AIDS Behav (2012) 16:2216–2225
DOI 10.1007/s10461-012-0153-x

ORIGINAL PAPER

Postnatal Depression Symptoms are Associated with Increased Diarrhea Among Infants of HIV-Positive Ghanaian Mothers

Harriet E. T. Okronipa · Grace S. Marquis · Anna Lartey · Lucy Brakohiapa · Rafael Perez-Escamilla · Robert E. Mazur

Published online: 14 February 2012

Abstract HIV infection is linked to increased prevalence of depression which may affect maternal caregiving practices and place infants at increased risk of illness. We examined the incidence and days ill with diarrhea among infants of HIV positive (HIV-P), HIV negative (HIV-N), and unknown HIV status (HIV-U) women, and determined if symptoms of maternal postnatal depression (PND) modulated the risk of diarrhea. Pregnant women ($n = 492$) were recruited from three antenatal clinics; mothers and infants were followed for 12 months postpartum. Diarrheal incidence was 0.6 episodes/100 days at risk. More HIV-P than HIV-N and HIV-U women tended to report PND symptoms ($\chi^2 = 4.76$; $P = 0.09$). Reporting symptoms was associated with an increased risk of infantile diarrhea only among HIV-P and HIV-U but not HIV-N women (interaction term, $\chi^2 = 7.84$; $P = 0.02$). Health care providers should be aware of the increased risk of infantile diarrhea when both maternal HIV and PND symptoms are present and take preventive action.

Keywords Infantile diarrhea · HIV · Depression · Postpartum

Resumen La infección VIH se liga a un aumento de la prevalencia de la depresión y puede afectar a las prácticas maternas del cuidado de los niños y colocar a niños pequeños en riesgo de enfermedad. Examinamos la incidencia y los días enfermos con diarrea entre niños de madres quienes eran seropositivas (VIH-P), seronegativas (VIH-N), o con estado del VIH indeterminado (VIH-U). También examinamos si los síntomas de la depresión postnatal materna (DPN) modularon el riesgo de diarrea infantil. Reclutamos a las mujeres embarazadas ($n = 492$) de 3 clínicas; madres y niños fueron seguidos por 12 meses después del parto. La incidencia de diarrea fue de 0.6 episodios/100-d de riesgo. Más mujeres VIH-P que mujeres VIH-N y VIH-U tendieron a reportar los síntomas de DPN ($\chi^2 = 4.76$; $P = 0.09$). Los síntomas de DPN aumentaron el riesgo de diarrea infantil solamente para mujeres VIH-P e VIH-U pero no para las mujeres VIH-N ($\chi^2 = 7.84$; $P = 0.02$). Los trabajadores de salud deben ser conscientes de un aumento en el riesgo de diarrea infantil cuando la infección de VIH y los síntomas de DPN están presentes juntos y deben tomar medidas preventivas.

H. E. T. Okronipa · G. S. Marquis (✉)
School of Dietetics and Human Nutrition, CINE Building Macdonald Campus, McGill University, 21,111 Lakeshore Road, Sainte Anne-de-Bellevue, Montreal, QC H9X 3V9, Canada
e-mail: grace.marquis@mcgill.ca

G. S. Marquis
Department of Food Science and Human Nutrition, Iowa State University, Ames, IA, USA

A. Lartey
Department of Nutrition and Food Science, University of Ghana, Legon, Ghana

L. Brakohiapa
Nutrition Department, Noguchi Memorial Institute for Medical Research, Legon, Ghana

R. Perez-Escamilla
School of Public Health, Yale University, New Haven, CT, USA

R. E. Mazur
Department of Sociology, Iowa State University, Ames, IA, USA

Introduction

Diarrhea remains a leading cause of child morbidity and contributes to 19% of deaths in children under 5 years of

age [1]. A plethora of studies have described the epidemiology as well as risk factors associated with diarrheal morbidity and mortality, including poor infant feeding practices, low maternal education, and poverty. In a multicountry analysis, the absence of breastfeeding was associated with an almost sixfold increase in risk of death during early infancy [2]. Although the effect of no breastfeeding decreased with age, low maternal education more than doubled the infant mortality risk associated with not breastfeeding, presumably in part due to inadequate knowledge and resources to prepare a safe substitute for breast milk. Similar results were reported in a study in urban Accra, Ghana [3]. Diarrheal prevalence among infants and preschool-age Ghanaian children was highest among poor households, those with illiterate mothers as well as among those with inadequate hygiene and water quality. Improving water and sanitation services for households is often the focus of interventions to reduce diarrhea. Cairncross et al. analyzed recent systematic reviews to identify the reduction in diarrheal mortality that could be attributed to specific interventions prioritized for scaling up [4]. The reduction in diarrheal mortality was estimated at 43% with proper hand washing, 36% with adequate excreta disposal, and 17% with improved household water quality.

The HIV/AIDS pandemic has added an additional concern for young child survival as HIV infection may compromise a household's ability to provide adequate child care. Reduced financial resources as well as compromised physical and mental health of caregivers may contribute to poor hygienic environments and suboptimal infant feeding practices; misguided beliefs about disease etiology may contribute to limited use of health care services when children become ill [5]. HIV infection has been reported to be associated with a twofold increase in risk for adult major depressive disorders [6] which may, in turn, be a contributing factor to the observed increase in infant morbidity [7] and mortality from infectious diseases, even among HIV-negative infants [8]. Recent studies have identified maternal mental health as an important determinant of infant health outcomes. Rahman and colleagues reported that postnatal depression (PND) was associated with a threefold increase in the risk of having five or more diarrheal episodes per year among Pakistani infants [9]. These studies were conducted, however, in non-HIV-affected populations. No known study has examined the association between PND and infant health in HIV-affected populations. The co-existence of HIV infection and maternal depression may synergistically influence infant morbidity outcomes including diarrhea. The present study examined the incidence and number of days ill with diarrhea among Ghanaian infants living in communities affected with HIV and examined the interaction between maternal HIV status and symptoms of PND on infant risk of having diarrhea. We hypothesized that:

(i) maternal HIV infection would be associated with infant diarrheal morbidity,
(ii) symptoms of PND among mothers would be associated with infant diarrheal morbidity, and
(iii) there would be a synergistic effect of maternal HIV infection and symptoms of PND such that infants of women who were affected by both conditions would have a risk of diarrhea that was greater than the sum of the individual risks associated with the two conditions.

Methods

Study Site

This study [Research to Improve Infant Nutrition and Growth (RIING) Project (2004-2008)] was conducted in the Manya and Yilo Krobo districts, Eastern region, Ghana. This region has consistently recorded the highest HIV prevalence; the 2007 prevalence (4.2%) was more than twice the national rate of 1.9%. The Manya Krobo district was the first in the country to benefit from services and support for voluntary counseling and testing (VCT) for HIV in 2001.

Recruitment and Follow-up

Recruitment of pregnant women occurred at prenatal clinics in three hospitals. Pregnant women were recruited and enrolled after VCT. In 2003, under the national VCT program, all pregnant women received counseling on the risk of HIV transmission and were informed about the available services, after which they were invited to be tested for HIV ('opt-in' system). In 2005, the national program was changed to an 'opt-out' system in which all women were tested after counseling unless they requested not to be.

Women were considered eligible for the study if they (1) were at least 18 years old, (2) were pregnant at the time of enrollment, and (3) had completed pre- and post-VCT, or only pre-VCT if they had refused testing. For those who completed pre- and post-VCT, they were considered eligible if they agreed to have their HIV test results released to the project coordinator. The rapid test 'Abbott Determine HIV-1/2′ (Abbott Laboratories, Abbott Park, IL, USA) was used at the hospital to test for HIV. Samples from indeterminate results were sent to the Noguchi Memorial Institute for Medical Research (NMIMR) for confirmation with polymerase chain reaction (PCR)

analysis. The participants were classified as HIV positive (HIV-P, tested positive for HIV), HIV negative (HIV-N, tested negative for HIV) or unknown HIV status (HIV-U, refused to be tested for HIV). A participant was considered eligible for the postpartum longitudinal surveillance if (1) she gave birth to a live infant, (2) her infant was free of any birth defect that may otherwise hinder feeding, and (3) she was free of any physical condition that may limit her ability to care for her infant. Only the field supervisor had access to women's HIV status. There was no information available on participants' CD4 counts and viral loads at the time of entry into the study as these tests were not done routinely by the Ghana Health Services. Antiretroviral therapy was limited to the administration of Nevirapine by Ghana Health Services staff to the mother during labor and to the newborn at birth to prevent mother-to-child transmission of HIV.

Mother–infant pairs were followed from birth up to 12 months. Twice a week, mothers were visited to collect information on infant health, including total number of stools and stool characteristics (e.g., liquid). For each symptom, the mother was asked to recall the events for the day of visit and for each preceding day since she was last visited by the field worker for up to a maximum of 7 days of recall. Infant feeding information was collected with the same methodology. The mother was asked if she breastfed the baby and if the baby received any non-breast milk liquids (water, infant formula, other non-human milk) or semi-solid or solid food.

Symptoms of maternal PND were measured shortly after birth (10.0 ± 0.5 days) and at 6 months (189.0 ± 0.4 days) using the Edinburgh Postnatal Depression Scale (EPDS), a 10-item scale that documents symptoms that occurred over the past 7 days [10]. Each item on the EPDS was scored on a 4-point rating scale that represented the level of occurrence. The Cronbach's alpha for the EPDS was 0.82. The day on which the scale was administered did not differ among the three HIV groups at either time point (birth: $\chi^2 = 3.42$, $P = 0.18$; 6 months: $\chi^2 = 0.28$; $P = 0.87$).

Maternal stress was measured at enrollment (prenatal) using the Perceived Stress Scale (PSS), a 4-item scale (Cronbach's alpha = 0.87) used to measure the degree to which situations in a person's life are perceived as stressful [11]. Each item on the PSS measures the frequency of occurrence. Total scores range from 4 (low stress) to 20 (high stress).

Infant weight was measured at birth, then monthly. Maternal weight was measured monthly and height was measured once at 6 months postpartum. Duplicate weight measurements were made using the Tanita digital weighing scale (Tanita Corporation of America Inc., Arlington Heights, IL, USA) and measured to the nearest 0.1 kg. Maternal height was measured in duplicate to the nearest 0.1 cm using a wooden stadiometer (Shorr Productions; Maryland, USA).

Variables

Diarrhea was defined as passing three or more liquid or semi-liquid stools in a 24 h period [12]. An episode was separated from another by at least two symptom-free days [13]. Incidence rate was calculated as the number of new episodes divided by the number of days at risk (days at risk = (days observed) − (# days ill) + (# episodes)) [14]. Diarrheal incidence and days ill were standardized to 100 days of observation. The main outcome measures included (i) total number of days ill per days observed, (ii) incidence rate of diarrhea, and (iii) risk of having diarrhea on any day during the first 3 months of life.

An infant was considered to be exclusively breastfed (EBF) if since birth the infant received only breast milk (excluding medicines). EBF ceased on the day that the infant received any non-breast milk liquids or semi-solids.

A binary variable was used for maternal PND. Mothers with total EPDS scores below 13 were classified as not showing symptoms of PND whereas those with total EPDS scores 13 and above were classified as showing symptoms of PND [10, 15]. Maternal perceived stress score was analyzed as a continuous variable.

Statistical Analysis

Morbidity was described for four age intervals (0–3, 3–6, 6–9 and 9–12 months) and for the first year of life (0–12 months). The descriptive data are presented as means and standard errors or frequencies and percentages. Chi-square or Fisher's exact test were used for categorical variables and Analysis of Variance for normally distributed continuous variables. The non-parametric Kruskal–Wallis test was used for non-normally distributed continuous data. The greatest unadjusted effect of PND on illness was in early infancy, therefore the focus of the analysis using multiple logistic regression included data only from 0 to 3 months using the SAS PROC GENMOD procedure. Logistic regression provided a better fitted model than linear regression because of the frequent response of zero or few days ill among our sample. The models were fitted with the assumption that the data were generated from a binomial distribution. Overdispersion, a condition that occurs when the variance is larger than expected under a given model, was checked and adjusted for (using the D-scale syntax) whenever it occurred. The initial model to explain risk of diarrhea included maternal (parity, marital status, prenatal stress score), infant (EBF status, low birth weight), and household (primary water source, cooking fuel, toilet facility) factors that were identified through the

bivariate analysis and the review of the literature. An HIV-PND interaction term was included in the model to test for the interaction between HIV status and PND; the reference cell was HIV-N with no depressive symptoms. Variables were removed from the model in a manual backward stepwise procedure until only significant variables remained. All analyses were completed with SAS version 9.13 for Windows (SAS Institute, Cary, NC, USA) and significant results were reported at $\alpha < 0.05$ unless otherwise indicated.

Ethics

Ethical approval was obtained from the institutional review boards of McGill University, University of Ghana, Iowa State University, and University of Connecticut. Signed informed consent was obtained from each woman for herself and her infant.

Results

Study Sample

Six hundred and ninety-two pregnant women were informed about the study, out of which 552 women were enrolled. Out of 505 recorded live births, morbidity data were available for 492 infants.

Baseline Characteristics

Maternal age ranged from 18 to 48 years with a mean of 28.5 ± 0.3 years. Study subjects had 0-8 prior live births, with a median of 1. The women reported illness symptoms (respiratory, gastrointestinal, skin, and gynecological) on about 18% of the observed days, with no difference by HIV status. The majority of women (69%, $n = 339$) were of the Ga-Adangme ethnic group. More than two-thirds of the women were not married and were either living with a partner ($n = 245$) or had no partner ($n = 95$). Most women ($n = 440$) had some form of formal education although one-third ($n = 162$) had not reached secondary school. The public tap served as the main water source for the majority of households (67%, $n = 328$). Less than one-sixth (16%, $n = 77$) of the women had flush toilets. Wood was used by a minority of households (10%, $n = 50$) as the main cooking fuel. On the whole, HIV-P women were poorer than other women, as indicated by less secondary or higher education, lower likelihood to be married and less access to flush toilet, in-house tap and charcoal, gas or electric stove (Table 1).

Table 1 Demographic and socioeconomic characteristics of Ghanaian study population at baseline, by maternal HIV status

	HIV-P N = 152	HIV-N N = 176	HIV-U N = 164	χ^2	P value[a]
Maternal age (y)	28.3 ± 0.5	29.0 ± 0.4	28.1 ± 0.4	2.3689	0.3059
Parity (#)	1.5 ± 0.1	1.6 ± 0.1	1.4 ± 0.1	2.3085	0.3153
Maternal education				21.93	0.0002
None	25 (16.4)	13 (7.4)	14 (8.5)		
Primary	47 (30.9)	30 (17.0)	33 (20.1)		
Secondary and higher	80 (52.6)	133 (75.6)	117 (71.3)		
Ethnicity[b]				20.86	<0.0001
Non-local	26 (17.1)	62 (35.2)	65 (39.6)		
Local	126 (8.29)	114 (64.8)	99 (60.4)		
Marital status				29.87	<0.0001
Not married	128 (84.2)	99 (56.2)	113 (68.9)		
Married	24 (15.8)	77 (43.7)	51 (31.1)		
Cooking fuel				4.62	0.09
Wood	22 (14.6)	14 (7.9)	14 (8.5)		
Other[c]	129 (85.4)	162 (92.0)	150 (91.4)		
Main water source				13.82	0.0010
No tap in home	126 (83.4)	124 (70.4)	107 (65.2)		
Tap in home	25 (16.6)	52 (29.5)	57 (34.7)		
Toilet facility[d]				14.41	0.0061
KVIP	86 (56.9)	80 (45.4)	95 (57.9)		
Other	52 (34.4)	62 (35.2)	39 (23.8)		
Flush toilet	13 (8.6)	34 (19.3)	30 (18.3)		

Results are presented as mean ± standard error or *N* (%)

HIV-P, HIV positive; HIV-N, HIV negative; HIV-U, unknown HIV status

[a] Kruskal-Wallis tests for continuous data; Chi–square test for categorical data

[b] Non-local = Ewe, Akan, northerner, any other ethnicity; Local = Ga-Adangme

[c] Other = charcoal, gas cooker, electric stove

[d] KVIP = Kumasi Ventilated Improved Pit latrine; Other = bucket, latrine, pit latrine, bush

Table 2 Infant diarrheal days ill (per 100 days of observation) and incidence of diarrhea (episodes per 100 days at risk), by maternal HIV status

	HIV-P	HIV-N	HIV-U	χ^2	P value[a]
Days ill (d/100 d observed)					
0–3 months	1.6 ± 0.4 [151]	2.3 ± 0.6 [175]	2.7 ± 0.5 [163]	5.13	0.0767
3–6 months	2.2 ± 0.4 [135]	3.9 ± 0.6 [167]	4.1 ± 0.6 [160]	5.48	0.0646
6–9 months	2.4 ± 0.4 [123]	3.0 ± 0.4 [164]	3.1 ± 0.4 [152]	2.52	0.2837
9–12 months	1.8 ± 0.3 [107]	2.9 ± 0.4 [161]	2.9 ± 0.4 [146]	5.71	0.0576
0–12 months	1.6 ± 0.2 [152]	2.3 ± 0.3 [176]	2.6 ± 0.3 [164]	5.77	0.0557
Incidence (episodes/100 d at risk)					
0–3 months	0.6 ± 0.1 [151]	0.5 ± 0.1 [175]	0.8 ± 0.1 [163]	4.37	0.1123
3–6 months	0.7 ± 0.1 [135]	1.1 ± 0.1 [167]	1.1 ± 0.2 [160]	4.29	0.1172
6–9 months	1.0 ± 0.2 [123]	1.1 ± 0.1 [164]	0.9 ± 0.1 [152]	1.65	0.4370
9–12 months	0.8 ± 0.1 [107]	1.1 ± 0.1 [161]	1.1 ± 0.1 [146]	5.47	0.0649
0–12 months	0.6 ± 0.1 [152]	0.6 ± 0.1 [176]	0.7 ± 0.1 [164]	3.25	0.1968

Results represented as mean ± standard error [*N*]

HIV-P, HIV positive; HIV-N, HIV negative; HIV-U, unknown HIV status

[a] Kruskal–Wallis tests

HIV and Diarrhea

The total number of days ill with diarrhea was 2.2 per 100 days observed (8.0 days ill/year). There was an average of 0.6 new episodes of diarrhea per 100 days at risk (2.3 episodes/year). Over the 12 months, although the diarrheal incidence was similar among the three groups of infants, infants of HIV-P mothers tended to have a lower number of days ill (P = 0.06; Table 2).

Maternal Postnatal Depression and Diarrhea

About 10% of women reported symptoms of PND shortly after birth. HIV-P women tended to be more likely to report symptoms at birth than HIV-N and HIV-U women (14% vs. 7% and 10%, respectively; $\chi^2 = 4.76$; P = 0.09). The analysis of diarrheal morbidity by maternal PND status showed that having symptoms of PND shortly after birth was associated with more episodes and days ill with diarrhea (Table 3). In the first 3 months of life, infants of mothers reporting PND symptoms had almost twice the number of diarrheal episodes ($\chi^2 = 12.24$; P = 0.0005) and more than twice as many days ill with diarrhea ($\chi^2 = 13.81$; P = 0.0002) compared to infants whose mothers reported no PND symptoms. No significant association was seen after three months. At 6 months, 9.3% of women reported PND symptoms; these reports were more common among HIV-P women than HIV-N or HIV-U women (17% vs. 3% vs. 10%, $\chi^2 = 14.83$; P = 0.0006). PND symptoms reported at 6 months were not significantly associated with diarrheal morbidity between 6 and 12 months (data not shown).

Other Maternal, Child, and Household Factors and Diarrhea

Increased risk of diarrhea in the first three months of life was associated with parity, PND symptoms, single marital status, and use of wood as cooking fuel and decreased risk with low birth weight (Table 4). These factors, with the exception of parity, remained significant in the adjusted model (Table 5). Maternal stress was a significant predictor of risk of diarrhea only in the adjusted model. Sanitation indicators (water source and latrine) were not significant in either the unadjusted or adjusted model. Exclusive breastfeeding was common in this population: 87, 80 and 63% infants were EBF at 1, 3, and 5 months, respectively. Exclusive breastfeeding during the first 3 months was not a significant factor in either model.

Maternal HIV Status-PND Interaction

To examine the synergistic effect of maternal HIV infection and symptoms of PND on risk of diarrhea, the analysis focused on the first three months postpartum when a strong association between risk of infant diarrhea and maternal PND assessed soon after birth was noted. Multiple logistic regression results showed a significant interaction between maternal HIV status and PND symptoms soon after birth on infant risk of having diarrhea in the first three months of life (Table 5). The association between PND symptoms and infant diarrhea differed according to maternal HIV status. Compared to infants of HIV-N women who reported no PND symptoms, infants of HIV-N women with symptoms had no increased risk whereas infants of HIV-P and

Table 3 Infant diarrheal days ill (per 100 days of observation) and incidence (episodes per 100 days at risk), by symptoms of maternal postnatal depression reported by mothers shortly after birth

	Symptoms of PND[a]	No symptom of PND	χ^2	P value[b]
Days ill (d/100 d observed)				
0–3 months	4.4 ± 1.0 [49]	2.0 ± 0.3 [419]	13.81	0.0002
3–6 months	3.3 ± 0.8 [46]	3.4 ± 0.3 [400]	1.94	0.1636
6–9 months	3.3 ± 0.9 [43]	2.7 ± 0.2 [381]	0.75	0.3842
9–12 months	2.7 ± 0.5 [38]	2.6 ± 0.2 [362]	1.13	0.2868
0–12 months	2.8 ± 0.5 [49]	2.1 ± 0.2 [419]	2.70	0.1000
Incidence (episodes/100 d at risk)				
0–3 months	1.1 ± 0.2 [49]	0.6 ± 0.1 [419]	12.24	0.0005
3–6 months	1.2 ± 0.2 [46]	1.0 ± 0.1 [400]	3.53	0.0603
6–9 months	1.1 ± 0.2 [43]	1.0 ± 0.1 [381]	0.89	0.3440
9–12 months	1.1 ± 0.2 [38]	1.0 ± 0.1 [362]	1.62	0.2024
0–12 months	0.8 ± 0.1 [49]	0.6 ± 0.1 [419]	4.18	0.0409

Results represented as mean ± standard error [*N*]

[a] PND, Postnatal depression; symptoms of PND were measured shortly after birth. Participants were classified as showing symptoms of PND if they scored 13 or more on the Edinburgh Postnatal Depression Scale (EPDS) [10]. Participants with EPDS scores <13 were classified as not showing symptoms of PND

[b] Kruskal–Wallis tests

HIV-U women with symptoms had a twofold and threefold increased risk of diarrhea, respectively. Infants of HIV-P women who showed no symptom of PND however had a reduced risk of having diarrhea compared to infants of HIV-N women who showed no symptom of PND.

Finally, the difference in diarrheal risk that was associated with PND symptoms was compared within HIV groups, adjusting for perceived prenatal stress, marital status, low birth weight, and cooking fuel. Whereas there was no difference in infant risk of diarrhea by reported PND symptoms among HIV-N women (OR = 0.99, 95% CI: 0.28–3.43), reporting PND symptoms was associated with a large increase in diarrheal risk for infants of both HIV-P and HIV-U mothers (Fig. 1). Infants of HIV-P and HIV-U women had a fivefold (OR = 5.39, 95% CI: 2.48–11.68) and fourfold (OR = 4.53, 95% CI: 2.47–8.32) increased risk of having diarrhea, respectively, if their mother reported PND symptoms compared to if their mother did not have PND symptoms.

Discussion

To the best of our knowledge, this is the first study to show a synergistic relationship between maternal HIV status and symptoms of PND on an indicator of infant health (risk of having diarrhea). One explanation of the increased risk may be that the presence of PND contributes to HIV-P mothers performing fewer preventive child health behaviors; however, the evidence on PND is inconsistent in the literature. Grupp-Phelan and colleagues [16] reported that mothers with symptoms of depression perceived that they were less able to "take care of their children in the way they would like to." In a study by Minkovitz et al. [17], mothers with PND symptoms were about 20% less likely to carry out preventive health care behaviors (well-child visits, vaccinations) as women without symptoms. In contrast, breastfeeding and timely well-baby visits did not vary by presence of symptoms in a study by Chung et al. [18]. These inconsistent findings may reflect different social environments, the severity of other stressors that women experienced, and the quality of health services received. Watson and Kemper [19], for example, reported that maternal depression did not explain frequency of delayed immunizations in a population highly stressed by poverty and drug abuse. There may be two reasons for their results: (i) the effect of PND was not detectable because other factors such as drug use were much stronger determinants of child health, or (ii) the sample selected (a population already receiving health services) was one in which clinic support successfully mitigated the effect of PND. A close examination of the overall environment and services as well as the co-existence of PND with other stressors (such as HIV in this study) will help elucidate the role that PND plays in child health in diverse settings.

Increased infant diarrheal morbidity may also have occurred because HIV-P women with PND symptoms were clinically sicker and therefore unable to adequately care for their infants. Antelman and colleagues reported an increase in risk of disease progression (HR = 1.61, 95% CI:

Table 4 Unadjusted odds ratios for explanatory variables of infant risk of having diarrhea in the first 3 months of life

	Unadjusted OR (95% CI)	χ^2	*P* value
Parity (#)	1.13 (1.01–1.25)	5.06	0.0245
Maternal age (year)	0.99 (0.96–1.02)	0.24	0.6211
Maternal height (cm)	0.98 (0.95–1.02)	1.07	0.3004
Maternal HIV status			
Positive	0.68 (0.43–1.09)	2.55	0.1102
Unknown	1.17 (0.79–1.73)	0.65	0.4185
Negative	Reference		
Postnatal depression symptoms[a]			
Yes	2.36 (1.53–3.67)	14.84	0.0001
No	Reference		
Perceived prenatal stress score[b]	0.97 (0.92–1.02)	1.47	0.2250
Marital status			
Not married	2.35 (1.48–3.72)	13.36	0.0003
Married	Reference		
Ethnicity			
Non-local[c]	1.20 (0.84–1.73)	1.02	0.3125
Local	Reference		
Low birth weight			
Yes	0.20 (0.05–0.76)	5.63	0.0177
No	Reference		
Exclusive breastfeeding to 3 months			
No	0.96 (0.65–1.42)	0.03	0.8636
Yes	Reference		
Cooking fuel			
Wood	1.64 (1.02–2.65)	4.21	0.0402
Other[d]	Reference		
Main water source			
No tap in home	1.35 (0.89–2.05)	2.08	0.1493
Tap in home	Reference		
Toilet[e]			
KVIP	1.27 (0.77–2.12)	0.92	0.3383
Other	0.90 (0.51–1.59)	0.12	0.7268
Flush toilet	Reference		

[a] Participants were classified as showing symptoms of postnatal depression (PND) if they scored 13 or more on the Edinburgh Postnatal Depression Scale (EPDS) [10]. Participants with EPDS scores < 13 were classified as not showing symptoms of PND

[b] Perceived prenatal stress used the 4-item Perceived Stress Scale [11]; total scores ranged from 4 (low stress) to 20 (high stress)

[c] Non-local = Ewe, Akan, northerner, any other ethnicity; Local = Ga-Adangme

[d] Charcoal, gas cooker, electric stove

[e] KVIP = Kumasi Ventilated Improved Pit latrine; Other = bucket latrine, pit latrine, bush OR, Odds ratio; CI, confidence interval; HIV-P, HIV positive; HIV-N, HIV negative; HIV-U, unknown HIV status

1.28–2.03) and all-cause mortality (HR = 2.65; 95% CI: 1.89–3.71) among Tanzanian HIV-infected women who were depressed [20]. This explanation, however, is unlikely in our study as most women were in early stages of the disease and maternal illness rates were similar across HIV status.

The only other study that has examined the relationship between maternal depression and infant diarrhea was conducted in a non-HIV population in Pakistan and demonstrated similar results as our study. The researchers reported a three-fold (OR = 3.1; 95% CI: 1.8–5.6) increase in risk of frequent diarrheal illness (defined as ≥5 diarrheal episodes/year) among infants of women who were depressed [9]. Underweight (<−2 weight-for-age) at 6 months in the Pakistani study was common (18% overall) and was associated with more than twice the risk. We chose to not include a similar mid-point anthropometric predictor in our model for various reasons. First, only predictors that occurred prior to the outcome of interest were included to clarify temporal relationships. Second, differences in anthropometric measurements were pronounced from birth and retained thereafter (data not shown). Finally, birth weight is highly correlated with weight during the first year of life and therefore an additional weight indicator may be redundant in the model.

The estimate of diarrheal incidence (2.3 episodes/year) in this study is similar to that reported in a WHO global review (2.6 episodes/year) [21] and a study of non-HIV affected children in Turkey (2.8 episodes/year) [22]. This estimate contrasts the reports of 7.7 –18.6 episodes per year

Table 5 Factors associated with infant risk of having diarrhea in the first 3 months after birth

	aOR[a] (95% CI)	χ^2	P value
Maternal HIV status			
Unknown	1.62 (0.81–3.24)	1.90	0.1685
Positive	0.86 (0.41–1.81)	0.15	0.6980
Negative	Reference		
Postnatal depression symptoms[b]			
Yes	2.89 (1.71–4.89)	15.84	0.0001
No	Reference		
HIV status*PND symptoms interaction[c]		7.84	0.02
HIV-P and PND symptoms	2.00 (1.01–3.94)	4.01	0.0451
HIV-P and no PND symptoms	0.37 (0.20–0.67)	10.43	0.0012
HIV-U and PND symptoms	3.45 (1.90–6.27)	16.58	0.0001
HIV-U and no PND symptoms	0.76 (0.47–1.21)	1.30	0.2537
HIV-N and PND symptoms	0.99 (0.28–3.43)	0.00	0.9942
HIV-N and no PND symptoms	Reference		
Perceived prenatal stress[d]	0.92 (0.87–0.97)	7.75	0.0054
Marital status			
Not married	4.03 (2.39–6.78)	27.42	0.0001
Married	Reference		
Low birth weight			
Yes	0.25 (0.07–0.81)	5.30	0.0213
No	Reference		
Cooking fuel			
Wood	2.03 (1.27–3.25)	8.79	0.0030
Other[e]	Reference		

[a] The multiple logistic regression model adjusted for all the variables shown in the table including the interaction term; adjusted odds ratios are shown

[b] Participants were classified as showing symptoms of postnatal depression (PND) if they scored 13 or more on the Edinburgh Postnatal Depression Scale (EPDS) [10]. Participants with EPDS scores < 13 were classified as not showing symptoms of PND

[c] HIV status-postnatal depression interaction was significant (P = 0.02)

[d] Perceived prenatal stress used the 4-item Perceived Stress Scale [11]. Total scores ranged from 4 (low stress) to 20 (high stress)

[e] Other = charcoal, gas cooker, electric stove

aOR, adjusted odds ratio; CI, confidence interval; HIV-P, HIV positive; HIV-N, HIV negative; HIV-U, unknown HIV status; PND, Postnatal depression

in South Africa, Kenya and Zimbabwe [23]. The comparatively lower rates recorded in Ghana could be due to high breastfeeding and exclusive breastfeeding (EBF) rates; only nine infants of HIV-P mothers (2.7%) did not breastfeed at birth and only 20% of all mothers were not EBF at 3 months. Exclusive breastfeeding is protective against diarrhea [24, 25]. Among HIV-uninfected infants of HIV-P mothers, non-exclusive breastfeeding was associated with a 2.5 fold (95% CI: 1.7–3.8) increased risk of diarrhea [26]. The high EBF rate seen in our study is consistent with another Ghanaian study [27], and may have reduced incidence rates to a level at which we were unable to detect significant differences in diarrhea across HIV groups. Regardless, the HIV group difference was in the opposite direction of what was expected. Infants of HIV-P women tended to report less, not more, diarrheal illness for their infants. This unexpected relationship may reflect the health education in the HIV clinics. The VCT nurses provided HIV-P women with one-on-one counseling that included infant feeding and care. This education may also explain the lower risk of diarrhea associated with low birth weight as the majority of low birth weight babies were in the HIV-P group.

The lack of a significant direct association between maternal HIV and infant diarrhea in other settings may also reflect the environment in which the study is conducted. For example, maternal HIV was also not associated with increased diarrhea morbidity among 6-month-old infants in

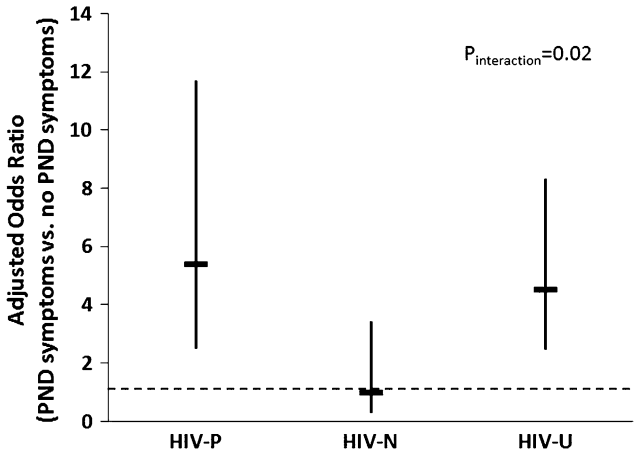

Fig. 1 Infants' risk of having diarrhea on any day, 0 – 3 months of age, associated with symptoms of postnatal depression (PND), by maternal HIV status. Symbols indicate adjusted Odds Ratios (aOR; adjusted for perceived prenatal stress, marital status, low birth weight, and cooking fuel); vertical lines indicate 95% CI. The comparisons shown use absence of PND symptoms as the reference group within each HIV category: HIV-P (aOR = 5.39, 95% CI: 2.48-11.68); HIV-U (aOR = 4.53, 95% CI: 2.47-8.32); HIV-N (aOR = 0.99, 95% CI: 0.28-3.43). Dotted line represents OR = 1. HIV-P, HIV positive; HIV-N, HIV negative; HIV-U, unknown HIV status

Botswana even though overall infant mortality was higher [28]. In contrast to our study, the 5 month EBF rates were low (17.5% vs. 9.5% for HIV-P vs. HIV-N, respectively) and infants were weaned early (median was 5.8 and 9 months among HIV-P and HIV-N women, respectively). About one-third of 6-month-old infants had at least one episode of diarrhea regardless of whether their mother was HIV-P or HIV-N, suggesting that other factors, such as poor hygiene and non-EBF, were the primary determinants of diarrhea.

Maternal marital status was significantly associated with diarrhea in this study. Being unmarried may indicate poor socioeconomic status [29] and low socioeconomic status may affect a mother's ability to access adequate resources for the care of her child. Mothers who were not married had infants with increased risk of having diarrhea; this association is consistent with the increased risk seen with another indicator of poverty, the use of wood as the main source of cooking fuel. Poverty was positively associated with diarrhea morbidity in a previous study in Ghana [3].

Twice weekly data collection reduced errors from poor maternal recall and allowed for confirmation of health status by the field staff when the illness coincided with the visit. Field workers were masked to mothers' HIV status, thereby reducing differential bias. Despite these methodological strengths, this study had limitations. Firstly, maternal HIV status was tested only at enrollment. Some mothers may have become infected during the study; new infections would have diminished our ability to observe group differences. Secondly, our analysis did not include the infant's HIV status. At the time of the study, the health ministry protocol included testing of infants only at 18 months of age or with presentation of symptoms. Although the project offered free testing for all infants, few mothers agreed to have their child tested. Infant HIV infection is associated with increased morbidity; however, given the decreased risk of HIV transmission with EBF compared to mixed feeding, the majority of infants may have remained uninfected during early infancy.

In summary, infants of HIV-P and HIV-U mothers who reported symptoms of PND had an increased risk of having diarrhea in the first three months of life. Health care programs in HIV-affected communities need to train their personnel to identify and address the multiple stressors that contribute to poor maternal mental and physical health and affect infant health. Multisector prevention and curative programs that address the complex situations in which HIV-affected households live are needed to improve maternal well-being and decrease infant morbidity and mortality.

Acknowledgments Rula Souieda and Dr. Roger Cue at McGill University provided assistance with data management and statistical analysis, respectively. This publication was funded by Grant No. HD 43260, National Institute of Child Health and Development (NICHD)/ National Institutes of Health. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of NICHD.

References

1. Boschi-Pinto C, Velebit L, Shibuya K. Estimating child mortality due to diarrhoea in developing countries. Bull WHO. 2008; 86(9):710–7.
2. Victora CG, Barros AJD. Effect of breastfeeding on infant and child mortality due to infectious diseases in less developed countries: a pooled analysis. Lancet. 2000;355(9202):451–5.
3. Boadi OK, Kuitunen M. Childhood diarreal morbidity in the Accra Metropolitan Area, Ghana, socioeconomic, environmental and behavioural risk determinants. World Health & Population. (previously, Journal of Health & Population in Developing Countries). http://www.longwoods.com/content/17646. Accessed Jan 15, 2012.
4. Cairncross S, Hunt C, Boisson S, et al. Water, sanitation and hygiene for the prevention of diarrhoea. Int J Epidemiol. 2010;39(Suppl 1):193–205.
5. Veenstra N, Whiteside A. Economic impact of HIV. Best Pract Res Clin Obstet Gynaecol. 2005;19(2):197–210.
6. Ciesla JA, Roberts JE. Meta-analysis of the relationship between HIV infection and risk for depressive disorders. Am J Psychiatry. 2001;158(5):725–30.
7. Thea DM. St. Louis ME, Atido U, et al. A prospective study of diarrhea and HIV-1 infection among 429 Zairian infants. N Engl J Med. 1993;329(23):1696–702.
8. Brahmbhatt HP, Kigozi GMD, Wabwire-Mangen FP, et al. Mortality in HIV-infected and uninfected children of HIV-infected and uninfected mothers in rural Uganda. JAIDS. 2006;41(4):504–8.

9. Rahman A, Bunn J, Lovel H, Creed F. Maternal depression increases infant risk of diarrhoeal illness: A cohort study. Arch Dis Child. 2007;92(1):24–8.
10. Cox JL, Holden JM, Sagovsky R. Detection of postnatal depression. Development of the 10 item Edinburgh Postnatal Depression Scale. Br J Psychiatry. 1987;150(6):782–6.
11. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983;24(4):385–96.
12. Baqui AH, Black RE, Yunus MD, Hoque ARA, Chowdhury HR, Sack RB. Methodological issues in diarrhoeal diseases epidemiology: definition of diarrhoeal episodes. Int J Epidemiol. 1991;20(4):1057–63.
13. Morris SS, Cousens SN, Lanata CF, Kirkwood BR. Diarrhoea – defining the episode. Int J Epidemiol. 1994;23(3):617–23.
14. Bashour HN, Webber RH, Marshall T. A community-based study of acute respiratory infections among preschool children in Syria. J Trop Pediatr. 1994;40(4):207–13.
15. Harris B, Huckle P, Thomas R, Johns S, Fung H. The use of rating scales to identify post-natal depression. Br J Psychiatry. 1989;154(6):813–7.
16. Grupp-Phelan J, Whitaker RC, Naish AB. Depression in mothers of children presenting for emergency and primary care: impact on mothers' perceptions of caring for their children. Ambul Pediatr. 2003;3(3):142–6.
17. Minkovitz CS, Strobino D, Scharfstein D, et al. Maternal depressive symptoms and children's receipt of health care in the first 3 years of life. Pediatrics. 2005;115:306–14.
18. Chung EK, McCollum KF, Elo IT, Lee HJ, Culhane JF. Maternal depressive symptoms and infant health practices among low-income women. Pediatrics. 2004;113:e523–9.
19. Watson JM, Kemper KJ. Maternal factors and child's health care use. Soc Sci Med. 1995;40(5):623–8.
20. Antelman G, Kaaya S, Wei RL, et al. Depressive symptoms increase risk of HIV disease progression and mortality among women in Tanzania. JAIDS. 2007;44(4):470–7.
21. Bern C, Martines J, de Zoysa I, Glass RI. The magnitude of the global problem of diarrheal disease : a ten year update. Bull WHO. 1992;70(6):705–14.
22. Etiler N, Velipasaoglu S, Aktekin M. Risk factors for overall and persistent diarrhoea in infancy in Antalya, Turkey: a cohort study. Public Health. 2004;118(1):62–9.
23. Wright JA, Gundry SW, Conroy R, et al. Defining episodes of diarrhea: Results from a three-country study in Sub-Saharan Africa. JHPN. 2006;24(1):8–16.
24. Howie PW, Forsyth JS, Ogston SA, Clark A, Florey CD. Protective effect of breast feeding against infection. BMJ. 1990;300(6716):11–6.
25. Bhandari N, Bahl R, Mazumdar S, et al. Effect of community-based promotion of exclusive breastfeeding on diarrhoeal illness and growth: A cluster randomised controlled trial. Lancet. 2003; 361(9367):1418–23.
26. Fawzy A, Arpadi S, Kankasa C, et al. Early weaning increases diarrhea morbidity and mortality among uninfected children born to HIV-infected mothers in Zambia. J Infect Dis. 2011;203:1222–30.
27. Aidam BA, Pérez-Escamilla R, Lartey A. Lactation counseling increases exclusive breast-feeding rates in Ghana. J Nutr. 2005; 135(7):1691–5.
28. Shapiro RL, Lockmann S, Kim S, et al. Infant morbidity, mortality, and breast milk immunologic profiles among breast-feeding HIV-infected and HIV-Uninfected women in Botswana. J Infect Dis. 2007;196(4):562–9.
29. Mather M. U.S. children in single-mother families. Population Reference Bureau Data Brief May 2010. http://www.prb.org/Publications/PolicyBriefs/singlemotherfamilies.aspx. Accessed Jan 15, 2012.