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BREASTFEEDING AND MATERNAL ALCOHOL USE: PREVALENCE AND EFFECTS ON CHILD OUTCOMES AND FETAL ALCOHOL SPECTRUM DISORDERS

Philip A. May, Ph.D.[1,2,3], **Julie M. Hasken, M.P.H.**[1], **Jason Blankenship, Ph.D.**[2], **Anna-Susan Marais, BCur.**[3], **Belinda Joubert, B. SocC S.W.**[3], **Marise Cloete, M.S.W.**[3], **Marlene M. de Vries, M.S.W.**[3], **Ronel Barnard, B SocC**[3], **Isobel Botha, M.A.**[3], **Sumien Roux, B.S.W.**[3], **Cate Doms, M Diac**[3], **J. Phillip Gossage, Ph.D.**[2], **Wendy O. Kalberg, M.A., L.E.D.**[2], **David Buckley, M.A.**[2], **Luther K. Robinson, M.D.**[4], **Colleen M. Adnams, M.D.**[5], **Melanie A. Manning, M.D.**[6], **Charles D.H. Parry, Ph.D.**[3,7], **H. Eugene Hoyme, M.D.**[8], **Barbara Tabachnick, Ph.D.**[9], and **Soraya Seedat, M.D., Ph.D.**[3]

[1]The University of North Carolina at Chapel Hill, Nutrition Research Institute

[2]The University of New Mexico, Center on Alcoholism, Substance Abuse and Addictions

[3]Stellenbosch University, Faculty of Medicine and Health Sciences

[4]State University of New York, Buffalo, Department of Pediatrics

[5]University of Cape Town, Department of Psychiatry and Mental Health

[6]Stanford University School of Medicine, Departments of Pathology and Pediatrics

[7]Medical Research Council of South Africa, Alcohol, Tobacco & Other Drug Research Unit

Corresponding Author: Philip A. May, Ph.D., Research Professor, Department of Nutrition, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Nutrition Research Institute, 500 Laureate Way, Kannapolis, NC 28081. Phone: 704-250-2002. Fax: 704-250-5001. philip_may@unc.edu.

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Author Contributions

Philip May was the principle investigator of the NIH grant that funded this research and he, with assistance from Julie Hasken on final data analysis and table preparation, was the major writer and final editor of all drafts. Anna-Susan Marais was the program manager who supervised all data and protocols in the main office at the Faculty of Medicine and Health Sciences of Stellenbosch University. Belina Joubert, Marise Cloete, Isobel Botha, Suimen Roux, Ronel Barnard, and Cate Doms interviewed all of the mothers in this study regarding multiple risks for FASD, including breastfeeding and alcohol use. Marlene de Vries oversaw most of the final data compilation in the field program offices, including contributing greatly to final data quality and manuscript preparations. Jan Gossage, Wendy Kalberg, and David Buckley supervised data entry, files, and data sets in the United States. Colleen Adnams and Wendy Kalberg designed and oversaw the cognitive testing and behavioral checklist data collection in the field and the analysis of results for diagnosis and manuscript preparation. Eugene Hoyme, Luther Robinson, and Melanie Manning provided physical exams and generated all dysmorphology data for the team in the field and made final diagnoses of the children in multidisciplinary case conferences. Soraya Seedat and Charles Parry are the South African co-investigators who participated in the design and facilitated all study activities in South Africa both in the field and at Stellenbosch University. Barbara Tabachnick performed the advanced statistical analyses for this manuscript and worked closely with Jason Blankenship on creating the special breastfeeding data set. Jason Blankenship suffered an untimely death in October, 2013 right after completing the first analysis of these data. Each author contributed to, read, edited, and approved various drafts of the manuscript.

[8]Sanford Research, University of South Dakota Sanford School of Medicine, Department of Pediatrics

[9]California State University, Northridge

Abstract

Objective—Determine any effects that maternal alcohol consumption during the breastfeeding period has on child outcomes.

Methods—Population-based samples of children with fetal alcohol spectrum disorders (FASD), normally-developing children, and their mothers were analyzed for differences in child outcomes.

Results—Ninety percent (90%) of mothers breastfed for an average of 19.9 months. Of mothers who drank postpartum and breastfed (MDPB), 47% breastfed for 12 months or more. In case control analyses, children of MDPB were significantly lighter, had lower verbal IQ scores, and more anomalies in comparisons controlling for prenatal alcohol exposure and final FASD diagnosis. Utilizing a stepwise logistic regression model adjusting for nine confounders of prenatal drinking and other maternal risks, MDPB were 6.4 times more likely to have a child with FASD than breastfeeding mothers who abstained from alcohol while breastfeeding.

Conclusions—Alcohol use during the period of breastfeeding was found to significantly compromise a child's development.

Keywords

breastfeeding; alcohol; fetal alcohol spectrum disorders (FASD); pregnancy; child health and development

1. INTRODUCTION

1.1 Breastfeeding, Child Health, and Development

Breastfeeding is the safest and best method for providing optimal infant growth and development and protection from many diseases [1]. Internationally, professionals recommend exclusive breastfeeding until a child reaches six months of age with continued breastfeeding and complimentary foods until two years [2]. Breastfeeding during the early postpartum period varies widely by country [3] and is practiced by 43% of women internationally. Forty percent (40%) of infants six months or less are exclusively breastfed [1]. Breastfeeding is linked to improved infant survival rates, lower mortality, better growth, development, and cognitive and neurological outcomes [4–6]. For centuries extended breastfeeding has been considered the foundation of child health, immunity, growth, and development. While there is uniform support for the general health benefits of breastfeeding [1], in this study we examine a possible exception to the above rule. When alcohol is consumed by the mother during the period of breastfeeding, is child development compromised?

Exclusive breastfeeding for the first six months of pregnancy is promoted as the best option, but oftentimes supplementation with solid foods occurs early in infancy. In South Africa (ZA) solid food supplementation has been reported to occur frequently, but the foods

provided are often low in energy and micronutrients [7]. Furthermore, many mothers have significantly inadequate dietary intake and are often malnourished themselves which may compromise development [8,9]. Some studies in low socioeconomic status (SES) communities of ZA have found that a high percentage of infants (90% or more whose mothers initiated breastfeeding) are deficient in vitamin A and iron and are suffering from anemia even though their diets were often supplemented by solid foods at 3.6 months [10]. For low SES ZA children ages 2 – 5 years, nutrient deficiencies have been found which may reflect poor quality diets high in carbohydrates, low in animal protein [11] and are linked to poor child development [12,13]. Furthermore, mothers in one of the five predominantly lower SES communities studied here have significantly inadequate dietary intake, and are poorly nourished on virtually all vital nutrients [8,9]. Therefore low SES and insufficient maternal and child nutrition may exacerbate any effects that alcohol introduced via breastmilk may have on the development of infants and young children.

1.2 Maternal Alcohol Consumption in the Prenatal Period

Moderate to heavy maternal alcohol consumption during the prenatal period adversely affects the health and development of a fetus and can result in a range of physical, cognitive, and behavioral problems known as fetal alcohol spectrum disorders (FASD). Proximal maternal risk factors such as the quantity, frequency, and timing of alcohol consumption (during gestation) affect the structure and severity of FASD traits [14,15]. Distal risk factors such as advanced maternal age, high gravidity, a low body mass index (BMI), low SES conditions, and individual maternal metabolic differences can further restrict growth, delay development, and increase the severity of FASD overall in alcohol-exposed fetuses [14,16–20].

1.3 Maternal Alcohol Use in the Postpartum Period

Upon pregnancy recognition many women reduce alcohol consumption or abstain; however, once the child is born, many women return to pre-pregnancy levels of alcohol consumption [21–23]. Few studies report the prevalence of maternal alcohol consumption while breastfeeding. Binge drinking of more than 5 drinks per occasion was reported by 29% of Norwegian mothers 6 months postpartum despite few women reporting alcohol consumption during pregnancy [24]. Among mothers in the United States (US), 36% of mothers who breastfed reported consuming alcohol [25]. Forty-seven percent (47%) of breastfeeding Australian mothers [26], and 20% of Canadian mothers reported alcohol consumption while breastfeeding [27]. In the Netherlands, 22% to 19% reported consuming alcohol during the breastfeeding period [21]. Therefore, alcohol use during the breastfeeding period may have international implications.

1.4 Alcohol Delivered via Breastmilk: Difficult to Measure But a Limited Effect?

The belief that alcohol consumption during breastfeeding has a deleterious effect on child development has been long held, but empirical evidence is not abundant [28]. Mechanistic studies have shown that low doses of alcohol are delivered to the infant via breastmilk (between 0.5% and 3.3% of the mother's dose, or a mean of 1.7 + 0.3 %), and that infants have a limited capacity to oxidize alcohol [29]. And soon after maternal drinking, the mother's milk smelled (and tasted) of alcohol and infants reduced their intake of milk [29].

Another study concluded that: potential infant alcohol doses were low (3.0 – 58.8 mg (mean 13.4 mg)); predicted time required for milk to return to zero alcohol content was 175 minutes after drinking; health risks to the infant from a single dose were low; but nursing activity should be postponed for three hours after the maternal alcohol use of a dose equal to one standard drink [30]. Academy of Breastfeeding Medicine guidelines also recommend a two hour wait before resuming nursing, but state that "possible long-term effects of alcohol in maternal milk remain unknown" [31]. Therefore, frequent drinking, and heavy, binge drinking over time during the breastfeeding period appear to present a risk to the development of an infant and toddler, for alcohol is a potent teratogen and may also negatively affect development postpartum.

One study compared development in infants exposed to alcohol in the breastmilk after controlling for alcohol exposure during gestation [32]. No effect was found in performance on the Bayley Mental Development Index, but motor control measured by the Psychomotor Development Index was significantly lower in infants exposed to alcohol via breastmilk. After controlling for multiple confounders, the authors concluded that "alcohol ingested through breastmilk has a slight but significant detrimental effect on motor development, but not mental development, in breast-fed infants." [32] In another study the authors of the above study were unable to replicate these findings with Griffiths Scale intelligence test in 18 month-old toddlers. They concluded: that the dose of alcohol delivered to the toddler is small, and tests of very young children have a limited ability to detect small effects [33]. Therefore, most inquiries into the effect of alcohol delivered to infants and toddlers via breastmilk have concluded that the amounts transmitted to the child are relatively small, especially when compared to the higher concentrations of alcohol delivered to the fetus in the prenatal period. And the effects on the child may be rather inconsequential for cognitive/behavioral development if drinking is only occasional. But these previous studies have had rather small samples and the outcome variables utilized were not as comprehensive as are the many physical and neurobehavioral traits that comprise a diagnosis on the continuum of FASD. Nor were the tests used with infants and toddlers sensitive enough or administered to children old enough for measuring significant outcomes. Physical or neurobehavioral effects may not be manifest and measureable until the later years.

1.5 Purpose of This Study

This study utilized a large epidemiologic data set on FASD in six to eight year olds to examine the prevalence and duration of alcohol exposure to infants and toddlers via breastfeeding. Furthermore, we sought to objectively measure any effects on child development, independent of alcohol exposure during the prenatal period, that consuming alcohol during the period of breastfeeding might have on physical and neurobehavioral outcomes in first grade children. In the study communities women have proven to be very candid in reporting their alcohol use, and heavy binge drinking is common and practiced regularly each weekend among large subsets of the population, even among many pregnant women [15]. Furthermore, FASD are more prevalent in these communities than in any other general population in the world [34,35]. Therefore we sought to determine if alcohol delivered to developing children via breastfeeding has any measureable independent effect on development.

2. METHODS

2.1 Sample and Diagnosis

The data for this exploration originate from four population-based, active-case ascertainment studies of FASD among first grade students and their mothers in five communities in the Western Cape Province (WCP) of South Africa (ZA) [34,36,37]. Children were screened for growth deficiency via height, weight, and occipitofrontal (head) circumference (OFC). Those children who were ≤ 25th centile on standard ZA growth charts and children who were randomly selected as control candidates received identical, standardized dysmorphology exams, cognitive/behavioral testing, and a final IOM diagnosis [38] on the continuum of FASD or of development within the normal range for these communities. The full active-case ascertainment process for these samples is described elsewhere [34,36,37]. But to summarize, data collection for each child included all domains and variables required for a specific diagnosis within FASD: fetal alcohol syndrome (FAS), partial FAS (PFAS), alcohol-related neurodevelopmental disorders (ARND), and alcohol-related birth defects (ARBD) [38]. The required domains are: 1) child physical growth, facial, and other dysmorphology, 2) cognitive and behavioral testing/assessment, and 3) maternal risk factors. Mothers of each child in the study (cases and controls) were administered a retrospective maternal risk assessment via face-to-face interview. Included in this interview were data on: demographics, physical health/status, childbearing history, timeline-follow-back details of the index pregnancy including quantity, frequency, and timing of alcohol use, dietary intake, breastfeeding, and family information. Final child diagnoses were made by pediatric medical geneticists utilizing revised IOM diagnostic guidelines in a formal, multi-disciplinary case conference which evaluated the empirical findings from each of the above domains [38,39]. In this study, a number of child outcomes are reported, but the major outcome variable is child diagnosis with a FASD or not in the first grade. The diagnosis of a FASD or not is a comprehensive measure of child physical and neurobehavioral development.

2.2 Basic Statistical Analysis

Data were analyzed using Epi-Info [40] and SPSS [41]. In case control comparisons, chi-square tests were calculated on frequencies for dichotomous data. T-tests and one-way analysis of variance (ANOVA) were used on continuous data. A range of possible maternal risk factors from this sample was explored, and criterion α levels were in most comparisons adjusted for multiple comparisons using Bonferroni adjustment. Post-hoc Dunnett's Correction (C) analyses of significant pairwise differences (α =.05) were used to control for error produced when performing multiple comparisons of group means, but no differences were found in the data reported here [42].

2.3 Advanced Analysis: Data Screening and Processing

The data were combined to produce a data set for a sequential logistic regression evaluating the main effects of whether the woman drank during breastfeeding, the duration of breastfeeding (1–11 months vs. 12 or more months), and their interaction, after adjusting for various maternal characteristics. But overall, the breastfeeding variable is examined as a categorical variable, for we were not able to determine how much supplementation with solid food occurred and the exact duration of supplementation. The logistic regression

evaluated effects on the child's diagnosis in a categorical manner: FASD or not. Transformations were undertaken to meet the statistical assumptions underlying missing data imputation.

Three of the variables measuring drinking quantity were trichotomized to reduce unacceptable skewness and kurtosis associated with lower levels of drinking and abstinence for the group of mothers whose children were not diagnosed with FASD. Average quantity of drinks per day during pregnancy was coded as 0 = "no drinks", 1 = "fewer than 3 drinks", 2 = "3 or more drinks". Average quantity of drinks per week during pregnancy was coded as 0 = "no drinks", 1 = "fewer than 7 drinks", 2 = "7 or more drinks". The variable representing number of days per month that a woman drank her usual amount of alcohol during pregnancy was coded as follows: 0 = "no drinks", 1 = "fewer than 8 days", 2 = "8 or more days" These ordinal variables were then treated as if continuous [42] in subsequent analyses, as were dichotomous variables (urban vs. rural residence, whether mother drank 3 or more drinks per occasion, and 5 or more drinks per occasion).

Varying amounts of data were missing on the measures, from no missing data for several variables to about 17% of cases missing values for the number of days per month during pregnancy that the mother drank her usual amount of alcohol. Logarithmic, inverse, and square root transformations were applied to several of the variables to comply with the multiple imputation process within SPSS MI [41]. The software created five complete (imputed) data sets, each with $N = 926$ women who breastfed the index child: 416 diagnosed with a FASD and 510 with no FASD diagnosis. Once transformations were applied, outlying cases were not extreme and varied over imputations and groups, so that no case deletion was deemed necessary.

3. RESULTS

3.1 Prevalence and Duration of Breastfeeding and Alcohol-Exposure

In Table 1, 90.4% of all mothers participating in the four samples (n=1047) breastfed for an average of 19.9 months. There was no statistical difference across diagnostic groups in the percentage who breastfed or the average duration. Of the 71% of mothers who consumed alcohol while breastfeeding, there was a significant difference among the diagnostic groups with mothers of children with FAS most likely to drink during the period of breastfeeding.

Table 2 cross-tabulated maternal groups by child diagnosis. There was a significant relationship between alcohol consumption during at least 12 months of breastfeeding and child diagnosis, χ^2 (2,N=1040) = 6.54, p = .011). Mothers of children with FASD were most likely to consume alcohol during breastfeeding (50%) and mothers who did not drink during pregnancy (unexposed controls) were least likely to consume alcohol postpartum. Nevertheless, even 42% of mothers who did not drink prenatally, did drink for 12 months or more postpartum while breastfeeding. Drinking during breastfeeding roughly followed the pattern of drinking during pregnancy.

Table 3 presents breastfeeding variation by key childbearing and demographic characteristics. Breastfeeding in general was practiced in similar proportions across

demographic strata and childbearing practices, for only residential location was significantly different. Those who drank alcohol postpartum and breastfed (MDPB) for 12 months or more during the breastfeeding period had significantly higher gravidity, suffered more stillbirths, had lower educational achievement, lower BMI, and were more likely to live in rural areas. There was no significant difference in duration of breastfeeding between mothers who consumed alcohol during the period of breastfeeding and those who did not. In general, MDPB were more likely to be lower SES, lower BMI, and had longer, more eventful childbearing experiences.

3.2 Prenatal Drinking by Mothers

Prenatal alcohol use patterns of MDPB were compared for mothers of children with a FASD diagnosis and the mothers of normal children (Table in supplemental information). Mothers of children with FASD were significantly more likely than mothers of normal controls ($p<.001$) to drink postpartum (see also Table 2) and to drink more during pregnancy when measured by: average drinks per drinking day, drinks per week, drinking days per month, and to have reported binges of 3 or more or 5 or more standard drinks per occasion (see table in online supplemental material). This exact pattern held in comparisons for both all women who breastfed and also for those who breastfed more than 12 months.

3.3 Simple Assessment of Selected Child Outcomes via Case Control Comparisons

Measures of specific child outcomes from MDPB are presented in Table 4. To control generally for prenatal exposure, separate comparisons were made for prenatally-unexposed normal controls and children with FASD (heavy exposure). Children with FASD (right columns) that were also exposed to alcohol via breastmilk for 12 months or more, had significantly higher average dysmorphology scores ($\alpha = .05$), which indicates the presence of more minor anomalies associated with poorer physical development of the specific features often associated with FAS. They also had lower average verbal IQ and smaller heads, but these differences only approached statistical significance. In the left hand columns of Table 4, normal control children unexposed to alcohol in the prenatal period, but exposed via breastmilk for 12 months, had significantly lower weight and verbal IQ with Bonferroni-adjusted alpha (.01). Total dysmorphology score and palpebral fissure length (often considered an indicator of poor brain growth and development) approached statistical significance. Therefore, in simple t-test comparisons, where prenatal alcohol exposure is controlled via FASD diagnosis and prenatally unexposed normal children, the effect of maternal alcohol use in the postpartum period while breastfeeding is most demonstrated in the not-FASD group.

Because the verbal IQ test measure was significantly lower in one of the breastfeeding comparisons and approached significance in the other comparison, partial correlations controlling for mother's education and household income (SES measures) were performed on the entire sample. The children of mothers who drank alcohol and breastfed 9 months or more had significantly lower verbal IQ scores (partial $r = -.098$, $p=.006$).

3.4 Sequential Logistic Regression

Logistic regression was pursued next for increased statistical control of maternal covariates. Mothers were divided into two groups: those whose children were diagnosed with FASD and those whose children were not. Sequential logistic regression was used to determine, first, which covariates predicted the diagnostic group (FASD) and then, second, which indicators of breastfeeding during pregnancy predicted diagnosis. Covariates were entered at step 1 of the analysis: measures of maternal physical characteristics (logarithm of BMI), demographics (square root of education, rural vs. urban residence), pregnancy (logarithm of gravidity) and drinking (three or more drinks per occasion during pregnancy, five or more drinks per occasion during pregnancy, average number of days drinking usual amount during pregnancy, average number of drinks per week during pregnancy, and average number of drinks per day during pregnancy). Three predictors of interest were entered at the second step: whether the mother drank alcohol during breastfeeding, short vs. long duration of breastfeeding, and the interaction between drinking alcohol and duration.

The covariates by themselves strongly predicted diagnosis, $\chi^2(9, N = 926)$ ranging from 418.95 to 459.16, $p < .001$, Nagelkerke R^2 ranging from .48 to .52. Addition of the three breastfeeding predictors significantly increased prediction of FASD in four of the five imputations, with χf children who were $\chi^2(3, N = 926)$ ranging from 7.33, $p = .062$ to 13.26, $p = .004$. Nagelkerke R^2 increased only slightly, ranging from .50 to .53.

Table 5 presents the results of the final logistic regression analysis including all covariates and predictors, pooled over the five imputations. Four covariates (mother's education, mother's BMI, three or more drinks per occasion during pregnancy, and number of days drinking a usual amount during pregnancy) were significant independent predictors of a FASD diagnosis when entering the analysis. Higher maternal education was protective, the frequency of drinking per month was a risk factor, and these were the strongest covariates in terms of odds ratios. These were followed in strength by mother's BMI (protective) and reporting a binge of three or more drinks (risk). Among the three predictors, only drinking alcohol during breastfeeding significantly added to prediction of a FASD diagnosis ($B = 1.86$, SE = 0.73, $p = .011$). MDPB were about 6.4 times more likely to have children with FASD than mothers who did not drink during the breastfeeding period (OR = 6.44, 95% CI = 1.5 to 26.9), after adjusting for maternal physical characteristics, demographics, pregnancy variables, and drinking behavior during pregnancy. Within this sample, and utilizing this logistic regression model where variance in duration of breastfeeding does not vary greatly, duration of breastfeeding did not reach statistical significance, nor did the interaction between alcohol consumption during breastfeeding and duration of breastfeeding.

Statistically significant covariates, adjusted for each other and for the predictors, included mothers' education, BMI, bingeing on three or more drinks per occasion, and number of days during breastfeeding that she drank her usual amount of alcohol. Table 6 shows classification results for the five imputations. About 80% of cases were correctly classified as FASD or not on the basis of all covariates and predictors. Classification rate was approximately equal for both FASD and non-FASD cases.

4. DISCUSSION

We sought to explore two questions with these analyses: 1.) how prevalent is the practice of drinking alcohol during the period of breastfeeding in these ZA populations, and 2.) is there any effect on child development from alcohol delivered via breastmilk? Different analytic techniques yielded information which all pointed in the same direction. Even though previous studies have indicated that the amounts of alcohol delivered are relatively small, mothers who breastfed and consumed alcohol have children who by age seven were more likely to have negative indicators on key physical and neurobehavioral outcomes as measured individually and jointly by the diagnostic criteria for FASD.

Ninety percent of the women in these communities breastfed their children for an average duration of 19.9 months. Drinking during both pregnancy (40 – 45%) [14,15] and the postpartum period is commonly practiced by a substantial proportion of the mothers (71%) in these communities. Drinking alcohol during the breastfeeding period was significantly more common among mothers who drank prenatally with these same children, for even 42% of the mothers who were abstinent during pregnancy reported drinking during the postpartum period. MDPB were: higher gravidity, had lower education levels, lower BMI, and lived in generally lower SES rural areas. MDPB reported higher mean values for both specific quantity and frequency measures of drinking and also binge drinking during pregnancy. These alcohol use patterns do not differ when examined in both those who breastfed the longest (>12 months) and those who breastfed with alcohol.

Case control comparisons, where maternal risk and protective confounders were controlled by FASD diagnosis and in another group by reports of no prenatal alcohol use, indicated that at least two significant differences were found in MDPB children in the normal control group: MDPB children had significantly lower weight at seven years than those receiving no alcohol in the breastmilk and verbal IQ was lower on average. Among the children diagnosed as FASD, children of MDPB had significantly higher total dysmorphology scores (more minor anomalies overall) than children from other mothers. Each of these represents a key comparative indicator of depressed growth from prenatal alcohol consumption in these ZA populations [34,36,37,39,45–48]. It appears that drinking during the breastfeeding period also negatively affected the growth and development of these traits.

The logistic regression analysis was the most comprehensive, statistically controlled assessment of the effect of maternal alcohol use during breastfeeding on child outcomes. These analyses indicated a significant detrimental impact on overall status or multiple child physical and neurobehavioral traits. Controlling for nine empirically proven variables of prenatal risk (including five prenatal drinking measures), alcohol use during the period of breastfeeding was associated with a six fold (OR =6.4, 95% CI =1.5 to 26.9) increase in the likelihood of a diagnosis of FASD. In other words, alcohol delivered through breastmilk is associated with a greater likelihood of a diagnosis on the FASD continuum, and therefore more severe growth delay, more physical anomalies, and poorer cognitive and behavioral development. The less robust case control analyses trended or pointed in this direction with a number of specific traits: weight, verbal IQ, and total anomalies. Therefore, delivery of alcohol to infants and toddlers via breastmilk appears to be harmful in other ways for

development (e.g., depressed head circumference and poor brain development) which result in a greater likelihood of a diagnosis on the continuum of FASD.

These results reinforce the idea that exposure to alcohol via breastmilk may independently depress physical growth and neurobehavioral development in early life whether prenatal exposure has occurred or not. In ZA the severity of damage exhibited at seven years of age has resulted in very high rates of FAS, much higher than are found in other populations where PFAS and ARND are the vast majority of the cases diagnosed [46–48]. Therefore, these results lead one to conclude that a high prevalence of MDPB is a significant proximal influence on growth and development. Maternal drinking in the breastfeeding period, as measured by the likelihood of association with the physical anomalies and cognitive/behavioral deficits required for one of the specific diagnoses within FASD, is significantly associated with exposure to alcohol in breastmilk even when other proximal and distal risk factors are controlled. Exposure to alcohol via breastmilk was independently associated with depressed child development overall in populations characterized by frequent and regular binge drinking. The exact duration of exposure that is critical is not clear from this sample or these analytic methods.

4.1 Strengths of the Study

1.) From this sample of children in ZA who were alcohol-exposed and unexposed in various combinations in both the prenatal and postpartum periods, we were able to detect a general overall impact of alcohol delivered to the child via the breastmilk via FASD diagnosis while controlling for proven confounders [17,18]. 2.) Furthermore the study was carried out in a population of women well known for candid and generally accurate reporting of alcohol use, even for sensitive childbearing and child rearing periods [15]. 3.) In this study population high rates of breastfeeding and alcohol use during the breastfeeding period were demonstrated, and there is much previous documentation of similarly high rates of regular and frequent binge drinking among women in these communities [14,34,49]. Problematic prenatal drinking practices were also confirmed to be associated with those who breastfeed their children postpartum, even among those reporting no prenatal exposure to alcohol with these children. 4.) Specific features and comprehensive diagnostic data from dysmorphology exams, cognitive and behavioral testing, and extensive maternal interviews were used to explore a number of possible outcomes from consuming alcohol during the period of breastfeeding. 5.) And in the final regression analysis of the overall effect on diagnoses, a number of proven, significant confounding variables in these populations were controlled, most particularly the mother’s physical status (BMI), SES, and prenatal drinking levels.

4.2 Limitations

The study also had limitations. 1) The low SES conditions (e.g. poor nutrition) and culture in these communities are: quite basic, somewhat unique to these particular ZA community populations, may independently impact growth and development, and therefore exacerbate the effects we have ascribed to postpartum alcohol exposure via breastmilk. 2) Therefore, these findings may not apply directly to other populations, particularly to higher SES, better nourished, more highly-stimulated and advantaged populations. 3) The data were collected retrospectively for a comprehensive epidemiologic study of FASD, so in spite of the finely-

tuned, time-line-follow-back, data-collection methods, recall bias may exist, even though other research has supported the validity of similar retro-specific approaches [52, 53]. 4) We did not measure exact levels of alcohol in the breastmilk via biological samples at any time during the breastfeeding period. Nor do we have specific reports from the mothers of exactly how much they drank in the immediate breastfeeding period: only before, during, and seven years after the pregnancy of each index child and their estimations back to the breastfeeding period which was reported to be similar to 'current' drinking by over 80% of the respondents. 5.) Similarly, we did not measure average micronutrient content in the milk or collect information on supplementation with solid foods. It could be that child dietary intake overall was inadequate or that nutrigenetic or epigenetic factors limited transmission of some essential nutrients to the child. 6.) While we did control for some maternal physical and SES variables that might have differentially affected the physical outcomes of the children, we were not able to directly control for the intelligence (IQ) and parenting skills of the mothers which may have differentially affected development [5,50,51].

5. CONCLUSION

These findings reinforce the recommendations of public health agencies [2,31] call for further investigation into any possible effect that alcohol in breastmilk may have on child growth and development. Alcohol exposure via breastmilk in these samples are definitely associated with multiple, negative developmental traits in children by age 7 that lead to a diagnosis of FASD and to the FAS phenotype in general. They also support a conservative conclusion that women who breastfeed their children should avoid drinking alcohol during the breastfeeding period, especially in large amounts over short periods of time (binge drinking), and especially if the child was already exposed to alcohol in the prenatal period. Even though the amounts of alcohol that have been found to pass from mother to baby are proportionally low, and the effects/specific outcomes in young children are difficult to measure in a study like this one, alcohol in the breastmilk has been found to be a significant enough factor to limit or otherwise further delay a child's physical growth and neurodevelopment.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Research Highlights

- 90% of mothers breastfed for an average of 19.9 months.
- 71% of mothers who breastfed used alcohol simultaneously.
- 42 to 48% of mothers of normal controls drank and breastfed.
- Maternal drinking while breastfeeding limits physical and neurobehavioral outcomes.
- Alcohol use during the breastfeeding period is not recommended.

Table 1

Breastfeeding prevalence, duration, and alcohol consumption while breastfeeding by FASD diagnosis of offspring

	All Mothers[1] N=1047	Diagnostic Group of Offspring N = 1047					
		FAS	PFAS	ARND	Prenatally Exposed R-S Controls	Prenatally Unexposed R-S Controls	*p*
Mothers who Breastfed (% Yes)	90.4	92.3	90.9	89.3	89.5	89.3	.731[a]
Average Duration Breastfeeding Mean in months (SD)	19.9 (20.0)	20.6 (21.4)	22.9 (19.5)	20.3 (20.4)	19.9 (20.1)	18.3 (19.5)	.216[b]
Reported Drinking during the Breastfeeding period (%)	71.0%	91.8	81.7	87.3	85.7	29.4	<.001[a]

[a] χ^2 test statistic;

[b] ANOVA (*F*) test statistic

[1] All mothers column was excluded from significance test. The percentages in each category of Table 1 are calculated with the denominator indicated in that category. Variance in the data available across the categories for the 3 questions is due to mainly minor questionnaire differences across the 4 samples and also to missing data.

Table 2

Mothers Who Breastfed for at Least 12 Months Who Did and Did Not Consume Alcohol During Breastfeeding for Three Diagnostic Categories of Children

		Breastfed for at least 12 months with alcohol	
Maternal groups by Child Diagnosis		**No**	**Yes**
FASD	Count (%)	245 (49.6%)	249 (50.4%)
Exposed Controls	Count (%)	76 (52.4%)	69 (47.6%)
Unexposed Controls	Count (%)	222 (58.3%)	159 (41.7%)
Total	Count (%)	543 (53.2%)	477 (46.8%)

χ^2 (2, N=1040) = 6.54, p=.011

Table 3

Maternal demographic characteristics and alcohol consumption of those who breastfeed and those who reported alcohol use while breastfeeding

	Breastfed index child				Reported alcohol consumption in the breastfeeding period			
	Yes (n=943)	**No (n=101)**	**χ^2**	***p***	**Yes (n=530)**	**No (n=216)**	**χ^2**	***p***
Maternal Age (%)								
< 25 years	40.3	40.6	.005	.945	38.6	44.1	2.565	.109
≤ 25 years	59.7	59.4			61.4	55.9		
Gravidity (%)								
≤ 2	34.7	41.6	1.905	.168	32.1	39.5	5.103	.024
>3	65.3	58.4			67.9	60.5		
Stillbirths (%)								
None	94.1	92.7	.170	.680	61.1	82.1	6.692	.010
≥ 1	5.9	7.3			38.9	17.9		
Education (%)								
< 8 years	50.1	40.4	3.365	.067	55.7	36.4	31.024	<.001
≥ 8 years	49.9	59.6			44.3	63.6		
Body Mass Index – Mean (SD)	24.9 (7.5)	24.9 (10.0)	t = .004[a]	.997	23.6 (6.7)	27.8 (7.9)	t = −6.921[a]	<.001
Location (%)								
Rural	93.1	6.9			77.7	22.9		
Urban (conventional)	87.4	12.6	9.180	.010	63.5	36.5	19.062	<.001
Urban (squatter camp)	93.1	6.9			59.1	40.9		
Duration of breastfeeding (%)								
≤12 months	55.8	--	--	--	55.1	50.5	1.366	.243
> 12 months	44.2	--			44.9	49.5		

[a] t-test rather than χ^2

Table 4

Selected physical and cognitive/behavioral outcomes of children whose mothers who drank postpartum and breastfed (MDPB) by diagnostic category: South African samples II–V

	Duration of breastfeeding greater than 12 months									
	Unexposed Controls with Alcohol in Breastmilk (n=26)		Unexposed Controls without Alcohol in Breastmilk (n=64)			FASD with Alcohol in Breastmilk (n=167)		FASD without Alcohol in Breastmilk (n=31)		
Child Variables	**Mean**	**SD**	**Mean**	**SD**	**p**	**Mean**	**SD**	**Mean**	**SD**	**p**
Weight centile	15.9	(14.7)	26.8	(22.5)	.007	6.8	(9.3)	11.4	(14.9)	.107
OFC centile	22.2	(26.7)	30.0	(25.0)	.185	10.9	(17.2)	16.7	(18.3)	.090
Palpebral fissure length centile	20.2	(14.2)	26.5	(15.8)	.077	9.2	(10.9)	10.9	(11.1)	.434
Total dysmorphology score	9.7	(4.8)	7.7	(4.4)	.053	16.4	(4.1)	14.2	(5.2)	.029
Verbal IQ (TROG) Score	18.2	(13.3)	27.6	(19.8)	.011	8.8	(12.2)	15.9	(16.8)	.059

Bonferroni-corrected alpha = .01

Table 5

Logistic Regression Analysis of FASD Diagnosis as a Function of Mother's Characteristics and Drinking During Pregnancy: Breastfeeding and Duration of Breastfeeding. Pooled over Five Imputations

					95% EXP(B) C.I.for				
Variable	***B***	***S.E.***	**Sig.**	***Odds Ratio***	**Lower**	**Upper**	**Fraction Missing Info.**	**Relative Increase Variance**	**Relative Efficiency**
Covariates									
Gravidity (logarithm)	−.821	.647	.205	.440	.124	1.565	.063	.065	.988
Mother's education (square root)	−.880	.202	<.001	.415	.278	.618	.167	.186	.968
Rural vs. urban	−.152	.195	.437	.859	.586	1.260	.050	.051	.990
Mother's BMI (logarithm)	2.449	.980	.014	11.578	1.658	80.836	.215	.249	.959
Three or more drinks per occasion during pregnancy	.674	.320	.038	1.962	1.038	3.709	.238	.281	.955
Five or more drinks per occasion during pregnancy	.438	.319	.179	1.550	.811	2.965	.372	.509	.931
Average number of drinks/day during pregnancy (trichotomized)	−.406	.324	.227	.666	.336	1.319	.530	.920	.904
Average number of drinks/week during pregnancy (trichotomized)	−.379	.419	.397	.685	.252	1.859	.820	3.405	.859
Number of days per month during pregnancy drank usual amount	−.366	.137	.009	.693	.528	.911	.262	.318	.950
Predictors									
Drank alcohol while breastfeeding	1.863	.729	.011	6.446	1.543	26.924	.025	.025	.995
Short vs. long duration of breastfeeding	.913	.551	.097	2.493	.847	7.338	.004	.004	.999
Interaction	−.781	.426	.066	.458	.199	1.054	.004	.004	.999
Constant	−3.071	2.068	.140	.046	.001	2.781	.193	.219	.963

Table 6

Classification of Children into FASD Status using Covariates and Predictors for Five Imputations[a]

			Predicted		
			Diagnosis		
			Dichotomous		
Imputation Number			FASD	Not FASD	Percentage Correct
1	Diagnosis	FASD	336	80	80.8
		Not FASD	96	414	81.2
	Overall Percentage				81.0
2	Diagnosis	FASD	326	90	78.4
		Not FASD	107	403	79.0
	Overall Percentage				78.7
3	Diagnosis	FASD	326	90	78.4
		Not FASD	100	410	80.4
	Overall Percentage				79.5
4	Diagnosis	FASD	329	87	79.1
		Not FASD	97	413	81.0
	Overall Percentage				80.1
5	Diagnosis	FASD	327	89	78.6
		Not FASD	99	411	80.6
	Overall Percentage				79.7

[a]The cut value is .500