# Correlates of Depressive Symptoms Among Mothers With Acutely Ill Children Admitted To Hospitals In Low- And Middle-Income Countries

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## Abstract

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## Abstract

**Background**: Maternal depression is the second leading cause of maternal disability globally. In addition to causing significant maternal morbidity, maternal depression may also be associated with increased child morbidity and mortality, possibly through a reduction in the ability of mothers to meet children's care needs. Mothers in low-and-middle income countries (LMICs) have higher rates of depression after childbirth than high-income peers. Despite a well-established body of evidence surrounding maternal depression in high-income countries (HICs), few studies have addressed correlates of maternal depression in LMICs. This study used data from the Childhood Acute Illness & Nutrition Network to investigate potential correlates of maternal depression among caregivers with a child being admitted to hospital in nine LMIC settings.

**Methods:** 2,949 biological mothers were included in this secondary analysis. Demographic and socioeconomic data were collected from caregivers upon the admission of acutely ill children to

nine hospitals within six LMICs. The participants were asked to complete the patient health questionnaire-9 (PHQ-9) within 6 hours of their children's admission, to screen for depressive symptoms. The cumulative PHQ-9 score was coded as a continuous variable throughout our secondary analysis and all analyses were conducted in R. Using univariate, bivariate, and multivariate interaction models, we estimated hypothesized variables as effect modifiers and also examined their direct effects on PHQ-9 scores in bivariate and multivariate analyses and we investigated the correlates of maternal depressive symptoms in our study context.

**Results:** Overall, there were 1671 male children (57%) and 1271 female children (43%) in the sample. No crude relationship between child sex and maternal PHQ-9 score was found (β:0.3, 95% CI -0.1, 0.6, P=0.15), but a significant interaction between the Migori Hospital site (Kenya) and child gender suggests that have a male child at this site was associated with a 1.7 point greater reduction in PHQ-9 than having a male child at other sites (95% CI: -3.2, -0.3, p= 0.02). Mothers who were the child's primary financial provider also appeared to affect the relationship between child's sex and maternal PHQ-9 in crude models (β: 1.7, 95% CI -2.4, -1.1 & p <0.001), but this association was not significant in multivariate models. Multiple other exposures of interest were independently associated with PHQ-9 scores in multivariate models. These exposures are sites of: Blantyre (β: -3.4, 95% CI -4.3, -2.6, p <0.0001); Karachi (β: -2.9, 95% CI -3.8, -1.9, p <0.0001); Matlab (β: -4.1, 95% CI -4.7, -3.5, p <0.0001; and Migori (β: 1.0, 95% CI 0.0, 1.9, p=0.04). Also, food insecurity (β: 0.4, 95% CI 0.4, 0.5, p <0.001; marital status (β: -0.8 (95% CI -1.3, -0.3, p <0.001); child's age at admission (β: 0.3, 95% CI 0.3, 1, p <0.029); and the middle upper arm circumference (MUAC) (β: -0.2, 95% CI -0.3, -0.1, p <0.001).

**Conclusion:** Mothers of admitted acutely ill children to hospitals in LMICs may be at a particularly high risk of depression, both due to higher risk of child illness in these families and

due to situational stress during prolonged periods of intense contact with the healthcare system. Multiple strong correlates of maternal mental health were identified at pediatric admission in the context of an acutely ill child being admitted to hospitals. Some of these correlates appeared relevant across study sites, while others, such as gender, appeared restricted to individual sites. Understanding these correlates could improve the detection of maternal depression in low and middle-resource settings and could contribute to the design of target mental health interventions during pediatric hospitalization.

## Introduction

According to the World Health Organization (WHO), 5.4 million children under age five died in 2017[1]. Despite multiple efforts, children die of preventable diseases each year and the majority of these deaths occur in LMICs.[2,3] In 2017, the global Under 5 Mortality Rate [U5MR] – (deaths in children 0 to 4 years/1000 live births) was of 39/1000, significantly higher than the global target of U5MR set out in the Sustainable Development Goals (30/1000). [1]

Also, there are notable differences between the U5MR in HICs (U5MR of 5/1000) compared to low income countries (U5MR of 66/1000).[4] Even with the remarkable drop of U5MR by more than 50% from 1990 to 2015, the universal progress in child survival reflects a gap in achieved goals between high and low resource settings.[4]

In 2015, the WHO ranked depression as the single largest contributor to global disability, causing 7.5% of all Years Lived with Disability (YLDs).[5] Worldwide, depression is almost twice as common in women of childbearing age than in men. Maternal mental disorders affect children in different domains, including nutritional status, health outcomes, cognitive, and socio-emotional development.[6, 7] Infants born to women with untreated depression are at risk of prematurity, low birth weight, and intrauterine growth restriction.[8] After delivery, maternal depression can lead to diminished ability to meet child's needs, which can lead to increased child morbidity and mortality. Also, depression can cause mothers not to seek medical advice nor breastfeed their infants. [9] Compared to High-Income Countries (HICs), mothers in LMICs have greater rates of depression after childbirth.[10,11,12] However, few studies have addressed correlates of maternal depression in LMICs.[11] Maternal depression increases risk of suicide, which is a leading cause of mortality in women of child-bearing age.[13] In general, maternal

depression can deprive children of needed care.[14,15] That deprivation can lead to more illnesses and stunted growth of those children, and consequently decreased survival.[16]

The CHAIN Network is a global research network focused on optimizing the management and care of the sick and undernourished child in resource-limited settings to improve survival.[17] The CHAIN Network aims to identify the biological mechanisms and the socio-economic factors that determine a child's risk of mortality in the six months following presentation to medical care with an acute illness.[17] Although treating mothers with depression in LMICs led to a decrease in undernourishment and diarrheal diseases in some studies[18], delivery of maternal mental health services is still an underutilized intervention to reduce the U5MR in those low resource settings.[18] Maternal depression is a substantial problem for many women in LMICs, but it is often not properly diagnosed and as a consequence, frequently left untreated. [19] There are many social, environmental and political factors that are common across many settings with low resources that might contribute to maternal depression.[11, 18, 19]

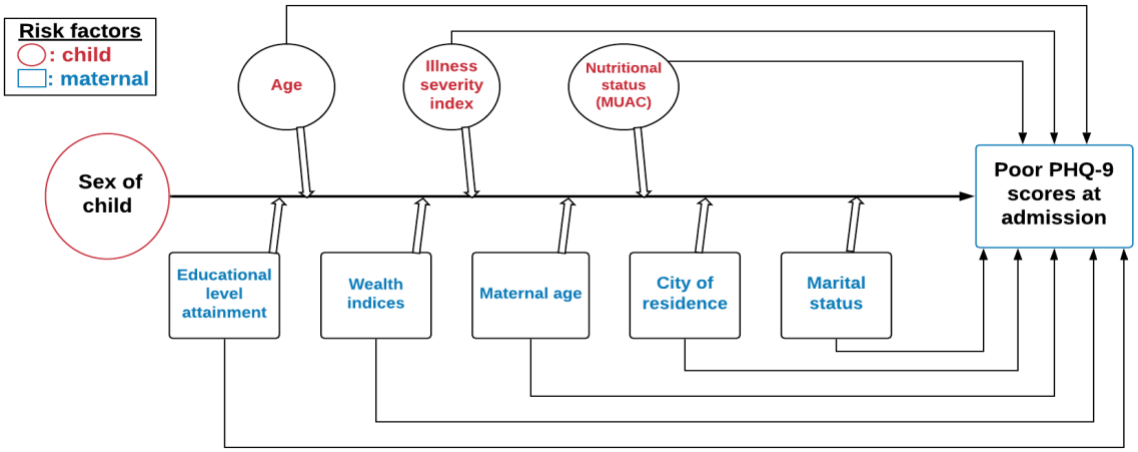
Several risk factors have been shown to increase susceptibility to maternal depression including intimate partner violence, maternal low educational attainment, lack of social support, and low socioeconomic status.[19, 20, 21, 22] Several programs and networks recommended that these identified risk factors be taken into account when maternal depression in LMICs is being studied.[23, 24] The time around a child's illness may represent a particularly vulnerable period for mothers. There may be additional risk factors for maternal depression in these mothers and these risk factors may offer insight into additional interventions.

Male gender bias, or "baby boy preference", is common in many LMICs.[25, 26, 27, 28] In some low resource settings, families consider their male children to be an investment. A study of the fetal gender effect in a cohort of Chinese women showed that postpartum depression

among those who gave birth to a female infant was 24.6%, while the rate in those women who gave birth to a male infant was 12.2%.[22] In India, male children carry with them certain benefits valued by parents such as taking care of them in old age, while girls are expected to marry and move to their husband's home.[29] Another study from India shows that, compared to girls, boys are more likely to be breastfed longer and to be given vitamin supplements.[30] Other studies conducted in Kenya[31], Nigeria[32], India[33], and Sudan[34] show male gender bias as well. Moreover, a systematic review of perinatal depression in LMICs showed that giving birth to female was a risk factor for common perinatal mental disorders with odds ratio [OR] range: 1.8 (95% CI: 1.4–2.3), 2.6 2.6 (95% CI: 1.2–6.5).[10]

Using the data collected from the CHAIN Network's parent study, we tested three hypotheses. First, we tested the hypothesis that compared to an admitted acutely ill female child, admission of an acutely ill male child will be correlated with the presence of depressive symptoms identified with higher PHQ-9 scores. Second, we tested the hypothesis that a range of modifiable factors (child's illness severity, child's nutritional status, maternal educational level attainment, city of residence, and wealth) and non-modifiable factors (maternal age and child's age) affect the relationship between sex of child and the presence of depressive symptoms identified with higher PHQ-9 scores. Third, we tested the hypothesis that the same range of modifiable risk factors (child's illness severity, child's nutritional status, maternal educational level attainment, city of residence -urban v. rural-, and wealth) and non-modifiable risk factors (maternal age and child's age) are correlates of depressive symptoms identified by higher PHQ-9 scores. Furthermore, each site will be tested as a possible correlate of depressive symptoms among participating subjects, as we hypothesized that living in rural cities in LMICs would be associated with depressive symptoms manifested with higher PHQ-9 scores.

**Figure 1: (**Conceptual framework)




## Methods

**Study design**: The parent study, a longitudinal cohort study, was conducted by the CHAIN Network at nine sites within six LMICs. The study aims to identify the biological mechanisms and the socio-economic factors that determine a child's risk of mortality in the six months following presentation to medical care with an acute illness. Between January 2018 and April 2019, demographic and socioeconomic data were collected from the caregivers of the admitted acutely ill children. In addition, they were asked to complete the patient health questionnaire-9 (PHQ-9) within 6 hours of their children's admission. The Patient Health Questionnaire (PHQ-9) is a depression screening tool.[35, 36] The PHQ-9 scores each of the nine DSM-IV criteria for Major Depressive Disorder as "0" (not at all) to "3" (nearly every day).[37] In one study conducted in high-resource settings, after the participating subjects self-administered the PHQ-9, mental health professionals re-interviewed the same subjects as the criterion standard; a PHQ-9 score ≥10 had a sensitivity of 88% and a specificity of 88% for major depression.[38] The PHQ-9 has been validated as a screening tool for depression in LMICs such as in Kenya[39], Uganda[40], Malawi[41], and Pakistan[42].

The CHAIN Network's Cohort study received ethical approval from University of Oxford, University of Washington, and appropriate site-specific bodies, and is registered with clinicaltrials.gov.[43] This analysis was not human subjects research as all data were de-identified. All analyses were conducted in R.

**Setting**: This study was conducted at multiple health care facilities in Kenya, Uganda, Malawi, Burkina Faso, Bangladesh and Pakistan. In Kenya, there are 3 participating hospitals; Kilifi County hospital, Mbagathi District Hospital in Nairobi, and Migori Sub-county Referral Hospital. In Bangladesh, there are two hospitals from two different cities (Dhaka and Matlab). Only one hospital participated in the CHAIN Network's parent study from each of the following cities: Blantyre in Malawi, Karachi in Pakistan, Kampala in Uganda, and Banfora in Burkina Faso.

**Selection of study subjects**: Subjects were identified from the CHAIN Network's parent study that was conducted at nine hospitals with the aforementioned six LMICs. At each site, the parent study aimed to recruit approximately 625 children between 2 and 23 months old. Out of those 625 children, the parent study aimed to recruit 500 acutely ill children admitted to hospital. Of those 500 admitted children, 200 children had severe acute malnutrition, 200 children had moderate acute malnutrition, and 100 without malnutrition.

Approximately 125 non-acutely ill children from the community catchment area were recruited in order to establish community norms for demographic and biological factors. These community norms are used to define recovery from acute illness and will help the study establish why acutely ill children remain at risk of death after apparent recovery defined by current clinical tools. Hospitalized children were enrolled to the parent study, and assessed by questionnaires and clinical examination at admission, during hospitalization, and at discharge.

Eligible children's caregivers were approached for consent at admission to hospital.

*Inclusion criteria*: for the parent study, caregivers of the eligible children were consented and completed the study assessments. For our secondary analysis, only the consented biological mothers of acutely ill hospitalized children that met the aforementioned parent study inclusion criteria were included in this secondary analysis. At admission of their children, the mothers were asked to complete a self-administered PHQ-9 and other questionnaires, and they received a physical examination and their anthropometric measures were recorded.

*Exclusion criteria*: for the current study, I excluded the caregivers who were not biological mothers as well as the caregivers (including the biological mothers) of the non-acutely ill children that were recruited from the community catchment (figure 2).

**Data collection**: The PHQ-9 was self-administered, completed, and collected from the mothers who consented upon the admission of their acutely ill children to the hospitals participating in the CHAIN Network's parent study. In addition to maternal demographic data and anthropometric measures, the child's age in months, the child's mid-upper arm circumference (MUAC), the child's nutritional status, and the child's illness severity, were all measured and documented upon admission.

**Measures:** We used indices that were created by the CHAIN Network team. These indices are: the food insecurity index, the child's illness severity index, and three wealth indices; wealth index 1, wealth index 2, and wealth index 3. The wealth indices were made by using principle component analysis. Wealth index 1 is a score of how rural and poor the subject is, as it loads on animal ownership and distance to water source. Wealth index-2 loads on animals, Televisions, and cellphones ownership. Wealth index-3 loads on radios and smartphone ownership.

**Statistical Analysis**: All statistical analyses were performed in R. The cumulative PHQ-9 score (our outcome) was coded as a continuous variable.

*Relationship between the sex of the child and the depressive symptoms (hypothesis 1a)*: linear regression was used to estimate the association between the sex of the child and the presence of depressive symptoms identified by the presence of higher PHQ-9 scores.

*Effect modification of different variables on the relationship between the sex of the child and the depressive symptoms identified by higher PHQ-9 scores (hypothesis 1b):*

the tested variables included continuous variables which are maternal age, child illness severity index, wealth index, and food insecurity index. The tested variables also included the following categorical variables which are sex of the child, city of residence, maternal marital status, and maternal educational level attainment. Interaction terms between the index child's sex and the exposures of interest were built and significance tests were conducted in these models (Equation1). After univariate interaction testing, exposures with a significant interaction were included in a site adjusted model to establish if observed interactions are attributable to differences across sites.

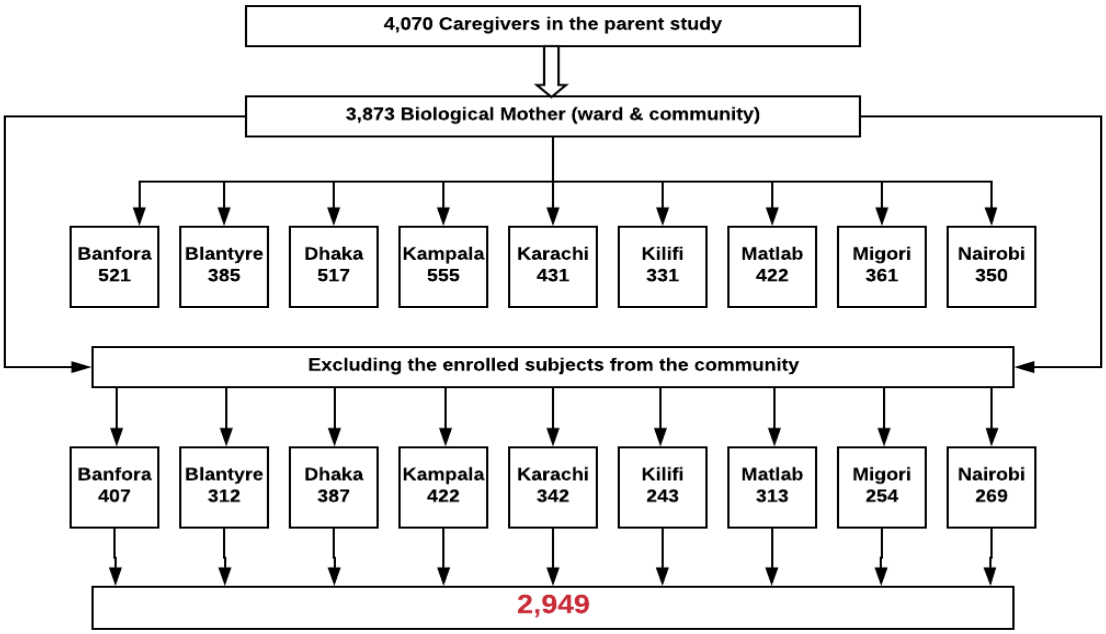
**Equation 1**: $PHQ - 9 = B_0 + B_1 * SEX + B_2 * Exposure + B_3 * Sex * Exposure$

*Correlates of depressive symptoms identified by higher PHQ-9 scores (hypothesis 2):* Each exposure of interest was included in a site-adjusted model. Those with a statistically significant relationship were then carried into a multivariate analysis to test for independent associations.

**Sample size**: 4,070 primary caregivers were consented and enrolled in the CHAIN Network's parent study. For this secondary analysis, only biological mothers were included, as the main focus is to investigate the correlates of high PHQ-9 scores which indicated the presence of maternal depressive symptoms. Of the 4,070 primary caregivers included in CHAIN, 3,873

biological mothers were identified. Biological mothers of the non-acutely ill children that were recruited from the community catchment area were excluded from the secondary analysis. A total of 2,949 biological mothers were included in this analysis. For an exposure of interest present in 10% of mothers, and a 20% prevalence of depressive symptoms measured with PHQ-9 scores, this sample size gives us 80% power to detect an absolute increase in prevalence of poor PHQ-9 scores of 7%, assuming an alpha of 0.05.

**Figure 2:** (Sampling process and size)




## Results

*Characteristics of the cohort*: The mean cumulative PHQ-9 score was 7.4 (standard deviation (SD) = 4.6). In each participating site, the number of admitted male children exceeded the number of admitted female children (Table 1). Overall, there were n=1671 male children (57%) and n=1278 female children (43%); however, the prevalence of our exposures of interest appeared well balanced between male and female children. The mean age of the mothers was 26

years (SD= 5.7) (Table 1). In rural sites (Banfora, Kilifi, Matlab, and Migori), percentages of mothers with admitted male children and female children were balanced [n=694 (42%) and n=523 (41%), respectively). Also, 1108 (66%) mothers with male children and 891 (70%) mothers with female children had attained either primary or secondary education. Monogamous marriage was common in the cohort and distribute evenly among mothers of admitted male children (n=1310;78%) and mothers of admitted female children (n=994; 78%) (Table 1). The children's mean age in months was 10.7 months (SD= 5.8). The illness severity index was categorized into three groups; mild, moderate, and severe. There were 791 male children (38%) and 635 female children (40%), with moderate to severe illness. There were 1522 child (51%) with mild illness, 1109 (38%) with moderate illness, and 314 (11%) with severe illness. There were 542 male children (33%) and 503 female children (39%), with severe acute malnutrition (Table 1).

*Univariate/ Bivariate models:* the sex of the child was not associated with PHQ-9 scores (Table 2). Other factors had statically significant associations with the PHQ-9 scores: site of residence represented in six sites: Blantyre (β -2.3, 95% CI 3.0, -1.7, p <0.001); Kampala (β: 1.2, 95% CI 0.5, 2.0, p <0.001); Karachi (β: -1.3, 95% CI 2.0, -0.6, p <0.001); Matlab (β: -4.4, 95% CI -4.7, -4.0, p <0.001); Migori (β: 3.8, 95% CI 2.6, 4.9, p <0.001); and Nairobi (β: 2.5, 95% CI 1.7, 3.3, p <0.001). In addition, maternal and child variables associated with PHQ-9 scores were: the mother being the primary financial provider of the family (β: 1.8, 95% CI 1.1, 2.5, p<0.001); the mother being in a monogamous marriage (β: -2.0, 95% CI -2.6, -1.3, p<0.001); food insecurity (β: 0.5, 95% CI 0.4, 0.6, p<0.001); wealth index #2 (β: -0.4, 95% CI -0.5, -0.3, p<0.001); wealth index #3 (β: 0.4, 95% CI: 0.2, 0.5, p<0.001); illness severity (β: 5.0, 95% CI 3.1, 7.0, p<0.001); and the nutritional status (MUAC in centimeters) (β: -0.3, 95% CI -0.5, 0,2, p <0.001).

*Interactions/ effect modifiers:* two variables showed interaction with the sex of the child: i) mother with an admitted male child at Migori site in Kenya (β: -1.7, 95% CI -3.2, -0.3, p<0.05), and ii) mother of an admitted male child that is the primary financial provider for her family (β -1.7, 95% CI -2.4, -1.1, p <0.001).

*Site-adjusted univariate model:* after adjusting for site in a univariate model, those exposures of interest that showed association with PHQ-9 scores (Table 2, coefficients) were included in a site-adjusted univariate model. The following exposures of interest were associated with maternal PHQ-9 scores: food insecurity (β: 0.4, 95% CI 0.4, 0.5, p <0.001); wealth index #1 (β: 0.1,95% CI 0.0, 0.2, p< 0.03); wealth index #2 (β: -0.2, 95% CI -0.3, -0.1, p <0.001); and wealth index #3 (β: -0.3, 95% CI -0.4, -0.1, p <0.001); advanced maternal age (β: 0.4, 95% CI 0.1, 1.0, p=0.013); and the mother being in a monogamous marriage (β: -1.2, 95% CI -1.7, -0.7, p<0.001) (Table 3).

*Multivariate model - Correlates of PHQ-9*: three sites showed negative correlation with PHQ-9 scores. These sites are: Blantyre (β: -3.5, 95% CI of -4.3, -2.7, p<0.001); Karachi (β: -2.9, 95% CI -3.7, -1.8, p<0.001; and Matlab (β: -4.1, 95% CI -4.8, -3.5, p<0.0001). The site of Migori showed positive correlation with PHQ-9 scores (β: 1.0, 95% CI 0.0, 1.9, p<0.04) (Table 3).

Other exposures that showed positive independent associations (i.e. higher PHQ-9 scores) with maternal PHQ-9 scores are: i) food insecurity (β: 0.4, 95% CI 0.3, 0.5, p <0.01); and ii) older child's age (in months) (β: 0.3, 95% CI 0.0, 0.6, p<0.05). (Table 3)

Exposures that showed negative independent associations (i.e. lower PHQ-9 scores) are: i) being in a monogamous marriage (β: -1.2, 95% CI -1.7-, -0.7, p <0.05); and ii) higher MUAC (which is an indicator for a better nutritional status) (β: -0.2, 95% CI -0.3, -0.1, p<0.001) (Table 3).

The illness severity did not show independent association with PHQ-9 scores (β: 1.2, 95% CI -0.1, 2.4, p >0.08) (Table 3).

*Effect modifiers*: the site of Migori showed effect modification of the relationship between the sex of the child and the PHQ-9 scores by (β: 0.7, 95% CI -0.1, 1.7, p=0.04). However, being the primary financial provider no longer appears to be an effect modifier for the same relationship (β 0.0, 95% CI -0.1, 0.04, p=0.28). (Table 3)

## Discussion

We found no overall association between the sex of the admitted child and maternal PHQ-9 scores, but at the Migori hospital site having a male child was associated with lower PHQ-9 scores. We also found a crude interaction between the sex of the child and the mother being the primary financial provider, but this interaction appeared to be an artifact of the higher rates of maternal employment in Migori county. Four sites, which are Blantyre, Karachi, Matlab, and Migori, were found to be independent predictors of PHQ-9 scores. Other predictors of PHQ-9 scores that were found are: food insecurity, older child's age (in months), being in a monogamous marriage, and higher MUAC scores.

*Relationship between the sex of the child and the depressive symptoms (hypothesis 1a)*: Because of the observed phenomenon of gender bias (a.k.a. baby boy preference) in some LMICs in Africa and Asia[25, 26, 27,44] during the postpartum period, we explored the sex of the child as a correlate of maternal depressive symptoms. We hypothesized that compared to an admitted acutely ill female child, admission of an acutely ill male child will be correlated with higher maternal PHQ-9 scores. We didn't find in literature the role of child's sex on maternal PHQ-9 scores or depression in this specific context. In our analysis, we aimed to test whether the data collected from nine sites within six LMICs would be consistent with the literature on baby boy preference. We found

no difference in mothers' PHQ-9 scores in relation to the sex of the admitted acutely ill child in univariate analyses.

*Differences among sites of residence:* the site of residence was among the exposures of interest that we investigated its effect on PHQ-9 scores as well as its potential effect modification on the relationship between the sex of the child and the maternal PHQ-9. One important aspect to consider when interpreting the results from these cities is their rural, urban, or mixed nature. In some studies, evidence show that compared to rural cities[45,46], living in urban cities correlates with perinatal depression[47,48]. Though, in other studies evidence show that, compared to living in urban cities, living in rural cities correlates with a higher risk of maternal depression, which might be related to the lack of medical services as well as the low maternal educational level attained[10,49,50]that in turn might be related to gender inequality. In our analysis, we hypothesized that in the context of admitting and acutely ill child to a hospital, living in a rural site would correlate with higher PHQ-9 scores. Sites of Blantyre in Malawi (urban), Karachi in Pakistan (urban), and Matlab in Bangladesh (rural) were correlated with lower PHQ-9 scores, while Migori in Kenya (rural), Kampala in Uganda (urban), and Nairobi in Kenya (urban) showed correlation with higher PHQ-9. Migori is a rural site where its residents work mainly in agriculture, fishing, and mining. Compared to other participating sites, Migori has the lowest income. Female genital mutilation is a common practice there. Also, women in Migori suffer from gender inequality which leads to quitting schools and getting married at an early age. When comparing between the risk factors of depression among different cities in different countries, it is crucial to think about the role of the sociocultural practices in each of those cities. Understanding the roots of these practices and their effects on the people can explain why similar settings showed different results towards a set of risk factors. Moreover, considering the different

socio-politico-cultural backgrounds of the cities/ countries in comparison would make the interpretation more valid. For example, in our study, some cities had a majority of Muslim populations while other cities have a majority of Christian populations. Religious and spiritual practices can be protective factors against depression [51,52,53] but with such different backgrounds, an individual analysis for each site would provide more understanding.

*Effect modification of different variables on the relationship between the sex of the child and the depressive symptoms identified by higher PHQ-9 scores (hypothesis 1b):* we hypothesized that a range of modifiable factors (child's illness severity, child's nutritional status, maternal educational level attainment, rural/ urban residence, and wealth index) and non-modifiable factors (maternal age and child's age) effect the relationship between sex of child and maternal PHQ-9 scores. Only the site of Migori showed an interaction with sex of the child, such that having a male child in Migori was associated with lower PHQ-9 scores. Living in Migori is the only effect modifier of the relationship between the sex of the child and the PHQ-9 scores. Migori was the only site of residence where having a male child was associated with lower PHQ-9 scores, which was the opposite of what we hypothesized that a male child preference would be reflected in higher PHQ-9 scores for an acutely ill male compared to an acutely ill female child. That might be attributed to the gender bias phenomenon that is embedded in many cities in LMICs. Another important point to consider is that urbanicity or rurality may not be the salient characteristic of these sites that is influencing the relationship with depressive symptoms.

*Other correlates of depressive symptoms identified by higher PHQ-9 scores (hypothesis 2):* we found that the following exposures are correlated with higher PHQ-9 scores: i) mother is not in a monogamous marriage; ii) food insecurity; iii) older child's age at admission; and iv) increased severity of child's acute malnutrition.

Multiple studies show that low socioeconomic status[26,54,55], food insecurity,[56,57] child malnutritional status[58], advanced maternal age[59,60], and not being in a monogamous marriage[44,61,62,63], are all determinants of maternal depression. In the literature, maternal low educational attainment was found to be related to maternal depression [23,55], but in our results, low maternal educational level was not found to be associated with poor PHQ-9 scores. More than two thirds of the subjects in our analysis reported finishing at least primary or secondary education. This inconsistency of our results with literature can be due to confounding by site of residence. Advanced maternal age has been associated with maternal depression[59, 60], though not in our sample. This might be attributed to not having enough women of advanced maternal age in our sample.

Although wealth index-1 hypothetically looks highly correlated with site, but it didn't show an association in the bivariate model, but it showed significance in the site-adjusted univariate model. Wealth index-2 and wealth index-3, both showed association with PHQ-9 scores, but without interaction with the sex of the child. When included in site-adjusted univariate models, wealth index-2 and wealth index-3 were correlated with lower PHQ-9 scores. When the three indices were included in a multivariate model, none of them showed independent association with PHQ-9 scores. In site adjusted models being affluent (wealth index-1, wealth index-2 & wealth index-3) reduced PHQ-9 but in multivariate analysis this was not true. This would indicate the SES factors are not independent of the covariates, perhaps because their effect is mediated by other variables in the model.

Increasing the child's age didn't show interaction with child sex, though it showed evidence of association in the site-adjusted univariate model as well as in the multivariate model which means that, in our results, older child age was found to be independently associated with higher

PHQ-9 scores. We hypothesized that child malnutrition (measured by mid-upper arm circumference -MUAC) would be a correlate of poor PHQ-9 scores. Our results proved that, which is consistent with what we found in literature before we conduct our analysis. From the mother's perspective, that can be a sign of a serious illness that can lead to the loss of her child, which can explain the high PHQ-9 scores. The direction of this relationship is not very clear as it might be unidirectional or bidirectional. In other words, Children with depressed mothers may be at greater risk of poor nutrition, and mothers of malnourished children may show more depressive symptoms.

*Illness severity index and its correlation to maternal depressive symptoms:* as it represents the main premise of our study, we hypothesized that as child's illness severity increases, the higher the PHQ-9 score will be, which was evident and showed significance in bivariate models and site-adjusted univariate model, but not in the multivariate model. This suggests that illness severity has no independent association with maternal PHQ-9 scores. Considering this specific context, we could not find literature regarding the relationship between the admitted child's illness severity and maternal PHQ-9 scores or depressive symptoms in similar circumstances.

## Limitations

The results of this study should be interpreted with caution. In addition, this is a cross-sectional study and there is no follow up of the subjects over time nor information about past depressive episodes/ symptoms. Despite the multiple comparisons, these results cannot be generalized to the rest of the LMICs. In addition, psychological effects attributable to gender of child if any, have been studied in the immediate postpartum period –these effects may not hold several months postpartum. The median age in the current study was 10 months.

Despite these limitations, our study has several strengths. This is a cross-sectional study, though there is longitudinal data from the parent study that can be analyzed in the future. The analysis introduced important knowledge regarding the correlates of poor maternal PHQ-9 scores upon the admission of acutely ill children to nine sites in six LMICs. To our knowledge, no studies in the past have tackled the topic of maternal depressive symptoms within the context of a study of child survival. The study informs research child survival. It is crucial to have maternal mental health assessments embedded in research in Under-5 survival to investigate the possible correlates of maternal depression and its effects on child's survival. Our study fills a knowledge gap in LMICs, especially with the lack of mental health research in settings with limited resources. Also, many of our results were consistent with literature, and can be used for further research in the future. Importantly, this is a rich longitudinal data set with the potential for studying much more about the relationship between maternal mental health and child survival.

## Conclusion

We did not find evidence to suggest that compared to an admitted acutely ill female child, admission of an acutely ill male child will be correlated with higher maternal PHQ-9 scores. However, our data suggest that the correlates of poor PHQ-9 scores can be used to leverage the child and maternal health care systems in LMICs, especially in our six participating countries. Paying attention to the presence of these correlates in the context of admitting acutely ill children to hospitals in LMICs could inform the future research concerning maternal depression interventions as well as the provided mental health services, which in turn could ameliorate the child survival and wellness. Embedding questions into routine maternal and child health that emphasize the marital status of the mother, the food security status of the household, and the

child's nutritional status, can improve the screening for depression. In addition, training the health care professionals on understanding how these correlates can impact the maternal mental health, can help ameliorate the delivery of mental health services in LMICs.

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| Table 1 | Male Child n=1,671 (%) | Female Child n=1,278 (%) |
|---|---|---|
| **Residence/ Site** | | |
| Banfora* (407) | 236 (14%) | 171 (13%) |
| Blantyre (312) | 173 (10%) | 139 (11%) |
| Dhaka (387) | 241 (14%) | 146 (11%) |
| Kampala (422) | 229 (14%) | 193 (15%) |
| Karachi (342) | 186 (11%) | 156 (12%) |
| Kilifi* (243) | 136 (8%) | 107 (8%) |
| Matlab* (313) | 181 (11%) | 132 (10%) |
| Migori* (254) | 141 (8%) | 113 (9%) |
| Nairobi (269) | 148 (9%) | 121 (9%) |
| **Maternal characteristics** | | |
| **Age (years)[a]** | | |
| <18 | 48 (3%) | 43 (3%) |
| ≥18 <35 | 1,611 (96%) | 1,221 (96%) |
| ≥35 | 5 (0%) | 4 (0%) |
| **Education[b]** | | |
| < Primary | 453 (27%) | 306(24%) |
| Primary - secondary | 1,108 (66%) | 891 (70%) |
| > Secondary | 106 (6%) | 76 (6%) |
| **Marital status** | | |
| Married monogamous | 1,310 (78%) | 994 (78%) |
| Other | 360 (22%) | 280 (22%) |
| **Household** | | |
| **Food insecurity** | | |
| Low | 714 (43%) | 537 (42%) |
| Medium | 585 (35%) | 486 (38%) |
| High | 364 (22%) | 248 (19%) |
| **Wealth index 1** | | |
| Low | 391 (24%) | 290 (23%) |
| Medium | 927 (55%) | 708 (55%) |
| High | 353 (21%) | 280 (22%) |
| **Wealth index 2** | | |
| Low | 269 (16%) | 192 (15%) |
| Medium | 1,125 (67%) | 866 (68%) |
| High | 277 (17%) | 220 (17%) |
| **Wealth index 3** | | |
| Low | 456 (27%) | 378 (30%) |
| Medium | 1,085 (65%) | 806 (63%) |
| High | 130 (8%) | 94 (7%) |
| **Child characteristics** | | |
| **Age (months)** | | |
| 2-5 | 380 (23.0%) | 250 (20.0%) |
| 6-11 | 612 (37.0%) | 474 (37.0%) |
| 12-24 | 679 (40.0%) | 554 (43.0%) |
| **Illness severity** | | |
| Mild | 880 (52.7%) | 642 (50.3%) |
| Moderate | 615 (36.8%) | 494 (38.7%) |
| Severe | 176 (10.5%) | 141 (11.0%) |
| **Nutritional status (MUAC)** | | |
| SAM (<11.5) | 542 (32.5%) | 503 (39.4%) |
| MAM (≥ 11.5 < 12.5) | 450 (27.0%) | 348 (27.3%) |
| NAM (> 12.5) | 676 (40.5%) | 426 (33.3%) |

**Table 1: Participant characteristics**. * Indicates rural site; a= 16 missing cases; b= 9 missing cases; c= 101 missing cases; d= 9 missing cases.

| Table 2 | Coefficient (95% CI) | Interaction coefficient (95% CI) |
|---|---|---|
| **Sex of the child** | 0.3 (-0.1, 0.6) | |
| **Residence/ site** | | |
| Banfora | 0.5 (-0.2, 1.1) | 0.7 (-0.1, 1.5) |
| Blantyre | -2.3 (-3.0, -1.7)** | 0.5 (-0.5, 1.4) |
| Dhaka | 0.2 (-0.5, 0.9) | 0.2 (-0.8, 1.2) |
| Kampala | 1.2 (0.5, 2.0)** | 0.5 (-0.6, 1.5) |
| Karachi | -1.3 (-2.0, -0.6)** | -0.6 (-1.5, 0.2) |
| Kilifi | -0.3 (-1.3, 0.7) | 0.6 (-0.8, 2.0) |
| Matlab | -4.4 (-4.7, -4.0)** | -0.4 (-0.8, 0.1) |
| Migori | 3.8 (2.6, 4.9)** | -1.7 (-3.2, -0.3)* |
| Nairobi | 2.5 (1.7, 3.3)** | 0.2 (-0.9, 1.3) |
| **Maternal** | | |
| BMI | 0.0 (0.0, 0.1) | 0.0 (0.1, 0.1) |
| Age | 0.0 (0.0, 0.1) | 0.1 (0.0, 0.1) |
| 1ry financial provider | 1.8 (1.1, 2.5)** | -1.7 (-2.4, -1.1)** |
| Marital status | -2.0 (-2.6, -1.3)** | -0.4 (-1.3, 0.5) |
| Educational level | 0.0 (-0.3, 0.3) | -0.2 (-0.4, 0.4) |
| Consanguinity | -0.7 (-1.3, -0.1)* | -0.5 (-1.4, 0.3) |
| **Household** | | |
| Food insecurity | 0.5 (0.4, 0.6)** | 0.0 (-0.2, 0.1) |
| Wealth index 1 | 0.1 (0.0, 0.2) | 0.0 (-0.2, 0.2) |
| Wealth index 2 | -0.4 (-0.5, -0.3)** | 0.0 (-0.2, 0.2) |
| Wealth index 3 | 0.4 (0.2, 0.5)** | 0.1 (-0.2, 0.3) |
| **Child** | | |
| Age (months) | 0.0 (0.0, 0.1) | 0.0 (0.0, 0.1) |
| Illness severity | 5.0 (3.1, 7.0)** | -1.7 (-4.3, 0.9) |
| Nutritional status | -0.3 (-0.5, -0.2)** | 0.1 (-0.1, 0.3) |

**Table 2: Interactions between effect modifiers of interest and the sex of the admitted child**. ** Indicates p-Value <0.001; * indicates p-value<0.05

| Table 3 | Univariate adjusted by site | Multivariate (95% CI) |
|---|---|---|
| **Residence/ Site** | | |
| Banfora | | -- |
| Blantyre | | -3.5 (-4.3, -2.7)** |
| Dhaka | | -- |
| Kampala | | -0.3 (-1.3, 0.6) |
| Karachi | | -2.9 (-3.7, -1.8)** |
| Kilifi | | -- |
| Matlab | | -4.1 (-4.8, -3.5)** |
| Migori | | 1.0 (0.0, 1.9)* |
| Nairobi | | 0.7 (-0.1, 1.7) |
| **Maternal** | | |
| Nutritional status (BMI) | -0.01 (-0.1, 0.03) | -- |
| Age | 0.0 (0.0, 0.1) * | 0.0 (0.0, 0.1) |
| As 1ry financial provider | 0.0 (-0.1, 0.04) | -- |
| Marital status | -1.2 (-1.7, -0.7)** | -0.8 (-1.3, -0.3)* |
| Educational level | -0.2 (-0.5, 0.0) | -- |
| Consanguinity | -0.2 (-0.7, 0.2) | -- |
| **Household** | | |
| Food insecurity | 0.4 (0.4, 0.5)** | 0.4 (0.3, 0.5)** |
| Wealth index 1 | 0.1 (0.0, 0.2)* | 0.0 (-0.2, 0.1) |
| Wealth index 2 | -0.2 (-0.3, -0.1)** | 0.0 (-0.1, 0.1) |
| Wealth index 3 | -0.3 (-0.4, -0.1)* | -0.1 (-0.2, 0.1) |
| **Child** | | |
| Age at admission (months) | 0.0 (0.0, 0.1)* | 0.3 (0.0, 0.6)* |
| Illness severity | 1.5 (0.2, 2.7)* | 1.2 (-0.1, 2.4) |
| Nutritional status (MUAC) | -0.2 (-0.3, -0.1)** | -0.2 (-0.3, -0.1)** |

**Table 3: Linear regression models with adjustment for site and multivariate analysis to test for correlates of PHQ-9 scores**. ** Indicates p-Value <0.001; * indicates p-value <0.05

## PATIENT HEALTH QUESTIONNAIRE (PHQ-9)

NAME:_____ DATE:_____

Over the last *2 weeks,* how often have you been bothered by any of the following problems?
*(use "✓" to indicate your answer)*

| | Not at all | Several days | More than half the days | Nearly every day |
|---|---|---|---|---|
| **1.** Little interest or pleasure in doing things | 0 | 1 | 2 | 3 |
| **2.** Feeling down, depressed, or hopeless | 0 | 1 | 2 | 3 |
| **3.** Trouble falling or staying asleep, or sleeping too much | 0 | 1 | 2 | 3 |
| **4.** Feeling tired or having little energy | 0 | 1 | 2 | 3 |
| **5.** Poor appetite or overeating | 0 | 1 | 2 | 3 |
| **6.** Feeling bad about yourself—or that you are a failure or have let yourself or your family down | 0 | 1 | 2 | 3 |
| **7.** Trouble concentrating on things, such as reading the newspaper or watching television | 0 | 1 | 2 | 3 |
| **8.** Moving or speaking so slowly that other people could have noticed. Or the opposite —being so figety or restless that you have been moving around a lot more than usual | 0 | 1 | 2 | 3 |
| **9.** Thoughts that you would be better off dead, or of hurting yourself | 0 | 1 | 2 | 3 |
| | add columns | | + | + |
| *(Healthcare professional: For interpretation of TOTAL, please refer to accompanying scoring card).* | TOTAL: | | | |

| | |
|---|---|
| **10.** If you checked off *any problems,* how *difficult* have these problems made it for you to do your work, take care of things at home, or get along with other people? | Not difficult at all _____<br>Somewhat difficult _____<br>Very difficult _____<br>Extremely difficult _____ |


A2663B 10-04-2005

**Figure 3: PHQ-9 questionnaire**