

THE PENNSYLVANIA STATE UNIVERSITY  
SCHREYER HONORS COLLEGE  
DEPARTMENT OF NUTRITIONAL SCIENCES

**CONFIRMATORY FACTOR ANALYSIS OF THE CENTER FOR THE  
EPIDEMIOLOGICAL STUDY OF DEPRESSION (CES-D) AND MATERNAL  
IRON DEFICIENCY WITH AND WITHOUT ANEMIA IN BANGLADESH**

AMY L. HUDAK  
Spring 2012

A thesis  
submitted in partial fulfillment  
of the requirements  
for a baccalaureate degree  
in Science with interdisciplinary honors  
honors in Nutritional Sciences and Science

Reviewed and approved\* by the following:

Dr. Laura E. Murray-Kolb  
Professor of Nutritional Sciences  
Thesis Supervisor

Dr. Jill Patterson  
Professor of Nutritional Sciences  
Honors Reader

Dr. Ronald Markle  
Professor of Biology  
Honors Adviser

\*Signatures are on file in the Schreyer Honors College

**ABSTRACT**

The aim of this study was to determine the factor structure of the Center for the Epidemiological Study of Depression (CES-D) questionnaire among childbearing mothers in rural Bangladesh with the purpose of drawing conclusions about the relationship between maternal iron deficiency anemia, infant nutritional status and depressive symptomatology.

**TABLE OF CONTENTS**

Abstract.....	i
List of Figures.....	iii
List of Tables.....	iii
Acknowledgements.....	iv-v
Introduction and Background.....	1-4
Iron Status.....	1-3
Depressive Symptomatology.....	3-4
Materials and Methods.....	4-6
Recruitment.....	4
Maternal Blood Samples.....	4-5
Maternal Depressive Symptoms.....	5
Statistical Analysis.....	6
Results.....	6-7
Discussion.....	7-8
Key Observations.....	7-8
Future Directions.....	8
Academic Vita.....	12-14
Special Thank You.....	15

**LIST OF FIGURES**

Figure **1-1**: Supplementation/Data Collection Timeline.....9

**LIST OF TABLES**

Table **1-1**: Center for Epidemiological Study of Depression Scale Items.....10

Table **1-2**: Four Factor Model Interpretation of the CES-D.....11

## **ACKNOWLEDGEMENTS**

- ACC/SCN (United Nations Administrative Committee on Coordination, Sub-Committee on Nutrition). 2000. Fourth report on the world nutrition situation: Nutrition throughout the life cycle . Geneva: ACC/SCN in collaboration with IFPRI.
- Beard, J et al. Maternal Iron Deficiency Anemia Affects Postpartum Emotions and Cognition The American Society for Nutritional Sciences J. Nutr. 135:267-272
- Black MM et al. Maternal depressive symptoms and infant growth in rural Bangladesh Am J Clin Nutr March 2009 vol. 89 no. 3 951S-957S
- Black MM et al. Depressive symptoms among rural Bangladeshi mothers: implications for infant development. Journal of Child Psychology and Psychiatry.
- Black, R et al. Interactive effects of iron and zinc on biochemical and functional outcomes in supplementation trials. Am J Clin Nutr July 2005 vol. 82 no. 1 5-12
- Coppen A, Bolander-Gouaille C. Treatment of depression: time to consider folic acid and vitamin B12. J Psychopharmacol. 2005;19:59-65.

Faisal IM, Parveen S. Food security in the face of climate change, population growth, and resource constraints: implications for Bangladesh. *Environmental Management*, 2004 Oct;34(4):487-98.

Hels, O et al. Food consumption, energy and nutrient intake, and nutritional status in rural Bangladesh: Changes from 1981–1982 to 1995–96. *European Journal of Clinical Nutrition* 57(4): 586–594.

Kazi, A. Social Environment and Depression Among Pregnant Women in Urban Areas of Pakistan: Importance of Social Relations. *Journal of Social Science and Medicine*. 2005; 1466-1476.

Lozoff B, Jimenez E, Wolf AW. Long-term developmental outcome of infants with iron deficiency. *New England Journal of Medicine*. 1991;325:687–694

Radloff L. The CES-D Scale. A Self-Report Depression Scale for Research in the General Population. *Applied Psychological Measurement* June 1977 vol. 1 no. 3 385-401

World Health Organization. "Micronutrient Deficiencies." Iron Deficiency Anaemia: The Challenge. Web. 19 Mar. 2012.  
<<http://www.who.int/nutrition/topics/ida/en/index.html>>.

## **Introduction-**

### *Iron Status-*

Iron deficiency, the most common micronutrient deficiency, affects more than 2 billion people globally (ACC/SCN, 2000). The World Health Organization estimates that upwards of 30% of the world's population are anemic, many due to iron deficiency (World Health Organization, 2012). Iron deficiency (ID) and iron deficiency anemia (IDA) are associated with adverse outcomes including an increased morbidity in children, shortness of breath, fatigue, impaired motor and cognitive functioning, weakness, pallor, poor immune function and decreased productivity and/or physical capacity. Maternal iron deficiency specifically can hinder the trajectory of a child's development during gestation and postpartum and can poorly affect the emotional tie a mother forms with her infant (Lozoff, 1991). Thus, a bidirectional effect of maternal and infant behavior exists.

South Asian countries report the highest prevalence of iron deficiency (Zlotkin et al., 2004). In Bangladesh, an estimated 61% of children 0-4 years of age are iron deficient and 79% of all pregnant women are anemic (World Health Organization, 1994). Dietary sources and environmental factors explain the majority of iron deficiency cases, but anemia has a more complex etiology.

The common Bangladesh diet is extremely low in bioavailable heme iron and contains scarce iron absorption factors such as ascorbic acid, meat, fish and poultry. Moreover, the traditional diet is composed of high levels of iron antagonists including oxalic acid, phytates, polyphenols and casein. Studies have reported that 80% of the

Bangladeshi diet is comprised of polished rice, vegetables and lentils (Hels et al., 2003). The aforementioned are rich sources of iron antagonists, which bind little available iron and inhibit its absorption. Polished rice, in which the seed coat has been removed, does not provide adequate amounts of nutrients including iron even when consumed in excessively large portions. Similarly, the phytates in rice contain high amounts of iron inhibiting factors further inhibiting absorption of the essential trace mineral.

With 50% of Bangladesh's population of >140 million living below poverty line and being food insecure, families simply cannot afford nutritious food sources such as meat, fish, poultry and fresh fruits (Faisal, 2004). Moreover, many children and adults are infected with hookworm and other forms of intestinal parasites, which sequester nutrients from the body and put individuals at increased risk for a poor nutritional status. The high inflammatory status present in infected individuals often masks a clinically poor iron status.

A growing body of evidence from research suggests an association between a less than optimal iron status and depressive symptoms. The World Health Organization reports that approximately 121 million people worldwide are burdened by depression (World Health Organization, 2012). Depression is one of the leading causes of disability globally; however, fewer than 25% of those affected have access to effective treatments. Sadly, an estimated 10-25% of women of reproductive age are affected by depression (Coppin, 2005). Such stagger statistics suggest adverse consequences in nutritional status for future generations. This particularly holds true in less developed countries where poverty holds individuals back from education, diagnosis and treatments.



Iron is known to be essential for oxygenating the parenchyma cells of the brain as well as for the production and release of many neurotransmitters including dopamine and enzymes of the nervous system (Beard et al., 1993). Iron deficiency can significantly reduce neurotransmitter response and alter neurological functioning throughout the lifespan. Postpartum depression, stress, and cognitive impairment in poor women may be related to a poor iron status associated with iron deficiency and/or iron deficiency anemia. Furthermore, it has been shown that depression and stress both respond positively to appropriate iron therapy (Beard et al., 2005). Correcting depression linked to micronutrient deficiencies holds promise for reversing adverse consequences associated with both iron deficiency, with or without anemia, and depression.

#### *Depressive Symptomatology-*

The Center for Epidemiological Study of Depression (CES-D) questionnaire, a 20 question self-scoring assessment, is the most commonly used identifier for determining depressive symptoms among people in a general population. The factor structure of the CES-D, which describes the variability among the correlated variables in the assessment has been analyzed for Westernized cultures; however, it is necessary to assure the factor structure of the scale is comparable for other regions of the world. The cultural dimensions in Bangladesh differ quite drastically from the United States and Western societies. Extreme poverty and a lack of nutritious food put families and communities at risk for chronic iron deficiency and ultimately anemia. Moreover, religious beliefs,

gender inequality, disease stigma, extreme poverty and financial and/or family pressures make effective diagnosis and treatment of depression extremely difficult.

Reliability, validity, and factor structure have all been shown to be similar across an extensive variety of demographic characteristics in the general population samples tested – both in household and psychiatric settings. With a high internal consistency and test-retest repeatability, the CES-D scale is a useful tool for the epidemiologic study of depression (Radloff, 1977). Research has confirmed similar findings for a four factor structure in both the United States and the Western world in addition to numerous developing countries including Southeast Asian populations.

## **Materials and Methods:**

### *Recruitment:*

500 infants, ages 6-18 months and their respective mothers were recruited to participate in this study. 25 mothers were excluded from the study due to non-compliance, or unwillingness to have anthropometric or blood data collected. Complete data sets including the CES-D mental health questionnaire was collected for 475 mothers.

### *Maternal Blood Samples:*

Venous blood samples were drawn from each mother at baseline and after 6 months of supplementation. Samples were analyzed for zinc, ferritin, transferrin receptor and C-reactive protein (a marker of inflammation). The World Health Organization

defines the cutoffs for iron deficiency and iron deficiency anemia as a serum ferritin value <15 ug/L and a hemoglobin concentration <110 g/dL respectively.

*Maternal Depressive Symptoms:*

Maternal depressive symptoms were analyzed using the Center for Epidemiological Studies Depression Scale (CES-D) (Radloff 1977). The 20 question self-scoring assessment designed for the general population, was administered to each mother at baseline and after 3 and 6 months of supplementation in the infants. The test addresses six aspects of depression, including: depressed mood, guilt/worthlessness, helplessness/hopelessness, lethargy/fatigue, loss of appetite and sleep disturbances. Participants read statements such as “I felt like I could not get going” and “I was bothered by things that usually do not bother me.” The component of the CES-D questionnaire “I had crying spells” was omitted from the procedure for cultural and gender reasons. Individuals were asked to determine how often they have felt a certain way in the last week: rarely or none of the time (less than 1 day), some or a little of the time (1-2 days), occasionally or a moderate amount of the time (3-4 days), or most or all of the time (5-7 days). Negatively worded questions were reverse coded prior to statistical analysis. The scores were summed with a possible range from 0 to 60. A score of 16 was used as the minimum indicator of depression, but since this cutoff value has not been confirmed for Bangladesh, the scores were evaluated as continuous (Black et al.)

*Statistical Analysis:*

The statistical method of confirmatory factor analysis was used to determine the variability among 19 of the 20 questions that comprise the CES-D. This method reduces the 19 questions that were on the Bangladesh version of the CES-D questionnaire into broad concepts known as factors. The SAS structural equation modeling software was used to determine the maximum likelihood parameter. This estimates based on the sample covariance matrix to determine the extent to which the original Radloff four-factor model of the CES-D fit the Bangladesh population in this study.

**Results-***Principle Component Factor Analysis:*

Principal component factor analysis for the 20-item CES-D questionnaire was done for the maternal participants at baseline and again at the three and six month time points. Among all mothers, there were 4 eigenvalues greater than one, which together accounted for a total of 25% of the variance. Therefore, the normal varimax rotation to a four factor structure was examined. This pattern of factor loadings is quite consistent across other populations in including Hispanic, Chinese, Japanese and Bangladeshi. The internal consistency among the CES-D was excellent with an alpha chronbach value,  $\alpha \geq .9$ . Including items with loadings above .40 in all three groups, the four factors can be interpreted as the following:

- I. Depressed affect (blues, depressed, lonely, crying, sad)
- II. Positive affect (good, hopeful, happy, enjoy)
- III. Somatic and retarded activity (bothered, appetite, effort, sleep, get going)
- IV. Interpersonal (unfriendly, dislike)

## **Discussion-**

### *Key Observations:*

Two key observations can be concluded after conducting the study on maternal iron deficiency and depressive symptomatology. The first is that a strong negative correlation exists between maternal iron status and depressive symptoms; that is, the lower the iron status of the woman including values indicative of either iron deficiency or iron deficiency anemia, the higher the rating of depression symptoms. The second observation is that the factor structure of the CES-D can be confirmed as a four-factor model in Bangladesh, allowing for further analysis of the symptomatology screening tool of the CES-D in the context of South East Asia.

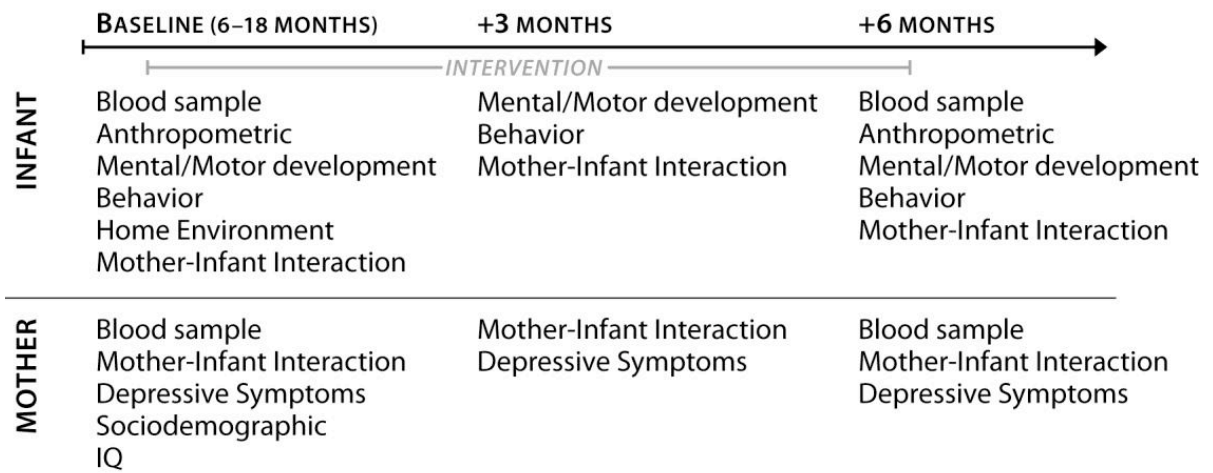
Confirmatory factor analysis in previous studies has yielded similar results with a four-factor structure. Guarnaccia et al. reported a four-factor structure among Hispanic populations in a 2002 Health and Nutrition Examination Survey consisting of depressed affect, positive affect, somatic/retarded activity and interpersonal affect. Moreover, the multiculturally validated instrument of the CES-D has also been validated in India, Pakistan, Bangladesh and pregnant populations (Kazi et al., 2005). With confirmed

validity and accuracy in numerous different contexts, the CES-D has been used extensively throughout the world, including Bangladesh (Tsutsumi et al., 2004; Black et al. in press). Previous studies have reported a correlation between maternal depressive symptoms as determined by the CES-D and child development specifically in Bangladesh (Black et al. in press). Furthermore, the CES-D has been shown to be valid and reliable as a measure of symptoms of depression and as a screening tool for further evaluation in the context of health and wellbeing (Radloff 1977).

*Future Directions:*

Screening for maternal iron deficiency and iron deficiency anemia holds great promise for preventative treatment of postpartum depression among women. Not only is the mother's physical and mental health at stake with a diagnosis of postpartum depression, the developmental trajectory of her infant and/or other children in the context of the family unit is also affected. As was aforementioned, the maternal-infant bond can be greatly compromised when maternal depression is in play. The future holds great promise with respect to effectively and efficiently screening for depressive symptoms among mothers. However, in numerous parts of the world including poverty-stricken Bangladesh in particular, the resources are just not available to administer the CES-D, never mind supplement the diet with iron therapy and improve the diet among families and communities. Thus, a key component in improving the health status in developing countries is not only educating people with regard to their dietary practices, but also fostering direct change by means of providing iron therapy and fortified food resources.

Figure 1-1: Supplementation/Data Collection Timeline



\* Adopted from Dr. Black and Dr. Murray-Kolb's 2009 Project Proposal

**Table 1-1.** Center for Epidemiological Study of Depression Scale Items

Participant ranks the number of days of the week (0-7) she feels the following way:

1. Number of days the woman felt bothered by things that did not usually bother her
2. Number of days the woman faced loss of appetite/did not like to take on anything during the last week
3. Number of days the woman felt sadness/sorrow during the last week
4. Number of days the woman felt like normal people
5. Number of days the woman faced problem keeping attention on her work
6. Number of days the woman felt frustrated
7. Number of days the woman felt it was difficult to do easy work
8. Number of days the woman felt fruitless feature
9. Number of days the woman felt unsuccessful all life
10. Number of days the woman felt insecure/timid
11. Number of days the woman could not sleep properly
12. Number of days the woman felt happiness
13. Number of days the woman was not interested in talking with others
14. Number of days the woman suffered from loneliness
15. Number of days the woman thought others had unfriendly attitudes
16. Number of days the woman felt happiness/pleasure in life
17. Number of days the woman felt unhappiness
18. Number of days the woman felt nobody likes her
19. Number of days the woman felt she was not supposed to do anything



**Table 1-2.** Four Factor Model Interpretation of the CES-D

I. Depressed affect (blues, depressed, lonely, crying, sad)

II. Positive affect (good, hopeful, happy, enjoy)

III. Somatic and retarded activity (bothered, appetite, effort, sleep, get going)

IV. Interpersonal (unfriendly, dislike)

## ACADEMIC VITA

Amy L. Hudak  
 117 E. McCormick Ave., Apt 6  
 State College, PA 06801  
 alh5331@psu.edu  
 203.927.9747

---

**CAREER GOAL:** To be educated on how to provide optimal patient care and gain practical knowledge and experience for future healthcare endeavors, in a professional, medical setting.

### EDUCATION:

*The Pennsylvania State University, Schreyer Honors College*  
 State College, Pennsylvania  
 Prospective Bachelor of Sciences May 2012  
 Major: Life Sciences; Minor: Nutritional Sciences

### Leadership and Awards

President's Freshman Award recipient  
 President's Sophomore Sparks Award recipient  
 President's Junior Evan Pugh Award recipient  
 Candidate for President's Senior Award  
 Dean's List all eight semesters standing  
 Member of the National Society of Collegiate Scholars  
 Committee Chairwoman, Penn State's Senior Class Gift 2012 Philanthropy

### EXPERIENCE

*Undergraduate American Heart Association Research Fellow* Hershey, Pennsylvania  
 The Milton S. Hershey School of Medicine, Department of Physiology June 2010-August 2010  
 Examined stress-inducible gene expression in the myocardium  
 Effectively composed an abstract with research findings

*Undergraduate Nutritional Sciences Researcher* University Park, Pennsylvania  
 The Pennsylvania State University, Department of Nutritional Sciences August 2010-Present  
 Pursuing findings related to iron status throughout the lifespan with respect to  
 developmental processes, cognition, productivity, infectious disease and health status  
 Currently composing a thesis on the aforementioned topics

Successfully fostering my desire for lifelong learning

*Volunteer Public Educator* University Park, Pennsylvania  
 The Pennsylvania State University, Diabetes and Obesity Institute March 2010  
 Effectively disseminated information to community members about controlling  
 diabetes through nutrition and lifestyle choices

*Undergraduate Teaching Assistant* University Park, Pennsylvania  
 The Pennsylvania State University December 2008-  
 Present  
 Effectively taught a biology lab to undergraduate students  
 Lead course instruction for an undergraduate nutrition course  
 Lead course instruction for a graduate level nutrition course  
 Organized and lead course content for a human development course

*Committee Chairwoman, Penn State's Senior Class Gift 2012 Philanthropy* University Park, Pennsylvania  
 The Pennsylvania State University January 2011-Present  
 Efficiently composed press releases advocating giving to the University  
 Represented a senior class of 10,000 students by carrying on a 150 year old tradition with honor  
 Interacted with University leaders and donors

*Job Shadowing* New Haven, Connecticut  
 Yale, New Haven Hospital, Department of Surgery and Anesthesia May 2008  
 Sat in on several surgeries including general, cardiothoracic and neurological

#### OTHER RELATED EXPERIENCE

*Community Tutor* University Park, Pennsylvania  
 January 2008-January 2012  
 Enthusiastically helped students reach their academic potential  
 Instructed a diverse range of topics including biochemistry, English, mathematics and biology

*ThirdPlace Organization Volunteer* State College, Pennsylvania  
 December 2011  
 Worked with community teams to pack food for famine victims in the Horn of Africa

*Charity Running* University Park, PA/Medina, OH  
 August 2008-Present  
 Run with family and friends for The American Heart Association,  
 Penn State Dance Marathon, Susan G. Komen, and the American Red Cross

**RELEVANT SKILLS**

Interpersonal skills: former swimming and diving coach and mentor, community volunteer cheerleading coach

Writing skills: effective grasp of the English language and grammar

Thank You, Dr. Laura E. Murray-Kolb

A special thank you to my wonderful honors thesis adviser Dr. Laura E. Murray-Kolb for inspiring my ability to conduct research in an experimental and safe environment. Her time and dedication to all students surpassed all expectations every day. I feel truly honored to have had such an intelligent and inspiring mentor during my time at Penn State. There is no doubt in my mind that my desire to embark on a career in a professional medical setting has to do with the experiences I have had while working alongside Dr. Murray-Kolb.