ORIGINAL ARTICLE

Impact of Maternal Depression on Infant Nutritional Status and Illness

A Cohort Study

Atif Rahman, PhD; Zafar Iqbal, MSc; James Bunn, MSc, MRCP; Hermione Lovel, PhD; Richard Harrington, MD

Background: The risk for emotional and behavioral problems is known to be high among children of depressed mothers, but little is known about the impact of prenatal and postnatal depression on the physical health of infants.

Objective: To determine whether maternal depression is a risk factor for malnutrition and illness in infants living in a low-income country.

Design: Prospective cohort study.

Setting: Rural community in Rawalpindi, Pakistan.

Participants: Six hundred thirty-two physically healthy women were assessed in their third trimester of pregnancy to obtain at birth a cohort of 160 infants of depressed mothers and 160 infants of psychologically well mothers.

Main Outcome Measures: All infants were weighed and measured at birth and at 2, 6, and 12 months of age, and they were monitored for episodes of diarrhea and acute respiratory infections. The mothers' mental states were reassessed at 2, 6, and 12 months. Data were collected on potential confounders of infant outcomes, such as birth weight and socioeconomic status.

Results: Infants of prenatally depressed mothers showed significantly more growth retardation than controls at all time points. The relative risks for being underweight (weight-for-age *z* score of less than –2) were 4.0 (95% confidence interval [CI], 2.1 to 7.7) at 6 months of age and 2.6 (95% CI, 1.7 to 4.1) at 12 months of age, and the relative risks for stunting (length-for-age *z* score of less than –2) were 4.4 (95% CI, 1.7 to 11.4) at 6 months of age and 2.5 (95% CI, 1.6 to 4.0) at 12 months of age. The relative risk for 5 or more diarrheal episodes per year was 2.4 (95% CI, 1.7 to 3.3). Chronic depression carried a greater risk for poor outcome than episodic depression. The associations remained significant after adjustment for confounders by multivariate analyses.

Conclusions: Maternal depression in the prenatal and postnatal periods predicts poorer growth and higher risk of diarrhea in a community sample of infants. As depression can be identified relatively easily, it could be an important marker for a high-risk infant group. Early treatment of prenatal and postnatal depression could benefit not only the mother's mental health but also the infant's physical health and development.

Arch Gen Psychiatry. 2004;61:946-952

From the School of Psychiatry and Behavioural Sciences, University of Manchester, Manchester, England (Drs Rahman and Harrington); Human Development Research Foundation, Islamabad, Pakistan (Dr Rahman and Mr Iqbal); Department of Tropical Child Health, Liverpool School of Tropical Medicine, Liverpool, England (Dr Bunn); and World Health Organization Collaborating Centre for Primary Care, School of Primary Care, University of Manchester (Dr Lovel).

MORE THAN 150 MILLION children under the age of five years in the developing world are malnourished. Malnutrition is implicated in more than half of all child deaths worldwide,[1] and nutritional deficiencies at all stages of growth have long-term damaging effects on the intellectual and psychological development of children.[2,3] Malnutrition thus represents an enormous waste in potential of millions of children.

Half of these children live in South Asia. Determinants of disproportionately higher rates of malnutrition in this largely food-sufficient region are poorly understood,[4] the problem having been referred to as the "Asian enigma."[5] Evidence seems to indicate that as the amount of food available per person increases, its power to reduce child malnutrition weakens.[6] Therefore, attention has gradually been turning to factors other than nutritional intake, such as household behaviors and sociocultural practices, which may influence child health and development.[7]

Depression around childbirth is common, affecting approximately 10% to 15% of all mothers in Western societies.[8] Recent epidemiological findings suggest that prevalence rates may be almost twice as high in South Asian mothers.[9,10] Depression ranks among the top 5 disabling disorders worldwide.[11] There is compelling evidence that maternal depression adversely affects the psychological and intellectual development of children.[12] It is

plausible that maternal depression may also put the child's physical health at increased risk, especially in low-income countries where the environment is frequently more hostile than in the developed world.[13] Maternal depression is also likely to interfere with the emotional quality of child care, which is a known risk factor for poor growth.[14,15] The area is underresearched in low-income developing countries. Three health center–based studies have found positive associations between maternal mental health and infant growth[16-18] but have limitations of small, selective samples and designs that cannot establish the direction of association.

The aim of this study was to systematically investigate the association between prenatal and postnatal maternal depression and infant physical outcomes in a representative rural community–based sample in Rawalpindi, Pakistan, using a longitudinal, prospective cohort design.

METHODS

PARTICIPANTS

The study was carried out in a rural subdistrict 60 km southeast of the city of Rawalpindi. The study area comprised 10 Union Councils (a Union Council is a geographically defined administrative area consisting of 5-10 villages) in the south of the subdistrict, having an area of about 500 km^2 and a population of 150 000. The area is predominantly agrarian, food sufficient, and socioculturally homogeneous. The sample consisted of all women aged 17 to 40 years in their third trimester of pregnancy, recruited from the study area during a 4-month period. Subjects were identified by obtaining official lists from 120 government-employed Lady Health Workers, who routinely collect data on new pregnancies, including an estimate of the gestational age (based on the last menstrual period). Each Lady Health Worker covers a population of 1000 (approximately 130 households) and visits about 30 to 35 houses per week. As an additional incentive, they were paid a small amount for every subject identified. In some villages, these data were verified by employing local traditional birth attendants and key informants to carry out door-to-door surveys. Thus, near-full coverage of the study area was achieved. Identified women were included in the study if they were currently married, did not have a physical illness for which they were undergoing treatment, and had had an uneventful pregnancy. Women with severe depression or other mental disorders were excluded. Stillbirths, infants who died before reaching their first birthday, and infants born with a congenital abnormality were excluded from the study, as were mothers who gave birth prematurely (<37 weeks according to the gestational age calculated by the Lady Health Workers).

PROCEDURES

Assessment of Maternal Depression and Disability

Informed written consent was obtained from all participants after we explained the study and provided a detailed information sheet (local health workers read out and explained the information to nonliterate participants and obtained written consent on their behalf). Mental state was assessed using the Schedules for Clinical Assessment in Neuropsychiatry (SCAN),[19] developed by the World Health Organization as an internationally validated semistructured interview generating *International Classification of Diseases, 10th Revision (ICD-10)*[20] diagnoses of depressive disorder. All interviews were carried out by 2 trained and experienced clinicians. Interrater reliability was established prior to the study when both interviewers independently assessed 20 women (10 had clinical depression) and agreed on the diagnosis of 19 (κ=0.90). Interviews were carried out in the third pregnancy trimester and at 2, 6, and 12 months postnatally by the 2 interviewers who were blind to the health status of the infants. Disability in mothers at these time points was assessed using the crossculturally validated Brief Disability Questionnaire,[21] an 8-item questionnaire asking subjects whether they had been limited in various everyday activities (eg, lifting heavy objects, carrying groceries or goods, climbing stairs, walking uphill, or routine personal and family functions) during the last month. The Brief Disability Questionnaire has a maximum score of 16, constituting a nonparametric, hierarchical scale.

Assessment of Infant Nutritional and Physical Health Status

Infant growth measurements were carried out using standard anthropometric techniques and equipment.[22] All growth measurements, except birth weight, were carried out by a single trained researcher at 2, 6, and 12 months postnatal. Birth weight was measured by trained local health workers. Growth data were converted into standard deviations (z scores) for weight and length using Epi Info 2002 software (Centers for Disease Control, Atlanta, Ga). Infants were classified as underweight or stunted if their weight-for-age z scores or length-for-age z scores were less than −2, on the basis of National Center for Health Statistics/World Health Organization reference data.[23]

Infants of both groups (depressed and nondepressed mothers) were seen fortnightly for a year by the same health workers to assess the number of episodes of diarrhea and acute respiratory infection (ARI) during the previous 2 weeks. Diarrhea was defined as 3 or more unformed stools passed in a 24-hour period, and a diarrheal episode was defined as episodes separated by at least 3 diarrhea-free days; ARI was defined as the presence of cough, nasal/postnasal secretions, and rapid breathing, each episode separated by at least 7 days.[24] On average, a Pakistani child has 5 episodes of diarrhea and 6 episodes of ARI per year.[25] On this basis, these outcomes were classified as 5 or more diarrheal episodes per year or as 6 or more ARI episodes per year. To minimize recall bias, the mother's report of infections during the previous 2 weeks was corroborated from another member of the household, such as the grandmother, the husband, or an older sibling. Records of immunization were assessed at 1 year for all infants in the study, and we classified subjects into those with or without up-to-date immunization status. All infant outcomes were assessed by researchers blind to the psychiatric status of the mother.

Assessment of Economic and Social Status

Depressed and nondepressed mothers were compared on ownership of household assets derived from the World Bank Assets Questionnaire for Pakistan.[26] More subtle socioeconomic differences were assessed by inquiring if the household was in debt and by asking Lady Health Workers, who lived in the same locality and had intimate knowledge of the families being studied, to rate the household on a 5-point Likert scale ranging from 1 (richest) to 5 (poorest). A single dichotomous variable of relative poverty was created by combining these 2 measures, ie, subjects who were both in debt and rated below 3 on the socioeconomic 5-point Likert scale were classified as being relatively poor.

Social support was assessed by inquiring about the traditional *chilla* period: postdelivery confinement of mothers for a period of 40 days, when all domestic responsibilities are taken over by other female family members. The mother is presented fortified dietary items as gifts by friends and neighbors

and assisted in child care by more experienced family members. The completion of the 40-day *chilla* period is a good proxy indicator of social support because it encompasses both family and community support and is an easily understood concept. The mother was asked if she had been able to observe *chilla* for the full 40 days, who had been the main person supporting her during the period, and whether she enjoyed full rest and dietary supplementation. Based on the responses to these queries, the observance of the *chilla* period was rated as satisfactory or not satisfactory, as a proxy measure for social support.

Maternal financial empowerment within the household was measured by asking the mothers if they were given a lumpsum amount of money for day-to-day household expenses and whether they could make independent decisions about its use. Mothers who answered yes to both questions were classified as financially empowered within the household.

Assessment of Other Risk Factors

Data were also collected on other known variables that could confound the association between maternal depression and infant health outcomes. These variables were categorized on an a priori basis as: (1) Female vs male infant sex. In some South Asian communities, the male child is more valued than the female child, receiving preferential treatment in terms of nutrition and care.[27] The birth of a female child has also been shown to be a risk factor for maternal depression.[9] (2) Low birth weight defined as 2500 g or less vs normal birth weight of more than 2500 g. Low birth weight is an important contributor to continuing malnutrition and infant mortality, especially in the first year of life.[28] (3) Duration of exclusive breast-feeding: less than 6 months vs at least the first 6 months of life. The World Health Organization recommends exclusive breast-feeding for the first 6 months.[29] (4) Maternal age of 20 years or younger vs 21 years or older. Younger maternal age is associated with increased morbidity and mortality of infants.[30] (5) Maternal age of 30 years or older vs 29 years or younger. Older maternal age is also associated with increased morbidity and mortality of infants.[30] (6) Low maternal body mass index at 1-year post partum defined as 18.5 or lower vs maternal body mass index of higher than 18.5. Low body mass index indicating chronic energy deficiency in mothers is associated with poor child nutritional status[31] and may also impact maternal mood. (Body mass index is measured as the weight in kilograms divided by the height in meters squared.) (7) Each parent's education: no education vs at least 4 years of primary education. Four years of schooling was chosen as a cutoff because many Pakistani female children attend primary school for 4 years, after which many children from low-income families stop attending. (8) Two or more children younger than 7 years vs fewer than 2 children younger than age 7. In Western societies, having 2 or more young children to look after is associated with depression in women[32] and may also mean that the mother has less time to attend to the new infant's needs. (9) Four or more children vs fewer than 4 children. This cutoff was chosen because we believed that low-income families with 4 or more children might have additional difficulties such as financial constraints and overcrowding. (10) Nuclear family (parents and children only) or extended family (3 generations, ie, one or both parents with married sons and their wives and children). The extra support from an extended family could have a protective influence on the infant's health, especially if the mother's care-taking abilities are compromised because of poor mental health.

STATISTICAL ANALYSIS

Preliminary analyses consisted of descriptive frequencies and χ^2 and Mann-Whitney *U* tests to compare differences between depressed and nondepressed mothers in household assets, delivery care, and personal characteristics. Mean differences in weight-for-age *z* scores and length-for-age *z* scores at all time points between the exposed group (infants of prenatally depressed mothers) and the nonexposed group (infants of prenatally nondepressed mothers) were analyzed, first by using growth indices as continuous measures. Univariate analyses were then carried out to estimate relative risks with 95% confidence intervals (CI) of being underweight (weight-for-age *z* score <-2) and stunted (length-for-age *z* score <-2). Univariate analyses were also carried out to estimate the relative risk of other outcomes (low birth weight, diarrhea, ARI rate, and immunization status). We did not match on variables such as socioeconomic status or education because we could not be sure if these were confounders or part of a causal pathway linking maternal depression to infant growth, and matching would not have allowed us to study their effects.[33] Multiple logistic regression was used to simultaneously control for the confounding effects of all the variables under study and obtain odds ratios as measures of association. Population-attributable risk was calculated as the proportion of stunting (a good indicator of malnutrition) in the 12-month-old infants that would not have occurred if the effect associated with maternal depression were absent. This took into account relative risk adjusted for the full cohort of 632 infants. To assess a dose-response relationship, similar analyses were carried out on a subcohort of chronically depressed mothers (depressed at all 4 time points) and mothers not depressed at any time point. All analyses were carried out with Stata.[34]

Estimates on indices of undernutrition (weight-for-age and height-for-age *z* scores <-2) in Pakistani children range from 38% to 50%. Assuming a conservative estimate of a 20% prevalence of undernutrition among infants of nondepressed mothers and a 2-fold increase in risk with depressed mothers, a sample size of 91 infants in both groups would be sufficient to detect this with a precision of 0.05 and 80% statistical power.

The research ethics committees of the University of Manchester and Rawalpindi Medical College approved the study.

RESULTS

Seven hundred one women in their last trimester of pregnancy (mean, 6 weeks from delivery date) were identified. Thirty-one (4%) refused to take part; of the remaining 670, 14 (2%) suffered from a physical disorder, and 24 (4%) had other mental disorders (mostly generalized anxiety) and were excluded. Thus, 632 women were interviewed with the SCAN for an evaluation of their mental state. Of these, 160 were diagnosed as having an *ICD-10* depressive episode, giving a prevalence rate of depressive disorder in the prenatal period of 25%. Each depressed woman was matched with a psychologically well woman of similar gestation residing in the same Union Council. Depressed mothers had significantly higher scores on the Brief Disability Questionnaire than nondepressed mothers, both prenatally (median score, 7 vs 2; $P<.01$) and 12 months postnatally (median score, 8 vs 1; $P<.01$).

At birth, 8 infants (3%; 4 from the depressed group and 4 from the nondepressed group) were born prematurely and were excluded. Two mothers discontinued participation because of the severity of depression. Eighteen (6%; 10 from the depressed group and 8 from the nondepressed group) had stillbirths or neonatal deaths,

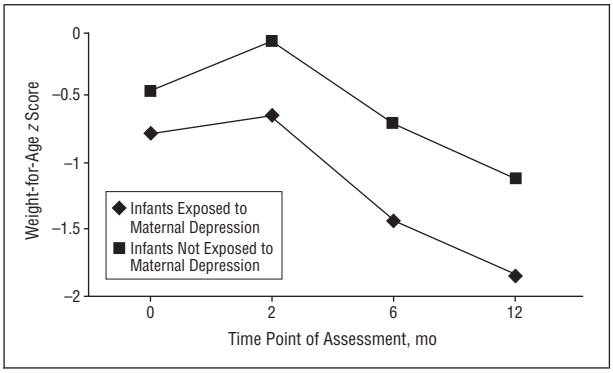

Figure 1. Mean weight-for-age *z* scores at birth and at 2, 6, and 12 months of age: exposed vs nonexposed infants.

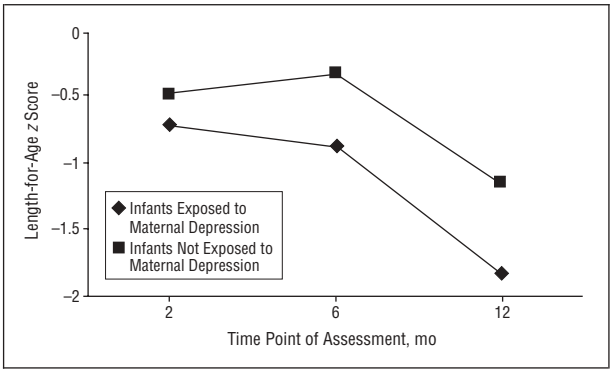

Figure 2. Mean length-for-age *z* scores at 2, 6, and 12 months of age: exposed vs nonexposed infants.

and 2 newborns (1 each from the depressed and the nondepressed groups) had congenital abnormalities and were excluded. During 1 year, 25 (8%; 14 from the depressed group and 11 from the nondepressed group) dropped out. The overall response rate was therefore 92% with little differential loss of follow-up between the 2 groups.

Depressed and nondepressed mothers were similar in terms of household and personal characteristics studied. Ninety-eight percent of households in both groups possessed electricity (χ^2_1=0.002; P=1.0), and 41% depressed vs 38% nondepressed owned agricultural land (χ^2_1=0.22; P=.60). No differences were found between the 2 groups on principal sources of drinking water: manual well (67% in depressed group vs 68% in nondepressed group), well with pump (25% vs 26%), and tap (8% vs 6%) (χ^2_2=0.35; P=.80); or type of toilet facility used: field or pit (53% vs 52%), flush toilet (45% both groups), or other such as bucket (2% vs 3%) (χ^2_2=0.59; P=.70). No significant differences were found between depressed and nondepressed mothers in the type of delivery care received: birth attended by medically trained personnel (26% vs 24%), by traditional birth attendants (17% vs 21%), and by family member at home (57% vs 54%) (χ^2_2=0.78; P=.70). The median age at birth in both groups of mothers was 26 years (interquartile range, 24-30 years). Median body mass index at 12 months postnatal in depressed mothers was 21.4 (interquartile range, 19-24.7), and that of nondepressed mothers was 22 (interquartile range, 19.6-25.4); the difference was not statistically significant (Mann-Whitney U, 1.24; P=.20). About 45% of mothers in both groups had had no formal schooling, and only 5% in both groups were employed outside the home.

Figure 1 and **Figure 2** show differences in mean weight-for-age and length-for-age *z* scores of infants of both groups at all times of assessment. The differences increased with the age of the infant, becoming maximum at 1 year. Mean weight-for-age *z*-score difference at birth was 0.30 (95% CI, 0.01 to 0.59; P<.05), increasing at 1 year to 0.70 (95% CI, 0.48 to 0.92; P<.01). Mean length-for-age *z*-score difference at 2 months was 0.24 (95% CI, –0.01 to 0.48; P=.06), increasing at 1 year to 0.63 (95% CI, 0.38 to 0.88; P<.01). Length was not measured at birth.

The prevalence of underweight (weight-for-age *z* score of less than –2) and stunting (length-for-age *z* score of less than –2) in the sample was 5% and 6%, respectively, at 2 months; 18% and 10% at 6 months; and 29% and 24% at 12 months. Because prevalence at 2 months was low, further analyses were only carried out for measurements at 6 and 12 months. Univariate analyses (**Table 1**) showed a significant relative risk of being underweight or stunted at both 6 and 12 months with maternal depression. Other factors that had a significant negative impact on infant weight or length include low birth weight, less than 6 months of breast-feeding, 5 or more diarrheal episodes per year, lack of parental education, and relative poverty, whereas maternal financial empowerment had a positive impact. Relative risk from all other variables studied was insignificant (data not shown in table). Multiple logistic regression (**Table 2**) showed that after simultaneous adjustment for all variables, the association between infant growth and maternal depression remained significant. The only other variables that continued to show a statistically significant association include 5 or more diarrheal episodes per year and relative poverty, whereas association with low birth weight, less than 6 months of breast-feeding, lack of parental education, and maternal financial empowerment became insignificant. Association with all other variables also remained insignificant (data not shown in table).

Assuming that the associations are causal and not confounded, the population-attributable risk for stunting at age 12 months is 30% (95% CI, 19 to 41). The population-attributable risk is the proportion by which the incidence of stunting would be reduced if maternal depression were eliminated from the population. Fifty-six percent of mothers depressed in the prenatal period were depressed at all points of assessment in the postnatal period, indicating that the rate of chronic depression in the sample was high. When these chronically depressed mothers (n=72) were compared with mothers not depressed at any time point (n=108), the relative risk for the infants being underweight and stunted increased substantially (at 6 months of age, relative risk for underweight was 5.9; 95% CI, 2.7 to 12.8; for stunting at 6 months of age, relative risk was 5.5; 95% CI, 1.9 to 16.0; at 12 months age, relative risk for underweight was 3.5; 95% CI, 2.2 to 5.6; and for stunting at 12 months of age, relative risk was 3.2; 95% CI, 1.9 to 5.4).

Table 3 shows the association of maternal depression with other outcomes of interest at birth and at 12

Table 1. Unadjusted Relative Risks of Malnutrition With Maternal Depression and Other Risk Factors in 265 Infants at Ages 6 and 12 Months

	At 6 mo				At 12 mo			
	Underweight (n = 48)*		Stunted (n = 26)†		Underweight (n = 77)*		Stunted (n = 64)†	
Risk Factor	No. (%)	Relative Risk (95% CI)	No. (%)	Relative Risk (95% CI)	No. (%)	Relative Risk (95% CI)	No. (%)	Relative Risk (95% CI)
Maternal depression	38 (79)	4.0 (2.1-7.7)	21 (81)	4.4 (1.7-11.4)	55 (71)	2.6 (1.7-4.1)	45 (70)	2.5 (1.5-4.0)
Low birth weight (≤2500 g)	17 (35)	1.7 (0.9-2.8)	11 (42)	2.2 (1.1-4.6)	29 (38)	1.8 (1.3-2.6)	26 (41)	2.1 (1.4-3.1)
Breastfed <6 mo	11 (23)	2.0 (1.1-3.5)	5 (19)	1.6 (0.7-4.0)	11 (14)	1.1 (0.6-1.9)	12 (19)	1.6 (0.9-2.6)
≥5 Diarrheal episodes per year	33 (69)	3.0 (1.7-5.2)	17 (65)	2.6 (1.2-5.6)	47 (61)	2.1 (1.4-3.1)	40 (63)	2.3 (1.5-3.5)
Mother uneducated	25 (52)	1.4 (0.8-2.3)	13 (50)	1.3 (0.6-2.7)	41 (53)	1.5 (1.0-2.1)	36 (56)	1.7 (1.1-2.6)
Father uneducated	10 (21)	1.3 (0.7-2.4)	7 (27)	1.8 (0.8-4.0)	15 (19)	1.2 (0.7-1.8)	16 (25)	1.6 (1.1-2.5)
Maternal financial empowerment	17 (35)	0.6 (0.3-1.0)	7 (27)	0.4 (0.2-1.0)	28 (37)	0.6 (0.4-0.9)	20 (31)	0.5 (0.3-0.8)
Relative poverty	29 (60)	2.4 (1.4-4.0)	16 (62)	2.5 (1.2-5.3)	39 (51)	1.6 (1.1-2.3)	31 (48)	1.5 (0.9-2.3)

Abbreviation: CI, confidence interval.
*Weight-for-age *z* score of less than –2.
†Length-for-age *z* score of less than –2.

Table 2. Estimates of Simultaneous Effects of Maternal Depression and Other Risk Factors on Malnutrition in 265 Infants at Ages 6 and 12 Months Through Multiple Logistic Regression

	At 6 mo				At 12 mo			
	Underweight*		Stunted†		Underweight*		Stunted†	
Risk Factor	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value	Odds Ratio (95% CI)	*P* Value
Maternal depression	3.5 (1.5-8.6)	<.01	3.2 (1.1-9.9)	<.05	3.0 (1.5-6.0)	<.01	2.8 (1.3-6.1)	<.01
Low birth weight (≤2500 g)	1.2 (0.5-2.7)	.70	1.3 (0.5-3.5)	.50	1.3 (0.8-3.5)	.20	1.4 (0.6-3.0)	.40
Breastfed <6 mo	2.3 (0.8-6.1)	.10	1.5 (0.4-5.3)	.50	1.1 (0.4-2.8)	.90	2.1 (0.8-5.5)	.20
≥5 Diarrheal episodes per year	2.2 (1.0-4.7)	.05	1.8 (0.7-4.8)	.30	2.0 (1.1-3.9)	<.05	2.2 (1.1-4.6)	<.05
Mother uneducated	1.2 (0.5-2.8)	.60	0.9 (0.3-2.7)	.90	1.5 (0.8-3.1)	.20	1.8 (0.8-3.9)	.01
Father uneducated	0.6 (0.2-1.6)	.30	1.3 (0.4-3.8)	.60	0.8 (0.4-1.8)	.60	1.3 (0.5-2.9)	.50
Maternal financial empowerment	0.9 (0.4-2.1)	.80	0.6 (0.2-1.8)	.40	0.9 (0.4-1.8)	.70	0.5 (0.2-1.0)	.05
Relative poverty	2.3 (1.1-5.2)	<.05	2.2 (0.8-5.8)	.10	1.1 (0.5-2.2)	.80	0.7 (0.4-1.8)	.70

Abbreviation: CI, confidence interval.
*Weight-for-age *z* score of less than –2.
†Length-for-age *z* score of less than –2.

Table 3. Relative Risk of Other Infant Outcomes With Maternal Depression (n = 265)

Outcome	No.*	No. (%)†	Relative Risk	95% CI
Low birth weight (≤2500 g)	66	44 (67)	2.1	1.3-3.3
≥5 Diarrheal episodes per year	112	78 (69)	2.4	1.7-3.3
≥6 Acute respiratory infection episodes per year	139	71 (51)	1.1	0.9-1.4
Immunization not up to date at 1 year	132	70 (53)	1.3	1.1-1.6

Abbreviation: CI, confidence interval.
*Number of infants with the outcome out of total sample of 265.
†Number and percentage of infants with the outcome whose mothers had prenatal depression.

months. Relative risks for both low birth weight and excessive diarrheal episodes were statistically significant; however, there was no association with excessive ARI episodes and only a weak association with immunization status being up to date.

COMMENT

To our knowledge, this is the first longitudinal, population-based study exploring the impact of maternal depression on infant health in a rural area of a developing country. Exposure and outcome measures were carefully defined, and the study achieved a high follow-up rate. The main findings are that infants of prenatally depressed mothers have poorer growth and an increased risk of diarrheal infection compared with infants of psychologically well mothers. The study population is comparable to that of the developing world in general on important human development indicators such as infant mortality rate (56 per 1000 live births in the study area vs 63 per 1000 live births for all developing countries) and female literacy rate (53% vs 65%).[35] However, the findings would need to be applied with caution in poorer populations faced with grave food shortages.

By determining the exposure status prior to the development of outcomes, the study ensured that the cor-

rect causal temporal sequence was achieved. A higher proportion of infants of prenatally depressed mothers had lower birth weight, indicating that part of the later disadvantage could have been conferred in utero. However, the impact of maternal depression on later growth remains significant after adjusting for low birth weight, showing that postnatal depression has an independent effect. Longer duration of depression in the mothers confers a greater risk, and infants of mothers who remain well throughout the year achieve the best outcome, indicating a dose-response relationship. It cannot be assumed, however, that this dose-response relationship is unidirectional. Poor infant health may be a stressor for mothers and therefore act as a maintaining factor for their depression.

The effect-size of maternal depression is greater than that of important known risk factors for poor growth such as low birth weight, frequent diarrhea, and socioeconomic status, and this effect remains significant after simultaneous adjustment for these factors. Maternal depression in this sample proved to be a stronger predictor of poor growth than the other known risk factors studied; reductions in the prevalence of maternal depression could result in a reduction in infant growth retardation of up to 30%. Thus, maternal depression could make an important and possibly major contribution to poor infant growth outcomes and morbidity in other less resourced countries.

Possible mechanisms by which maternal depression affects infant growth and illness include a less healthy lifestyle and reduced care-seeking in the prenatal period; maternal disability in the postnatal period resulting in deficient physical and emotional care and psychosocial stimulation of the infant; and associated psychosocial difficulties such as lack of family support to the mother and lack of financial empowerment, which could impact infant care.[13] Infants of depressed mothers were less likely to be fully immunized at 12 months compared with infants of nondepressed mothers, possibly indicating a lack of appropriate health-seeking behavior in depressed mothers. Another finding that may indicate deficiency in care is that although infants of depressed mothers have more diarrheal episodes, rates of ARI are the same (Table 3). Maternal child-care behaviors such as hand-washing before feeding, safe food preparation and storage, and obtaining clean drinking water are more likely to influence diarrhea than ARI.[36] It might be expected that disability in depressed mothers could influence such preventive activities, thus increasing the risk for diarrhea, whereas ARI prevention does not have such a direct link with maternal child-care behavior. Socioeconomic status and parental education appear to have only weak effects on infant growth, but further research is required to understand the nature of possible mechanisms and interactions with these and other factors such as social support and empowerment, which may moderate the effects of maternal depression.

Vulnerability to undernutrition after the first 6 months of life is very high, particularly at the time complementary foods are introduced to an immunologically vulnerable infant.[28] Although the prevalence of poor-growth outcomes increases with age, the risk from maternal depression relatively decreases. One possible explanation is less reliance on the mother (other carers may assist in care and complementary feeding, and the infant may start to forage for food), diluting the effect of maternal depression. Another possible explanation is the gradual recovery of many mothers from this self-limiting disorder. While these are plausible explanations, there may be some other unknown factor particular to the study sample that is responsible for this pattern of infant growth.

The study has implications for both mother and child health. Ordinary health workers can identify depression with relative ease, using simple checklists that have excellent validity. The use of these instruments can help identify groups of mothers whose infants are at a greater risk for poor health. Interventions could then be targeted to these groups.

Recent approaches to child survival strategies call for a focus on the household as a center for child health activity.[7] Preventive household behaviors, such as infant-feeding practices, immunization, and home-health and care-seeking practices, rely heavily on the mother, who is the primary care provider in most developing societies. The impact of health-promoting activities is therefore related to the functional capacity of mothers, their receptivity to health care messages, and their uptake of the intervention offered. Attention to the mothers' psychological well-being could increase the effectiveness of such programs.

The association between maternal mental health and infant physical health could help promote women's mental health in the health care agenda. It could also provide a window of opportunity to elevate the social status of women in developing countries and in the process improve their own and their children's physical and mental well-being.

Submitted for publication November 27, 2003; final revision received February 26, 2004; accepted March 18, 2004.

This study was supported by grant 060177/Z/00/Z from the Wellcome Trust, London, England.

We thank Naeem Tariq, PhD, and Mohammed Pervez, PhD, at the National Institute of Psychology, Islamabad, Pakistan, for their support and assistance.

Correspondence: Atif Rahman, PhD, University of Manchester Department of Child Psychiatry, Royal Manchester Children's Hospital, Hospital Road, Pendlebury, Manchester M27 4HA, England (atif.rahman@ntlworld.com).

REFERENCES

1. Pelletier DL, Frongillo EA, Schroeder DG, Habicht JP. The effects of malnutrition on child mortality in developing countries. *Bull World Health Organ*. 1995;73:443-448.
2. Grantham-McGregor S. Linear growth retardation and cognition. *Lancet*. 2002;359:542.
3. Cheung YB, Khoo KS, Karlberg J, Machin D. Association between psychological symptoms in adults and growth in early life: longitudinal follow up study. *BMJ*. 2002;325:749.
4. Bhutta ZA. Why has so little changed in maternal and child health in south Asia? *BMJ*. 2000;321:809-812.
5. Ramalingaswami V, Johnsson U, Rohde J. The Asian enigma. In: *Progress of Nations*. New York, NY: United Nation's Children Fund; 1996.
6. Smith LC, Haddad LJ. *Explaining Child Malnutrition in Developing Countries: A Cross-Country Analysis*. Washington, DC: International Food Policy Research Institute; 2000.

7. Claeson M, Waldman RJ. The evolution of child health programmes in developing countries: from targeting diseases to targeting people. *Bull World Health Organ*. 2000;78:1234-1245.
8. O'Hara MW, Swain AM. Rates and risk of postpartum depression: a meta-analysis. *Int Rev Psychiatry*. 1996;8:37-54.
9. Patel V, Rodrigues M, DeSouza N. Gender, poverty, and postnatal depression: a study of mothers in Goa, India. *Am J Psychiatry*. 2002;159:43-47.
10. Rahman A, Iqbal Z, Harrington R. Life events, social support and depression in childbirth: perspectives from a rural community in the developing world. *Psychol Med*. 2003;33:1161-1167.
11. Murray CJL, Lopez AD, eds. *The Global Burden of Disease: A Comprehensive Assessment of Mortality and Disability From Diseases, Injuries, and Risk Factors in 1990 and Projected to 2020*. Cambridge, Mass: Harvard University Press; 1996.
12. Cooper PJ, Murray L. Postnatal depression. *BMJ*. 1998;316:1884-1886.
13. Rahman A, Harrington R, Bunn J. Can maternal depression increase infant risk of illness and growth impairment in developing countries? *Child Care Health Dev*. 2002;28:51-56.
14. Widdowson EM. Mental contentment and physical growth. *Lancet*. 1951;195: 1316-1318.
15. Frank DA, Zeisel SH. Failure to thrive. *Pediatr Clin North Am*. 1988;35:1187-1206.
16. de Miranda CT, Turecki G, Mari Jde J, Andreoli SB, Marcolim MA, Goihman S, Puccini R, Strom BL, Berlin JA. Mental health of the mothers of malnourished children. *Int J Epidemiol*. 1996;25:128-133.
17. Patel V, DeSouza N, Rodrigues M. Postnatal depression and infant growth and development in low income countries: a cohort study from Goa, India. *Arch Dis Child*. 2003;88:34-37.
18. Rahman A, Lovel H, Bunn J, Iqbal Z, Harrington R. Mothers' mental health and infant growth: a case-control study from Rawalpindi, Pakistan. *Child Care Health Dev*. 2004;30:21-27.
19. World Health Organization. *SCAN: Schedule for Clinical Assessment in Neuropsychiatry*. Geneva, Switzerland: World Health Organization; 1994.
20. World Health Organization. *International Classification of Mental and Behavioural Disorders: Diagnostic Criteria for Research*. 10th ed. Geneva, Switzerland: World Health Organization; 1993.
21. VonKorff M, Ustun TB, Ormel J, Kaplan I, Simon G. Self-report disability in an international primary care study of psychological illness. *J Clin Epidemiol*. 1996; 49:297-303.
22. World Health Organization. *Physical Status: The Use and Interpretation of Anthropometry*. Geneva, Switzerland: World Health Organization; 1995. Technical report series No. 854.
23. Dibley MJ, Goldsby JB, Staehling NW, Trowbridge FL. Development of normalized curves for the international growth reference: historical and technical considerations. *Am J Clin Nutr*. 1987;46:736-748.
24. Sempertegui F, Estrella B, Camaniero V, Betancourt V, Izurieta R, Ortiz W, Fiallo E, Troya S, Rodriguez A, Griffiths JK. The beneficial effects of weekly low-dose vitamin A supplementation on Acute Lower Respiratory Infections and diarrhea in Ecuadorian children. *Pediatrics*. 1999;104:e1.
25. Pakistan Medical Research Council. *National Health Survey of Pakistan: 1990-94*. Islamabad, Pakistan: Pakistan Medical Research Council; 1998.
26. Gwatkin DR, Rustein S, Johnson K, Pande R, Wagstaff A, HNP/Poverty Thematic Group. *Socioeconomic Differences in Health, Nutrition, and Population in Pakistan*. Washington, DC: World Bank; 2000.
27. Lovel HJ, Sabir NI, Cleland J. Why are toddler girls at risk of death and undernutrition in a slum area of Pakistan? *Lancet*. 1984;1:797.
28. Waterlow JC. *Protein-Energy Malnutrition*. London, England: Edward Arnold; 1992.
29. Bhandari N, Bahl R, Mazumdar S, Martines J, Black RE, Bhan MK; Infant Feeding Study Group. Effect of community-based promotion of exclusive breastfeeding on diarrhoeal illness and growth: a cluster randomised controlled trial. *Lancet*. 2003;361:1418-1423.
30. Rutstein SO. Factors associated with trends in infant and child mortality in developing countries during the 1990s. *Bull World Health Organ*. 2000;78:1256-1270.
31. Naidu AN, Rao NP. Body mass index: a measure of the nutritional status in Indian populations. *Eur J Clin Nutr*. 1994;48:S131-140.
32. Brown GW, Harris T. *Social Origins of Depression*. London, England: Tavistock; 1978.
33. Grimes DA, Schulz KF. Bias and causal associations in observational research. *Lancet*. 2002;359:248-252.
34. *Stata Statistical Software* [computer program]. Version 7.0. College Station, Tex: Stata Corporation; 2001.
35. Mahbub ul Haq Development Centre. *Human Development in South Asia 2001*. New York, NY: Oxford University Press; 2002.
36. Thongkrajai E, Thongkrajai P, Stoeckel J, Na-nakhon S, Karenjanabutr B, Sirivatanamethanont J. Socioeconomic and health programme effects upon the behavioral management of diarrheal disease in northeast Thailand. *Asia Pac J Public Health*. 1990;4:45-52.