THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF NUTRITONAL SCIENCES

INFLUENCE OF MATERNAL DEPRESSION AND IQ ON CHILD NUTRITIONAL STATUS

MEGAN KATHLEEN MCGILL
SPRING 2015

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

Reviewed and approved* by the following:

Katazyrna Kordas, PhD
Adjunct Associate Professor of Nutrition
Thesis Supervisor

Rebecca L. Corwin, PhD
Professor of Nutritional Neuroscience
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

The relationship between a mother and child represents one of the most complex and unique connections that exists between humans. The mother plays a critical role as the primary caregiver for the child's emotional, physical, and cognitive health and development. For this reason, the health of the mother presents a significance influence to her ability to care for the child, and thus influences the child's health and development in turn. Specifically, the current study addressed the role that maternal depression in the context of low IQ has on child nutritional status, specifically child iron status, as measured through hemoglobin status. Overall, 211 mother-child pairs from Montevideo, Uruguay were included in this study. Blood samples were performed on the children and sent to the Pennsylvania State University for analysis. Child iron status was assessed through blood samples evaluating CRP-adjusted serum ferritin concentration, hemoglobin status, and presence of anemia. Maternal IQ was evaluated through the Wechsler Adult Intelligence Scale III (WAIS III, TEA Ediciones, S.A., Madrid, Spain). Maternal Depression was assessed using the Argentine adaptation of the Beck Depression Inventory II (BDI II, Ediciones Paidós, Buenos Aires, Argentina). Trained psychologists from the Catholic University of Uruguay Research Institute conducted these assessments. All statistical analyses were carried out using STATA 12.0 (STATA Corp, College Station, TX). The statistical analyses were set up with several outcome and two main predictor variables (maternal depression and IQ). Four different models were run to test associations between the different variables. The models were covariate-adjusted for child sex, the presence of crowding in the house, number of household possessions, maternal age, maternal education, and the area of Montevideo where the child lived, the number of hours children spent watching television,

playing video games, and using the computer, to account for sedentary activity, the factor score representing support for children's autonomy and the HOME score representing cognitive support. For the participating mothers who were assessed, overall intelligence quotient was low, indicating an average of 83.3 ± 14.2 points, and 36.4% scoring below 80 points (Table 1). 15.6% of mothers reported experiencing moderate depression, as indicated by a score of more than 19 points for depressive symptoms (Table 1). Approximately 63% of children were iron-deficient and approximately 8% had anemia (Table 2). Children consumed a mean of 4.62 mg iron per 1000 kcal (Table 2). There was no significant interaction score between maternal IQ and depressive symptoms and child iron status. Overall, this study concludes that maternal depression in the context of low IQ did not influence child iron status. However, a large body of existing literature supports the influence of maternal psychosocial and emotional health on child health and potentially nutritional status, thus, further studies with larger sample sizes are needed to clarify the results.

TABLE OF CONTENTS

LIST OF TABLES

ACKNOWLEDGEMENTS

I would like to acknowledge the researchers and staff at the Catholic University of Uruguay for collecting the data that was used for this study.

Thank you to my academic advisor, Dr. Rebecca Corwin, for her continuous encouragement, support of my passions in nutrition and research, and belief in my ability to accomplish this thesis. I would not have been able to complete this project without her dedicated help at every step along the way.

Also, I would like to thank my thesis advisor, Dr. Katazyrna Kordas, who has inspired me with her expertise in research and many accomplishments within the nutrition and public health fields. It was her continued flexibility in working with me from an especially long distance, support, passion, advice, and dedication that made this thesis possible.

Finally, I would like to thank my parents for their continued love and support throughout my Penn State career, and especially in accomplishing my honors thesis. Thank you for always believing in me and pushing me to pursue my dreams. Also, thank you to my brilliant and compassionate twin sister Kelly, who was with me every step of the way, providing support and encouragement even in the midst of completing her own thesis.

INTRODUCTION

Global Prevalence of Iron-deficiency and Iron-deficiency Anemia

Iron-deficiency (ID) represents the most prevalent global nutritional deficiency (Ahmed, Hossain, & Sanin, 2012; WHO, 2001; Murray-Kolb & Beard, 2009). Iron-deficiency afflicts 50-80 percent of women of reproductive age in the world (Murray-Kolb & Beard, 2009). Although iron absorption increases during pregnancy, ID before pregnancy often leads to depleted stores and reduced recovery in the post natal period (WHO, 2001; Murray-Kolb & Beard, 2009). ID is known to reduce work capacity, decrease immune function, and contribute to changes in cognitive ability, emotions, and behavior (Murray-Kolb, 2009).

Amongst infants and young children in the developing world, anemia resulting from iron-deficiency (IDA) represents the most prevalent and widespread nutrition problem, with the prevalence of IDA being higher at this age than at any time in the lifecycle (Lutter, 2008). ID and IDA present serious consequences for young children who need sufficient iron for the energy to not only grow and develop physically, but to develop emotionally and cognitively, through exploration and play (Murray-Kolb & Beard, 2009). The negative effects of ID in young children also present a host of serious and potentially irreversible effects on neurocognitive and behavioral development (Beard, 2008). Research has shown that sufficient iron is necessary from the start of life, in order for the infant brain to develop properly and begin executing normal motor, emotional, social, and explorative functions that enhance learning and overall development (Beard, 2008). Studies have also indicated that the presence of IDA in the first two years of life can result in cognitive impairment in a child through ages five, six, and up until age 10 (Walter, 2003).

To further complicate the negative effects of ID and IDA on child development, additional research has associated low socio-economic status with even poorer outcomes for iron deficient children (Lozoff, Jimenez, & Smith, 2006). Results from one particular study on cognitive test scores revealed that even with iron therapy to correct for IDA, children who had chronic ID during infancy did not catch up later in life, and that children from low SES backgrounds were even worse off, reflecting even poorer cognitive performance (Lozoff et al., 2006).

Further studies revealed consistent patterns in the harmful effects of ID and IDA on child cognition, despite discriminating by age (Pollitt, 1993). Children ages 2-5 years with IDA showed decreased cognitive performance compared to children who were iron-sufficient. Specifically, IDA was associated with a reduction in intelligence test scores and diminished discriminatory learning, or ability to give selective attention to certain visual cues (Pollitt, 1993). The negative influence of IDA on attention and motivation to perform at this age were suggested as potential explanations for these findings (Pollitt, 1993). Iron-therapy was shown to improve cognitive performance and raise IQ scores in preschool-aged children (older than 24 months).

School-aged children (older than 6 years) with IDA also performed poorly on intelligence tests compared to iron-sufficient children of the same age (Pollitt, 1993; Lozoff, Jimenez, Hagen, Mollen, & Wolf, 2000). Specifically, children with IDA showed reduced short-term memory and attention. One study in particular indicated the effect of ID and IDA on school achievement tests, revealing reduced performance on language tests between ID and IDA school-aged children in Thailand compared to iron-sufficient children (Pollitt, 1993). Outcomes of a study in Mexico led to the association of IDA with lower cognition in first grade children (ages 6-8 years) (Kordas et al., 2004). The addition of nutritional factors, such as hemoglobin, serum ferritin, and lead concentration revealed an even stronger effect between anemic children and reduced cognition compared to non-anemic children (Kordas et al., 2004). Iron-therapy also proved advantageous to this age group, improving cognition through improvements in attentiveness, short-term memory, and visual perception (Pollitt, 1993).

In contrast, other studies conducted among school-aged children revealed cognitive delays despite corrective treatment for chronic ID and IDA in infancy (Lozoff et al., 2000). Follow-up studies of children ages 4-8 in Israel, Chile, and France; and children ages 11-14 in Costa Rica, revealed more attention problems, and decreased mental and motor function in these children compared to their peers who were iron-sufficient as infants (Lozoff et al., 2000). Specifically, the Costa Rican children showed decreased visual-spatial and working memory, and inhibited selective attention ability. More children in this group required tutoring and/or had repeated a grade (Lozoff et al., 2000). Overall, these findings demonstrate that ID and IDA in infancy causes altered cognitive function in both preschool and school-aged children that may or may not be reversible with iron-therapy, highlighting the essentiality for interventions to prevent ID and IDA in children.

In order to conduct interventions that reduce or prevent ID and IDA in children, factors that influence child nutritional status as a whole must be taken into account. The idea that the nutritional status of the mother and child is linked is well supported; there is evidence of an association between maternal and child health as related to malnutrition (Ahmed et al, 2012; Smith, Ramakrishnan, Ndiaye, Haddad, & Martorell, 2003). The prevalence of both maternal and child under-nutrition in the world remains high today despite a sufficient quantity of food to sustain everyone (Ahmed et al., 2012). Maternal malnutrition begins a cycle through intrauterine growth restriction and low birth weight that often prevents children of malnourished mothers from catching up to normal growth standards (Ahmed et al., 2012). Girls who grow up malnourished then enter adolescence and pregnancy in the same state and the cycle continues (Ahmed et al., 2012). Clearly, maternal under-nutrition and health play a role in child nutritional status. Other factors that highlight and support this association between maternal health and child nutrition include the mother-child relationship, maternal decision-making, and caregiving. The relation of these factors to the nutritional status of children of varying ages is discussed below.

Maternal Factors Related to Child Nutritional Status

Mother/Child Relationship

The relationship between a mother and child represents a connection that is universally accepted for the simplicity of its significance, yet uniquely defined by the complexity of its nature. Through becoming a mother, maternal identity is formed (Mercer, 2004). Ideally, an intimacy with the new infant develops, accompanied by love, confidence, and acceptance of this role (Mercer, 2004; Fowles & Horowitz, 2006). Love and engagement are recognized as two critical components of the maternal role (Fowles & Horowitz, 2006). Love fosters an attachment between mother and infant. Engagement includes all of the activities associated with care and changes in care as the infant ages (Fowles & Horowitz, 2006). Both of these components set the stage for a woman's role as a mother, encouraging her to take on the immense responsibility for the wellbeing and health of the child, despite the accompanying stress and exhaustion (Logsdon, Wisner, & Pinto-Foltz, 2006; Mercer, 2004).

Numerous research studies have focused on the nature of the attachment between mother and child. The significance of mother-child interaction in fostering this attachment is well known (Ainsworth, 1979). Infants acquire knowledge about their world and how to develop within it through interactions with their mothers (Logsdon, Wisner, & Pinto-Foltz, 2006). Mothers develop self-esteem and confidence in their responsiveness and ability to care for the infant through interaction (Logsdon, Wisner, & Pinto-Foltz, 2006). More specifically, secure attachments form when mothers demonstrate responsiveness to infant cues early on (Crockenberg, 1981). Responsive mothers pay more attention to how they hold and interact face-to-face with their infant. These mothers also demonstrate more sensitivity and control over feeding practices (Crockenberg, 1981). The quality of mother-child interactions has been associated with physical and emotional health across childhood (Corapci, Radan, & Lozoff, 2006; Crockenburg, 1981; Lozoff et al., 2000; Mäntymaa, Puura, Luoma, Salmelin, Davis, Tsiantis, Ispanovic-Radojkovic, Paradisiotou, & Tamminen, 2003).

Several influential factors exist in determining the quality and security of the mother-child bond. Research has indicated that the mother's childhood relationship with her own mother plays a key role in her interactive and affective behavior towards her child (Ma¨ntymma, Tamminen, Puura & Luoma, 2006). In one study, mothers who had more positive relationships with their own mothers in childhood demonstrated more sensitivity, responsiveness, warmth, acceptance, and non-demanding behavior. The interactions of these mothers also reflected more happiness and relaxation than mothers who had more neutral or negative childhood relationships with their mothers (Ma¨ntymma, Tamminen, Puura & Luoma, 2006).

Additionally, a study conducted in Costa Rica revealed the significant implication of mother-child interactions on child emotional health, specifically in the context of ID and IDA (Corapci, Radan, & Lozoff, 2006). Research supports the idea of "functional isolation" in infants who experience chronic ID or IDA. This term refers to the idea that infants with chronic ID or IDA are less likely to seek and/or receive interactions that foster emotional development (Corapci, Radan, & Lozoff, 2006). Mothers of infants with chronic ID or IDA tend to show less positive affect, such as laughing or smiling, and allow less exploration in play (Corapci, Radan, & Lozoff, 2006).

The purpose of this study was to examine how chronic ID or IDA in infancy influenced the mother-child interaction and thus child emotional development at 5 years old. Children in this study who had been treated for ID with moderate anemia in infancy and those who had been treated but continued to have abnormalities in hemoglobin even after reaching sufficient iron status (>100 ug/dL) comprised the chronic ID group (Corapci, Radan, & Lozoff, 2006). Researchers observed mother-child pairs from this group and a control group of children who had been iron-sufficient in infancy. Both mother and child participated in a play task. The study found that mothers of children from the chronic ID group were more likely to demonstrate less positive affect, use less verbalization, and show more restriction or use more negative control during the interaction. The children in this group also demonstrated less positive affect, less verbal communication, and showed less activity than the children in the iron-sufficient group.

The overall quality of the mother-child interaction for the chronic ID group showed less reciprocity and less responsiveness than the iron-sufficient group, both during the task and in the home (also observed). Overall, the study concluded that mothers of the chronic ID group were less likely to be "developmentally facilitative", as defined by showing positive affect and scoring high for reciprocity, verbalization, and responsiveness (Corapci, Radan, & Lozoff, 2006). Significantly, the study showed that even with correction of ID and IDA in infancy and achieving "excellent" iron status by age 5, the children from the chronic ID group showed less activity, less verbalization, and less positive affect than their iron-sufficient peers (Corapci, Radan, & Lozoff, 2006). A potential mechanism for these results includes the reduced exposure to an enriching social environment among infants with chronic ID, as mothers would have been more likely to keep the infant in close proximity. This study suggested that maternal depression and/or nutritional status could have influenced the mother's behavior as well (Corapci, Radan, & Lozoff, 2006). Ultimately, ID and IDA in infancy resulted in a negative influence on the emotional development of these children at the critical age at which they would be entering the new social and emotional environment of school.

Another factor that influences mother-child interactions is social support. Social support in this context refers to support given to the mother following a stressful life event, for example, childbirth (Crockenberg, 1981). Social support in this study was assessed in three areas: the father, older children, and people outside of the family. The degree of social support was associated with security of mother-child attachment. Low social support reflected more anxious attachment, characterized by high resistance and avoidance in the infant, especially when irritability of the infant was considered. Mothers' responsiveness was also associated with attachment, however only when support was low. Infants with anxious attachments had less responsive mothers. Social support from other sources (grandparents, fathers, older children) demonstrated a potential protective effect for the infant in forming secure attachments even when maternal responsiveness was low (Crockenberg, 1981).

In relation to social circumstances, another study revealed an association between the quality of a mother's negotiation skills with other family members regarding infant care practices and her feeding competencies (Pridham, Melby, Brown, & Clark, 2010). This study involved infants who were considered very low birth weight (VLBW). Maternal feeding competencies, including mother-infant social-emotional interaction during feeding and maternal behavior were examined. The infant's VLBW status was taken into account, as the severity of the condition may challenge maternal feeding competencies if the infant struggles with feeding. The primary focus of this study was on how mothers interact in discussing infant feeding and care with other family members involved in these two aspects. Pridham et al. (2010) predicted that maternal interactions with family members would parallel maternal-infant interaction, through demonstration of responsiveness and sensitivity to the needs of others. The mother's ability to resolve differences, negotiate, accept direction, integrate interests, and share feelings with other family members was assessed in relation to handling issues such as the baby crying, feeding, sleeping, and other practices related to the baby's health (Pridham et al., 2010). Findings from the study supported this hypothesis. Maternal problem solving and negotiating competence in interacting with other family members about the infant was associated with Parental Negative Affect and Behavior (PNAB) (Pridham et al., 2010). This measurement included maternal sensitivity and responsiveness, ability to structure an environment conducive to feeding skills and nutrient intake, and the absence of an angry tone, negative attitude towards or handling of the baby, and inflexible behavior. This study concluded that a mother's competence in interaction with other family members involved in the infant's care is indicative of her competence in positively interacting with the infant through feeding (Pridham et al., 2010). These findings indicate how influential social circumstances are to the mother-child relationship, nutrition, and health.

Maternal Decision-making

One of the most prevalent determinants of social circumstances for women in developing countries relates to their status in society (Smith, Ramakrishnan, Ndiaye, Haddad, & Martorell, 2003). The idea that women are the primary caregivers for children is universally accepted (Smith et al., 2003). However, less acknowledged is the idea that women must also care for themselves. In developing countries, men often have more control over income, household resources, and health decisions for the family (Smith et al., 2003). Women face restricted access to resources and education, have more time-constraints, less social support, and diminished mental health, confidence, and self-esteem (Ahmed et al., 2012; Smith et al., 2003). These barriers present significant consequences for the health of women and children. Women who have low status in societies may not believe they can care for themselves or their children because they do not possess control over decisions such as purchasing food or medicine, or accessing information about health or reproductive care (Smith et al., 2003). Time presents a key barrier in a woman's ability to adequately care for herself and her children. Women who are expected to fulfill domestic responsibilities and contribute to income face less time to devote to caring for a child, which holds significant implications for child health and nutrition (Smith et al., 2003). Low status as compared to men contributes to poor mental health and diminished self-esteem and self-efficacy in women (Smith et al., 2003). Women may not perceive their own health as a priority (Smith et al., 2003). This has critical implications for the health and nutritional status of both women and children.

The influence of decision-making power on health and nutritional status of women and children has also been well studied (Smith et al., 2003). A study conducted in South Asia, Sub-Saharan Africa, and Latin America examined household decision-making power of women relative to their husbands. The study revealed that higher decision-making power has a positive influence on the nutritional status of women in South Asia (Smith et al., 2003). In all three regions, the relative decision-making power of women was positively associated with prenatal care (Smith et al., 2003). Higher education for women was also associated with prenatal care in South Asia (Smith et al., 2003). Additionally in all three regions, relative decision-making power was positively and significantly associated with child caregiving practices related to health and nutrition. These practices included introduction of complementary foods, feeding frequency, dietary quality, treatment for diarrhea, and child vaccinations (Smith et al., 2003). One of the most significant conclusions of the study overall involved the improvement in the quality of the pathways that influence child nutrition with the improvement of women's status in each region (Smith et al., 2003). The identified pathways include nutritional status of women, prenatal care, child complementary feeding practices, treatment and immunization of children, and quality of substitute child-care (Smith et al., 2003).

Maternal Caregiving

As evident above, both the mother-child relationship and maternal decision-making influence child nutritional status. Maternal caregiving serves to encompass both of these factors and additionally influence child nutritional status. The term "caregiver" has been defined as "the person who looks after infants and young children" (WHO, 2004). As previously mentioned, the idea that mothers are the primary caregivers is an idea that is universally accepted (Smith et al., 2003). Research supports the idea a child requires care that is both sensitive and responsive to facilitate healthy neurophysiological, physical, and psychological development (WHO, 2004). Sensitivity and responsiveness are recognized universally as the two focal aspects of positive caregiver-child relationships (WHO, 2004). Research further supports the concept that caregiving behaviors function as a key determinant in a child's environment and survival, equating a positive and nurturing relationship with food, care, stimulation and discipline in terms of essentiality for child growth and development (WHO, 2004). The early establishment of this loving and mutual relationship also sets the stage for the child's confidence and ability to feel worthy of love and express love towards others (WHO, 2004).

In relation to this concept, one study conducted on risk factors for nutritional growth of young children in Peru revealed that love and affection received by the child remain amongst the best predictors for growth, independent of socioeconomic status (Lanata, 2001 as cited in WHO, 2004). Additionally, caregiving characteristics including demonstration of love and affection, decisions about child feeding, and care seeking behaviors positively influence child nutrition and growth even with low socioeconomic status and limited resources (WHO, 2004; Kumar Range, Naved, & Bhattarai, 1997). Hepner and Maiden (1971) found "nurturant" mothering to be protective for young school-aged children and adolescents facing the stress associated with rapid growth and low quality nutrient intake, while "inadequate mothering" fostered malnutrition even with improved nutrient intake and quality (as cited in WHO, 2004). These findings highlight the degree of the impact of quality of maternal care on child nutritional status, independent of resources and socioeconomic circumstances that may influence quantity and quality of actual nutritional intake.

A similar outcome was reflected in the growth of children aged 6-18 months in Bangladesh (Kumar Range, Naved, & Bhattarai, 1997). In this study, "positive deviance" indicated adequate child growth even under poor socioeconomic conditions and "negative deviance" indicated failure to grow despite good economic conditions (Kumar Range, Naved, & Bhattarai, 1997). Researchers examined the relationship between positive and negative nutritional deviance in children and factors related to child care, such as infant feeding practices; complementary child feeding practices; maternal diet, health, and nutrition; indicators of psychosocial care; and hygiene and health care knowledge and practices (Kumar Range, Naved, & Bhattarai, 1997). Children who reflected negative deviance in nutritional status were from households with significantly higher income than the median deviant children, and positive deviant children were from households with significantly lower income than the negative deviant children. These results demonstrate that factors other than income, such as care, play a more central role in determining child nutritional status (Kumar Range, Naved, & Bhattarai, 1997).

Breastfeeding, complementary feeding, and quality and quantity of nutrient intake were all positively associated with children in the positive deviance group. These children had significantly higher nutrient intakes than the other two groups, especially for iron (Kumar Range, Naved, & Bhattarai, 1997). Attention to child diet and intake, as well as variety was associated with this outcome. Other maternal care factors that were associated with positive deviance in children included affect and attentiveness. Additionally, negative deviant children received more attention than the other two groups when cared for by the mother specifically; however when cared for by someone else they received significantly less attention (Kumar Range, Naved, & Bhattarai, 1997). These results suggest that the relationship between maternal care and child nutritional or health status is bidirectional.

This study also looked at maternal psychosocial health and influence on child nutritional deviance, a factor that has received less attention than maternal diet and nutrition (Kumar Range, Naved, & Bhattarai, 1997). Research suggests that maternal self-confidence and mental/emotional health may impact child nutrition through influencing quality of maternal care. Previous studies indicated that "happy" mothers in Bangladesh and Mexico had children who reflected the best nutritional statuses (Kumar Range, Naved & Bhattarai, 1997). The determinants of whether or not these mothers were "happy" included socioeconomic factors, but this factor was strongly associated with child growth. Social networks and support were also higher amongst mothers of positive deviant children, suggesting a potential link between social support and child nutritional status through increased quality of maternal care (Kumar Range, Naved, & Bhattarai, 1997).

Clearly, maternal caregiving influences child nutritional status through multiple facets, including caregiving characteristics such as sensitivity, responsiveness, love, affection, and attentiveness to child diet. Research has shown that these characteristics positively influence child nutrition through enhancing the mother-child relationship, demonstrating attentiveness and ability to make decisions about child health and diet, and overall supporting child growth and development, even with limited income and resources (Hepner & Maiden, 1971 & Lanata, 2001 as cited in WHO, 2004; Kumar Range, Naved, & Bhattarai, 1997; WHO, 2004).

Thus far, factors that influence maternal caregiving, either through their influence on mother-child relationships or maternal health and caregiving ability, have also been noted. These factors include maternal nutritional status and health, a mother's childhood relationship with her own mother, degree of social support, problem-solving and negotiation skills, time, as well as other barriers that inhibit a mother's ability to provide adequate care, which may include income, decision-making power, and/or psychosocial health. Though research has indicated that all of these factors play a role in determining quality of maternal care, perhaps the most influential factor that impacts maternal care and thus child health and nutritional status is maternal psychosocial health, specifically maternal depression.

Maternal Factors Related to Maternal Care

Maternal Depression

An estimated 10-15% of women suffer from depressive symptoms in the post-partum period (Tronick & Reck, 2009). Referred to as "post-partum depression" (PPD) or more often as "perinatal depression", symptoms of this condition include anxiety, depressed mood, loss of interest or pleasure in activities, changes in appetite and sleep patterns, excessive or abnormal feelings of guilt or worthlessness, decreased energy, decreased ability to make decisions, and even thoughts of suicide or death (Logsdon, Wisner, & Pinto-Foltz, 2006; Tronick & Reck, 2009). These symptoms may occur in the post-partum period, developing within weeks of giving birth, or symptoms may develop before or during pregnancy and continue after birth, increasing risk of severity and potential negative impact (Logsdon et al., 2006; Tronick & Reck, 2009).

Strong evidentiary support exists for the idea that the presence of maternal depressive symptoms negatively influences the mother-child relationship, an essential aspect of maternal care (Beck, 1995; Logsdon et al., 2006, McLearn, Minkovitz, Strobino, Marks, & Hou, 2006; Tronick & Reck, 2009). As previously mentioned, the mother is typically considered the primary caregiver, and thus the primary influence on the social environment of the infant in the first few months of life (Beck, 1995). "Mutual regulation" refers to the communicative role between mother and infant (Logsdon et al., 2006; Tronick & Reck, 2009). Maternal depression alters this process, disrupting the normal regulation of mismatched mother-child emotions and inhibiting development of trust (Tronick & Reck, 2009). Studies observing these interactions revealed that maternal depressive symptoms negatively influence infant social and emotional development (Tronick & Reck, 2009). Another study revealed that depressive symptoms also inhibit the ability to successfully function in the maternal role (Logsdon et al., 2006). This study indicated that depressed mothers demonstrate a decrease in self-esteem and self-efficacy, in addition to the loss of pleasure and gratification associated with positive interactions with the infant and ability to care for the infant (Logsdon et al., 2006). Another study that examined depressive symptoms in mothers revealed that earlier experience of symptoms, specifically related to sensitivity and responsiveness in interactions, decreased the chances of later establishing parenting practices related to safety and child development (McLearn et al., 2006). Clearly, the presence of maternal depressive symptoms inhibits the formation of the positive social and emotional connection between mother and child necessary for child development.

In addition to the negative influence on mother and infant attachment, maternal depression has severe consequences for subsequent child growth and health. A study conducted on maternal psychological distress and fetal growth revealed significant associations (Henrichs, Schenk, Roza, van den Berg, Schmidt, Steegers, Hofman, Jaddoe, Verhurst, & Tiemier, 2009). Maternal depressive symptoms and anxiety were studied together. Reduced fetal weight grain was associated with maternal experience of depressive symptoms and anxiety. Maternal distress was also associated with fetal size in the last trimester and at birth. This finding reflects the potential that the most harm from maternal distress may present in later pregnancy, during which environmental factors play more of a role in determining intrauterine growth (Henrichs et al., 2009). Henrichs et al. (2009) also found that maternal distress was associated more with growth of the central organs, such as head circumference and abdominal growth. Reduced head growth poses critical implications for brain development, suggesting the association between maternal psychological distress and child cognitive development (Henrichs et al., 2009). This study also introduced nutrition as a potential link between maternal distress and impaired fetal growth. Mothers who experience depression or anxiety may have a reduced food intake, including lower intake of essential fatty acids and critical nutrients, like folic acid and vitamin B12 (Henrichs et al., 2009). Clearly, maternal distress in pregnancy related to depressive symptoms and anxiety impairs fetal growth and development.

Another study conducted in rural Pakistan revealed that maternal depressive symptoms play a role in the physical health of the child (Rahman, Iqbal, Bunn, Lovel, & Harrington, 2004). Specifically, infants whose mothers experienced prenatal depressive symptoms reflected poorer growth and more episodes of diarrhea than infants whose mothers did not experience any symptoms (Rahman et al., 2004). This study indicated that infants of the depressed mothers were less likely to be immunized, more likely to be underweight, and at increased risk for undernutrition (Rahman et al., 2004). These findings suggest that depressed mothers may be less likely to seek out health care in the prenatal period, and that poor infant health in the postnatal period may act as a maintaining factor for the depressive symptoms (Rahman et al., 2004). Similarly, research in a low-income population in Brazil indicated an association between depressed mothers and short stature in children (Surkan, et al., 2008). This study concluded that children whose mothers experience depressive symptoms might be at increased risk for stunting, especially if they are already nutritionally vulnerable (Surkan et al., 2008). These authors suggest that mothers who experience depressive symptoms may have more trouble encouraging a child to eat, may be less likely to breast feed, and may be less likely to engage in other healthy feeding practices.

Income along with maternal psychological health has also been examined in relation to child health. A study conducted in the UK found that low income was associated with poor child health (Propper, Rigg, & Burgess, 2007). Maternal mental health was determined to be a mediating factor between income and child health (Propper, Rigg, & Burgess, 2007). This study implied that maternal mental health plays just as significant a role in child physical health as in behavioral and cognitive health. Possible mechanisms through which maternal mental health influences child physical health included poorer reporting of child physical health when mental problems were present, and the influence of stress and anxiety on child care and health-seeking behaviors. Consistent financial hardship may exacerbate maternal mental health problems and thus poor child health, or child health problems may cause additional stress and anxiety for the mother and influence her mental health in a negative way (Propper, Rigg, & Burgess, 2007).

Other research on economic disadvantages and maternal depression indicated that mothers in these situations were more likely to experience psychological distress than mothers who had a social advantage (Petterson & Albers, 2001). Evidence also supported the well-accepted idea that maternal depression is significantly associated with measures of child development, specifically cognitive and motor development (Petterson & Albers, 2001). In this study, children of depressed mothers showed delays both cognitively and in motor development (Petterson & Albers, 2001). Persistent poverty indicated a stronger negative effect on development for girls than for boys (Peterson & Albers, 2001). Another conclusion from this study was that affluence had a potential buffering effect on the negative consequences on child development related to maternal depression, however only when depression was not severe (Petterson & Albers, 2001). Maternal depression and psychological distress in the context of income holds critical implications for child health and development.

Clearly, maternal psychological health, both during pregnancy and in the postnatal period, can have detrimental effects on infant and child development, growth, and health. While it is clear that this factor, as well as the multiple factors related to maternal care that were initially mentioned, play a role in child nutritional status, the interactive influence of maternal depressive symptoms and IQ on child nutritional status is less clear. The aim of this thesis is to examine possible nutritional consequences that children may face when mothers experience depressive symptoms in the context of low IQ.

Maternal Education/IQ

Maternal education, or years of schooling, has been associated with child nutrition in several ways (Wachs, 2008). In developing countries, higher maternal education has been associated with increased duration and exclusivity of breastfeeding in some instances (Wachs, 2008). In both developed and developing countries, higher levels of maternal education have been associated with higher quality and quantity of child diet, increased physical growth of infants and young children, more involvement in child health and nutrition, and increased women's access to resources through increased family income and wealth (Wachs, 2008). Studies have also recognized maternal education as an indicator of involvement in decision-making about family resources (Wachs, 2008; Smith et al., 2003). Wachs (2008) suggested that higher levels of education enhance a woman's ability to make successful decisions, cope with difficult situations, acquire and use health information, and also enhance availability of opportunities to access resources or supplement income. All of these outcomes would enhance both quality of maternal care and health, and child health and nutritional status.

A significant association between maternal education and maternal intelligence has been examined (Wachs, 2008). It has been suggested that higher intellectual functioning as a result of more years of education, may mediate the relationship between maternal education and child nutrition, especially in the context of low income (Wachs, 2008). Maternal intelligence has been associated with longer duration of breastfeeding, more adequate infant dietary intake, and increased hemoglobin levels for infants and young children (Wachs, 2008).

Wachs (2008) further suggests an association between maternal intelligence and depression. Infants of depressed mothers who also had lower IQs demonstrated poor physical growth (Wachs, 2008). As previously discussed, maternal depression has been associated with a host of negative consequences for child cognition, development, and mother-child attachment and interaction. However, increased education poses a potential protective effect against these consequences by lowering a woman's risk for post-partum depression (Wachs, 2008).

Another study conducted in South India examined the influence of maternal depression and low intelligence on child nutritional status (Anoop, Saravanan, Joseph, Cherian, & Jacob, 2004). Both post-partum and current depression, defined as experience of depressive symptoms during one month after birth and within one month, respectively, was assessed in mothers using the Diagnostic and Statistical Manual III Revised (DSM III R) (Anoop et al., 2004). Intelligence was assessed using the Revised Bhatia's Short Battery of performance tests. Grade of weight-for-age was used as an indicator of child malnutrition (Anoop et al., 2004). This study revealed significant associations between current maternal depression and low birth weight, and post-partum depression and low maternal intelligence (Anoop et al., 2004). Malnutrition was associated with both PPD and current depression; low maternal intelligence was associated with increased child malnutrition and low birth weight (Anoop et al., 2004). Current depression demonstrated the least significant risk for child malnutrition, as child malnutrition may be a causative factor for current depression (Anoop et al., 2004). The increased emotional distress associated with a poorly nourished child, coupled with decreased desire and initiative in child feeding and care due to depressive symptoms highlights the difficult cycle that depressed mothers face (Anoop et al., 2004). One suggested mechanism through which lower maternal intelligence influences child malnutrition is in lowering a mother's ability to care for the child nutritionally, specifically through decreased ability to recognize the need for complementary foods during weaning (Anoop et al., 2004). This study highlights the need for increased awareness about the harmful effects of depression in new mothers and also for more instruction about prenatal maternal nutrition and supervision of mothers of lower intellectual status to ensure the nutritional health of mother and child (Anoop et al., 2004).

The specific question raised in this thesis is whether or not there is any connection between maternal depressive symptoms in the context of low maternal IQ and the nutritional status in school children, as measured by iron status. There is currently very little evidence on the associations between maternal IQ or education and child nutritional status in general and in school children more specifically. Whereas the nutritional care of very young children, through early infancy and weaning, receives quite a lot of attention, the nutrition of older children is much more under-studied.

Iron status is measured along a continuum from Iron-deficiency with anemia (IDA) to Iron-deficiency without anemia (ID) to normal iron status, including different amounts of stored iron, to iron overload (WHO, 2001). ID indicates diminished stored iron in the form of ferritin and hemosiderin as the result of long-term negative iron balance in the body (WHO, 2001). Diminished supply of iron from these iron storage molecules leads to a decrease in saturation of the iron transport molecule, transferrin, and a subsequent increase in transferrin receptors due to increasing need of iron for tissues (WHO, 2001). Hemoglobin, a protein component of red blood cells, reflects the capacity of red blood cells to carry oxygen in the body. Severely reduced hemoglobin concentration is indicative of IDA (WHO, 2001).

Children's iron status represents a key part of nutritional status and overall health. As previously mentioned, ID represents the most prevalent nutritional deficiency worldwide, and both ID and IDA hold critical implications for the proper physical, social, emotional, behavioral, and neurocognitive development of infants and young children (Ahmed et al., 2012; Beard, 2008; Lutter, 2008; Murray-Kolb & Beard, 2009; Walter, 2003; WHO, 2001).

Murray-Kolb & Beard (2009) examined the relationship between iron-deficiency anemia (IDA) in mothers and mother-child interactions in a double-blind intervention trial conduced in South Africa. The Emotional Availability Scale assessed mother-child interactions at 10-weeks and 9-months post-partum. Maternal iron-deficiency anemia negatively influences mother-child interactions in poor women

(Murray-Kolb & Beard, 2009). Specifically, the responsiveness of both mother and infant was reduced. More differences observed between the control group of non-anemic mothers, the mothers with IDA who received iron supplementation, and the mothers with IDA who received the placebo at the 9-month period than the 10-week period may indicate the cumulative nature of the effects of IDA, which may increase over time (Murray-Kolb & Beard, 2009). The sensitivity of mothers in the control group decreased from the 10-week to the 9-month period. This result suggested a potential increase in depression experienced by these mothers during that time (Murray-Kolb & Beard, 2009). The study noted that the participants lived in an environment conducive to anxiety and depression, and in fact, the IDA mothers demonstrated more anxiety and depression (Murray-Kolb & Beard, 2009). The main conclusions from this study included that maternal IDA affects both mother and infant interactive functioning, and iron nutritional status greatly impacts maternal emotional functioning, especially sensitivity and responsiveness (Murray-Kolb & Beard, 2009). The study further suggested that ID in infants and children may foster less interaction and responsiveness and thus contribute to less positive emotional development between mother and child (Murray-Kolb & Beard, 2009). Iron supplementation was also shown to be protective of mother-child interactions (Murray-Kolb & Beard, 2009). Clearly, maternal iron status plays a significant role in mother-child emotional development and attachment.

Additional research suggests connections between IDA in mothers and other factors that may influence the mother-child relationship and child development. One study revealed that early postpartum anemia, as measured by low hemoglobin concentration, presented a significant risk for the development of PPD (Corwin, Murray-Kolb, & Beard, 2003). Hemoglobin concentration in this study was measured on days 7, 14, and 28 during the 28-day period following birth and depressive symptoms were assessed on day 28 using the Center for Epidemiological Studies Depressive Symptomatology Scale (CES-D). Corwin and colleagues (2003) found no correlation between Hb level and CES-D score on day 28. This finding has several interesting implications. Low Hb in the few days or weeks following birth may negatively influence a mother’s ability to recognize her infant’s cues from the beginning, thus contributing to increased feelings of impatience and a reduction in the happiness normally associated with a new baby (Corwin, Murray-Kolb, & Beard, 2003). Experience of these feelings may then result in experience of clinical depression on day 28 (Corwin et al., 2003).

Another study examined the association between maternal and child blood lead and hemoglobin levels and maternal parenting perceptions (Kordas, Ardoino, Ciccariello, Mañay, Ettinger, Cook, & Queirolo, 2011). This study found an association between maternal and child exposure to lead and associated elevation in blood lead levels and maternal perceptions of parenting in regards to limit setting and discipline. Specifically, when child blood lead levels were elevated, mothers reported having "less ease" in discipline or limit setting. The fact that this study indicated no correlation between maternal and child blood lead levels revealed the possibility that exposure independently influences maternal parenting perceptions, as opposed to just the behavioral problems associated with elevated child blood lead levels causing a mother to feel less in control over the child's behavior and thus inadequate as a parent (Kordas et al., 2011). Maternal anemia was associated with decreased likelihood of allowing a child to explore his or her environment, suggesting that the decision for exploration is partly the mother's, a concept that was previously debated whether the decision stemmed more from the infant/child or mother. Related to low hemoglobin level and anemia in the child, mildly anemic children had mothers who were four times more likely to report low scores on perception of emotional support and sensitivity to the child's needs compared to mothers of children without anemia (Kordas et al., 2011). The findings from this study indicate the significance of the effects of lead exposure and mild anemia on maternal perceptions of parenting (Kordas et al., 2011). The idea that child hemoglobin level and anemia may reduce a mother's self-esteem and perception of ability to adequately parent holds critical implications for subsequent child health and development.

Clearly, multiple factors play a role in determining child nutritional status. The most influential of these factors includes the mother-child relationship, maternal decision-making, and maternal care, the quality of which is also influenced by multiple factors, including family and social circumstances;

maternal psychological health, depression, nutritional status, societal status, and education. While these maternal factors have been the subject of many previous research studies related to child health, this thesis focuses specifically on the relationship between maternal depressive symptoms in the context of low IQ on child nutritional status, and specifically iron status and intake. Additionally, though some current research supports the idea that maternal depression and IQ influence nutritional status of children, most of the research is focused on infants and young children. The primary objective of this thesis is to determine the role that maternal depression in the context of low maternal IQ plays in iron status of school-aged children.

The potential implication of this work is that it may provide further evidence for a relationship between maternal depression, IQ, and child nutritional status. Overall, the central hypothesis of this thesis is that mothers with low IQ and higher depressive symptoms will have children who have particularly low iron status.

METHODS

Study Setting

This study was conducted in the southern region of Uruguay in the capital city of Montevideo. The study took place in private elementary schools from six different neighborhoods in the Montevideo area. Previous studies indicate prevalence of metal exposure in this population of children (Kordas, Queirolo, Ettinger, Wright, & Stoltzfus, 2010; Mañay, Cousillas, Alvarez C, & Heller, 2008; Queirolo, Ettinger, Stoltzfus, & Kordas, 2010).

Participant Recruitment

Recruitment began with advertisements and announcements targeted at parents and school directors. Invitations were sent to private elementary schools in the six neighborhoods identified by their potential for lead and other metal exposure from the environment. Letters of invitation to the school directors were followed up with phone calls. A full explanation detailing all aspects of the study was provided to interested school directors through in-person meetings. Upon directors' agreement to participate in the study, letters describing the study were sent out to parents of all the school children. Additional information sessions were offered at the schools for parents interested in learning about the study to further explain the study rationale and procedures in person. Of the nine elementary schools that chose to participate in the study, 410 first-grade children total were eligible.

Sample

211 children out of the 410 children who were eligible for the study and their mothers were enrolled. The children were between six and eight years old. 14 of the mother-child pairs chose not to continue and withdrew from the study.

My Role

My specific role on this project was data entry of all participant information, including assessments and questionnaire responses.

Ethical Concerns

The Ethics Committee for Research Involving Human Participants at the Catholic University of Uruguay and the Office of Research Protections at the Pennsylvania State University approved the study. School directors who agreed to participate in the study signed a letter indicating their interest in participation. Consent from all first grade teachers was obtained either at or following the meetings with directors. Parental consent forms were distributed at the information sessions at each participating school. Parents were given the opportunity to read and sign consent at the meeting or after returning home to discuss participation with spouses and family. Upon completion of the consent form, parents were given a copy of consent for their own records. Study personnel were available to answer any questions or concerns about the study before consent was given. Additionally, oral assent from each child was obtained before blood collection and cognitive testing.

Procedure

The study consisted of several evaluations. Mothers were invited to the school to fill out self-administered questionnaires regarding home environment, parental stress, child's medical history, and socio-demographic characteristics. Assistance was provided when needed by research staff. Typically, evaluations of mothers and children were conducted at the schools. However, mothers were also given the option for evaluation at the Research Center at the Catholic University of Uruguay, if necessary.

Children in the study participated in cognitive testing with trained psychologists at the school to evaluate different cognitive functions, performance, and achievement. Children and mothers were also invited to participate in a clinical assessment at the school. Samples of fasting venous blood, hair, and first morning urine were collected. Anthropometric assessments of the children were conducted including height, and weight, which allowed for BMI (body mass index) to be derived for each child. Children were evaluated for hemoglobin level and referred to a pediatrician if anemia was detected. All clinical results were shared with the parents. Children participated in a 24-hour diet recall to assess diet. Mothers or other caregivers were present during the recall. Approximately two weeks after the first recall, a second recall was obtained over the phone.

Mothers were invited to participate in a different evaluation. Trained psychologists assessed the presence of depressive symptoms and anxiety, as well as IQ, details provided below.

Assessments

Biochemical

A fasting blood sample was performed on each child between the hours of 8am-11am at the school. A 25-guage safety butterfly blood collection set (Vacutainer, Becton Dickinson, Franklin Lakes, NJ) was used to draw venous blood from each child participant. Blood collected for whole blood lead analysis was collected in a lithium heparin tube (Becton Dickinson, Franklin Lakes, NJ). A portable hemoglobinometer (HemoCue Inc, Lake Forest, CA) was used to measure hemoglobin from the sample immediately following collection; quality control was checked daily using the controls provided by the manufacturer. Blood was also drawn for serum and plasma tubes. The Research Center at the Catholic University of Uruguay stored all collected samples at -20 degrees Celsius until they were transported on dry ice to the Department of Nutritional Sciences at Pennsylvania State University and (stored at -20 degrees Celsius) for analysis.

Serum Ferritin (SF) concentrations were measured with a CV of less than 10% by an immunoradiometric assay using an aliquot of 10 µl (Coat-A-Count Ferritin IRMA; SIEMENS Diagnostic Products, USA). Ferritin is measured between the two antibodies, ^{125}I-labeled anti-ferritin polyclonal and monoclonal anti-ferrtin, in liquid phase and coated to the wall of a polystyrene tube, respectively. The ^{125}I- labeled anti-ferritin polyclonal antibody is used as a radioactive tracer. The radioactivity was measured as count per minute with a gamma counter (Packard Cobra II Auto gamma counter, Perkin Elmer). The concentration of ferritin is directly proportional to the radioactivity in the tube. An eight point standard curve from a set of calibrators obtained from the manufacturer calculated the serum ferritin concentration. 4.2% and 9.5% represent the intra-assay and inter-assay coefficients (CV).

Subclinical inflammation/infection in the children was detected through concentration of C-reactive protein (CRP). An ELISA technique described by Erherdt and colleagues (2004) was used to measure CRP in duplicate. The capture antibody Goat anti-Human CRP antibody (Bethyl Laboratories, TX) and the detection antibody HRP conjugated Goat anti-human CRP antibody (Bethyl Laboratories, TX) were used to indicate the concentration of CRP. Serum samples (Liquicheck, Bio-Rad) were used as controls. An automated micro plate reader (Epoch Microplate Spectrophotometer, Biotek, Winooski, VT) was used to read the plates at 450nm. Serum CRP was measured in a 7 point curve. Variability within the assays was measured. The intra-assay coefficient (CV) was 4.9% and the inter-assay CV was 8%.

For statistical analysis, serum ferritin values were adjusted for CRP based on the methodology reported by Thurnham and colleagues. All values with CRP concentrations above 5 mg/dL were identified and a correction factor of 0.63 was applied to those values. Furthermore, iron deficiency was defined as a CRP-adjusted serum ferritin concentration below 15 μg/dL. Statistical analyses were conducted using both the continuous serum ferritin variable and the likelihood of ID as outcomes.

Dietary Intake

An assessment of each child's diet was conducted through two 24-hour recalls performed by trained nutritionists. The child's mother (or another caregiver) answered questions regarding the child's diet, however the child accompanied the mother to the recall and also participated. The child answered questions about food consumed at school. The first recall was conducted at the time of the blood draw at school. Approximately two weeks later a nutritionist made a phone call to the child's mother and conducted the second recall through a phone interview.

Nutritionists collected a list of foods and beverages consumed by the child in the preceding 24 hours. Questions were asked regarding the name of the meal, time and place it was consumed, amount of food or portion consumed, how the food was prepared, and any brand names associated with commercial products used. Models and measuring cups brought to the school interviews were used to indicate size/portion of food or beverage consumed. Other questions were asked regarding vitamin and mineral intake. Questions regarding intake of food/beverage at certain times, such as at bedtime or after school prompted more accurate recall overall. Specific codes for each food in addition to consumption amounts were entered into a database of typical Uruguayan foods and the nutrient values. Uruguayan fortification of milk products with iron in schools and fortification of wheat flour with iron and folic acid (30 mg and 2.4 mg, respectively) was taken into account for calculations. Total energy, carbohydrate, protein, total fat, fiber, iron, zinc, calcium, folate, and vitamin C include the nutrients that were measured in this study.

For analysis, the intake values from the two recalls were averaged to estimate the daily intake of total calories, carbohydrate, protein, total fat (as well as percent energy contribution from carbohydrate, protein and fat). Where only a single recall was available, that recall was used in nutrient intake calculations. The average daily intakes of dietary fiber, iron, zinc, calcium, folate, and vitamin C were also calculated. Nutrient intakes were tested for systematic differences among nutritionists using ANOVAs with Scheffe comparisons, and none were found. Consequently, no further adjustment by nutritionists was made.

To account for the fact that individual nutrient intake will vary depending on the amount of food (and thus, energy) consumed, the intake of nutrients was adjusted by dividing each individual nutrient value by the number of calories consumed and multiplying by 1000. Thus, the intake of each nutrient was expressed on a per 1000 kcal basis (for example, for the intake of iron, the value is given as mg Fe/1000 kcal), and this value was used as the outcome variable in statistical analysis.

Cognitive/Emotional Assessment of the Mother

Maternal IQ was evaluated through the Wechsler Adult Intelligence Scale III (WAIS III, TEA Ediciones, S.A., Madrid, Spain). The study estimated a value for IQ through the scores of five sub-tests: similarities, arithmetic, vocabulary, block design, and object assembly. To minimize scoring errors, two psychologists calculated each participant's scores. The test administrator and coordinating psychologist communicated and addressed discrepancies in scoring.

The Argentine adaptation of the Beck Depression Inventory II (BDI II, Ediciones Paidós, Buenos Aires, Argentina) was used to evaluate depressive symptoms in the mothers. Symptoms that are assessed through the BDI II correspond to symptoms of depressive disorders in adults in the Diagnostic and Statistical Manual of Mental Disorders IV (DSM IV). The symptoms of depression that were assessed in this study include the following: sadness, pessimism, failure, feelings of guilt, self-criticism, suicidal thoughts, and others. Four phrases were used to reflect each mother's feelings in the two weeks preceding the evaluation. The phrases indicated the severity of distress, including statements such as "I do not feel sad" or "I am so sad or so unhappy that I cannot stand it" in response to the question regarding "sadness". A total BDI score was calculated from summation of the responses to all of the questions. Mothers were classified as having mild depressive symptoms for BDI scores of 14-19 points. Scores of 20-28 points and 29-36 points indicated moderate and severe depressive symptoms, respectively.

Statistical Analysis

All analyses were carried out using STATA 12.0 (STATA Corp, College Station, TX). The objective of the study was to measure the association among maternal depression, IQ and children's nutritional status and nutrient intake. Accordingly, the statistical analyses were set up with several outcome and two main predictor variables. For outcomes involving nutritional status indicators, the hemoglobin value (continuous variable), anemia (dichotomous), CRP-adjusted serum ferritin value (continuous), and ID (dichotomous), were tested as dependent variables. For the consumption of micronutrients (all continuous), the intake of fiber, iron, zinc, calcium, total folate, and vitamin C were used as dependent variables. Maternal IQ (continuous) and Beck Depression Inventory score above 19 points (defined as moderate depression) were used as the main predictor/independent variables. Initially, separate unadjusted Ordinary Least Square (OLS) regression models were run to test the association between maternal IQ (Model 1) and the dependent variables, as well as to test the association between moderate depression and the dependent variables (Model 2). In another set of unadjusted statistical models (Model 3), the two predictor variables and their interaction term were tested together. Where the interaction term did not reach a p-value of 0.15, the main effects models were re-run. In those cases where the interaction term was significant at a $p<0.15$, the association between maternal IQ and the given dependent variable was investigated in models stratified by depression score dichotomized at 19 points.

Essentially, the association between maternal IQ and outcome was tested in children whose mothers did or did not have moderately high depressive symptoms.

A final set of models (Model 4) was run testing the two predictor variables (maternal IQ and depressive symptoms) and their interaction term, together with covariate-adjustment. Covariates for this analysis were chosen based on previous knowledge of the factors that could influence children's nutritional status. Covariate adjustment was conducted in two phases. In the first phase, a core set of covariates was entered into the models; this included child sex, the presence of crowding in the house, number of household possessions, maternal age, maternal education, and the area of Montevideo where the child lived. In the second phase of covariate adjustment, the core set of covariates was augmented by the addition of the factor score representing support for children's autonomy and the HOME score representing cognitive support.

Before conducting regression analyses as described above, patterns of missing values were evaluated. This analysis revealed that the highest level of missing information was in the two predictor variables, with 75-76 (33%) mothers missing an IQ or Beck Depression Inventory score. In terms of outcome variables, 28-30 (14%) children did not have information on dietary intake and 42 children (20%) did not have serum ferritin values. Finally, up to 48 children (23%) did not have information on at least one covariate. The likelihood of having missing values for IQ, moderate depression, and serum ferritin was investigated using separate logistic regressions. Models predicting the missing status (yes/no) of the three variables were fit with child sex, crowding, possessions, maternal age, maternal education, neighborhood, support for child autonomy and HOME cognitive score—the variables slated for use as covariates in the planned statistical analyses. None of the potential covariates were associated with the likelihood of having missing ferritin values. Only neighborhood was associated with the likelihood of missingness in the maternal mental health variables, in that women living in two of the poorer neighborhoods were considerably (80%) less likely to have missing data. To address the issue of missing values, multivariate multiple imputation was carried out using chained equations (*mi ice* command in

STATA), according to methodology outlined by Royston and White (2011). Because it is important to run imputation models on the same variables that will later be used in regression analyses, the imputation model included all the outcome, predictor and covariate variables entered together. Additionally, the interaction term between maternal IQ and moderate depression was included in the imputation model. Finally, 25 iteration cycles of the imputation were run, resulting in 25 imputed datasets (and as many series of estimated values for all missing variables) that could subsequently be combined for the regressions testing the study hypotheses

RESULTS

Table 1 highlights basic socioeconomic information for the mother-child pairs who participated and were able to provide this information. For the participating mothers who were assessed, overall intelligence quotient was low, indicating an average of 83.3 ± 14.2 points, and 36.4% scoring below 80 points (Table 1). Notably, 15.6% of mothers reported experiencing moderate depression, as indicated by a score of more than 19 points for depressive symptoms (Table 1). It is also important to note that more than half of the mothers scored above the median on a scale indicating a strong belief in child autonomy. Overall participant socioeconomic status was low, as indicated by scores on the number of household possessions (Table 1).

Overall nutritional status for the children who participated was fairly good (Table 2). In relation to iron status, specifically, approximately 63% of children were iron-deficient and approximately 8% had anemia (Table 2). Daily iron intake (in mg) exceeded the RDA for Uruguayan children at 10.2 mg/day compared to 7 mg/day recommended (Ministerio de Salud Público, 2007). Total iron intake was adjusted for calories to account for the fact that children who consume more total calories are likely to have more adequate nutrient intakes overall compared to children who eat less. Expressed in those terms, children consumed a mean of 4.62 mg iron per 1000 kcal (Table 2).

Table 3 provides the unadjusted associations between maternal IQ, depression and education, and child nutritional status or nutrient intake and Table 4 provides the associations adjusted for covariates. There was no significant interaction score between maternal IQ and depressive symptoms and child iron status. Nevertheless, in unadjusted regression, iron intake (mg/1000kcal) was modestly higher in children when the mother had a higher IQ. Specifically, for each 1 point increase in maternal IQ, the intake of iron increased by 0.03 ± 0.01 mg/1000 kcal (Table 3, Model 1). This result was unaffected when maternal depression was also entered into the model (Model 3). This indicates that while the presence of depression appears to make no difference in iron intake, higher IQ does. However, this finding was no longer significant once the model was adjusted for covariates (Table 4).

Interestingly, the results with the interaction term between maternal IQ and depressive symptoms, and child folate intake were significant, both in unadjusted and covariate-adjusted models (Tables 3 and 4). Because the interaction term was significant, the association between maternal IQ and folate intake was explored further by conducting two separate regression models, one for mothers who had depressive symptoms and one for mothers who did not. In women without depressive symptoms, there was no significant association between maternal IQ and the folate intake of their children ($\beta \pm SE$ in a covariate-adjusted model: -0.57 ± 0.54, $p > 0.05$). On the other hand, in women who reported having depressive symptoms, each 1 point increase in IQ was associated with a covariate-adjusted 4.73 ± 1.70 µg/1000 kcal ($p = 0.016$) increase in their children's folate intake.

DISCUSSION

Although much of published research supports an association between maternal health and child health, and maternal psychosocial health and child health, existing research regarding how these factors influence nutritional status overall and iron status specifically is limited to infants and young children. The primary motivation for this thesis was to examine how maternal depressive symptoms in the context of low IQ influence nutritional and iron status in school-aged children.

Overall, the results for this study do not suggest an association between maternal depression and IQ and child nutritional status. Despite the fact that 63% of children in this study were iron-deficient, and approximately 8% of children were anemic, total daily iron intake (in mg) exceeded the RDA for Uruguayan children at 10.2 mg/day compared to 7 mg/day recommended (Ministerio de Salud Público, 2007). The value for this nutrient was adjusted for total caloric intake, however the results suggest that most children had a sufficient iron and nutrient intake, and the cases of iron-deficiency and anemia are likely due to factors other than inadequate intake of iron or the presence of maternal depressive symptoms and IQ. Although this current study does not reveal any association between maternal depression and IQ, and child nutritional status, several other studies indicate that maternal psychosocial health influences child health and nutritional status, and potentially child iron status.

A few studies have examined the effect of postpartum maternal depressive symptoms on later child growth and development in preschool and school-aged children. One of these studies looked at the relationship between maternal depressive symptoms 9 months postpartum and child growth at ages 4 through 6 years, or upon entering preschool and kindergarten (Surkan, Ettinger, Ahmed, Minkovitz, & Strobino, 2012). Data was collected from the Early Childhood Longitudinal Study Birth Cohort, including approximately 10, 700 children born in the United States and followed from 2001 and 2007 (birth to kindergarten). Data collected included socioemotional, psychomotor, cognitive development and growth. Data for this study focused on child growth at 4 and 5 years of age whose mothers experienced depressive symptoms when the child was 9 months old (Surkan et al., 2012). Assessment of maternal depressive symptoms was evaluated through the Center for Epidemiological Studies Depression Scale. This scale measures severity of depressive symptoms on a scale of 0-3, or “rarely” to “most”, with a potential total score of 36. Child weight was measured at 9 months, 4 years, and 5 years. Weight-for-age, height-for-age, and weight-for-height was assessed at age 4 and 5 years. Maternal depressive symptoms experienced in the child’s first year of life, whether mild or moderate to severe, put the child as increased risk for being less than 10 percentile for height-for-age at ages 4 and 5 years, according to the 2000 US Center for Disease Control and Prevention growth charts (Surkan et al., 2012). At age 4 years, mild to moderate or severe depressive symptoms indicated a 40 percent increased risk, and age 5 showed a 50 percent increased risk (Surkan et al., 2012). The fact that other growth measures were not influenced by the experience of maternal depressive symptoms indicates that postpartum maternal depression may negatively influence caregiving factors, effecting child growth over a prolonged period of time and resulting in reduced stature. This study also suggests that the increased stress associated with maternal depression also increases child stress and impacts growth). It is important to note that Surkan et al. (2012) mentions this study as one of the first studies in a developed country to look at maternal depression and child growth beyond 3 years of age, thus supporting the idea that more research is needed in this field regarding school aged children.

A similar study examined the relationship between prolonged maternal depression and child growth outcomes at age 4 years. This study was conducted in Brazil, with approximately 3800 mother-child pairs (Santos, Matijasevich, Domingues, Barros, & Barros, 2010). Maternal depression was assessed at 3, 12, 24, and 28 months using the Edinburgh Postnatal Depression Scale, which evaluates intensity of depressive symptoms within the past week. Categories included “never depressed” (EDPS <13 at all 3 follow-up points), “depressed” in 1-2 follow-ups, or “always depressed” (EPDS ≥13 at each follow-up visit). Growth outcomes assessed included underweight, stunting, and wasting at 48 months.

There was a positive association between maternal depression and both underweight and stunting, with prevalence higher than 3 percent for children with depressed mothers compared to non-depressed mothers. At 4 years of age, the prevalence of stunting was 1.4 times higher than expected for a healthy population, and prevalence of overweight was 5 times higher. For children whose mothers experienced either mild or chronic depression in those 4 years, the prevalence of stunting and underweight was 2 and 3 times higher than in children without depressed mothers (Santos et al., 2010). However, this finding was attributed to problems aside from maternal depression once results were adjusted. Though this study itself did not support the idea that maternal depression during infancy has lasting effects on child growth, Santos et al. (2010) compared their work to other similar studies, suggesting that socioeconomic and sociocultural factors play a key role in mediating the effects of maternal psychosocial health on child nutritional status and growth.

Based on other research, one of these potential factors is low income. Burdette, Whitaker, Harvey-Berino, and Kahn (2003) studied the relationship between maternal depressive symptoms and emotional and social functioning in low-income preschool children ages 3-4. The Center for Epidemiological Studies Depression Scale was also used in this study to evaluate maternal depressive symptoms. Emotional and social functioning was assessed through the Pediatric Quality of Life Inventory. Approximately 31 percent of mothers fell into the category of "clinically depressed" or CES-D scores greater than or equal to 16. Girls with clinically depressed mothers had significantly lower social functioning than girls with non-clinically depressed mothers, at 62% as compared to 27% (Burdette et al., 2003). Additionally, smoking status appeared to have a significant effect in mediating the relationship between maternal depression and child social/emotional functioning. For example, social/emotional function was much lower in children of mothers who were smokers and clinically depressed as opposed to mothers who were nonsmokers; the percentage of low social/emotional functioning was 54% as opposed to 29%, respectively. Ultimately, this study supports the idea that maternal depressive symptoms influence child social and emotional functioning, especially when taking gender and smoking status into account (Burdette et al., 2003).

Other research exists that supports the idea that low socioeconomic status plays a moderating role in the influence of maternal depression on child psychosocial health. Melchior, Chastang, Lauzon, Galéra, Saurel-Cubizolles, & Larroque (2012) conducted a study using data from the EDEN mother-child cohort study in France based on pre- and post-natal factors associated with child growth, behavior, and health. The CES-D scale was used to assess maternal depression. Child temperament was evaluated at 12 months using the EAS questionnaire that includes four categories for temperament: "emotionality (i.e. negativity, intense emotional reactions), activity (i.e. high frequency and intensity of motor responses), sociability (i.e. preference for being alone rather than with others, adaptability to others), and shyness (i.e. inhibited or tense behavior around unfamiliar persons, tendency to avoid social interactions)" (Melchior et al., 2012). In children with depressed mothers, emotionality was significantly higher, especially in the context of low income. Additionally, activity was higher in children who came from low-income families. Potential mechanisms behind the results from this study include biological pathways related to stress and maternal stress hormones when depression occurs during pregnancy, and that mothers who are depressed may be less likely to provide the child with the necessary attention and positive response needed to form secure attachment in infancy (Melchior et al., 2012). Overall, the results suggest that maternal depression may especially influence child emotional difficulties and temperament when low socioeconomic status is involved.

Some evidence relating to preschool and school-aged children exists that supports an association between maternal depression and child nutritional status, specifically, through effects on feeding practices. A study conducted by Goulding, Rosenblum, Miller, Peterson, Chen, Kaciroti, and Lumeng (2014) researched the effects of maternal depression on children ages 4-8 years in low-income families from Head Start programs in Southeastern Michigan. Maternal depression was also evaluated using the CES-D scale for this study. Maternal feeding practices were evaluated by three different methods, including questionnaires administered by interviews to the mothers, video-taped observations of mother-child feeding interactions in the lab and home settings, and semi-structured interviews with the mothers to elicit feelings about child feeding. Mothers who were classified as having elevated depressive symptoms, or were in the 80th percentile for the CES-D scale, showed more pressuring of the child to eat, were less likely to eat with the child and more likely to have the television on during meals at home, and exhibited less authority during feeding practices according to the semi-narrative interviews (Goulding et al., 2014). Additionally, these mothers were less likely to display "contingency responsiveness" or reciprocity between mother and child during feeding. This study suggests that potential mechanisms behind these findings include that mothers who experience depression may have enhanced recall of difficult feeding interactions, may have more negative parenting perceptions and lower self-esteem in feeding interactions, and also may be less likely to establish rules or expectations for the child during meals (Goulding et al., 2014). Ultimately, this study supports the idea that maternal depression, in the context of low income, presents significant implications for responsiveness in feeding practices, and thus healthy eating behaviors and child nutritional status.

A similar study looked at the influence of maternal depression on family eating behaviors and child weight status in children ages 2-5 years (McCurdy, Gorman, Kisler, & Metallinos-Katsaras, 2014). For this study, maternal depression was assessed using CES-D, and family eating behaviors were evaluated through a 20-item survey called the Family Food Behavior Survey, using a 5-point Likert scale. Food resource management skills were also assessed using a 5-point Likert scale. Examples of these skills included managing a budget, preparing nutritious or well-balanced meals, paying bills, and stretching groceries). Child weight status was assessed through BMI calculations and normal ranges of healthy weight (greater than or equal to 5th percentile) and overweight and obesity (greater than or equal to 85th and 95th percentile, respectively). Children whose mothers had better food resource management and were also present during meals were significantly more likely to have healthy weight status. Though maternal depression was significantly associated with all family eating practices, it was not considered a significant mediator between family eating practices and child weight status. Maternal depression was associated with less maternal control over eating, less presence during meals, more child control over eating, less food resource management skills, and more negative family mealtimes.

One potential mechanism supported by this study involved the family stress theory, indicating that maternal depression associated with stress (such as low income) may lead to less responsive parenting and affect behavior associated with child eating practices (McCurdy et al., 2014). Interestingly, neither maternal control nor child control over child eating behaviors predicted healthy or unhealthy weight status in these preschool aged children. Also interesting to note is the suggestion that maternal education may explain the connection between food resource management skills and healthier child weight status. For example, mothers with more education may know more about healthy nutrition and how to manage resources to make the most out of meals. The study was unclear as to whether it was good food resource management skills that influenced child weight or whether child weight status encouraged food resource management skills due to concern about child weight (McCurdy et al., 2014). Overall, the study concluded that maternal depression was only associated with family eating practices and not with child weight status, though maternal presence was highly predictive of child weigh status, and should be given more attention in future studies (McCurdy et al., 2014). Ultimately this study supports the idea that both maternal depression, and potentially maternal educational level may play a role in child eating behaviors and nutritional status.

Factors influencing child nutritional status have already been introduced and discussed extensively in this paper. These factors include the mother-child relationship and infant attachment, maternal autonomy and decision-making ability, maternal caregiving practices, and maternal nutritional status and overall health. The influence of maternal psychosocial health and educational status has also been discussed in relation to maternal care and child health.

A few studies have looked at the determinants of infant and child iron status, specifically, in relation to possible influences from maternal psychosocial health. Research conducted by Murray-Kolb and Beard (2009) supports an association between maternal IDA and increased depression, decreased emotional functioning, and reduced responsiveness in infant-mother interactions. This same study also suggested a relationship between ID in infancy contributing to less positive mother-child emotional development (Murray-Kolb & Beard, 2009). Other research by Corwin, Murray-Kolb, and Beard (2003) showed an association between maternal hemoglobin status during pregnancy and increased risk of post-partum depression, also potentially influencing emotional response towards the new child. Kordas et al. (2011) found an association between child hemoglobin level and maternal parenting perceptions, suggesting that reduced child hemoglobin level and anemia negatively influenced maternal self-esteem, perception of emotional support, and sensitivity to child's needs.

Although these studies suggest a connection between maternal psychosocial health and iron status or hemoglobin status in infants and young children, limited evidence exists to support an association between maternal depression, IQ, and nutritional or iron status of school-aged children. Much of the existing research on iron status of school-aged children is focused on associations between iron status and cognitive and emotional/social development, including the influence of ID and IDA in infancy on these factors in later life (Lozoff et al., 2000; Lozoff, Jimenez, & Smith, 2006; Kordas et al., 2004; Pollitt, 1993; Walter, 2003).

Although the current study did not support a direct association between maternal depression in the context of low IQ on child iron status, this topic requires further study. As mentioned in the studies described above, maternal psychosocial health does play a role in the growth outcomes and development of preschool to school-aged children, potentially through the mechanisms of low socioeconomic status and maternal feeding practices. The former, in particular, may explain why results for this study were not conclusive. Socioeconomic status was a potential cofounder for which results were adjusted. A more significant association may exist between maternal depression in the context of low socioeconomic status and child nutritional or iron status, as opposed to in the context of low IQ. For participants in this study, though IQ was low, with the mean score totaling 83.3, maternal education was relatively high, with majority of participants obtaining secondary education. If IQ scores or educational status for the mothers had been even lower, a more significant association may have been found. Though results indicated that some mothers did experience depressive symptoms (15.6%), more severe depression (higher scores) or more widespread depression (higher prevalence) is needed to detect these associations. Another possibility is that the women in this study had support networks that we did not measure, which cofounded the association between IQ/depression and child iron intake/status.

As for overall child nutritional status and iron status, this study revealed relatively good nutritional intake and iron intake exceeding the recommended daily requirement (~2255 kcal per day and ~10.2 mg iron per day). Even when iron intake was adjusted for total caloric intake, the value was still relatively good (~4.2 mg per 1000 kcal). Though the majority of children in this study did have ID (~63%), it was most likely attributed to factors other than maternal depression and IQ that we did not measure. For example, research supports the idea that iron-deficiency may occur as a result of blood loss from certain infections such as hookworm or schistosomiasis (WHO, 2001). Iron-deficiency may also occur as a result of poor absorption or reduced bioavailability from non-heme iron sources, or from lack of other micronutrients that enhance iron utilization from these sources (Davidsson & Haskell, 2011; WHO, 2001). New research supports existence of certain genetic conditions such as Iron Refractory Iron Deficiency Anemia, which involves a gene mutation that effects expression of hepcidin and causes microcytic, hypochromic anemia (Yilmaz & Yenicesu, 2015). Clearly, ID and IDA stems from multiple causes, as opposed to solely nutrition-related causes.

Interestingly, a significant association was found between child folate intake and maternal depression in the context of IQ. Results revealed that the association between maternal IQ and child folate intake was only significant in the presence of maternal depression. In these cases, for every one point increase in maternal IQ, child folate intake increased by 4.7 mg. These results ultimately suggest that higher maternal IQ may be protective for child folate intake, in the context of maternal depression.

Existing research supports an association between maternal antenatal and postnatal depression with maternal folate status, suggesting that maternal folate intake may be protective against depression during and after pregnancy (Chong, Wong, Colega, Chen, LW, van Dam, Tan, Lim, Cai, Broekman , Lee, Saw , Kwek, Godfrey, Chong, Gluckman, Meaney, & Chen H, 2014; Aishwarya, Rajendiren, Kattimani, Dhiman, Haritha, & Ananthanarayanan, 2014). Other research supports the idea that low maternal folate status in combination with depression negatively influences birth outcomes, particularly in relation to shorter gestational age and lower birth weight (Van Dijk, Eljsden, Stronks, Gemke, & Vrijkotte, 2010). For the purposes of the current study, since none of the above factors were measured other than maternal depression, it is impossible to know whether maternal folate status during pregnancy was affected by depression, or whether it played a role in determining child folate status. A potential explanation of this finding is that depressed mothers with higher IQs had the knowledge about the essentiality of folate in the child's diet, or as a result of anxiety associated with depression took extra precaution to ensure the child was consuming enough of adequate nutrients. Further research regarding a connection between maternal depression, IQ, and child folate status is necessary to explain these results.

Strengths of this study include the use of trained professionals to collect necessary data, such as the use of multiple psychologists to assess and calculate maternal IQ scores and evaluate presence of maternal anxiety and depression, and nutritionists to obtain information regarding child diet and nutritional intake. Reliable measurements were also obtained for child hemoglobin through use of credible lab tools.

Primary limitations include the small sample size of the study and the fact that the assessments of maternal depressive symptoms may not have been wholly accurate. For example, it is possible that some mothers may have felt uncomfortable in answering questions regarding their psychosocial health with complete honesty, or answering in a way they thought would please the psychologists. It is also possible that mothers choosing to participate in this study were of better psychosocial health and higher IQ to begin with, thus prompting their agreement to participate. Future studies evaluating effects of maternal depression in the context of low socioeconomic status on child nutritional or iron status and effects of maternal depression and IQ on child folate status in particular are necessary in order to better understand potential relationships between these factors.

Although no association was found between maternal depression in the context of low IQ on child nutritional or iron status, further research is needed regarding this relationship in order to draw more conclusive associations. Research strongly supports the idea that maternal health and nutritional status influences child nutritional status, growth, and development. As presented in existing literature, both maternal depression and educational status influence maternal factors related to childcare, such as the mother-child relationship, maternal decision-making autonomy, and maternal caregiving practices. Additionally, research exists that supports a relationship between maternal depression and maternal ID and IDA, as well as infant ID and IDA. Associations between maternal psychosocial health and emotional health and child emotional and cognitive development, as well as child iron status and emotional and cognitive development have also been found. More recent studies reveal a connection between maternal psychosocial health and child nutritional status in preschool to school age, with potential mediating factors including socioeconomic status and feeding practices. Ultimately, more research is necessary to explore these associations further, especially in relation to school-aged children. Research in these areas hold significant implications for continuing to improve maternal and child health and nutritional status overall.

Table 1 Participant Characteristics

Characteristic	N	M ± SD or %	Range
		Mother	
Age (years)	184	33.6 ± 6.8	21 – 57
Education level	183		
Primary		20.2%	
Secondary		65.6%	
Post-secondary		14.2%	
Occupation	171		
Unemployed		39.8%	
Domestic services		19.3%	
Work requiring less training		17.5%	
Work requiring more training		23.4%	
Weekly hours dedicated to paid work	180	17.9 ± 20.4	0 – 80
0		41.7%	
1 – 20		18.9%	
21 – 40		18.9%	
41+		20.6%	
Marital status	156		
Married		47.4%	
Divorced		16.7%	
Civil partnership		35.9%	

Intelligence quotient (points)	140	83.3 ± 14.2	29 – 128
<80 points		36.4%	
Depressive symptoms (points)	141	11.9 ± 8.8	0 – 43
>19		15.6%	
Belief in child autonomy factor score	168	15.9 ± 3.1	5 – 20
> median		58.3%	
Household			
HOME Inventory, emotional support	161	5.3 ± 1.4	1 – 8
HOME Inventory, cognitive support	174	4.6 ± 1.6	1 – 8
Occupant density	182	2.0 ± 0.8	0.7 – 5.0
>2		23.1%	
Household possessions	184	3.6 ± 1.4	0 – 6
>3		26.6%	
Child			
Age (months)	209	81.8 ± 6.7	57 – 103
Male sex	211	56.9%	
Child’s living arrangements	179		
With both parents		70.9%	
With bother and her partner		7.3%	
With only mother or father		20.7%	
With another person		1.1%	

Table 2 . Nutritional status and nutrient intake of the participating children.

Biomarker or nutrient	N	M ± SD or %	Range
		Indicator of nutritional status	
Hemoglobin (g/dL)	184	13.3 ± 1.1	10.1 – 16.3
Has anemia[1]		7.6%	
CRP-adjusted serum ferritin (μg/L)	174	14.2 ± 13.0	1.1 – 95.6
Has iron deficiency[2]		62.6%	
Height (m)	187	1.2 ± 0.6	1.1 – 1.4
Height-for-age Z score	187	0.5 ± 1.1	-1.9 – 4.4
< -1SD		6.9%	
Weight (kg)	188	25.8 ± 5.8	13.8 – 48.7
Weight-for-age Z score	187	0.8 ± 1.3	-3.4 – 4.7
< -1SD		8.0%	
Body mass index (kg/m^2)	187	0.7 ± 1.4	-4.9 – 4.3
Z-score > 1 SD		39.6%	
Z-score > 2 SD		19.8%	
		Daily nutrient intake	
Energy (kcal)	188	2,255 ± 603	937 – 4,236
Fiber (g)	188	3.7 ± 2.4	0.4 – 16.8
Iron (mg)	188	10.2 ± 3.7	4.2 – 21.8
Iron (mg/1000 kcal)	188	4.62 ± 1.46	1.98 – 10.56

Zinc (mg)	188	5.2 ± 2.5	0.8 – 16.6
Calcium (mg)	188	734.3 ± 283.4	86.5 – 1,556.2
Total folate (µg)	188	482.9 ± 190.0	132.2 – 1,066.8
Vitamin C (µg)	188	59.8 ± 56.2	0 – 342.3

[1]Defined as hemoglobin <12.0 g/dL; [2]Defined as –CRP-adjusted serum ferritin <15 µg/L;

Table 3. Unadjusted associations among maternal IQ, depression, and education, and child nutritional status or nutrient intake.

Biomarker or nutrient	Model 1	Model 2	Model 3		
	IQ score	Moderate depression	IQ score	Moderate depression	IQ x moderate depression
Hemoglobin (g/dL)	0.004 ± 0.007[1]	-0.16 ± 0.25	0.003 ± 0.007[1]	-0.13 ± 0.26	ns.
Anemia[3]	1.01 [0.96, 1.05][2]	0.49 [0.06, 4.08]	1.00 [0.96, 1.05][2]	0.59 [0.06, 4.28]	ns.
CRP-adjusted serum ferritin (µg/L)	0.06 ± 0.08	-2.08 ± 2.92	0.05 ± 0.08	-1.74 ± 2.98	ns.
Iron deficiency[4]	1.00 [0.98, 1.09]	1.33 [0.48, 3.70]	1.00 [0.98, 1.03]	1.32 [0.47, 3.74]	ns.
Iron (mg/1000 kcal)	0.03 ± 0.01***	0.04 ± 0.36	0.03 ± 0.01**	0.26 ± 0.35	ns.
Zinc (mg/1000 kcal)	-0.001 ± 0.007	0.16 ± 0.26	0.001 ± 0.007	0.17 ± 0.26	ns.
Calcium (mg/1000 kcal)	0.90 ± 0.80	17.98 ± 31.11	1.03 ± 0.82	25.07 ± 31.74	ns.
Total folate (µg/1000 kcal)	-0.21 ± 0.43	11.31 ± 16.50	-0.52 ± 0.44	-343.39 ± 123.87	4.58 ± 1.59***
Vitamin C (µg/1000 kcal)	0.15 ± 0.17	3.05 ± 6.78	0.17 ± 0.18	4.32 ± 6.96	ns.

[1]Value given as β ± SE; [2]Value given as OR [95% CI]; [3]Anemia defined as hemoglobin < 12.0 g/dL; [4]Iron deficiency defined as CRP-adjusted serum ferritin < 15 µg/L; [5]Mild stunting defined as height-for-age Z-score < -1 SD; [6]Mild wasting defined as weight-for-age Z-score < -1 SD; [7]Overweight defined as BMI-for-age Z score > 1 SD; [8]Obesity defined as BMI-for-age Z-score > 2 SD; *p<0.1, **p<0.05, ***p<0.01.

Table 4. Covariate-adjusted associations among maternal IQ, depression, and education, and child nutritional status or nutrient intake.

Biomarker or nutrient	Model 4		
	IQ score	**Moderate depression**	**IQ x moderate depression**
Hemoglobin (g/dL)[1]	0.003 ± 0.01[2,3]	-0.12 ± 0.26	ns.
Anemia[4]	1.03 [0.98, 1.09][5]	0.52 [0.06, 4.81]	ns.
CRP-adjusted serum ferritin (µg/L)	0.12 ± 0.10	-1.07 ± 3.15	ns.
Iron deficiency[6]	0.98 [0.94, 1.02]	1.19 [0.39, 3.62]	ns.
Fiber (g/1000 kcal)	0.004 ± 0.01	0.01 ± 0.25	ns.
Iron (mg/1000 kcal)	0.02 ± 0.01	0.39 ± 0.37	ns.
Zinc (mg/1000 kcal)	-0.001± 0.01	0.20 ± 0.27	ns.
Calcium (mg/1000 kcal)	0.75 ± 0.98	21.62 ± 32.93	ns.
Total folate (µg/1000 kcal)	-0.47 ± 0.52	-310.89 ± 124.26	4.21 ± 1.59***
Vitamin C (µg/1000 kcal)	0.24 ± 0.22	2.66 ± 7.43	ns.

[1]Value given as β ± SE; [2]Adjusted for child sex, the presence of crowding in the house, high number of household possessions, maternal age and maternal education; [3]Anemia defined as hemoglobin < 12.0 g/dL; [4]Value given as OR [95% CI]; [5]Iron deficiency defined as CRP-adjusted serum ferritin < 15 μg/L; [6]The models specifically testing BMI-for-age Z score, overweight and obesity as dependent variables were also adjusted for the number of hours children spent watching television, playing video games, and using the computer, to account for sedentary activity; [7]Overweight defined as BMI-for-age Z score > 1 SD; [8]Obesity defined as BMI-for-age Z-score > 2 SD; *p<0.1, **p<0.05, ***p<0.01.

REFERENCES

Ahmed, T., Hossain, M., & Sanin, K. (2012). Global burden of maternal and child undernutrition and micronutrient deficiencies. *Annals of Nutrition and Metabolism*, 61(supp 1), 8-17. doi: 10.1159/000345165

Ainsworth, M. (1979). Infant-mother attachment. *Journal of American Psychology*, 34(10):932-7. Retrieved from http://aggielandmoonwalks.tripod.com/blinn/Ainsworth.pdf

Anoop, S., Saravanan, B., Joseph, A., Cherian, A., & Jacob, K. (2004). Maternal depression and low maternal intelligence as risk factors for malnutrition in children: a community-based case control study from south india. *Arch Dis Child*, 89, 325-29. doi: 10.1136/adc.2002.009738

Aishwarya, S., Rajendiren, S., Kattimani, S., Dhiman, P., Haritha, S., & Ananthanarayanan, P. (2014). Homocysteine and serotonin: association with postpartum depression. *Asian Journal of Psychiatry*, 6(6), 437-7. doi: 10.1016/j.ajp.2013.05.007

Beard, J. (2008). Why iron deficiency is important in infant development. *Journal of Nutrition*, 138(12), 2534-6. Retrieved from http://jn.nutrition.org/content/138/12/2534.long

Beck, C. (1995). The effects of postpartum depression on maternal-infant interaction: a meta-anaylsis. *Nursing Research*, 44(5), 298-304). Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7567486.

Burdette, H., Whitaker, R., Harvey-Berino, J., & Kahn, R. (2003). Depressive symptoms in low-income mothers and emotional and social functioning in their preschool children. *Ambulatory Pediatrics*, 3(6), 288-94. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14616047

Corwin, E., Murray-Kolb, L., & Beard, J. (2003). Low hemoglobin level is a risk factor for postpartum depression. *Journal of Nutrition*, 133(12), 4139-42. Retrieved from http://jn.nutrition.org/content/133/12/4139.long

Corapci, F., Radan, A., & Lozoff, B. (2006). Iron deficiency in infancy and mother-child interaction at 5 years. Journal of *Developmenal and Behavioral Pediatrics*, 27(5), 371-378. Doi**:** 10.1097/00004703-200610000-00001

Chong, M., Wong, J., Colega, M., Chen, LW, van Dam, R., Tan, C., Lim, A., Cai, S., Broekman, B., Lee , Y., Saw, S., Kwek, K., Godfrey, K., Chong, Y., Gluckman, P., Meaney, M., & Chen H. (2014). Relationships of maternal folate and vitamin B12 status during pregnancy with perinatal depression: the GUSTO study. *Journal of Psychiatric Research*, 55, 110-6. doi: 10.1016/j.jpsychires.2014.04.006.

Crockenburg, S. (1981). Infant irritability, mother responsiveness, and social support influences on the security of infant-mother attachment. *Child Development, 52(3), 857-865.* Retrieved from http://www.jstor.org/stable/1129087.

Davidsson, L. & Haskell, M. (2011). Bioavailability of micronutrients: stable isotope techniques to develop effective food-based strategies to combat micronutrient deficiencies. *Food Nutrition Bulletin*, 32(1 supp), S24-30. Retrieved at http://www.ingentaconnect.com/content/nsinf/fnb/2011/00000032/A00101s1/art00004?token=00581e283f99c2236a489c437a63736a6f3547795d7d663f5f7b74766f644a467b4d616d3f4e4b348f73c547

Drewett, R., Blair, P., Emmett, P., Emond, A., & ALSPAC Study Team. (2004). Failure to thrive in the term and preterm infants of mothers depressed in the postnatal period: a population-based cohort study. *Journal of Child Psychology & Psychiatry, 45(2), 359-366.* doi: 10.1111/j.1469-7610.2004.00226.x.

Engle, P., Black, M., Behrman, J., Cabral de Mello, M., Gertler, P., Kapiriri, L. & International Child Development Steering Group. (2007). Child development in developing countries: 3 strategies to avoid the loss of developmental potential in more than 200 million children in the developing world. *Lancet, 369(9557), 229-242.* doi: 10.1016/S0140-6736(07)60112-3

Fowles, E. & Horowitz, J. (2006). Clinical assessment of mothering during infancy. *J Obstet Gynecol Neonatal Nursing,* 35(5), 662-70. DOI: 10.1111/j.1552-6909.2006.00090.x

Hepner, R. & Maiden, N. (1971). Growth rate, nutrient intake, and "mothering" as determinants of malnutrition in disadvantaged children. *Nutrition Reviews, 29(10), 219-223.* Retrieved from onlinelibrary.wiley.com/doi/10.1111/j.1753-4887.1971.tb07217.../pdf

Goulding, A., Rosenblum, K., Miller, A., Peterson, K., Chen, Y., Kaciroti, N., & Lumeng, J. (2014). Association between maternal depressive symptoms and child feeding practices in a cross-sectional study of low-income mothers and their young children. *International Journal of Behavioral Nutrition and Physical Activity, 11(5*), 1-11. doi:10.1186/1479-5868-11-75

Henrichs, J., Schenk, J., Roza, S., van den Berg, M., Schmidt, H., Steegers, E., Hofman, A., Jaddoe, V., Verhust, C., & Tiemier, H. (2009). Maternal psychological distress and fetal growth trajectories: the generation y study. *Psychological Medicine,* 40, 633-643. doi:10.1017/S0033291709990894

Lanata, C. (2001). Children's health in developing countries: issues of coping, child neglect and inter-national marginalisation. In D.Leon & G.Walt (Eds.), *Poverty, inequality and health: An international perspective*, 137–158. As cited in World Health Organization (WHO). (2004). The importance of caregiver-child interactions for the survival and healthy development of young children. *Maternal, Newborn, and Adolescent Health [Document]*. Retrieved from http://www.who.int/maternal_child_adolescent/documents/924159134X/en/

Logsdon, M. C., Wisner, K. L., & Pinto-Foltz, M. D. (2006). The impact of post-partum depression on mothering. *Journal of Obstetric, Gynocologic, & Neonatal Nursing, 35(5), 652-658.* doi: 10.1111/j.1552-6909.2006.00087.x

Lovejoy, M. C., Graczyk, P. A., O'Hare, E., & Neuman, G. Maternal depression and parenting behavior: a meta-anaylitic review. *Clinical Pyschology Review, 20(5), 561-592.* Retrieved from http://dx.doi.org/10.1016/S0272-7358(98)00100-7

Lozoff, B., Jimenez, E., Hagan, J., Mollen, E., & Wolf, A. (2000). Poorer behavior and developmental outcome more than 10 years after treatment for iron-deficiency in infancy. *Pediatrics*, 105(4), E51. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/?term=Poorer+behavior+and+developmental+outcome+more+than+10+years+after+treatment+for+iron-deficiency+in+infancy.

Lozoff, B., Jimenez, E., & Smith, J. (2006). Double burden of iron-deficiency in infancy and low socioeconomic status: a longitudinal analysis of cognitive test scores at age 19 years. *Arch Pediatr Adolesc Med*, 160(11), 1108-13. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17088512

Lutter, C. (2008). Iron deficiency in young children in low-income countries and new approaches for its prevention. *Journal of Nutrition,*138(12), 2523-8. doi: 10.3945/jn.108.095406.

Kordas, K., Ardoino, G., Cicariello, D., Mañay, N., Ettinger, A., Cook, C., Quierolo, E. (2011). Associations of maternal and child blood lead and hemoglobin levels with maternal perceptions of parenting their young children. *Neurotoxicology*, 32(6), 693-701. doi: 10.1016/j.neuro.2011.09.001.

Kordas, K., Lopez, P., Rosado, J., Vargas, G., Rico, J., Ronquillo, D., Cebrián, M., & Stoltfus, R. (2004). Blood lead, anemia, and short stature are independently associated with cognitive performance in mexican school children. *Journal of Nutrition, 134*, 363–371. Retrieved from www.researchgate.net/...children/.../549d964e0cf2fedbc311967e.pdf

Kordas, K., Queirolo, E., Ettinger, A., Wright, R. & Stoltzfus, R. (2010). Prevalence and predictors of exposure to multiple medals in preschool children from Montevideo, Uruguay. *Sci Tot Environ*, 408(20), 4488-94. doi: 10.1016/j.scitotenv.2010.06.041

Kumar Range, S. K., Naved, R., & Bhattarai, S. (1997). Child care practices associated with positive and negative nutritional outcomes for children in Bangladesh: a descriptive analysis. (Discussion Paper No. 24). Food Consumption and Nutrition Division. Retrieved from http://ageconsearch.umn.edu/bitstream/97297/2/Child%20care%20practices%20associated%20with%20positive%20and%20negative%20nutritional%20outcomes%20for%20children%20in%20Bangladesh.pdf

Mañay N, Cousillas A, Alvarez C, Heller T. (2008). Lead contamination in Uruguay: the "La Teja" neighborhood case. *Rev Environ Contam Toxicol*, 195, 93–115. Retreived from http://www.ncbi.nlm.nih.gov/pubmed/?term=Lead+contamination+in+Uruguay%3A+the+%22La+Teja%22+neighborhood+case.

Mäntymaa, M., Puura, K., Luoma, I., Salmelin, R., Davis, H., Tsiantis, J., Ispanovic-Radojkovic, V., Paradisiotou, A., & Tamminen, T. (2003). Infant-mother interaction as a predictor of child's chronic health problems. *Child: Care, Health, & Development*, 29(3), 181-191. doi: 10.1046/j.1365-2214.2003.00330.x.

Mäntymaa, M., Tamminen, T., Puura, K., Luoma, I., Kovisto, A., & Salmelin, R. (2006). Early mother-infant interaction: associations with the close relationships and mental health of the mother. *Journal of Reproductive and Infant Psychology*, 24(3), 213-231. **DOI:**10.1080/02646830600826214

Mclearn, K., Minkovitz, C., Strobino, D., Marks, E., & Hou, H. (2006). The timing of maternal depressive symptoms and mother's parenting practices with young children: implications for pediatric practice. *Pediatrics*, 118, e174-e182. doi:10.1542/peds.2005-1551

Mcurdy, K., Gorman, K., Kisler, T., & Metallinos-Katsaras, E. (2014). Associations between family food behaviors, maternal depression, and child weight among low-income children. *Appetite*, 79, 97-105. doi: 10.1016/j.appet.2014.04.015

Melchior, M., Chastang, J., Lauzon, B., Galéra C., Saurel-Cubizolles, M., & Larroque, B. (2012). Maternal depression, socioeconomic position, and temperament in early childhood: the EDEN mother-child cohort. *Journal of Affective Disorders*, 137(1-3), 165-169. doi:10.1016/j.jad.2011.09.018

Mercer, R. (2004). Becoming a mother versus maternal role attainment. *Journal of Nursing Scholarship*, 36, 226-232. DOI: 10.1111/j.1547-5069.2004.04042.x

Ministerio de Salud Público. Manual para la promoción de prácticas saludables de alimentación en la población Uruguaya. Montevideo, Uruguay, 2007; p 78.

Murray-Kolb, L. & Beard, J. (2009). Iron deficiency and child and maternal health. *American Journal of Clinical Nutrition*, 89(3), 946S-950S. doi: 10.3945/ajcn.2008.26692D

Petterson, S. M., & Albers, A. B. (2001). Effects of poverty and maternal depression on early child development. *Child Development, 72(6), 1794-1813*. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11768146

Pollitt, E. (1993). Iron deficiency and cognitive function. *Annual Review of Nutrition*, 13, 521-37. DOI: 10.1146/annurev.nu.13.070193.002513

Pridham, K., Melby, N., Brown, R., & Clark, R. (2010). The contribution of infant, maternal, and family conditions to maternal feeding competencies. *Parenting: Science & Practice, 10(1), 18-42*. doi: 10.1080/15295190903014596

Propper, C., Rigg, J., & Burgess, S. (2007). Child health: evidence on the roles of family income and maternal mental health from a UK birth cohort. *Health Economics, 16(11), 1249-69.* doi: 10.1002/hec.1221

Queirolo E, Ettinger A, Stoltzfus R, Kordas K. (2010). Association of anemia, child and family characteristics with elevated blood lead concentrations in preschool children from Montevideo, Uruguay. *Arch Environ Occup Health*, 65, 94–100.

Rahman, A., Iqbal, Z., Bunn, J., Lovel, H., & Harrington, R. (2004). Impact of maternal depression on infant nutritional status and illness. *Arch Gen Psychiatry*, 61(9):946-52. doi:10.1001/archpsyc.61.9.946.

Santos, I., Matijasevich, A., Domingues, M., Barros, A., & Barros, F. (2010). Long-lasting maternal depression and child growth at 4 years of age: a cohort study. *Journal of Pediatrics*, 157(3), 401-6. Doi: 10.1016/j.jpeds.2010.03.008

Smith, L., Ramakrishnan, U., Ndyaie, A., Haddad, L., & Martorell, R. (2003). The importance of women's status for child nutrition in developing countries. *International Food Policy Research Institute, Research Report 131,* 1-157 [document]. Retrieved from http://ageconsearch.umn.edu/bitstream/16526/1/rr030131.pdf

Stewart, R. C. (2007). Maternal depression and infant growth: a review of recent evidence. *Maternal and Child Nutrition, 3, 94-107.* Retrieved from http://www.medcol.mw/mentalhealthmalawi/wp-content/uploads/2011/09/Stewart-2007.pdf

Surkan, P., Ettinger, A., Ahmed, S., Minkovitz, C., & Strobino, D. (2012). Impact of maternal depressive symptoms on growth of preschool- and school-aged children. *Pediatrics*, 130(4), e847-e855. doi:10.1542/peds.2011-2118

Surkan, P. J., Kawachi, I., Ryan, L. M., Berkman, L. F., Carvalho Vieira, L. M., & Peterson, K. E. (2008). Maternal depressive symptoms, parenting self-efficacy, and child growth. *American Journal of Public Health, 98(1), 125-132*. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18048782

Surkan, P. J., Kennedy, C. E., Hurley, K. M., & Black, M. M. (2011). Maternal depression and early childhood growth in developing countries: systemic review and meta-analysis. *Bulletin of the World Health Organization, 89, 608-615E.* doi: 10.2471/BLT.11.088187.

Thurnham DI, McCabe LD, Haldar S, Wieringa FT, Northrop-Clewes CA, McCabe GP. Adjusting plasma ferritin concentrations to remove the effects of subclinical inflammation in the assessment of iron deficiency: a meta-analysis. Am J Clin Nutr. 2010; 92:546-55.

Tronick, E. & Reck, C. (2009). Infants of depressed mothers. *Harvard Rev Psychiatry*, 17(2), 147-56. doi: 10.1080/10673220902899714.

Wachs, T. D. (2008). Multiple influences on children's nutritional deficiencies: A system's perspective. *Physiology and Behavior, 94, 48-60.* Retrieved from http://dx.doi.org/10.1016/j.physbeh.2007.11.018

Walker, S. P., Chang, S. M., Powell, C. A., Simonoff, E., & Grantham McGregor, S. M. (2006). Effects of psychosocial stimulation and dietary supplementation in early childhood on psychosocial function in late adolescence: follow-up of randomized control trial. *BMJ, 333(7566), 472.* doi: 10.1136/bmj.38897.555208.2F

Walter, T. (2003). Effect of iron-deficiency anemia on cognitive skills and neuromaturation in infancy and childhood. *Food Nutrition Bulletin,* 24(4 supp), S104-10. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17016952

World Health Organization (WHO). (2001). Iron deficiency anaemia: assessment, prevention, and control. *[Document]*. Retrieved from http://www.who.int/nutrition/publications/micronutrients/anaemia_iron_deficiency/WHO_NHD_01.3/en/

World Health Organization (WHO). (2004). The importance of caregiver-child interactions for the survival and healthy development of young children. *Maternal, Newborn, and Adolescent Health [Document]*. Retrieved from http://www.who.int/maternal_child_adolescent/documents/924159134X/en/

Wright, C. M., Parkinson, K. N., & Drewett, R. F. (2006). The influence of maternal socioeconomic and emotional factors on infant weight gain and weight faltering (failure to thrive): data from a prospective birth cohort. *Archives of Disease in Childhood, 91(4), 312-317.* doi: 10.1136/adc.2005.077750

Van Dijk, A., Van Eljsden, M., Stronks, K., Gemke, R., & Vrijkotte, T. (2010). Maternal depressive symptoms, serum folate status, and pregnancy outcome: results of the Amsterdam Born Children and their Development study. *American Journal of Obstetrics and Gynocology*, 203(6). 563.e1-7. doi: 10.1016/j.ajog.2010.07.017

Yilmaz, K. & Yenicesu, I. (2015). Iron-refractory iron-deficiency anemia. *Turk J of Hematology*, 32(1), 1-14. doi: 10.4274/tjh.2014.0288.

ACADEMIC VITA

Megan McGill

mkm5322@psu.edu
724-992-2942 (cell)

478 East Calder Way
University Park, PA 16801

45 Old Hickory Lane
Grove City, PA 16127

Education: The Pennsylvania State University

B.S. in Nutritional Sciences (Dietetics Option) May 2015

Schreyer Honors College

Honors Thesis:

Influence of Maternal Depression and IQ on Child Nutritional Status

Relevant Experience:

March 2012-Present

Penn State Department of Nutritional Sciences, University Park, PA

Nutrition Research Lab Assistant

- ❖ Co-author with Dr. Katarzyna Kordas & 7 others on published research paper "*Maternal mental health, family finances, nutritional status and nutrient intake of school-age children in Uruguay"* –conducted background research that contributed to the introduction section of the paper
- ❖ Assisted in data entry of 200+ participant files from a research study on the effect of toxic metals on cognitive development in Uruguayan school children

May 2014- August 2014

Forbes Regional Hospital, Monroeville, PA

Department of Clinical Nutrition

Student Intern

- ❖ Shadowed RDs in ICU, CTICU, Oncology, Renal, Rehab units
  - Conducted practice nutrition assessments, re-assessments, & calorie counts on clinical patients
  - Calculated nutritional needs for patients based on various medical conditions
  - Learned to differentiate between high and moderate nutritional risk patients
  - Attended meetings with RD & nurses regarding high risk patients
  - Pre-interviewed/assessed patients for RD
  - Researched specific medications/conditions related to RD's patients
  - Performed patient nutrition education on heart healthy diets for post-operative heart patients
- ❖ Researched and completed formal report on Refeeding Syndrome & presented to other RDs
  - Developed display for community Summer Festival on Cancer Preventative Nutrition
  - Attended Dysphagia Work Group with speech therapists and nurses
  - Developed alternate patient diet nutrition training manual that will be used as a reference tool for all clinical nutrition staff

May 2012; May 2013
Children's Hospital of Pittsburgh, Pittsburgh, PA
Department of Clinical Nutrition/Nutrition Support
Student Volunteer

- ❖ Shadowed RD during rounds and scheduled appointments
- ❖ Performed calculations and entered patient diet records into nutrition analysis program

July 2012
Pediatric Therapy Professionals, Cranberry, PA
Student Volunteer

- ❖ Observed pediatric nutrition therapy applied in the home setting (7+ home visits), interacted with the patients and discussed nutrition-related growth issues and treatment options with the parents

June 2012-July 2012
Grove City Medical Center, Grove City, PA
Student Volunteer

- ❖ Shadowed RD during rounds and observed menu planning with the kitchen staff
- ❖ Assisted in teaching diabetes education classes

Leadership Experience:
September 2014-Present
Penn State IFC/Panhellenic Dance Marathon
Merchandise Captain Marketing/PR Liaison

February 2010-Present
Dairy Queen Orange Julius, Grove City Premium Outlets, Grove City, PA
Shift Leader

Activities/Honors:
Merchandise THON Committee Member *Oct 2012-Feb 2011* Dean's List
Fall 2011- 2014
PSU Student Nutrition Association *Sept 2011-Present* PSU Club XC
Fall 2011