levels in fifth grade. The mean differences were: − 1.3 mmHg (95% CI − 1.97, − 0.81) for SBP, − 0.81 mmHg (95% CI − 1.26, − 0.33) for DBP, − 0.08 (95% CI − 0.10, − 0.05) for log-TG levels, and 0.9 mg/dL (95% CI 0.33, 1.56) for HDL levels (Table 2). Effect sizes using Cohen's d ranged from 0.07 to 0.16 for the statistically significant outcomes (SBP, DBP, TG and HDL). No statistically significant differences were observed for TC, LDL, and non-HDL levels.

The unadjusted regression analysis showed that children who were ever vs. never breastfed had significantly lower SBP (b = − 1.39 mmHg; 95% CI − 1.97, − 0.81; p < 0.0001), DBP (b = − 0.79 mmHg; 95% CI − 1.26, − 0.33; p = 0.0009), log-TG (b = − 0.08; 95% CI − 0.1, − 0.05; p < 0.0001), and higher HDL (b = 0.95 mg/dL; 95% CI 0.33, 1.56; p < 0.0001) (Table 3, model 1). However, adjustments for the child's current BMI decreased the associations of ever vs. never breastfeeding for SBP (b = − 0.77 mmHg; 95% CI − 1.32, − 0.23; p = 0.005) and log-TG (b = − 0.05; 95% CI − 0.07, − 0.03; p = 0.048), while eliminating the statistically significant association for DBP (b = − 0.44 mmHg; 95% CI − 0.89, 0.02; p = 0.06) and HDL (b = 0.28 mg/dL; 95% CI − 0.29, 0.86; p = 0.335) (Table 3, model 2). Further adjustments for additional covariates eliminated the significant association between ever breastfeeding and SBP (b = − 0.43 mmHg; 95% CI − 0.98, − 0.13; p = 0.1349) and attenuated the association with log-TG but remained statistically significant (b = − 0.04; 95% CI − 0.06, − 0.01; p = 0.01) (Table 3, model 3).

Ever breastfeeding (yes vs. no) was significantly and inversely associated with log-TG of children after adjustment for BMI percentile in fifth grade, child's age, gender, race, maternal education at birth, number of previous pregnancies, and family history of cholesterol (F (8, 5339) = 118.84; p < 0.0001; adjusted R^2 = 0.15) (Table 4). Children who had a reported history of ever vs. never being breastfed showed a 0.04 (b = − 0.04; 95% CI − 0.06, − 0.01, t = − 2.65, p = 0.008) decrease in the log-TG levels. The amount of variance shared between ever breastfeeding and a childhood log-TG level was 0.13%.

No sex differences were observed in the additional sensitivity analysis that examined the interaction of reported history of breastfeeding by sex on blood pressure and lipid levels of children (b = − 0.03; 95% CI − 0.08, 0.02, t = − 1.15, p = 0.2495).

Discussion

Reported breastfeeding rates in this study were low; only 43% of the mothers reported ever breastfeeding their index child in this sample of WV children born between the years 1997–2004. State-specific breastfeeding data for these years are not available, but nationally, ever breastfeeding rates increased from 71.4% in 2002 to 81.1% in 2013 (NIS, 2002–2013). However, in 2013, WV ranked third lowest (64.6%) for ever breastfeeding rates in the nation (CDC 2016).

Overall, the results showed that children who were ever breastfed had significantly lower SBP, DBP, and TG levels, and higher HDL levels. After adjustment for the child's current BMI percentile in fifth grade, only SBP and TG remained significantly and positively associated with breastfeeding, although the associations were attenuated. Further adjustment for socio-demographic and lifestyle variables did not alter the inverse association with childhood TG levels, but eliminated that with SBP. These results suggest that BMI may in part mediate the observed association of breastfeeding with TG levels, and possibly SBP in childhood.

SBP and DBP

Our results are consistent with those of several previous studies that found no differences in the mean SBP and DBP of children who were breastfed as compared to those not breastfed during infancy (de Jonge et al. 2010; Fall et al. 2011; Horta et al. 2006; Izadi et al. 2013; Kramer 2010; Kramer et al. 2007; Kwok et al. 2013; Rudnicka et al. 2007). However, several studies have found the opposite, (Amorim Rde et al. 2014; Hosaka et al. 2013; Lawlor et al. 2004; Martin et al. 2004) including two earlier systematic reviews with meta-analysis (Martin et al. 2005; Owen et al. 2003). These systematic reviews concluded that the pooled mean difference in SBP (but not DBP) was significantly lower among children who had been breastfed as infants (Owen et al. 2003), while the later systematic review with meta-analysis found a statistically significant reduction in both SBP and DBP (Martin et al. 2005). Our results for both SBP and DBP are consistent with the evidence provided by the most recent systematic review published in 2015 (Horta et al. 2015), which demonstrated that for age groups 10–19, SBP was lower but not significant among those subjects who had been breastfed, whereas no association was observed for DBP. One of the possible explanations for the variation in results may be that previous studies that found a significant association focused on younger children less than 10 years old (Amorim Rde et al. 2014; Hosaka et al. 2013; Lawlor et al. 2004; Martin et al. 2004). Our study demonstrated that the association between breastfeeding and childhood blood pressure during 11 years is not independent of the child's current BMI and socio-demographic variables, thus suggesting the role of the child's current BMI as a potential mediator. Breastfeeding has shown to be inversely related to childhood obesity in several studies (Weng et al. 2012) including our earlier investigation in WV fifth grade children (Umer et al. 2015).

Lipid Levels

In this study, we found a statistically significant association between log-TG levels among fifth grade children who were ever breastfed independent of the child's BMI, socio-demographic, and lifestyle characteristics. To our knowledge, very few studies have examined this association in children. One study found a significant negative association in 17-year-old boys but not among girls (Kark et al. 1984) while another study among 18-year-old boys did not find any difference in ever vs. never breastfed adolescents (Victora et al. 2006). Conversely, another population-based study found that among 6 year old children the association was not significant after adjusting for age, sex, family-based socio-demographic, maternal lifestyle-related, and childhood factors (Durmus et al. 2014). We did not find any gender differences for the association between breastfeeding and log-TG levels. The standardized regression coefficient of the unadjusted association attenuated but remained statistically significant after adjusting for childhood BMI percentile and additional covariates. Based on these results, it would appear reasonable to suggest that this association is partially mediated by the child's current BMI levels. However, the change in R^2 showed that ever breastfeeding accounted for less than 0.2% of the unique variance in log-TG levels of fifth grade children, suggesting a small effect size.

The results of the current study are also consistent with studies that found no association between TC (Bekkers et al. 2011; Horta et al. 2015; Owen et al. 2002), LDL (Owen et al. 2002), and non-HDL levels among breastfed vs. non-breastfed children. The results of two systematic reviews with meta-analysis using random effects models showed that the mean TC and LDL levels in children were not significantly different when comparing breastfed infants to non-breastfed infants (Owen et al. 2002). The most recent meta-analysis also found no significant difference in the mean TC levels between breastfed and non-breastfed infants in children 10–19 years of age (Horta et al. 2015). For HDL, our study found a statistically significant positive association among children who were ever vs. never breastfed. However, the association was attenuated after adjustment for the child's BMI and became non-significant. The results are consistent with other studies (Bekkers et al. 2011) (Victora et al. 2006) that also adjusted for the child's current BMI (Bekkers et al. 2011).

Strengths, Limitations and Potential Implications

This study has several strengths. First, this study used a large sample size and population-based design. Second, the use of linked data from different time points allowed us to assess the influence of broad array of demographic, lifestyle, and health-related factors on the association between breastfeeding and childhood CVD risk factors. Third, while the effect size for the association between breastfeeding and log-TG levels was small, we believe that it is a novel finding in 11-year-old children that may be important from a population health perspective and worthy of additional examination with different study designs.

In addition to strengths, this study also has some potential limitations. These include a lack of information on certain potential confounders such as parental adiposity status, maternal pre-pregnancy weight, rapid weight gain during the first year of life, pubertal status, family history of hypertension, physical activity, and dietary behaviors. Additionally, information on history of breastfeeding was obtained retrospectively, and thus, subject to recall and social desirability bias. Furthermore, the fact that the question regarding breastfeeding asked "was your child breastfed?" and did not explicitely ask "was your child EVER breastfed?" As a result, this may have led to a misinterpretion of the question by the mothers. In addition, our data did not capture the method, extent, or duration of lactation, precluding examination of these factors. Furthermore, the investigative team was also unable to match data on ~ 40% of CARDIAC participants due to the fact that many participants were not born in WV and thus, did not have information available in the Birth Score database. Finally, as the study population was restricted to residents of a rural Appalachian state, the results may not be generalizable to other populations.

Potential implications and future recommendations based on the results of this study include designing large prospective studies that include comprehensive, carefully worded questions on breastfeeding in order to confirm the current findings in diverse populations. In addition, it appears plausible to suggest that biomedical research is needed to explore and understand the mechanism(s) underlying these findings at the molecular level. Focusing on preterm infants may also be worth exploring, as the causal mechanism may differ in that particular group given that they have different growth patterns and later CVD risk. As the breastfeeding rates in WV are one of the lowest in the nation, the current findings highlight the need to increase breastfeeding rates in the state so as to achieve both short and long-term health benefits. Finally, although the observed effects of breastfeeding on childhood TG lipid levels were small, the distal protective effects with respect to adult CVD risk may be nonetheless practically significant as these small changes are likely to not only to persist, but also amplify with age.

Conclusion

Breastfeeding has numerous health benefits for both the mother and the child. Our earlier work has shown that breastfeeding is protective for childhood obesity (Umer et al. 2015). This study further suggests that breastfeeding is inversely associated with childhood TG levels at 11 years of age independent of childhood obesity. However, significant associations were not observed with other childhood CVD risk factors examined. Future large prospective studies designed specifically to address this topic are needed to fully assess and understand the association of breastfeeding and CVD risks factors at various life stages.

Acknowledgements

The West Virginia WATCH/Birth Score Program is funded under an agreement with the West Virginia Department of Health and Human Resources, Bureau for Public Health, Office of Maternal, Child and Family Health. The CARDIAC project is funded by the West Virginia Bureau of Public Health. The authors wish to thank the children and families who have participated in the CARDIAC Project and the Birth Score Project. The authors would like to thank Cris Britton, data manager of WATCH/Birth Score Project for providing the matched data. GA Kelley and C Lilly were partially supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award no. U54GM104942. The content is solely the responsibility of the authors and does not necessarily represent the views of the National Institutes of Health.

References

AAP. (2012). Section on breastfeeding. Breastfeeding and the use of human milk. Pediatrics, 129(3), e827–e841. 10.1542/peds.2011-3552. [PubMed: 22371471]

Amorim Rde J, Coelho AF, de Lira PI, & Mde LC (2014). Is breastfeeding protective for blood pressure in schoolchildren? A cohort study in northeast Brazil. Breastfeed Medicine, 9(3), 149–156. 10.1089/bfm.2013.0118.

Bartick M, & Reinhold A (2010). The burden of suboptimal breastfeeding in the United States: A pediatric cost analysis. Pediatrics, 125(5), e1048–e1056. 10.1542/peds.2009-1616. [PubMed: 20368314]

Bekkers MB, Brunekreef B, Smit HA, Kerkhof M, Koppelman GH, Oldenwening M, et al. (2011). Early-life determinants of total and HDL cholesterol concentrations in 8-year-old children; the PIAMA birth cohort study. PLoS ONE, 6(9), e25533 10.1371/journal.pone.0025533. [PubMed: 21980486]

CDC. (2016). Division of nutrition, physical activity, and obesity, national center for chronic disease prevention and health promotion. Avaiable at https://www.cdc.gov/breastfeeding/data/nis_data/rates-any-exclusive-bf-state-2013.htm.

Chen X, & Wang Y (2008). Tracking of blood pressure from childhood to adulthood: A systematic review and meta-regression analysis. Circulation, 117(25), 3171–3180. 10.1161/CIRCULATIONAHA.107.730366. [PubMed: 18559702]

de Jonge LL, van Osch-Gevers L, Geelhoed JJ, Hofman A, Steegers EA, Helbing WA, et al. (2010). Breastfeeding is not associated with left cardiac structures and blood pressure during the first two years of life. The Generation R Study. Early Human Development, 86(8), 463–468. 10.1016/j.earlhumdev.2010.06.004. [PubMed: 20609534]

Durmus B, Heppe DH, Gishti O, Manniesing R, Abrahamse-Berkeveld M, van der Beek EM, et al. (2014). General and abdominal fat outcomes in school-age children associated with infant breastfeeding patterns. The American Journal of Clinical Nutrition, 99(6), 1351–1358. 10.3945/ajcn.113.075937. [PubMed: 24622802]

Fall CH, Borja JB, Osmond C, Richter L, Bhargava SK, Martorell R, et al. (2011). Infant-feeding patterns and cardiovascular risk factors in young adulthood: Data from five cohorts in low- and middle-income countries. International Journal of Epidemiology, 40(1), 47–62. 10.1093/ije/dyq155. [PubMed: 20852257]

Friedewald WT, Levy RI, & Fredrickson DS (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clinical Chemistry, 18(6), 499–502. [PubMed: 4337382]

Gaillard R, Rurangirwa AA, Williams MA, Hofman A, Mackenbach JP, Franco OH, et al. (2014). Maternal parity, fetal and childhood growth, and cardiometabolic risk factors. Hypertension, 64(2), 266–274. 10.1161/HYPERTENSIONAHA.114.03492. [PubMed: 24866145]

Gartner LM, Morton J, Lawrence RA, Naylor AJ, O'Hare D, & Schanler RJ (2005). Breastfeeding and the use of human milk. Pediatrics, 115(2), 496–506. 10.1542/peds.2004-2491. [PubMed: 15687461]

Horta BL, de Mola L,C, & Victora CG (2015). Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: A systematic review and meta-analysis. Acta Paediatrica Supplement, 104(467), 30–37. 10.1111/apa.13133.

Horta BL, Victora CG, Lima RC, Goncalves H, Guimaraes BE, & Barros FC (2006). Breastfeeding duration and blood pressure among Brazilian adolescents. Acta Paediatrica, 95(3), 325–331. 10.1080/08035250500434744. [PubMed: 16497644]

Hosaka M, Asayama K, Staessen JA, Ohkubo T, Hayashi K, Tatsuta N, et al. (2013). Breastfeeding leads to lower blood pressure in 7-year-old Japanese children: Tohoku study of child development. Hypertension Research, 36(2), 117–122. 10.1038/hr.2012.128. [PubMed: 22951522]

Huang RC, Mori TA, & Beilin LJ (2012). Early life programming of cardiometabolic disease in the Western Australian pregnancy cohort (Raine) study. Clinical and Experimental Pharmacology and Physiology, 39(11), 973–978. 10.1111/j.1440-1681.2012.05746.x. [PubMed: 22789124]

Izadi V, Kelishadi R, Qorbani M, Esmaeilmotlagh M, Taslimi M, Heshmat R, et al. (2013). Duration of breast-feeding and cardiovascular risk factors among Iranian children and adolescents: The CASPIAN III study. Nutrition, 29(5), 744–751. 10.1016/j.nut.2012.10.016. [PubMed: 23582077]

Juhola J, Magnussen CG, Viikari JS, Kahonen M, Hutri-Kahonen N, Jula A, et al. (2011). Tracking of serum lipid levels, blood pressure, and body mass index from childhood to adulthood: The cardiovascular risk in young finns study. The Journal of Pediatrics, 159(4), 584–590. 10.1016/j.jpeds.2011.03.021. [PubMed: 21514597]

Kark JD, Troya G, Friedlander Y, Slater PE, & Stein Y (1984). Validity of maternal reporting of breast feeding history and the association with blood lipids in 17 year olds in Jerusalem. Journal of Epidemiology and Community Health, 38(3), 218–225. [PubMed: 6470599]

Kolacek S, Kapetanovic T, Zimolo A, & Luzar V (1993). Early determinants of cardiovascular risk factors in adults. A. Plasma lipids. Acta Paediatrica, 82(8), 699–704. [PubMed: 8374223]

Kramer MS (2010). "Breast is best": The evidence. Early Human Development, 86(11), 729–732. 10.1016/j.earlhumdev.2010.08.005. [PubMed: 20846797]

Kramer MS, Matush L, Vanilovich I, Platt RW, Bogdanovich N, Sevkovskaya Z, et al. (2007). Effects of prolonged and exclusive breastfeeding on child height, weight, adiposity, and blood pressure at age 6.5 years: Evidence from a large randomized trial. The American Journal of Clinical Nutrition, 86(6), 1717–1721. [PubMed: 18065591]

Kuczmarski RJ, Ogden CL, Guo SS, Grummer-Strawn LM, Flegal KM, Mei Z, et al. (2002). 2000 CDC growth charts for the United States: Methods and development. Vital and Health Statistics, 11(246), 1–190.

Kwok MK, Leung GM, & Schooling CM (2013). Breastfeeding and adolescent blood pressure: Evidence from Hong Kong's "children of 1997" birth cohort. American Journal of Epidemiology, 178(6), 928–936. 10.1093/aje/kwt076. [PubMed: 23857775]

Lawlor DA, Najman JM, Sterne J, Williams GM, Ebrahim S, & Smith D,G (2004). Associations of parental, birth, and early life characteristics with systolic blood pressure at 5 years of age: Findings from the Mater-University study of pregnancy and its outcomes. Circulation, 110(16), 2417–2423. 10.1161/01.CIR.0000145165.80130.B5. [PubMed: 15477400]

Liburd LC, Giles HW, & Mensah GA (2006). Looking through a glass, darkly: Eliminating health disparities. Preventing Chronic Disease, 3(3), A72. [PubMed: 16776873]

Mamun AA, O'Callaghan M, Callaway L, Williams G, Najman J, & Lawlor DA (2009). Associations of gestational weight gain with offspring body mass index and blood pressure at 21 years of age: Evidence from a birth cohort study. Circulation, 119(13), 1720–1727. 10.1161/CIRCULATIONAHA.108.813436. [PubMed: 19307476]

Martin RM, Ben-Shlomo Y, Gunnell D, Elwood P, Yarnell JW, & Smith DG (2005). Breast feeding and cardiovascular disease risk factors, incidence, and mortality: The Caerphilly study. Journal of Epidemiology and Community Health, 59(2), 121–129. 10.1136/jech.2003.018952. [PubMed: 15650143]

Martin RM, Gunnell D, & Smith GD (2005). Breastfeeding in infancy and blood pressure in later life: Systematic review and meta-analysis. American Journal of Epidemiology, 161(1), 15–26. 10.1093/aje/kwh338. [PubMed: 15615909]

Martin RM, Ness AR, Gunnell D, Emmett P, Davey Smith G, & Team AS (2004). Does breast-feeding in infancy lower blood pressure in childhood? The Avon Longitudinal Study of Parents and Children (ALSPAC). Circulation, 109(10), 1259–1266. 10.1161/01.CIR.0000118468.76447.CE. [PubMed: 14993142]

McMurray RG, Harrell JS, Levine AA, & Gansky SA (1995). Childhood obesity elevates blood pressure and total cholesterol independent of physical activity. International Journal of Obesity and Related Metabolic Disorders, 19(12), 881–886. [PubMed: 8963356]

Mensah GA, & Brown DW (2007). An overview of cardiovascular disease burden in the United States. Health Affairs, 26(1), 38–48. 10.1377/hlthaff.26.1.38. [PubMed: 17211012]

Muratova VN, Demerath EW, Spangler E, Ogershok P, Elliott E, Minor VE, et al. (2002). The relation of obesity to cardiovascular risk factors among children: The CARDIAC project. West Virginia Medical Journal, 98(6), 263–267. [PubMed: 12645279]

Myrskyla M, & Fenelon A (2012). Maternal age and offspring adult health: Evidence from the health and retirement study. Demography, 49(4), 1231–1257. 10.1007/s13524-012-0132-x. [PubMed: 22926440]

National Immunization Survey (NIS). (2002–2013). Division of nutrition, physical activity, and obesity, national center for chronic disease prevention and health promotion. Avaiable at https://www.cdc.gov/breastfeeding/data/nis_data/index.htm.

Owen CG, Whincup PH, Gilg JA, & Cook DG (2003). Effect of breast feeding in infancy on blood pressure in later life: Systematic review and meta-analysis. BMJ, 327(7425), 1189–1195. 10.1136/bmj.327.7425.1189. [PubMed: 14630752]

Owen CG, Whincup PH, Kaye SJ, Martin RM, Smith D, Cook G, Williams DG, M S (2008). Does initial breastfeeding lead to lower blood cholesterol in adult life? A quantitative review of the evidence. The American Journal of Clinical Nutrition, 88(2), 305–314. [PubMed: 18689365]

Owen CG, Whincup PH, Odoki K, Gilg JA, & Cook DG (2002). Infant feeding and blood cholesterol: A study in adolescents and a systematic review. Pediatrics, 110(3), 597–608. [PubMed: 12205266]

Plagemann A, & Harder T (2005). Breast feeding and the risk of obesity and related metabolic diseases in the child. Metabolic Syndrome and Related Disorders, 3(3), 222–232. [PubMed: 18370791]

Plancoulaine S, Charles MA, Lafay L, Tauber M, Thibult N, Borys JM, et al. (2000). Infant-feeding patterns are related to blood cholesterol concentration in prepubertal children aged 5–11 years: The Fleurbaix-Laventie Ville Sante study. European Journal of Clinical Nutrition, 54(2), 114–119. [PubMed: 10694781]

Rodrigues AN, Abreu GR, Resende RS, Goncalves WL, & Gouvea SA (2013). Cardiovascular risk factor investigation: A pediatric issue. International Journal of General Medicine, 6, 57–66. 10.2147/IJGM.S41480. [PubMed: 23515212]

Rudnicka AR, Owen CG, & Strachan DP (2007). The effect of breastfeeding on cardiorespiratory risk factors in adult life. Pediatrics, 119(5), e1107–e1115. 10.1542/peds.2006-2149. [PubMed: 17473082]

Thorsdottir I, Gunnarsdottir I, & Palsson GI (2003). Association of birth weight and breast-feeding with coronary heart disease risk factors at the age of 6 years. Nutrition, Metabolism and Cardiovascular Diseases, 13(5), 267–272.

Umer A, Hamilton C, Britton CM, Mullett MD, John C, Neal W, et al. (2015). Association between breastfeeding and childhood obesity: Analysis of a linked longitudinal study of rural Appalachian fifth-grade children. Childhood Obesity, 11(4), 449–455. 10.1089/chi.2015.0026. [PubMed: 26186180]

United Health Foundation (UHF). (2014). America's health ranking. Available at http://www.americashealthrankings.org.

US Census Bureau. (2011). U.S. Census Bureau: State and County QuickFacts. Data derived from Population Estimates, American Community Survey, Census of Population and Housing, State and County Housing Unit Estimates, County Business Patterns, Nonemployer Statistics, Economic Census, Survey of Business Owners, Building Permits vol. 2014.

van den Berg G, van Eijsden M, Galindo-Garre F, Vrijkotte TG, & Gemke RJ (2013). Explaining socioeconomic inequalities in childhood blood pressure and prehypertension: The ABCD study. Hypertension, 61(1), 35–41. 10.1161/HYPERTENSIONAHA.111.00106. [PubMed: 23129697]

van Rossem L, Oenema A, Steegers EA, Moll HA, Jaddoe VW, Hofman A, et al. (2009). Are starting and continuing breastfeeding related to educational background? The generation R study. Pediatrics, 123(6), e1017–e1027. 10.1542/peds.2008-2663. [PubMed: 19482734]

Victora CG, Horta BL, Post P, Lima RC, De Leon Elizalde JW, Gerson BM, et al. (2006). Breast feeding and blood lipid concentrations in male Brazilian adolescents. Journal of Epidemiology and Community Health, 60(7), 621–625. 10.1136/jech.2005.044156. [PubMed: 16790835]

WATCH P (2013). West Virginia birth score project. This program is funded under an agreement with the West Virginia Department of Health and Human Resources, Bureau for Public Health, Office of Maternal, Child and Family Health. Available at http://www.wvdhhr.org/birthscore/. 2013 at http://www.wvdhhr.org/birthscore/.

Weng SF, Redsell SA, Swift JA, Yang M, & Glazebrook CP (2012). Systematic review and meta-analyses of risk factors for childhood overweight identifiable during infancy. Archives of Disease in Childhood, 97(12), 1019–1026. 10.1136/archdischild-2012-302263. [PubMed: 23109090]

Wilcox AJ (2001). On the importance—and the unimportance of birthweight. International Journal of Epidemiology, 30(6), 1233–1241. [PubMed: 11821313]

WVDHHR. (2015). West Virginia Vital Statistics. Health statistics center. Room 165, 350 Capitol Street Charleston, WV 25301–3701. DHHR. Avaiable at: http://www.wvdhhr.org/bph/hsc/statserv/VitalStats.asp.

Significance

Despite the well-known immediate benefits of breastfeeding on infants' health, the long term influence of breastfeeding on childhood cardiovascular disease (CVD) risk factors show inconsistent results. Limited research exists on this topic in West Virginia (WV); a state characterized by high CVD burden and low breastfeeding rates. This study gathered retrospective data on breastfeeding when the child was in the fifth grade. The results showed that less than half of the mothers ever breastfed their child. Children who were reported as ever being breastfed had significantly lower triglyceride levels in fifth grade compared to those who were not breastfed. These findings offer some support for the long-term health benefits of breastfeeding, and highlight the need to increase breastfeeding rates in WV.

Table 1

Maternal and child characteristics at birth and in fifth grade using merged data from the Birth Score Project (1998–2003) and the CARDIAC Project (2010–2013) for all infants who were born full-term (N = 10,457)

Variable	N	Missing	Frequency (%)/mean (SD)
Sex	10,457		
Female			5740 (54.89)
Male			4717 (45.11)
Race	10,070	387	
Others			630 (6.26)
White			9440 (93.74)
Marital status (at birth)	10,457		
Single			2788 (26.66)
Married			7669 (73.34)
No. of previous pregnancy (at birth)	10,457		
0			3651 (34.91)
≥1			6806 (65.09)
Health insurance of mother (at birth)	10,457		
Medicaid			4841 (46.29)
Non-Medicaid			5616 (53.71)
Family history of cholesterol	8879	1578	
No			6119 (68.92)
Yes			2760 (31.08)
Family history of CVD	10,457		
No			6114 (58.47)
Yes			4343 (41.53)
Smoking during pregnancy	10,395	62	
Yes			2580 (24.82)
No			7815 (75.18)
No. of prenatal care visits	10,457		
<12			4641 (44.38)
≥12			5816 (55.62)

Variable	N	Missing	Frequency (%)/mean (SD)
Breastfeeding	6833	3624	
No			3883 (56.83)
Yes			2950 (43.17)
Age of child (years)	10,457	0	10.97 (0.47)
Maternal age at birth (years)	10,424	33	25.79 (5.5)
Maternal education at birth	10,405	52	12.87 (2.12)
Weight gain during pregnancy (lbs.)	9597	860	30.79 (14.66)
Gestational age (weeks)	10,457	0	39.07 (1.12)
Birth weight (grams)	10,452	5	3352.64 (481.55)
BMI-percentile	10,444	13	72.58 (28)
Child SBP (mmHg)	10,254	203	108.43 (11.75)
Child DBP (mmHg)	10,255	202	67.49 (9.53)
Child TC (mg/dL)	9740	717	157.7 (27.51)
Child LDL (mg/dL)	9725	732	89.99 (24.41)
Child HDL (mg/dL)	9740	717	50.14 (12.37)
Child NON-HDL (mg/dL)	9740	717	107.56 (27.86)
Child TG (mg/dL)	9739	718	92.28 (54.99)
Child log TG	9739	718	4.38 (0.52)

CVD cardiovascular disease, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *TC* total cholesterol, *LDL* low-density lipoprotein cholesterol, *HDL* high-density lipoprotein, *non-HDL* non-high-density lipoprotein cholesterol, *TG* triglycerides

Table 2

Results of the Independent Sample *T* test for the mean difference in blood pressure and lipid levels in both fifth grade children who were breastfed vs. not breastfed and mothers who breastfed vs. did not breastfed for children born Full-Term using merged data from the Birth Score Project (1998–2003) and the CARDIAC Project (2010–2013)

	Childhood CVD risk factors				
	Breastfed	Not breastfed	Mean difference (95% CI)	P-value	Cohen's d effect size
BMI (percentile)					
N	2948	3877			
Mean (SD)	70.2 (28.6)	74.2 (27.5)	− 3.95* (− 5.29, − 2.62)	< 0.0001	0.14
SBP					
N	2866	3781			
Mean (SD)	107.3 (11.8)	108.6 (11.9)	− 1.3* (− 1.97, − 0.81)	< 0.0001	0.11
DBP					
N	2867	3781			
Mean (SD)	66.4 (9.5)	67.2 (9.7)	− 0.8* (− 1.26, − 0.33)	0.0009	0.08
TC					
N	2792	3644			
Mean (SD)	157.5 (27.8)	157.8 (27.9)	− 0.3 (− 1.71, 1.04)	0.6285	
LDL					
N	2788	3639			
Mean (SD)	89.4 (24.6)	89.3 (24.8)	0.1 (− 1.12, 1.31)	0.8868	
HDL					
N	2792	3644			
Mean (SD)	51.0 (12.4)	50.1 (12.5)	0.9* (0.33, 1.56)	0.0026	0.07
Non-HDL					
N	2792	3644			
Mean (SD)	106.4 (27.9)	107.7 (28.5)	− 1.3 (− 2.70, 0.11)	0.0705	
Log-TG					
N	2791	3644			
Mean (SD)	4.35 (0.5)	4.43 (0.5)	− 0.08* (0.33, 1.56)	< 0.0001	− 0.16

CVD cardiovascular disease, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *TC* total cholesterol, *LDL* low-density lipoprotein cholesterol, *HDL* high-density lipoprotein, *non-HDL* non-high-density lipoprotein cholesterol, *TG* triglycerides

*Statistically significant test result ($P \le 0.05$)

Table 3

Results of the multiple regression analysis for the association between reported history of breastfeedingdddd and CVD risk factors of Fifth-Grade WV Children born full-term using merged data from the Birth Score Project (1998–2003) and the CARDIAC Project (2010–2013)

Risk factors	Model 1				Model 2				Model 3			
	Unstandardized regression coefficient (95% CI)	P-value	Standardized beta	R^2	Unstandardized regression coefficient (95% CI)	P-value	Standardized beta	Adjusted R^2	Unstandardized regression coefficient (95% CI)	P-value	Standardized beta	Adjusted R^2
SBP	−1.39 (−1.97 to −0.81)	<0.0001	−0.06	0.0033	−0.77 (−1.32 to −0.23)	0.0052	−0.032	0.1188	−0.43 (−0.98 to 0.13)	0.1349	−0.02	0.1311
DBP	−0.79 (−1.26 to −0.33)	0.0009	−0.04	0.0017	−0.44 (−0.89 to 0.02)	0.06	−0.022	0.0633				
TC	−0.34 (−1.71 to 1.04)	0.6285	−0.006	0.000	−0.001 (−1.37 to 1.37)	0.999	−0.00001	0.0069				
LDL	0.09 (−1.13 to 1.31)	0.8868	0.002	0.000	0.62 (−0.59 to 1.83)	0.3164	0.012	0.0231				
HDL	0.95 (0.33 to 1.56)	0.0026	0.04	0.001	0.28 (−0.29 to 0.86)	0.335	0.011	0.1378				
Non-HDL	−1.29 (−2.68 to 0.11)	0.0705	−0.02	0.0005	−0.28 (−1.64 to 1.07)	0.6824	−0.005	0.0611				
Log TG	−0.08 (−0.1 to −0.05)	<0.0001	−0.07	0.005 3	−0.05 (−0.07 to −0.03)	<0.0001	−0.048	0.1302	−0.04 (−0.06 to −0.01)	0.008	−0.03	0.1499

Variables included in the model: Model 1: All the outcomes were regressed on breastfed variable (yes vs. no). Model 2: All the outcomes were regressed on breastfed variable and the child's BMI percentile in fifth grade. Model 3: All the outcomes were regressed on breastfed variable and the child's BMI percentile and additional covariates. Only covariates that were significant in the Spearman's correlation were used in the multiple regression analysis. Covariates included child's age, gender, race, infant birth weight in grams, maternal education status at birth (1–17 years of education), maternal health insurance status at time of delivery (non-Medicaid vs. Medicaid), family history of hypercholesterolemia (yes vs. no), number of previous pregnancies assessed at birth (≥ 1 vs. 0), maternal smoking status during pregnancy (yes vs. no), weight gain during pregnancy in lbs. Covariates that were not significant in the Spearman's correlation and were excluded: maternal age at birth of the index child, infant birth weight in grams, marital status of the mother at birth, number of prenatal care visits. Each non-significant covariate was deleted from the regression model one at a time. Variables retained in model for SBP: child's age, maternal education at birth. For TG: Child's age, sex, race, maternal education at birth, number of previous pregnancies, and family history of cholesterol

CVD cardiovascular disease, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *TC* total cholesterol, *LDL* low-density lipoprotein cholesterol, *HDL* high-density lipoprotein, *non-HDL* non-high-density lipoprotein cholesterol, *TG* triglycerides

Table 4

Results of the multiple regression analysis for all the variables in the model to predict triglyceride of fifth-grade WV children born full term using merged data from the Birth Score Project (1998–2003) and the CARDIAC Project (2010–2013)

	Full model					Covariate model				
	Unstandardized regression coefficients (95% CI)	Standardized Beta	t Value	P-value	Adjusted R^2	Unstandardized regression coefficients (95% CI)	Standardized beta	t Value	P-value	Adjusted R^2
Intercept	3.31 (2.97 to 3.64)	0.00	19.3	<0.0001	0.1499	3.17 (2.89–3.44)	0	22.56	<0.0001	0.1486
Age (years)	0.06 (0.04 to 0.09)	0.06	4.4	<0.0001		0.072 (0.05 to 0.10)	0.06	6.08	<0.0001	
Gender (male vs. female)	−0.11 (−0.14 to−0.08)	−0.10	−8.24	<0.0001		−0.11 (−0.13 to−0.09)	−0.11	−10.48	<0.0001	
Race (White vs. others)	0.14(0.09 to 0.19)	0.07	5.3	<0.0001		0.12(0.08 to 0.17)	0.06	5.58	<0.0001	
History of hypercholesterolemia	0.07 (0.04 to 0.10)	0.06	5.04	<0.0001		0.07 (0.05 to 0.10)	0.06	6.16	<0.0001	
Number of previous pregnancies (≥ 1 vs. 0)	−0.04 (−0.07 to−0.02)	−0.04	−3.12	0.0018		−0.03 (−0.06 to−0.01)	−0.03	−3.01	0.0026	
Maternal education (Years)	−0.010 (−0.017 to −0.004)	−0.04	−3.16	0.0016		−0.008 (−0.014 to −0.004)	−0.04	−3.43	0.0006	
BMI percentile	0.0065 (0.006–0.007)	0.35	27.45	<0.0001		0.0065 (0.006–0.007)	0.35	33.72	<0.0001	
Breastfed (yes vs. no)	−0.04 (−0.06 to−0.01)	−0.03	−2.65	0.008						

Only covariates that were significant in the Spearman's correlation were used in the multiple regression analysis. Covariates included child's age, gender, race, infant birth weight in grams, maternal education status at birth (1–17 years of education), maternal health insurance status at time of delivery (non-Medicaid vs. Medicaid), family history of hypercholesterolemia (yes vs. no), number of previous pregnancies assessed at birth (≥ 1 vs. 0), maternal smoking status during pregnancy (yes vs. no), weight gain during pregnancy in lbs. Covariates that were not significant in the Spearman's correlation and were excluded: maternal age at birth of the index child, infant birth weight in grams, marital status of the mother at birth, number of prenatal care visits. Each non-significant covariate was deleted from the regression model one at a time. These included infant birth weight in grams, family history of hypercholesterolemia (yes vs. no), number of previous pregnancies assessed at birth (≥ 1 vs. 0), maternal smoking status during pregnancy (yes vs. no), weight gain during pregnancy in lbs

WV West Virginia, *CI* confidence interval, *CVD* cardiovascular disease, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *TC* total cholesterol, *LDL* low-density lipoprotein cholesterol, *HDL* high-density lipoprotein, *non-HDL* non-high-density lipoprotein cholesterol, *TG* triglycerides