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Doctoral Thesis

The interaction of iron deficiency and psychosocial care on child behavior and cognitive outcomes: A longitudinal study of Senegalese children

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Abstract

The purpose of this thesis is to explore the relationships among child cognitive development, provision of care to the child, and the child's iron status through the use of quantitative and qualitative data. Iron deficiency and iron deficiency anemia remain widespread problems throughout much of the world and have potentially serious consequences for child development and learning outcomes. Cognitive development is influenced both through physiological and psychological mechanisms. Provision of care is a factor that can influence both nutritional status and cognitive development. This longitudinal study addresses the three concurrent relationships between iron status and cognitive development, iron status and interaction with the physical environment, and interaction and provision of care.

The first hypothesis is that children between 24 and 42 months with low hemoglobin levels (as defined by Hb ≤ 10.5 g/dl) have lower activity levels, and lower focused activity levels, than the children with higher hemoglobin levels, when observed in the home setting. This was tested using a test of means for two groups, dividing the children into anemic (Hb < 10.5 g/dl) and non-anemic (Hb ≥ 10.5 g/dl).

The second set of hypotheses test the relative importance of certain feeding practices on child anemia status, including the age of introduction of fish and the provision and quality of the late afternoon meal, the *diogonal*. Multiple regressions and ANOVA were used to determine the strength of the association between these practices and iron status, controlling for socio-economic status and age of child.

The third set of hypotheses tests the complex relationships between good care practices and activity, attentiveness and learning achievements of the anemic child, with the goal of assessing the degree to which good home care serves to mitigate the negative impacts of iron deficiency on child development. Children with lower iron status but higher levels of maternal interaction and cognitive stimulation will have better cognitive development that children with lower iron status who do not receive as much stimulation. This protective effect will persist beyond early childhood, leading to differences in school performance at age 10-11 years. Multiple regression was used to determine immediate impact of iron status and care on picture vocabulary score (at age 24-42 months) and later impact on school performance (at age 10-11 years).

Lower physical activity and lower focused activity that are present in the anemic child have implications for the child's cognitive development. We expect that more attentive mothers will have children with better iron status, but there is also an iterative relationship here where the child with better iron status will attract more maternal interaction and attention. The tests for cognitive outcomes were administered at two different points in time and have implications for the short- and long-term impacts of iron deficiency in early childhood. While the data are specific to the population and culture where the study was conducted, there will be conclusions drawn that will have a more general relevance. This information can be used both to design interventions and to influence policy decisions for early childhood nutrition and education programs.

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Acknowledgments

It has not been an easy process to distill into three succinct papers the enormous amount of data and potential analysis that I have been pondering for over ten years now. It is my hope that this paper accurately reflects what I believe are some of the key issues in the fields of iron nutrition and child development. It is also my hope that in some small way this work can contribute to increased attention and funding to programs addressing both the short-term and the long-term consequences of early nutritional insult.

In the intervening years, I have traveled and worked in many other countries around the world and have also begun to raise a family of my own. Today as I look back on my experiences and what motivates me to want to continue work in the field of international nutrition and development, it was my time in Senegal that made the greatest impression on me. My mentor Marian Zeitlin encouraged me from the beginning to dig deeper and ask more questions (and make more observations). Our colleagues at the small non-governmental organization supported and welcomed me in whatever way they could. These children taught me what the point of this work should be - to give them a chance, an opportunity, to be active, engaged citizens in their community and the world.

This thesis could not have been completed without the support and encouragement from my family and friends, especially my dear husband Keith who spent many nights and weekend afternoons concocting plans to keep our girls out of my hair and who in my darkest hours told me that I was going to finish this!

I would also like to thank my wonderful committee members, who never scolded me for the late drafts and also were confident in my ability to somehow make this work. Marian Zeitlin also deserves extra praise for her insight to show up in Ithaca at just the times when I needed her most, and for arranging my inclusion on her panel presentation at the Early Childhood Development Conference held in Dakar in November 2009.

Most of all, I would like to thank the children and families in Tonghor, who opened their homes so generously to me.

1. Introduction

This study began as an independent research project while I was an intern with the Yoff EcoVillage Program (formerly CRESP-Senegal, now Earth Rights EcoVillage - Senegal) from Summer 1998-Fall 1999 with the goal of learning more about the rate of iron deficiency anemia among the children in the seaside fishing village of Yoff, where it was based, and the familial practices that may play a role in the etiology of this micronutrient deficiency. The study was designed to include 12-hour observations of the children at home, both to help capture a more realistic image of the behavior of the anemic child and his interactions with parents and other caregivers as well as to discover potential “positive deviant” practices in the home that were associated with better iron nutriture, and could be used in program design for combating early childhood iron deficiency in the community.

The sample of children was chosen based on a recently completed census map of Tonghor, one of the seven traditional neighborhoods of Yoff, which included the ages of all children currently residing in each household. Our target age group was 24-42 months, after weaning age, so that it would be possible to estimate food intake without having to measure breast milk consumption. Also, there is a major brain growth spurt at this age coinciding with the child's increased verbal communication and exploration of his environment, making it an important time to assess whether iron deficiency is impacting the child's cognitive development. Seventy-eight households with children in this age range were identified for the first round of data collection.

The study collected anthropometric, hemoglobin, socioeconomic, and observational data and included questionnaires on the child's health and diet history. A picture vocabulary test was administered to assess child cognitive development. The methods were pretested in other neighborhoods. Participating families were open and receptive to involvement in the study. The observations allowed me to gain a better understanding of the constraints faced by these families as well as the richness of the lives of these children.

After the initial round of data collection in 1999, a second round of data collection was conducted in 2007 with an emphasis on child school attendance and performance. Ninety-one percent of the original cohort were found and surveyed at this time. Hemoglobin and anthropometric measures were repeated. Reading level was determined using local school readers to assess the child's current cognitive ability.

A. General statement of the problem to be studied

The purpose of this longitudinal study is to explore the concurrent relationships among child cognitive development, provision of care to the child, and the child's iron status through the use of quantitative and qualitative data. Iron deficiency and iron deficiency anemia remain widespread problems throughout much of the world and have potentially serious consequences for child development and learning outcomes. Cognitive development, though, is influenced through both physiological (e.g., iron deficiency) and psychological mechanisms. Provision of care, which can be measured through maternal attention, psychosocial stimulation, and appropriate responsive feeding, is a factor that can influence both nutritional status and cognitive development. While these forms of care are distinguished into nutritional care and psychosocial care, their individual effects interact to produce favorable child outcomes.

The conceptual framework presented below sets forth the basic relationships that were tested in this study.

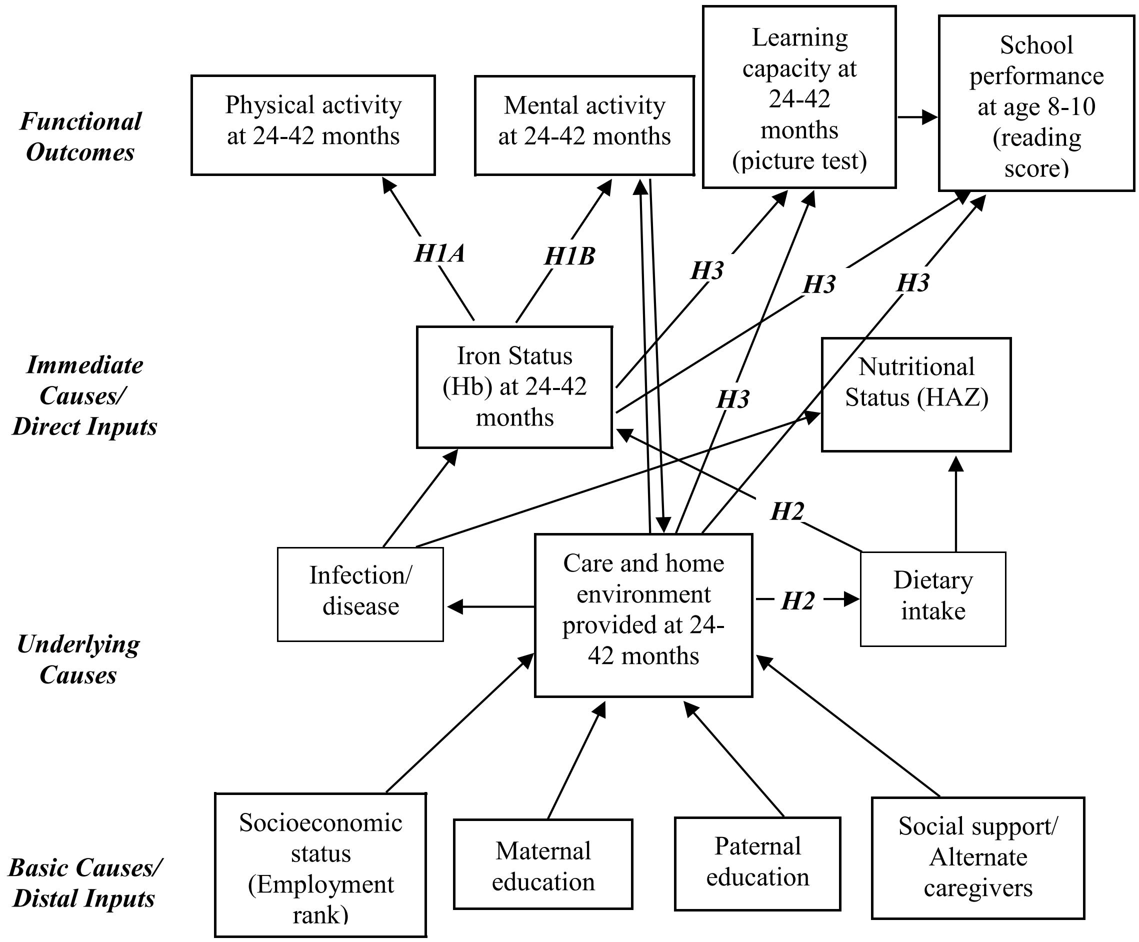

Figure 1.1. Conceptual Framework.

B. Study Hypotheses

The first hypothesis is that children between 24 and 42 months with low hemoglobin levels (as defined by Hb ≤ 10.5 g/dl, as used by Lozoff and colleagues (1986, 1991, 1998)) have lower activity levels, and lower focused activity levels, than the children with higher hemoglobin levels, when observed in the home setting.

H_{1A}: Children with low hemoglobin levels will have lower overall activity levels, than the children with higher hemoglobin levels.

H_{1B}: Children with low hemoglobin levels will have lower focused activity levels than the children with higher hemoglobin levels.

The second set of hypotheses relate to the relative importance of certain feeding practices on child anemia status, specifically the age of introduction of fish and the provision of fish as part of of the late afternoon children's meal, the *diogonal*.

H_{2A}: Children who begin to consume animal protein (fish in the case of these fishing families, as almost no meat was eaten and eggs not served to young children) at an earlier age will have better hemoglobin levels at age 24-42 months compared to children who begin fish consumption at a later age.

H_{2B}: The presence of fish in a child's *diogonal* meal will be associated with better hemoglobin levels than children who receive no *diogonal* at all or only left over rice. Four levels of consumption are compared: no *diogonal*, rice only, rice with fish, and rice with fish that is intentionally set aside and fed to the young children with parental supervision.

H_{2C}: Fewer children eating at the same bowl and more adult supervision during the *diogonal* are associated with better iron status.

The third set of hypotheses tested the complex relationships between psychosocial care by the mother and both short-term and long-term learning achievements of the anemic child, with the goal of assessing the degree to which good home care serves to mitigate the negative impacts of iron deficiency on child cognitive development. It was expected that better care will lead to increased focused activity and increased attentiveness in children 24-42 months. This increased attentiveness will lead to better learning ability in both the short-term, relating to language learning, and also the long-term, in terms of school performance.

H_3: Good care mitigates the negative impact of iron deficiency on child activity and later school performance.

H_{3A}: Anemic children who receive more attention at age 24-42 months from parents and other adult caregivers will have an increased amount of focused activity at age 24-42 months compared to anemic children receiving less stimulation.

H_{3B}: Anemic children who receive more maternal attention at age 24-42 months will have better performance in school at age 10-11 years compared to anemic children receiving less stimulation.

Lower physical activity and lower focused activity that are present in the anemic child have implications for the child's cognitive development. The hypothesis is that more attentive mothers will have children with better iron status, but the child with better iron status will also attract more maternal interaction and attention. The tests for cognitive outcomes were administered at two different points in time and have implications for the short- and long-term impacts of iron deficiency in early childhood. While the data are specific to the population and culture where the study was conducted, the conclusions have a more general relevance.

2. Review of the Literature

A. Introduction

Iron deficiency is one of the most prevalent nutritional deficiencies in the world (Pearson, 1990; Ryan, 1997; Vazquez-Seoane, Windom & Pearson, 1985), so understanding how iron deficiency (ID) and iron deficiency anemia (IDA) impact a child's development, physically and cognitively, in both short- and long-term time frames is crucial for determining when and how to intervene.

This review of the relevant literature will begin with a section on the definitions and distinctions of iron status, iron deficiency, and iron deficiency anemia. Dietary enhancers and inhibitors as well as environmental risks will be briefly discussed. This will be followed by a discussion of the different methods of measurement for both the inputs and the outcomes of iron deficiency anemia, including measures of physical activity, mental activity (focused activity), and cognitive development in relation to iron status.

Care interactions that are relevant to iron status, specifically active or responsive feeding behaviors and psychosocial stimulation will be explored as they relate to the thesis papers. Other factors that may influence outcomes for the iron-deficient child include the family/household environment and socioeconomic status.

The next section of the literature review discusses issues specific to the study setting, Senegal, which pertain to the study questions and give a background for the expectations and observations found in the following research papers. The literature review concludes with a summary of the findings and conclusions based on the synthesis of the ideas presented.

B. Definitions/Distinctions of iron status, iron deficiency, and iron deficiency anemia

Iron is critical to the oxygen-carrying capacity of the blood (Beaton, Corey & Steele, 1989) and is necessary for important metabolic functions including oxygen transport, oxidative metabolism, and cellular growth (Ryan, 1997). Iron deficiency occurs when insufficient iron is consumed by an individual, or when there is inadequate absorption of iron in the body, or when infection or blood loss increase the demands for iron that cannot be met through diet alone. Iron deficiency can occur in absence of iron deficiency anemia (Ryan, 1997). In other words, iron deficiency is a depletion of iron stores that has not yet reached the level of anemia.

Iron deficiency is one of the “hidden hunger” deficiencies because the outward physical signs of this deficiency are subtle and hard to identify by sight. Pale conjunctiva and decreased activity are subjective measures, but a sure diagnosis of iron deficiency involves detection of at least one factor (i.e. hemoglobin, hematocrit, erythrocyte protoporphorin, serum transferrin) in whole blood samples. Pica, or consumption of non-nutrient substances, can also be an observable side effect of iron deficiency anemia (Arbiter & Black, 1991), but is not specific enough to be a diagnostic tool. Decreased appetite may also be a side effect of ID (Lawless et al., 1994). Decreased cortisol production and delays in brain stem processing of auditory signals are long-term effects of early iron deficiency (Yehuda & Yehuda, 2006).

Early childhood is a time of increased iron needs due to rapid growth and, unfortunately, also a time when many children are not receiving enough of the iron-rich foods their bodies need (Beaton, Corey & Steele, 1989; Black, Baqui, Zaman, Persson, El Arifeen, Le et al., 2004; Stoltzfus, Heidkamp, Kenkel & Habicht, 2007). While iron deficiency does not have the overt physical symptoms of many other micronutrient deficiencies, it can have long term consequences for a child's physical and mental development. Iron deficiency during the major brain growth spurt that occurs around ages 12-24 months, can lead to an impairment in the myelination of the developing neurons (McCann & Ames, 2007; Beard & Connor, 2003; Gordon, 2003; Guesry, 1998; Youdim, Ben-Shachar & Yehuda, 1989).

The prevailing thought on the connection between iron deficiency and psychobiological impact is not without controversy. Pollitt (2001) has argued that while animal models have shown neurological deficits due to lack of iron, these are not enough to show long-term functional consequences in humans due to the potentially moderating effects of environmental factors. There has also been a lack of consistency among clinical trials in terms of age of onset and severity of iron deficiency which make it difficult to come to conclusions regarding the impact of iron deficiency on child development (Beard & Connor, 2003; Black et al., 2004; Grantham-McGregor & Ani, 2001) .

i. Intake/dietary requirements

In the diet, iron is consumed in two forms: heme (from animal sources) and non-heme (from plant sources). Heme iron is more readily absorbed in the body, while non-heme has a lower bioavailability.

a. Dietary promoters and inhibitors

The consumption of fruits and vegetables high in vitamin C promotes absorption of non-heme iron. There are also foods that inhibit absorption, such as phytates found in many whole grains and tannins found in tea when consumed at the time of the meal. Other inhibitors of iron absorption are polyphenols and calcium (Ryan, 1997).

Other dietary issues contributing to the development of IDA include late introduction of solid foods and consumption of cow's milk in early childhood (Keihaei et al., 2007; Czajka-Narins, Haddy & Kallen, 1978).

b. Environmental and social risk factors

Infection and helminths are also indicated in ID, being either causative themselves or exacerbating a nutritional deficiency such as ID (Beaton, Corey & Steele, 1989; Ehrhardt et al., 2006; Stoltzfus et al., 1996). Since helminthic infections are often concurrent or lead to iron deficiency, regular screening and/or deworming is often recommended in endemic areas (Stoltzfus et al., 1996). A combination treatment of both iron supplements and antihelmintic treatment was seen to be most effective in raising hemoglobin in primary school children in Egypt (Hussein, Elnaggar, Gaafar & Allam, 1981).

Low maternal education and low household socioeconomic status (Lozoff, Wolf

& Jiminez, 1996; Keikhaei, Zandian, Ghasemi & Tabibi, 2007) may contribute to IDA through lack of knowledge of proper feeding, insufficient resources to purchase iron rich foods, or decreased ability to seek appropriate health care leading to increased infections. Maternal education and household SES are also independently associated with child mental performance which may confound the relationship between IDA and mental performance (Beaton, Corey & Steele, 1989).

One study by Keikhaei and colleagues in Iran (2007) found the highest prevalence of iron deficiency in households where the mother had a high level of education and was employed outside of the home and in those households where parents were illiterate. These authors do not speculate as to why this paradox exists in this population, but it may be that children receive less than optimal care from their caretakers when the mother is at work, despite the economic ability to provide a better diet. A review of studies of the effect of iron deficiency on cognitive development in children found socioeconomic status a continual confounding effect (Grantham-McGregor & Ani, 2001).

Social factors such as greater number of siblings, and therefore increased competition for scarce food and possibly decreased attention and monitoring of food intake by caregivers, have also been shown to contribute to the development of IDA (Czajka-Narins et al., 1978).

It is important to revisit older findings and update knowledge through new studies, as advances in both measurement techniques and analysis can lead us to rethink how a problem is addressed within a community. A recent study from Ghana has challenged the traditional thinking that iron deficiency anemia provided some protection against malaria; malnourished, anemic children had a higher incidence of mortality from malaria than children who were better nourished (Ehrhardt et al., 2006).

ii. Treatment and prevention

The three avenues for the treatment and prevention of iron deficiency are supplementation, fortification, food-based or dietary strategies. Once a problem is identified, iron levels can be restored through supplemental iron and maintained through consumption of fortified cereals or grains. Depending on the age of the child, the regular (unfortified) diet alone may not be adequate for maintaining a normal iron status.

a. Supplementation

Supplementation is often a short-term intervention aimed at specific at-risk age groups or children who have already been diagnosed with iron deficiency. Iron supplementation may have the greatest potential for large scale programming targeting children in developing countries for reducing iron deficiency anemia (Stoltzfus, Heidkamp, Kenkel & Habicht, 2007; Mora, 2002). This is not without controversy, however, since issues of iron-overload (Ryan, 1997), decreased weight gain in toddlers (Idjradinate & Pollitt, 1993; Stephenson, 1995), and potential increase in infections (Walter, Olivares, Pizarro & Munoz, 1997) have been raised regarding the supplementation of children who are not iron deficient.

b. Food fortification

Commercial fortification of processed grains or infant cereal has been very effective in preventing iron deficiency in infants and young children in the U.S. (Backstrand, 2002; Pearson, 1990) and Chile (Yip & Ramakrishnan, 2002), although ID and IDA are still screened for in most children in the U.S. and other developed countries (Moy, 1999). Fortified cereal grains provided more than 50% of iron in the U.S. food supply by 1994 (Backstrand, 2002).

Home-based food fortification is one possibility for increasing iron consumption, and trials have been done with encapsulated-iron-and-micronutrient sprinkles, crushable tablets, and fat-based products (e.g. Nutributter), which have some advantages over commercial fortification, including being able to meet the nutritional needs of a narrow age range (Dewey, 2007; Mora, 2002) and could be targeted to children already diagnosed with ID or who would be considered at-risk for developing ID. Appropriate monitoring of the fortification and a population who already consumes processed foods are needed, but not always evident in developing countries where the need is particularly high (Yip & Ramakrishnan, 2002).

c. Food-based strategies

In many other countries where staple food or complementary food fortification is not the norm, increasing iron intake through food alone, particularly for the child aged 6-24 months, is just not possible even when considering the addition of high-heme animal products[1] (Dewey, 2007). While there have been some efforts at increasing iron intake at

[1] Trials have been conducted using egg, fish, beef, and chicken livers in various countries, and besides

the household level through support of fish ponds and animal husbandry, the results regarding iron intake have been mixed due to lack of integration of appropriate nutrition education in these projects (Ruel, 2001). The use of iron cooking pots is another possible intervention to increase the iron content of food consumed at the household level (Ruel, 2001). The promotion of cooking in iron pots has been shown to improve iron status in studies in Ethiopia, Malawi, and Brazil (Berti et al., 2004). In a review of studies looking at common feeding practices for breastfed infants, the author urged promotion of ground beef as an early complementary food, with a caveat that this would be preferable only if proper storage and preparation was possible (Krebs, 2000).

d. Effectiveness of Treatment

There is some disagreement about whether or not developmental delays can be corrected in iron-deficient infants and children, which may in part be due to differences in the length of treatment as well as the duration and severity of the initial deficiency in the various studies (Kalra, 1994; Sheard, 1994). Hematologic correction has not always led to reversal or catch-up in the motor and/or mental development deficits measured. Idjradinata and Pollitt (1993) found a catch-up of psychomotor skills possible between the ages of 12 and 18 months in Indonesia, although they did not accept subjects with hemoglobin levels below 8.0g/dl. Even mild iron deficiency can have an effect on behavior, but is more likely to be reversible with treatment (Walter, Kovalskys & Stekel, 1983).

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the economic barriers to regularly feeding these foods to small children in many impoverished households, it was difficult physically to get the children to eat the amount needed to meet their iron requirements (Dewey, 2007).

Gordon (2003) advocates for prophylactic iron therapy in infancy in order to prevent the need for remedial school later in the child's life. Early intervention is also advocated by Hurtado, Claussen, and Scott (1999), who found a significant correlation between low hemoglobin and later mild or moderate mental retardation in a sample of WIC participants. Whether this intervention should come about through large-scale fortification of staple foods or through supplementation of at-risk individuals may be decided in part by the resources available to different communities (Saloojee & Pettifor, 2001). Investments in education and community development would be more effective if the population is not impaired due to nutritional deficits (Scrimshaw, 1998).

Lozoff, Wolf and Jiminez (1996) used a 6 month treatment time frame and found consistently lower developmental scores for the anemic infants despite an improvement in blood iron levels. In Turkey, Akman and colleagues (2004) found initial differences in motor and mental test scores were corrected after 3 months of treatment in a prospective, single-blind, controlled study of 114 6-30 month old children. A combination supplement of iron and zinc was found to have the greatest impact on motor development and exploratory behavior in a double-blind, random assignment trial in Bangladesh (Black et al., 2004). However, Corapci and colleagues (2006) found continued lower levels of physical activity, positive affect, and verbalization in 5-year-old children who were diagnosed as chronically iron deficient in infancy.

A test of short-term iron supplementation in 6-24 month old infants with mild IDA found that one week was not long enough to improve the developmental deficits as measured by Bayley scores (Lozoff et al., 1982). Seshadri and Gopaldas (1989) found improvement in cognitive function after 8 months of treatment, but not after 4 months, and this improvement was greater for the older children in their studies (four studies with an age range from 5-15 years). Although in a study of 5-8 year old Indian children randomly assigned to iron supplements, the anemic children were able to catch up to their iron-sufficient peers in two different IQ tests (Draw-a-Man and Weschler) after 60 days of supplementation (Seshadri, Hirode, Naik & Malhotra, 1982). A meta-analysis of the randomized control trials with oral or parenteral iron supplementation found modest score improvement on mental and motor development for older children (> 7 years old), but not enough convincing evidence for impact on mental development in subjects < 27 months of age (Sachdev, Gera & Nestel, 2004), although this counterintuitive finding may be due to the fact that the authors did not separate studies that were preventive as compared to those that were therapeutic. Soewondo, Husaini and Pollitt (1989) found that anemic preschoolers were able to improve their psychological test scores after 8 weeks to the same level as their non-anemic peers. Impairments in psychomotor development do seem to persist after treatment leading to hematological correction (Walter, de Andraca, Chadud & Perales, 1989).

There was a similar improvement in hemoglobin levels for weekly versus daily supplementation regimens, although serum ferritin and IQ scores increased more in the daily supplementation group compared to the weekly supplementation group (Sungthong, Mo-Suwan, Chonsuvivatwong & Geater, 2004).

Supplementing pregnant or pre-pregnant women, while beneficial to the woman herself, is also thought to have an impact on her infant's iron stores. However, Zhou and colleagues (2006) found no effect on 4-year IQ scores of children whose mothers were given iron supplementation during pregnancy. This Australian population was relatively well-nourished to begin with, which may have limited the ability to find differences.

The ability of iron supplementation to reverse the negative effects of iron deficiency on physical and mental performance appears to depend on severity of the deficiency, timing (how soon the child is diagnosed) and duration of the supplement regime.

iii. Measurement of inputs: Iron in the body

Iron deficiency occurs in three stages, starting with depletion of iron stores in the body, leading to iron deficient erythropoesis (the production of red blood cells lacking iron), and finally iron deficiency anemia. While the measurement of hemoglobin, the iron-containing molecule that makes up part of the red blood cell, is the most common indicator for iron deficiency, decreases in hemoglobin levels are only seen at the third stage of iron deficiency. Hemoglobin is not very sensitive or specific for iron deficiency (Biesalski & Erhardt, 2007) since it can be influenced by blood-depleting parasites and chronic infections (Yip & Ramakrishnan, 2002; Tatala, Svanberg & Mduma, 1998). Whole blood samples are also used to measure hemoglobin, as well as hematocrit, red cell count, free erythrocyte protoporphyrin, serum iron, serum transferrin, transferrin saturation, and ferritin (Beaton, Corey & Steele, 1989). These measures offer different information used in the diagnosis of iron deficiency (ID) and iron deficiency anemia (IDA), and they also have different requirements and costs[2].

[2] In a departure from the normal procedure of taking blood samples, one large study from Russia utilized

Reticulocyte hemoglobin content is another measure that has been shown to be a good predictor of IDA, and could be done at significantly less cost (at least in the U.S.) according to Brugnara and colleagues (1999), but it does not have the combination of accuracy, ease of use, cost-effectiveness, and widespread availability of the traditional tests for iron deficiency (Besarab, 2006).

Hemoglobin and one nother measure (i.e. ferritin or transferrin saturation) are used to differentiate among ID, IDA, and anemia without iron deficiency (Bogen et al., 2000; Harahap et al., 2000; Petersen et al., 1996; Tatala, Svanberg & Mduma, 1998; Stoltzfus et al., 1996; Read & Boling, 1982; Lawless et al., 1994). Although in some cases, multiple measures are used to assess a broader picture of iron deficiency in the population being studied (Brugnara et al., 1999 ; Lozoff, Wolf & Jimenez, 1996; Keikhaei, Zandian, Ghasemi & Tabibi, 2007; Harahap et al., 2000; Schneider et al., 2005). In other studies, a single measure of iron may be used, often hemoglobin, which may be most useful when the population has high rates of low hemoglobin and it is possible to control for possible infection (Ehrhardt et al., 2006; Beaton, Corey & Steele, 1989). Response to iron supplementation is another way to assess the prevalence of iron deficiency in a population (Singla, Gupta, Ahuja & Agarwal, 1982). If hemoglobin improves with iron supplementation, it may be concluded that the cause was indeed iron deficiency.

Hemoglobin values are most often reported in the literature for defining iron deficiency anemia, although the actual cut-off point used varies somewhat by study,

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four rounds of 24-hour recalls to assess iron intake and bioavailability, with the intent to inform policy recommendations (Kohlmeier et al., 1998).

region[3], and age of subjects. Walter (1993) reports on evidence of different cut-off points depending on what is being measured. For example, hemoglobin values between 10.1 and 10.5 g/dl are implicated in decreased motor but not decreased mental functioning in young children. A prospective cohort study of 196 infants from birth to age 15 months with short- (10 days) and longer-term (3 months) iron therapy found that hemoglobin levels less than 10.5 g/dl for a duration of greater than 3 months correlated with lower mental and motor scores (Walter, 1989).

C. Outcomes of iron deficiency

Most studies of the impact of iron deficiency on children's physical and cognitive development have focused on infants and toddlers between the ages 6 and 24 months (Aburto et al., 2007; Akman et al., 2004; Angulo-Kinzler et al., 2002; Black et al., 2004; Czajka-Narins, Haddy & Kallen, 1978; Harahap et al., 2000; Heywood, Oppenheimer, Heywood & Jolley, 1989; Jahari, Saco-Pollitt, Husaini & Pollitt, 2000; Kariger et al., 2005; Lozoff et al., 1998; Lozoff, Klein & Prabucki, 1986; Pollitt et al., 2000; Shafir et al., 2008; Lozoff et al., 1982; Walter, de Andraca, Chadud & Perales, 1989). This age range is when the prevalence of iron deficiency is thought to be highest for the growing child and is an important time for physical and cognitive development (de Andraca, Castillo, & Walter, 1997). Fewer studies have looked at the impact of iron deficiency on pre-school or school aged children, and these include longitudinal studies that began

[3] There has been some discussion in the literature regarding possible differences in hemoglobin concentration in different populations (Dallman et al., 1978), but this is not entirely relevant to this dissertation since the population being studied is homogeneous in terms of race. It may account, however, for a small overestimation of iron deficiency if it is indeed the case that black Africans have a lower concentration of hemoglobin compared to white and Asian populations.

when the subjects were infants (Hurtado, Claussen & Scott, 1989; Johnson et al., 1992; Oyarzun, Aliaga, Cieciwa & Lopez, 1993; Palti, Pevsner & Adler, 1983; Seshadri & Golpas, 1989; Soewondo, Husaini & Pollitt, 1989; Walka et al., 2000; Walter et al., 1990). A comprehensive annotated bibliography published by the International Anemia Consultative Group (INACG) in 1998 cited only 5 studies of the effects of iron deficiency and anemia on mental and motor performance, educational achievement, and behavior in children ages 2-5 years (Nokes, van den Bosch & Bundy, 1998), although much work has been done since then as will be demonstrated in the following sections.

i. Iron status and physical activity

Physical and psychological development of the infant and young child is dependent on physical activity (Campos et al., 2000). The iron deficient child is less physically active (Angulo-Kinzler et al., 2002b; Wachs, 2000) and spends less time exploring his environment (Aburto et al., 2009), which in turn can lead to cognitive delay (Addy, 1986). Supplementation with iron has been shown to improve motor development (Beard & Connor, 2003). One study in Indonesia, with a relatively small sample size (18 anemic subjects and 18 controls matched for age and sex) using a random assignment of three treatments (high energy plus micronutrient mix which includes iron, micronutrient mix plus skimmed milk, or skimmed milk) found that the subjects who were initially anemic had increased motor development, including walking earlier, higher Bayley motor development scores, and were generally more physically active, with the micronutrient treatment compared to the non-anemic controls (Harahap et al., 2000; Jahari, Saco-Pollitt, Husaini & Pollitt, 2000; Pollitt et al., 2000). Anemia status has also been shown to be a predictor of walking in Zanzibari infants: in logistic regression modeling including sex, age, SES, HAZ, and WHZ, iron-deficient children began walking at a later date than their iron-replete peers (Kariger et al., 2005).

The iron deficient child has been shown to have affective differences compared to non-anemic peers, including increased fearfulness, unhappiness, and wariness (Stoltzfus, Heidkamp, Kenkel & Habicht, 2007; Addy, 1986; Lozoff, Wolf & Jiminez, 1996; Wachs, 2000). This was also seen in a more recent study by Aburto and colleagues in southern Mexico where decreased hemoglobin levels were shown to impact activity levels even before the child would be considered anemic (2009). The observation component of this particular study was comprised of fifteen minutes of individual play in a "novel environment" (play pen in the clinic).

In a cross-sectional study of 2-5 year old pre-school children in the U.S., there was a correlation between decreasing hemoglobin and increased behavior problems in girls, including increased social withdrawal and sleep problems (Johnson et al., 1992). Yehuda and Yehuda (2006) found increased sleep disturbances and lower IQs in 8-10 year old children who had been iron deficient at age 1 year.

ii. Iron status and focused/mental activity

The term "functional isolation" has been used in the literature to describe the range of behaviors and affects associated with the anemic child that may impair development (Lozoff et al., 1998). A specific test of the hypothesis of "functional isolation" found that iron-deficient anemic infants (ages 12-23 months) stayed closer to their caregiver, showed decreased pleasure and delight, were more wary, hesitant, and easily tired. During observations of free play with novel toys, the anemic infants made fewer attempts to play with the toys, had decreased attentiveness, and decreased playfulness (Lozoff et al., 1998). Pollitt and colleagues (2000) in Indonesia also found differences in social maturity and emotional regulatory behaviors in their longitudinal cohort study utilizing three different nutritional supplements. A sub-study on a sample of this cohort focusing specifically on play behavior found that the children supplemented with energy and micronutrients (including iron) started play sooner and had increased "functional play" time (Walka et al., 2000). Lozoff, Klein and Prabucki (1986) had seen these same sort of affective and attentional disturbances during an 8-minute observed free play session with 6-24 month old Guatemalan children.

Some authors believe that there is evidence for causality regarding iron deficiency and attention deficit and/or cognitive delay (Nokes, van den Bosch & Bundy, 1998). It is surprising that the literature is not more settled regarding the cognitive outcomes of iron deficiency. A more recent review found a "high probability of a causal link" between iron deficiency and cognitive outcomes, with 4-12 months of age being a sensitive period in development, although the authors reiterate that this is still a developing field of inquiry (Thomas, Grant & Aubuchon-Endsley, 2009).

iii. The role of iron in cognitive development

Nutrition is understood as one of the key influences on cognitive development in early childhood. Various macro- and micro-nutrients have been studied in relation to cognitive development, using a variety of standardized tests as the measures of outcome. The roles of iron and long-chain fatty acids are better understood compared to many nutrients (Guesry, 1998). Iron is a necessary element in central nervous system biochemistry, and a deficiency of this micronutrient has been shown to be related to decreased cognitive function, non-cognitive disturbances, decreased physical activity and decreased work capacity (Lozoff, 1989). Anemia in infancy can be a marker for disadvantaged cognition in childhood (Walter et al., 1990).

The bulk of iron supplementation trials have found significant improvements on cognitive tests and the ability to acquire language (Beard & Connor, 2003). This is in contrast to earlier literature questioning on whether large-scale fortification of staple foods with iron was necessary, since the causality for impaired attentional development and subsequent poor school performance was not adequately proven in the literature (Deinard, Murray & Egeland, 1976). A later review stated that while the connection between iron deficiency and cognitive deficits is stronger than the data on iron deficiency and behavioral problems, more studies are still needed to prove causality (Fairchild, Haas & Habicht, 1989). Sungthong and colleagues (2002) found a “dose-response” relationship between hemoglobin and cognitive function for iron-deficient school children in Thailand.

Even after hematologic correction, these deficits in cognitive ability and affect may remain, as seen in a case-control study of 18-60 month old children in Minnesota. The children with IDA at baseline remained less responsive and showed no improvement in Bayley scores or Stanford-Binet IQ (Deinard et al., 1986). In a case-control study looking at the effects of an energy and micronutrient supplement on iron deficiency anemia, physical activity, and motor and mental development in Indonesia, the iron-deficient children (mean age 15 months) showed increased physical activity after 6 months of iron supplementation, but there were no differences in mental scores after treatment (Harahap et al., 2000).

One of the difficulties in studying the impact of nutritional deficiencies on cognitive development is that there are confounding factors in most cases that make interpretation of data unreliable (de Andraca, Castillo & Walter, 1997; Pollitt, 2000; Pollitt, 1999; Saloojee & Pettifor, 2001). The situation that caused the nutritional deficiency is usually linked to a poor, non-stimulating environment (Guesry, 1998). Permissive parenting may exacerbate the impact of lower iron levels on child's cognitive test scores (Hubbs-Tait et al., 2009). Deficiencies in vitamin C and zinc, as well as lead toxicity, may be confounding factors in the relationship between iron deficiency and brain function (Hallberg, 1989; Wasserman et al., 1992). The presence of malarial parasites has been shown to be a modifier of the response to iron supplementation when looking at attention spans in young children (Heywood, Oppenheimer, Heywood & Jolley, 1989).

A key study trying to disentangle the nutrition versus psychosocial stimulation conundrum was published in 1991 by Grantham-McGregor and colleagues. In this case-control study conducted in Jamaica using the Griffiths Scale of Mental Development as the outcome measure, there was an additive effect of the two interventions (nutritional supplement and psychosocial stimulation) rather than an interaction between these (Grantham-McGregor et al., 1991). Liu and colleagues undertook a prospective, longitudinal study in Mauritius, measuring both nutritional factors and adverse psychosocial variables. They found that even when controlling for adversity, children who had poorer nutrition at age 3 years had a 15 point deficit in IQ at age 11 years (Liu et al., 2003; Liu, Raine, Venables & Mednick, 2004).

a. Educational consequences of iron deficiency

It has been known since the early 1920s that lower nutritional status, as indicated by anthropometry, is correlated with lower IQ (Poull, 1938). However, it wasn't until much later that scientists used school performance as an outcome measure related to nutritional status (for example, Abidoye & Eze, 2000). This probably has to do with the fact that most research into nutritional issues looks at infants and preschool-aged children, since this is a critical time in brain growth and development. There are several longitudinal studies that have followed children into their school-aged years, but these have used IQ or other standardized tests for measuring intelligence, a proxy for learning capacity (Liu et al., 2003; Liu et al., 2004; Lozoff et al., 2006; Lozoff, Jiminez & Smith, 2006; Grantham-McGregor et al., 1991).

Paxson and Schady (2007) argue that the influence of cognitive development at young ages on later school performance has received little attention in developing countries. Health and nutrition rather than care and home environment have been the main subjects of research and interventions looking at cognitive development. School-aged children are often underserved in regard to health and nutrition services compared to pre-school children and adults (Leslie & Jamison, 1990).

The nutrients with the strongest evidence for educational outcomes are protein-energy, iron, and iodine (Leslie & Jamison, 1990; Scrimshaw, 1998). B-vitamins and zinc may also be implicated (Scrimshaw, 1998). Two consequences of poor child nutrition are the lack of preparedness for school at the expected age and the failure to learn adequately while at school (Leslie & Jamison, 1990). Anemic older children (>2 years) consistently have poorer cognitive skills and school achievement compared to non-anemic children (Grantham-McGregor & Ani, 2001).

Another issue is that there are many confounding variables that need to be considered when looking at school performance as an outcome related to nutrition. Maternal education has been one indicator that is strongly correlated with child school performance (Abidoye & Eze, 2000), and maternal education has also been associated with child nutrition[4]. Maternal depression, low maternal education and lack of psychosocial stimulation can aggravate the effects of early nutritional insult (Gordon, 2003).

The relationship of iron status to cognitive growth and development has been studied extensively (Lozoff et al., 2006; Akman et al., 2004; Liu et al., 2003; Halterman et al,; 2001; Lozoff et al., 2000; Hurtado, Clausen & Scott, 1999; Walter et al., 1990; Deinard et al., 1986; Pollitt et al., 1986), even though the mechanisms are not exactly clear (McCann & Ames, 2007; Pollitt, 2000; Hallberg, 1989; Pollitt et al., 1989). Indeed,

[4] Abidoye and Eze (2000) did find that weight-for-age Z score did affect school performance, as measured by average grade over the last year. Unfortunately, the authors only used Chi-square tests to look at the importance of a range of variables, rather than using multiple regression to better understand the relationships between these variables.

it is the care given during the pre-school age that seems to have the most impact on a child's later school achievement, with child's improved language ability being one of the key mediators of language and cognitive skills acquisition (Raviv, Kessinich, & Morrison, 2004; Bradley & Caldwell, 1984; Hart & Risley,1992; Marchman & Fernald 2008; Hurtado, Marchman & Fernald, 2008; Dickinson & Porche, 2011; Dickinson 2011) This relationship is particularly important in developing countries where access to learning materials and extracurricular activities is limited (Leslie & Jamison, 1990; Grantham-McGregor et al., 1991). Yet even in the U.S., studies have shown that intensive early psychosocial intervention can positively alter the cognitive developmental trajectories of socially and biologically vulnerable young children (Landry et al., 2000; Ramey & Ramey, 1998).

Longitudinal studies looking at mental and motor function at different points in time have found continued cognitive disadvantages despite current normal hematologic and growth status (Lozoff, Jimenez & Wolf, 1991; Lozoff et al., 2000). In a 5 year follow-up of the Costa Rican cohort, however, psychosocial stimulation and care were not measured, but the authors do cite these as potential issues that should be considered (Lozoff, Jimenez & Wolf, 1991). In the 10 year follow-up of the same cohort, the differences in cognitive, socioemotional and motor functioning were still statistically significant, and measures of school performance found increased grade repetition, increased behavior problems and more attention issues with the formerly anemic students compared to the control group (Lozoff et al., 2000).

The few cross sectional studies of school performance in Africa and South

America have drawn conclusions about the importance of mother's education (Abidoye & Eze, 2000) and economic status (Paxson & Schady, 2007) in addition to health and nutritional status. Maternal education level was strongly positively correlated with child school performance in Nigeria (Abidoye & Eze, 2000). Similar correlations between parental education (both mother and father) and a cognitive test score were seen in a sample from Ecuador (Paxson & Schady, 2007). Paxson and Schady (2007) found that lower family SES exacerbated the differences in cognitive test scores as the child aged, citing a cumulative effect where poorer children become farther and farther behind their better economically situated peers. Fewer studies have been longitudinal (Liu et al., 2003; Lozoff et al. 2000; Walter et al., 1990). The longitudinal studies that have taken place in the United States were looking at the predictive value of the HOME Inventory, a measure of the home environment, on school behavior and achievement (Bradley, Caldwell, & Rock, 1988; van Doorninck et al., 1981). Another study used the HOME Inventory at age 12 months, 24 months and 7 years, plus 3 year IQ test to look at achievement test performance in first grade (SRA Achievement test battery) (Bradley & Caldwell, 1984). The conclusion from this study was that making developmentally stimulating toys and materials available to children was associated with better mental and achievement test performance. Looking at these same children again in 1988, the researchers again completed a HOME Inventory and then used three models to predict which HOME score was most accurate in describing current school performance. None of the models (early experience, contemporary environment, or cumulative effect of a stable environment) was better than the others, although correlations were as predicted

(Bradley, Caldwell & Rock, 1988).

A double-blind randomized control trial including a three-month iron supplementation treatment in 8-11 year old school children provided evidence of improved hematological status and improved IQ and achievement scores, but no statistical tests were used to see if these differences were significant (Soemantri, 1989). An earlier study in Indonesia found improved school achievement test scores with iron supplementation (Soemantri, Pollitt & Kim, 1985).

One of the possible biological mechanisms for explaining this is that iron deficiency in infancy can lead to a decrease in dopaminergic neurotransmission which in turn leads to learning deficits later in life, including externalizing behavior problems (Youdim, Ben-Shachar & Yehuda, 1989; Liu & Raine, 2006). Language ability at ages 3 and 4 years predict later reading comprehension through high school, and changing the way parents and other caregivers interact with preschool-aged children through use of a more sophisticated vocabulary and verbal interaction style can have a lasting impact (Dickinson, 2011; Dickinson & Porche, 2011).

Kordas and colleagues (2007) observed 6-8 year old children in their school classrooms and found iron deficiency anemia linked to more “off-task” behaviors and lower physical activity.

D. Factors that affect outcomes

i. Care interactions

One of the great challenges of nutrition research is that consumption of food is a social act. It is very difficult to study the role of nutritional factors on a human body without considering the concomitant role of care, especially when considering the young child and his development. This is especially important when considering both the etiology of the nutritional deficiency, and the rehabilitation and maintenance of good nutritional status. The links between psychosocial care and the child's nutritional status is interactive and bidirectional (Engle & Ricciuti, 1995). Observation of feeding sessions provides two different sets of information for the researcher: it is a social-emotional indicator of the relationship between the child and care giver, and is also important for understanding food intake (Armony-Sivan, et al., 2010).

a. Nutritional care

Poor care behaviors associated with observed iron deficiency have been noted in the literature for some time (Werkman, Shifman, & Skelly, 1964). Nutritional care is important for iron deficiency because good care includes making sure children eat enough, both in quantity and quality, and having some sort of response mechanism when they don't (i.e. caring during illness). Care can also play a role in both detecting illness and responding appropriately, including noticing when a child seems to be less active or less interested in eating. Good care is also important for counteracting some of the negative impacts of iron deficiency on the developing brain through psychosocial stimulation.

Availability of iron-rich foods in the household does not always translate into the adequate access by all members of the family (Engle, Menon & Haddad, 1999). Care can provide a crucial link between diet and health (Engle, Bentley & Pelto, 2000; Pelto, Dickin & Engle, 1999; Richter, 2004). In the case of iron nutriture, active feeding practices can ensure that when high quality foods are available, a child is encouraged to consume these foods, and the eating environment is monitored to enable adequate intake. This type of care can enhance both the intake of iron and the intake of foods known to promote iron absorption. In terms of cognitive development, social interaction and environmental stimulation can help to encourage brain growth and cognitive development. Children with low iron stores may be more lethargic or less interested in interacting with their environment at a crucial time in their brain development (Lozoff, 2007; Pollitt, 1993). There have also been several studies looking at the interactions between a mother and her iron deficient child that have shown differences in behaviors and expectations compared to mothers with iron sufficient children (Corapci, Radan & Lozoff, 2006; Czajka-Narins, Haddy & Kallen, 1978; Armony-Sivan et al., 2010). The mother has lower expectations for her anemic child, and there is less interaction between mother and child from both directions.

1. Responsive feeding

The young child depends upon his caregivers for almost all of his nutritional needs. Responsive feeding can be defined as a set of care behaviors that promote good nutrition or at least good food intake. Providing nutritious foods, responding to verbal and nonverbal hunger cues from the child, monitoring intake, and facilitating the eating environment are all ways that caregivers assist the young child. The exact behaviors vary depending on the physical and cultural environment, but the outcome will be the same. Responsive feeding is an opportunity for interaction between child and caregiver, providing cognitive and social enhancement as well as assuring consumption (Engle, Lhotska & Armstrong, 1997).

This was confirmed in an observational study of 91 mother-child pairs in Vietnam, where positive verbal comments by the mother led to 2.4 times higher likelihood that the child would accept the bite offered (Dearden et al, 2009). This was for 12-17 month old children,. In a similar age group (12-19 months), however, the active feeding behaviors were shown to compensate for the child's lack of interest in food, not necessarily as a means for enhancing growth (Engle & Zeitlin, 1996). In the compensatory care model, mothers only utilized these behaviors when the child was ill or deemed at risk, which did not lead to improved growth but perhaps protected against a decline.

Nti and Lartey (2008) defined responsiveness during feeding as encouraging the child to eat, demonstrating how to eat, offering more food, talking to the child, supervising and monitoring intake, and not ordering or threatening the child during feeding sessions.

2. Child feeding styles and their impact on child health

Engle, Bentley, & Pelto (2000) describe the range of care around child feeding styles that falls into three main categories: controlling, responsive, and laissez-faire. Of these styles, laissez-faire (letting the child decide for himself if he is hungry and when he is full) is correlated with higher rates of malnutrition. Responsive feeding includes encouraging, cajoling, offering more helpings, talking to the children while eating, and monitoring what the child eats. Modeling the eating of healthy foods and understanding hunger cues are also a part of responsive feeding (Engle, Bentley & Pelto, 2000). Dettwyler (1986) took an ethnographic approach to describing infant feeding in Mali. She used three categories for "maternal attitude" in describing care behaviors around feeding: above average (proactive), average, and below average (extreme laissez-faire). These were significantly related to the child's growth, where children with proactive mothers fared better. Some studies have shown a positive correlation between maternal education and child feeding practices (Guldan et al., 1993; Wachs et al., 2005), while others dispute this finding (Ruel et al., 1999).

Despite the policy papers and more recent emphasis on appropriate care during feeding, there have not been many studies that have empirically examined the relationship between responsive feeding and child nutrition outcomes (Pelto, 2000). A recent review found 21 studies, only 12 of which had data based on observation, that addressed this issue, and the authors concluded that a positive association between responsive feeding and child undernutrition had not been demonstrated (Bentley, Wasser, & Creed-Kanashiro, 2011). For example, Dearden and colleagues (2009) used videotaped interactions of two different meals for 179 mother-child pairs in Vietnam and found that verbal encouragement did increase the likelihood of the child, age 12 or 17 months, accepting a bite of food offered. However, this was only a cross-sectional study and nutritional status of the child was not considered. There is an assumption that more bites will lead to improved nutritional status, but this assumption is not tested. Analysis of observed complementary feeding in Bangladesh found no correlation between responsive feeding behaviors and child weight (Moore, Akhter & Aboud, 2006). Another issue with these studies is the range of socio-cultural practices related to feeding children, whether it be prevalence of force feeding young children, the use of compensatory feeding, or the age of introduction of nutrient-dense foods. In conclusion, Bentley and colleagues (2011) found that the impact of responsive feeding on child growth and/or health is not yet clear from the current literature.

A recent article that was not included in the Bentley review found mothers of iron-deficient children were less responsive to their children during a video-taped feeding session and that the children were less clear in their cues directed towards their mother during the session compared to their iron-sufficient peers (Armony-Sivan et al., 2010). In this cross-sectional study, it could not be determined, and was not discussed, whether the child's poor eliciting skills were due to his iron status or due to his mother's lack of caring skills, which may in turn have been one of the causes of the child's low iron status. One study found no differences in the mother's knowledge of feeding practices, most likely due to exposure to the same messages through WIC, despite a relatively high prevalence of iron deficiency anemia (35%, using Hb $\leq$ 11.2 g/dl as the cut-off point)[5], although reporting discussing issues of nutrition with the child's physician was correlated with increased hemoglobin levels (Gupta, Venkateswaran, Gorenflo & Eyler, 1999). Better care, as measured by responsiveness during feeding, was shown to lead to better-nourished children in a sample of 100 mother-infant (age 6-12 months) pairs in Ghana

5 It should be noted that low hemoglobin is one of the entry criteria for WIC.

(Nti & Lartey, 2008).

b. Care and cognitive performance (psychosocial stimulation)

There have been a few randomized controlled studies testing the interaction of psychosocial stimulation with supplemental protein and calories (Grantham-McGregor et al., 1991; Hamadani et al., 2006) and supplemental zinc (Meeks-Gardner et al., 2005) that have shown an additive impact of the combined interventions on cognitive outcomes. Often, though, health and nutrition are not considered in studies of the effects of care and home environment on cognitive development (Hirsh-Pasek & Burchinal, 2006; Kolobe, 2004; Landry et al., 2000; Berlin et al., 1995; Kirsh, Crnic, & Greenberg, 1995; Hart & Risley, 1992; Marchman & Fernald, 2008; Hurtado, Marchman & Fernald, 2008; Dickinson & Porche, 2011; Dickinson, 2011; Berlin, Brooksgunn, Spiker & Zaslow, 1995). Bradley and colleagues (1989) found that parental responsiveness and availability of stimulating play materials were more strongly related to child developmental status than socioeconomic status. In a recent review of programs in the U.S. and elsewhere that provide early educational intervention, there is evidence of short- and long-term effects on cognition, school progress, and anti-social behavior (Barnett, 2011). A randomized controlled trial of adding child development activities for 12 months into the regular activities of the Bangladesh Integrated Nutrition Program (BINP) found that the psychosocial stimulation improved the child's mental development, as measured by Bayley scores, observed behavior and maternal knowledge as compared to baseline measures, but there was not a change in nutritional status of the children receiving the intervention. Maternal iron deficiency has also been shown to have an impact on caregiving, with results for their infants' developmental test scores (Perez et al., 2005).

1. Verbalization as care

Increasingly we are learning about the importance of verbalization, or talking to and with the pre-verbal child, both in the development of language and in cognitive development. Studies in the U.S. with infants of different sociodemographic profiles, including Spanish-speaking Mexican immigrants, find that differences in the quantity and quality of infant directed speech (IDS) between about 10 months and 4 years result in large IQ differences at 3 and at 8 years (Dickinson, 2011; Dickinson & Porche, 2011). Mother's education has been correlated positively with her child's receptive language score (Berlin, Brooksgunn, Spiker & Zaslow, 1995). The structural and process measures of quality of child care are independently related to cognitive development (Burchinal, Roberts, Nabors & Bryant, 1996). Yet several studies have shown decreased maternal responsiveness and warmth to her iron deficient child, even after the iron deficiency has been corrected (Corapci, Radan & Lozoff, 2006; Armony-Sivan et al., 2010). One study in the U.S. found that increased crowding in homes can lead to decreased language complexity by parents and decreased verbal responsiveness to their children, independent of socioeconomic status (Evans, Maxwell & Hart, 1999). In a longitudinal study including monthly hour-long observations for 27 months, the amount of parenting[6] per hour and the quality of verbal content associated with that parenting strongly related to

[6] "Parenting" was measured in this study by the use of ten different variables that were chosen for their association in the literature with child language and intellectual outcomes. These ten measures were: present (proximity), joins in the child's activity, responds to child initiations, prohibitions, mean length of utterance (MLU) distance, different words, repeats, questions, words and turns (Hart & Risley, 1992).

the child's subsequent IQ (Hart & Risley, 1992). Children whose mothers spoke more words to them at age 18 months had a larger vocabulary and higher word recognition at age 24 months (Hurtado, Marchman & Fernald, 2008). Linguistic and cognitive skills at age 8 was predicted by vocabulary size at age 25 months (Marchman & Fernald, 2008). Amount of verbal stimulation was associated with developmental status in a group of 15-30 month old toddlers in Kenya (Sigman et al., 1988). The use of questions by the parent or caregiver has been seen to be important during shared play (Tenenbaum & Leaper, 1997).

An increasing body of literature is looking at different aspects of language development and the relationship to parent and caregiver interactions with the child. In a longitudinal study of Canadian families, with a follow-up at age 4, fathers' involvement with the child was correlated with expressive language, and interactions with mothers correlated with the child's receptive language scores (Magill-Evans & Harrison, 2001). Fathers education, particularly their literacy levels, were associated with toddler cognitive development in Kenya (Sigman et al., 1988). In a 10-minute semi-structured play scenario with both mothers and fathers in a sample of participants in the Early Head Start Evaluation, the importance of the father came out again, where father's education and income were independently associated with child outcomes (Tamis-LeMonda, Shannon, Cabrera & Lamb, 2004).

ii. Environment and socioeconomic status

Sensitive and stimulating caregiving, whether by parents or other regular caregivers, plays an important role in promoting cognitive and language development (Hirsh-Pasek & Burchinal, 2006). However, family factors and child characteristics are more strongly related to cognitive outcomes than their child care experiences in most circumstances (Hungerford & Cox, 2006). Mother's involvement with her 2 and 3.5 year old, as measured by a one hour home observations, was a predictor of a variety of child behaviors related to language and responsiveness. At age 4.5 years, mother's involvement at the earlier ages was also correlated to cognitive skills and social independence (Landry, Smith, Swank & Mailler-Loncar, 2000). Positive maternal affect at age 5 years has been shown to be positively correlated to child cognitive status, controlling for maternal education and earlier cognitive test scores (Kirsh, Crnic & Greenberg, 1995). This was confirmed by Kolobe (2004), showing maternal nurturing behavior, parent-child interaction, and quality of the home environment all being positively correlated with infant cognitive development.

Socioeconomic variables may play a distal role in relation to child health and development compared to proximal variables, such as nutritional care behaviors and attitudes toward child parenting (i.e. speech taboos), in relation to child health and development (Terrisse et al., 1998). Ruel and colleagues (1999) found that good care practices protected against poor child nutritional status in households with low SES and low maternal education. In the current thinking around positive deviance[7], it is the idea that behaviors and practices that are being used right now in a community are the key to the solution to pervasive problems, such as child undernutrition and iron deficiency

[7] Positive deviance is based on the observation that in every community there are certain individuals or groups whose uncommon behaviors and strategies enable them to find better solutions to problems than their peers, while having access to the same resources and facing similar or worse challenges (see http://www.positivedeviance.org).

anemia (Sternin, Sternin & Pascal, 2010). These behaviors and practices are possible despite deficits in educational systems, infrastructure, and economic development. Behaviors and practices can be learned by anyone in the community, which makes this modern definition of positive deviance much more powerful. The original work on positive deviance was a means for focusing on the characteristics of successful cases rather than the problems encountered by those that were failing (Zeitlin, Ghassemi & Mansour, 1990). Earlier research using the term "positive deviance (i.e. Pryer, Rogers, & Rahman (2004)) did not necessarily limit the findings to behaviors and practices, but included other characteristics which made these cases unique and were not necessarily factors that could be changed in current programming.

Tomopoulos and colleagues (2006) found correlations between more books and toys in the home and more reading aloud and better cognition and language development as well as decreased need for early intervention services in a low-income Latino population.

The variation across groups, including differences in proximity, reading to child, and methods for soothing the child, can be seen in an observational study of caregiver-child interactions in health clinic waiting rooms in Japan, Taiwan, and the U.S. (Wang, 1995). With a relatively large sample size (N=409 dyads) but relatively short observation time (15-30 minutes) using a time-sampling observation (one minute of observation followed by one minute of recording), Wang found a range of apparently cultural differences including that Japanese mothers spent more time closer to their child as well as more time playing and reading with their children compared to their American and

Taiwanese counterparts. American parents were more likely to be reading to their child as opposed to playing with the child. The American and Taiwanese children explored their environment more than the Japanese children, which was attributed in part to expectations or permissiveness of the parents.

E. Measurement of outcomes

i. Measuring child physical activity

Physical activity is measured in a number of ways in the studies mentioned above. The most widely-used instrument is the Bayley Scales of Infant Development, which provides an easily comparable score for both motor and mental development (Akman et al., 2004; Black et al., 2004; Idjradinata & Pollitt, 1993; Lozoff, Wolf & Jimenez, 1996; Walter, Kovalskys & Stekel, 1983; Wasserman et al., 1992). Other methods include: observation, either in the home or in a clinic setting (Aburto et al., 2009; Kariger et al., 2005; Kordas et al., 2007; Walka et al., 2000); leg actigraphs (Angulo-Kinzler et al., 2002a, 2002b); other standardized skill tests (Bénéfice, Fouré & Malina, 1999); or some combination of the above methods (Harahap et al., 2000; Jahari, Saco-Pollitt, Husaini & Pollitt, 2000). Shafir and colleagues (2008) used an extensive battery of tests (Gross motor developmental milestones, Peabody Developmental Motor Scale, Infant Neurological International Battery (INFANIB), motor quality factor of the Bayley Behavioral Rating Scale, and a sequential/bi-manual coordination toy retrieval task) on otherwise healthy 9-10 month olds and found impaired motor function in the iron-deficient child even before he would be considered anemic.

ii. Measuring child cognitive development

Cognitive development in infants and young children is assessed in a variety of ways. The Griffiths Scale of Mental Development (Grantham-McGregor et al., 1991) can be used for infants and young children from age 3 month to 2 years, Stanford-Binet Intelligence Quotient (IQ) (Liu et al., 2003) is more appropriate for use with older children, usually over 3 years of age. The Bayley Scales of Infant Development Mental Development Index (Akman et al., 2004; Wasserman et al., 1992) and the Denver Developmental Screening Test (Akman et al., 2004) are often used in younger ages. The Bayley Scales are appropriate up to age 3 years and have been used more frequently in international studies. The Denver Developmental Index can be used with a wider age range, but it does not have the same reliability and validity of the Bayley. While studies in infants have been more prevalent, IDA in the preschool period also has affective and behavioral effects that can affect cognitive development (Lozoff et al., 2007). Soewando, Husaini and Pollitt (1989) used two-choice discrimination learning, oddity learning tasks and the Peabody Picture Vocabulary Test[8] in their double-blind randomized control trial of preschool children in Indonesia. One of the difficulties in assessing cognitive development is that there is such a range of options for testing, and the different tests assess different functional outcomes, which may not be specific enough for the effects of a single micronutrient.

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8 In this case, the two-choice discrimination learning consisted of the child having to select which of two pictures had a smiley face on the reverse side, with the left-right orientation of the pictures changed between trials. Oddity learning consists of the child choosing which picture is different when a set of three pictures is presented where two pictures are identical. The Peabody Picture Vocabulary Test is a more formal assessment of the child's verbal intelligence, requiring no reading or writing by the child.

a. Use of picture vocabulary cards

The Peabody Picture Vocabulary Test (PPVT) is one tool used by researchers in assessing cognitive development in pre-literate children (Berlin, Brooksgunn, Spiker & Zaslow, 1995). Higher hemoglobin levels have been associated with higher PPVT scores in 6-8 year old Mexican school children (Kordas et al., 2004). The Raven Progressive Matrices, which consists of 5 sets of 12 cards where the subject needs to choose the shape that is missing in the element or pattern, and the Bourden-Wisconsin Test for Concentration, a measure of attention maintenance over time, are also used (Soemantri, Pollitt & Kim, 1985; Pollitt et al., 1989).

b. Measures of school outcomes - Achievement and reading scores

Iron deficiency, even before anemia, is a predictor of lower math scores in standardized tests in a sample of participants in the NHANES study (Halterman et al., 2001).

In a 10-year follow-up of a cohort that had been treated for iron deficiency anemia in infancy, the measures of school functioning included a review of school records and a teacher questionnaire to determine grade retention, requests for special testing or tutoring, and placement in special classrooms (Lozoff et al., 2000).

In a double-blind clinical trial of 9-11 year olds in Thailand, a Thai language test was used as a measure of school attainment (along with a math test and Raven Progressive Matrices). The study found a positive association between iron supplementation and test scores after three months of treatment (Pollitt et al., 1989).

iii. Measuring the home environment

The Caldwell HOME Inventory provides a mixture of parent questionnaire and observation to give an overall picture of the home environment. In some cases, the HOME Inventory has been adapted or modified for use in different countries (Black et al., 2004), but it remains theoretically meaningful and valid across cultures (Bradley, Corwyn & Whiteside-Mansell, 1996). Sugland and colleagues (1995) found that there is variation among different racial and ethnic groups in the applicability of the HOME Inventory, even though certain aspects of parenting are common across all groups. Higher HOME scores are correlated with higher developmental scores in a sample of 4-6 year old Canadian children (Terrisse, Roberts, Palacio-Quintin & MacDonald, 1998).

Within the larger HOME Inventory, shorter sub-scales can be used to assess certain characteristics of interest, such as the parental warmth or quality of assistance (Berlin, Brooksgunn, Spiker & Zaslow, 1995; Corapci, Radan & Lozoff, 2006). Berlin and colleagues (1995) found several parenting behavior measures that could be used to predict the reported behavior problems and/or receptive language abilities of children, but that these measures were different for white versus black parents. The HOME "Warmth" subscale was a better predictor for receptive language in the white parents, while the "Supportive Presence" subscale[9] was a better predictor for the black parents.

Lozoff and colleagues (1995) tested the HOME Inventory for use with Costa Rican infants and found that while the Bayley and IQ correlations were small or non-significant for this particular sample, they still felt that the HOME Inventory was helpful

[9] There are eight subscales within the HOME Inventory. The Warmth subscale gives a qualitative score to the emotional warmth shown by the mother to the child. The Supportive Presence subscale was measured during a problem-solving exercise presented to the child and looks at the level of support given by the parent to the child during the task.

in identifying children at risk for delayed development.

One interesting study used scores on the HOME Inventory at two points in time (ages 3 years and 8 years), to categorize the subjects (high vs. low) and then tested their brains' responses to different stimuli (Molfese, Molfese, Key & Kelly, 2003). There were clear differences between the children who received lower levels of psychosocial stimulation and those with higher HOME scores.

Parts of the HOME Inventory were used to measure maternal sensitivity and cognitive stimulation, which were shown to mediate between socioeconomic status and verbal comprehension, expressive language, and receptive verbal conceptual abilities (Raviv, Kessenich & Morrison, 2004).

F. Issues specific to Senegal/West Africa

While it is important to have a basic understanding of the current scientific knowledge regarding iron, child behavior and development, and care, and how these factors interact with each other, testing hypotheses requires the use of data collected from a specific place at a specific time. An understanding of culture and beliefs can help in the selection of questions as well as the interpretation of findings[10]. For example, grandmothers in Senegal are very important both as "guardians of tradition", giving advice to young parents in matters concerning nutrition and care, and are also regularly

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[10] The use of the multiple-day weighed record, often seen as a gold standard for measuring nutritional intake, was shown to be less than ideal in Senegal since intakes of both breast milk and solid food were lower on survey days compared to observation days where the mother did not know consumption was being estimated (Dop, Milan, Milan & N'Diaye, 1994). However, this study was looking at children aged 10-13 months, a group that does not have much autonomy in terms of how often and how much they eat. This study does point out the possibly disruptive nature of having an observer in the household, though.

alternate caregivers of young children in the typical extended family compound (Aubel, Toure & Diagne, 2004; Zeitlin & Barry, 2007). The role of fathers and other alternate caregivers[11] involved in child feeding was also emphasized as an area neglected in most studies of child nutrition in southern and eastern Africa (Engle, Menon, Garrett & Slack, 1997).

i. Iron deficiency in Senegal and the region

The effects of any nutrient deficiency are modified by severity, duration, age/stage of development at which the deficiency occurs, and the socio-cultural context (Grantham-McGregor, Walker & Chang, 2000). Iron has several very important roles in the growing body, and deficiency, especially at key points of growth and development, can lead to potentially irreversible changes (Stoltzfus, Heidkamp, Kenkel & Habicht, 2007; Beard & Connor, 2003). Most populations in developing countries have a large gap between iron intake and iron requirements between the ages of 6 to 24 months (Dewey, 2007).

Iron deficiency remains one of the most common micronutrient deficiencies in the world and affects 40-60% of the infants in Sub-Saharan Africa alone (Garcia, Virata & Dunkelberg, 2008). For Senegal, the rate of anemia (Hb < 11.0 µg/dl) was estimated at 82.6% for all preschool aged children (ages 6 months to 5 years) and 68.8% for those in the Dakar region in 2005 (WHO, 2007). Efforts to reduce infectious diseases, improve diets, and increase supplementation or fortification are necessary (UNICEF, 1990) to address the physiological need for iron in the human body. However, there is also a role

[11] One study looking at the relationship between sibling caregivers and growth failure (in highland Ecuador) found no association between peer care and child growth (Stansbury, Leonard & DeWalt, 2000), although the age range was quite broad (5-52 months) and the total sample size small (N=28) so it seems that it would be hard to make any generalizations.

for psychosocial stimulation to address the non-physiological manifestations of iron deficiency. In 1999, Bénéfice and her colleagues reported on a study of children in another region of Senegal (near Thiès) and hypothesized that “marginal nutritional circumstances were compromised by a poor non-stimulating environment.”

ii. Feeding and nutritional care

Families eat from a common bowl, with rice or millet couscous forming the base of the afternoon and evening meals. Fish or animal products as well as vegetables are placed in the center of the bowl with the ability to choose from these foods based on your status or age within the household. While in the case of the coastal fishing village, there is often plenty of fish available to the household, the youngest children do not often get more than a few morsels throughout the day[12]. Consequently, micronutrient consumption is less than ideal even though the child often gets enough in total calories. The common attitude towards child feeding and appetite would be considered laissez-faire, with the idea that the child knows when he is hungry and will feed himself (Dettwyler, 1986). Provision of an “adequate feeding situation”, both consistent and protected, (Engle, Lhotska & Armstrong, 1997) is often difficult when many competing interests come to the family bowl.

Several studies have helped to confirm anecdotal evidence from the field regarding child nutrition in Senegal. Simondon and Simondon published multiple papers exploring early feeding behavior among rural Senegalese (1995, 1997) which highlight

[12] The Lebou ethnic group, which resides mainly along the coastal areas near Dakar, were described in one study as not being susceptible to iron deficiency due to their high intake of fish (Fall, Sow, Diakhate & Senghor, 1982). It may be that population density and overfishing, especially by foreign fleets, in the subsequent years have changed this dynamic.

issues regarding age of introduction of complementary foods as related to nutritional status (physical growth) and more ethnographic concerns over choices mothers must make regarding child feeding[13]. The prevalence of very early complementary feeding is low compared to other regions of Africa[14] (12% of sample providing food other than breastmilk by age 2-3 months), although 37% still had not received complementary food after 7 months (Simondon & Simondon, 1997). Early nutritional deficits led to poorer motor coordination in childhood compared to children who did not experience undernutrition as infants (Bénéfice, Foueré & Malina, 1999). There is also a prevalent belief throughout West Africa that children are the best judge of their appetite (Simondon et al., 1996).

Direct observation of food intake can provide important information that cannot be gained otherwise regarding behaviors as well as measurement of food consumed outside of more formal meal times (Gittelsohn, Shankar, Pokhrel & West, 1994). Visual estimates of food consumption have been shown to be relatively accurate and indeed necessary in regions where shared plate eating is the norm (Shankar et al., 2001). Shared plate eating has also been seen to be related to increased dietary quality of children in some populations where this is practiced (Shankar et al., 1998).

The age of introduction of protein-rich supplementary foods has been shown to be an indicator for nutritional status in Nigeria, Nicaragua, and Indonesia, with earlier introduction of either animal or soy protein foods associated with better height-for-age Z

[13] Gittelsohn & Vastine (2003) found no impact of food taboos on child nutritional status in Uganda. Their overview of sociocultural and household factors that influenced consumption of animal source foods emphasized that often cultural rules are modified or ignored, even though members of the society are well versed in the prescriptions and proscriptions.

[14] Younger and more educated parents were more likely to introduce complementary food earlier, even though this was seen to have a negative impact on physical growth (Simondon & Simondon, 1997).

scores (Zeitlin, 1996).

iii. Child care and cultural beliefs

One of the major beliefs in Senegal and other countries in this region regarding child care and development is that children do not understand verbal explanations until the age of 5 years, so it is not necessary to talk to them. This can be measured through lower verbal interactions between mother and child in many African countries compared to other regions in the world (Bradley & Corwyn, 2005). Several studies mention the "poor, non-stimulating environment" found in many Senegalese households, which compounds the marginal nutritional situation (Benefice, Fouere & Malina, 1999; Bradley & Corwyn, 2005). These practices are underscored by both traditional fears of having the child be noticed by evil spirits and subsequently "taken" as well as the restrictions of the "age-set" bush school system whereby knowledge is rationed carefully and provided at specific times (Zeitlin & Barry, 2007).

In a study of Wolof-speaking Senegalese mothers and French-speaking French mothers living in Paris, there were distinct cultural conceptions that influenced both content and structure of the exchanges with their 4-month-old infants (Rabain-Jamin & Sabeau-Jouannet, 1997). While the Wolof-speaking mothers living in France may be different from their peers still living in Senegal, traditional beliefs were still a big part of how they talk (or don't talk) with their children, although a review of the importance of the caregiver-child interaction, as measured by attachment, development, and cultural adaptation, found that intra-country variation exceeds inter-country variation (Richter, 2004).

Much of the teaching and learning that occurs is in relation to small errands that the child is sent on. From a very early age, often as soon as a child can walk, he is sent on errands within the household, relays messages between adults, and even makes small purchases at a nearby vendor.

In large stratified samples, nutritional and health status are clearly related to socioeconomic status. However, there are conflicting conclusions regarding the influence of socioeconomic variables on some aspects of child health (Wachs et al., 2005), which may in part be due to the nuances of the relationship between the variables and the outcome of interest. Fotso and Kuate-Defo (2006) used Demographic and Health Survey data from five African countries (Burkina-Faso, Cameroon, Egypt, Kenya and Zimbabwe) to look at correlations between SES measures and child stunting and found SES to be statistically significant at both the household and community level. A longitudinal study in Costa Rica found a widening gap in cognitive test scores for children from low-SES families compared to those from higher-SES families both of whom who had had chronic iron deficiency in infancy (Lozoff, Jiminez & Smith, 2006). However, in a study from rural Senegal, it was the parents with higher education levels, often a variable used in determining SES, who introduced solid foods to infants at earlier ages (2-3 months) and subsequently had children with poorer nutritional status (Simondon & Simondon, 1997). This can be contrasted with findings from Uganda where lower maternal education, but not lower paternal education, was the best predictor of child stunting (Wamani et al., 2004). In DHS data from Mali, the health-seeking behaviors of the mother were more important than maternal education regarding child health (Uchudi, 2001).

In a cross-cultural review of studies utilizing the Caldwell HOME Inventory (a measure of the family environment that utilizes both observation and a semi-structured questionnaire), there was lower verbal interaction between mothers and children, fewer stimulating objects found in the home and fewer instances of teaching by parents in African countries as compared to other regions in the world (Bradley & Corwyn, 2005). Bradley and Corwyn (2005) do state in their review that it is difficult to disentangle the relationship between culture and socioeconomic variables in attitudes toward child development. A clear understanding is needed between what is a practice that is due to material poverty and what is based on shared values of a community. This also corresponds with Engle and Ricciuti's barriers to adequate psychosocial care: maternal beliefs and confidence, stress and depression, and control of resources (1995).

G. Summary and conclusions

There are several nutritional factors that are implicated in changes in infant and child behavior (Scrimshaw, 1998). This can be seen in both lethargic and lower-than-expected activity, as in the case of protein-energy malnutrition, as well as increased irritability and inability to focus on tasks which are also associated with severe malnutrition and micronutrient deficiencies including iron, zinc, and B vitamins (Wachs, 2000). Iron has been indicated in several behavioral abnormalities of the infant and young child, including "functional isolation" which includes lower reactivity, increased inhibition, and a greater negative affect (Wachs, 2000; Lozoff, 1998). It is often difficult to assign direct or independent causality because there are other environmental factors that occur in households where there is also iron deficiency. This may include decreased attention from mother and other caregiver; maternal iron deficiency and depression have also been implicated. A non-stimulating environment, whether due to poverty or cultural expectations, may also be present in the homes of anemic children.

Iron deficiency anemia has significant impact on a child's health and development, reaching long past the nutritional deficit in infancy and early childhood. The availability of iron in a child's diet is due in part to its availability to the household, but more importantly to the care practices, including meal frequency and monitoring of intake, provided by the mother and other adults in the household that enable these foods to be consumed by the child. In a population where a laissez-faire feeding style is predominant, age-appropriate feeding practices, including monitoring of eating, verbal and nonverbal encouragement to eat more, responding to cues for hunger and by providing more food, and facilitating the eating environment are important predictors of a child's iron status, regardless of the socioeconomic status of the household.

Three of the important external stimuli for cognitive development in children are physical activity, interaction with their environment (Campos, Anderson, Barbu-Roth, Hubbard, Hertenstein & Witherington, 2000), and frequency and quality of speech directed at infants and young children (Hart & Risley, 1992; Hart & Risley, 1995; Marchman & Fernald 2008; and Hurtado et al, 2008). Young children need to be active in order to develop physically and mentally (Kariger et al., 2005; Olney et al., 2007), yet iron-deficient children are more lethargic, less likely to respond to environmental cues, and may be less likely to effectively elicit interactions with other people around them (Black et al., 2004; Honig & Oski, 1984; Lozoff et al., 1998; Lozoff et al., 1986; Addy, 1986). Lozoff and colleagues (2007) observed less social looking towards mother, closer proximity to mother, and decreased positive affect in preschoolers with IDA who were presented with a novel toy. There have been several studies that have shown decreased activity in the anemic child compared to non-anemic counterparts (Olney et al., 2007; Honig & Oski, 1984; Jahari, Saco-Pollitt, Husaini & Pollitt, 2000; Pollitt et al., 2000; Lozoff et al., 1998).

Pollitt (2001) argues that there need to be more longitudinal studies to help bolster the argument for the functional consequences of IDA in children rather than the usual cross-sectional snapshots. This is also argued for by Wainwright and Colombo (2006), who feel that global measures of cognitive development should be discarded in favor of more specific tests related to the impacts expected due to the micronutrient being studied.

Fewer studies have looked at the long-term practical consequences of iron deficiency in early childhood. Children who have experienced an early nutritional insult such as iron deficiency anemia are more likely to be unprepared to begin school and to fail to learn adequately compared to their well-nourished peers (Leslie & Jamison, 1990). Learning capacity and the ability to succeed in school are natural outcomes related to the cognitive impact of this deficiency.

Anemic children have a poorer quality of attention during a critical time in their development when they are learning about the world around them. This loss of attentiveness will have both short-term and long-term consequences for the growing child. Despite all of the data available, the causal connection between iron deficiency during development and deficits in cognitive or behavioral function in later life is still debated by certain scholars (McCann & Ames, 2007), although it is taken for granted by many in the field (Sheard, 1994). There is a need for richer multi-disciplinary strategies, including the building of present capacities, to have an impact on "protecting brains, not simply stimulating minds" both for interventions and research (Shonkoff, 2011; Wachs, 2000).

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3. Methods

A. Overview

This study was conducted in Yoff, Senegal and employed a longitudinal design with two rounds of data collection. The first round of data collection was in 1999 (time 1) and included 12-hour observations of all subjects (age 24-42 months). The second round was in 2007 (time 2) and focused on school performance (age 10-11 years).

The first round of data received exemption from review from the Tufts University IRB (exemption category 4) because the data were collected as part of an earlier study, not involving Tufts University. This data set includes household information (expenditures, household size, educational status of mother and father, employment), information on the child (health status in last two weeks and last six months, and age of introduction of various foods), as well as notes from 12-hour observations of the children including a semi-quantitative measure of all foods consumed, an hourly qualitative measure of activity, and descriptions with time (time of day, which can be used to calculate duration) of interactions with other household members. Iron status was measured using a HemoCue machine that calculates hemoglobin based on a small drop of blood. At the end of the survey, a brief learning test was administered to the children using a simple picture card with names in both French and Wolof, the local language.

The second round of data collection received approval from the Tufts IRB and was a follow-up on the original sample, intended to include variables on school performance (current grade level, whether the child has had to repeat a class, grade average), height, weight, hemoglobin, and household socio-economic variables. In addition, reading level and math skills were determined with a short test using the books used in the schools in Yoff.

B. Population

The study was conducted in the village of Yoff, an ancient fishing village, now a part of the capital city of Dakar, in the country of Senegal. Households in the survey were selected based on the presence of a child aged 24-42 months at the time of the first data collection. The age range was chosen due to the fact that most Senegalese women breastfeed until 18-24 months. Since daily food intake was one of the variables being calculated in the study, it was decided that children who were no longer consuming breast milk would be chosen. All households in Tonghor, one of the seven traditional neighborhoods of Yoff, that met this criterion were approached to be included in the survey. The children were identified by the first author and a Senegalese assistant in house visits, with a total of 78 children meeting the age criterion. A verbal explanation of the study design in the local language (Wolof) was given to a parent or caretaker, usually the mother, as well as a written document in French to be kept at the household. All requested families agreed to be a part of the study; however 4 families were not able to participate in all parts of the data collection due to extended vacations or moving away from the village during the course of the survey. Data are available on 74 households/children from the first round of the study (95%) and on 68 children from the second round (91% from the original sample).

C. Physical and biochemical measurement

During the first round of data collection, two sets of anthropometric measures were taken on each child six months apart. Weight was measured using a spring scale with accuracy to 0.5 kilograms. Height was measured by having the child stand with heels against a wall, placing a rectangular box parallel to the floor on top of the head, for a 90^{o} angle, marking the wall at the lower intersection of the box, and measuring in millimeters, using a tape measure, following standard WHO instructions at the time (WHO, 1995).

The blood test for the hemoglobin value was performed using a HemoCue machine which was transported from house to house. Hemoglobin values were obtained at two different time points for the first round of data collection, 6 months apart. This helped to control for possible seasonal variation in hemoglobin level (paired sample t-test for seasonal differences was insignificant; mean Hb at time 1 was 8.9g/dl, mean at time 2 was 9.0g/dl; correlation was .77 between the measures).

Heights and weights were also obtained for the parents of the child using the same method (spring scale with accuracy to 0.5 kg for weights; right angle and tape measure for heights).

During the second round of data collection, hemoglobin, weight and height were measured again with the same methods.

D. Questionnaire

The main questionnaire[15], developed over several months of pretesting in other Yoff neighborhoods, was given to the mother, or child-care provider (in two cases). A native Yoff resident administered this survey, translating from the French questionnaire into Wolof. The first author, also fluent in Wolof, was present for the first twenty interviews. Questions were mainly closed-ended with some open-ended questions for qualifications (for example, "how many?" or "why?" in response to some health practices or to specify responses to the category "other"). Child health history since birth as well as in the two weeks prior to the interview were obtained, followed by the month of introduction of various foods for the infant and feeding behaviors when the child is ill. Socioeconomic variables were probed and monthly expenditures for various categories were also estimated. All responses were self-report by the respondent.

Questionnaire contents:

- Health history (both for last year and last 2 weeks)
- Breastfeeding duration (months) and method of cessation
- Age of introduction to 39 separate solid foods
- Household distribution of cooking and feeding tasks (who prepares meals and with whom the child eats)
- Strategies for when child refuses to eat, during illness or otherwise
- Socioeconomic data - type of housing, source of water for drinking and washing, whether mother engages in work for pay, household possessions (television, refrigerator, telephone, car), monthly expenditures (for list of 10 items), education

[15] The questionnaires from both rounds of data collection can be found in the Appendix.

of parents (level completed), and principal employment of father

A picture test was used to assess the child's learning ability and vocabulary during the first round of data collection. A male field worker brought to each family the simple picture-word sheet used in testing the children's vocabulary learning (a single photocopied and laminated A4 sheet of paper showing 14 familiar pictures, labeled in Wolof and French). This field worker tested the children's picture recognition, with responses recorded in Wolof and French. The paper was left with the family with the instructions to use this picture card together during the next week. After one week, the child was tested again for the number of pictures s/he could name.

As part of the second round of data collection, the same group of children was surveyed, this time with questions focusing more on their current school performance. Children were now aged 10-11 years old, and the questionnaire contained items on attendance at preschool, whether currently in school, grade level and average grade, and the number of repetitions, if any. The investigator also tested each child's reading level through a progressive recitation and response to reading comprehension questions using two levels of the local school readers (as well as a more advanced French novel for those able to master the school books).

The questionnaires for both rounds of data collection can be found in Appendices A and E.

E. Development and pretesting of observational methods

The principal investigator developed the event observation methods used in this study during several months of informal, semi-structured observations during home visits in non-surveyed neighborhoods of Yoff. Rather than pre-coding events, she used an unobtrusive child-following approach to record an uninterrupted narrative describing the index child's environment and all his/her interactions with the environment and all persons present. Throughout this research, periods during which the child was relatively immobile, sleeping, or engaged in the same quiet activity, permitted the observer to complete the recording process.

Increasing familiarity with events making up a typical day in the life of the sample children made it possible to insert starting and ending times to the event frames making up each narrative record. The investigator then formalized the style for the observation day and the methods used to record the children's activity levels and states by carrying out standardized pretests in several households. This pre-testing also allowed the investigator to identify a rough inventory of event frames and the activities typically occurring within them.

The approach to measuring the children's activity, states and moods evolved together with each event observation. At the end of each hour, the investigator estimated and recorded hourly percentages of time the child spent in a list of different activity levels and psychological states (See Table 3.1). She validated these time percentages against the start and end times of the events occurring during each hour.

Table 3.1. Categories for hourly percentages of time spent.

Activity	State	Mood
running walking standing sitting lying down being carried backed[16]	sleeping awake drowsy low-energy diffuse low-energy focused high-energy diffuse high-energy focused	happy neutral sad angry teasing/mischievous whiny/needy loud crying

In parallel, she contextualized the summary information on the children's states, and moods within twelve-hour narrative event observations. The starting and ending points of each narrative event, in turn, was triggered by changes in the child's activity, physical state, or emotional state/mood.

This study was not blinded (the researcher who obtained the hemoglobin measurements was the non-participant observer in all households); however, all efforts were made to limit the bias that could exist. Since the nature of this study was exploratory, there were not clear expectations about what would be observed. The hypotheses were that the anemic child would be less active and less interactive, but how this actually played out in the home environment had not been described in the literature. The long time period of the event observation (12 hours) allowed for a variety of interactions and opportunities usually from the time that the child awoke in the morning until s/he went to bed at night.

These twelve-hour event observations were carried out for all the children in the study. A sample of the narrative observation can be found in Appendix D.

[16] "Backed" refers to the carrying of the child on the caregiver's back, tied with a cloth as is the custom in Senegal and most of West Africa. For the older child, this is most often used for calming and/or getting ready to sleep, and allows the mother/caregiver full use of her arms.

F. Statistical analysis

For all papers, quantitative data were analyzed with SPSS 15.0 and IBM SPSS 20 and qualitative data were coded for analysis with Atlas.ti.

i. Paper 1 (Chapter 4)

The data for testing these hypotheses in the first paper (Chapter 4) come from both the quantitative questionnaire and the hourly summary of activity and psychological state data from the 12-hour event observations. A t-test of the difference in means for two groups, dividing the children into anemic (Hb < 10.5 g/dl) and non-anemic (Hb ≥ 10.5 g/dl)[17], was used to test the main hypothesis.

The qualitative data analysis was a multi-step iterative process. Key words or phrases were marked based on both pre-determined codes (for illustrative purposes of the hourly activity levels and psychological states) and on interactions of interest. For this analysis, "general activities" and "type of play" codes were used.

The general activities included the activities around the house such as the child being sent on an errand and the child engaging in housework. Social activities included were greetings and visiting, while care activities included grooming and bathing. Dancing, singing, watching people or objects, watching television, and bad behavior were also some of the most frequent activities observed. Differences between the number of these activities by category and the child's anemia status were calculated with a Chi-square test.

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[17] The cut-off of 10.5 g/dl was determined based on the literature (Palti, 1985; Lozoff, 1989; Lozoff et al., 1982; Idjadinata & Pollitt, 1993; Seshadri & Gopaldas, 1989) and cut-point analysis of the sample.

The types of play that the children engaged in were coded into four categories: imitative, imaginative, physical, and exploratory. “Imitative play” was used to code play activities that were direct imitation of household members or other people the children could observe, most often of common household tasks (washing clothes, sweeping, cleaning dishes, caring for a “baby”, etc.) “Imaginative play” was used to code play activities that were outside the direct observation or experience of the child, where the child had to pretend (imitating a lion, driving a pretend car, etc.). “Physical play” included running, tug-of-war, wrestling, and swinging from the arms of adults. “Exploratory play” was used to tag instances where the child was actively engaged in learning about an object in his environment. A T-test for the equality of means was used to test the differences for each play category between the anemic and non-anemic groups.

ii. Paper 2 (Chapter 5)

For each case, extractions of each narrative related to meals and snacks were prepared for qualitative analysis. Z scores were calculated using ANTHRO (CDC, 2005). Differences between mean values of demographic characteristics were calculated by T-test.

The first hypothesis is that children who begin to consume fish at an earlier age will have better hemoglobin levels at age 24-42 months compared to children who begin fish consumption at a later age. When the subjects are grouped into anemic (hb < 10.5 g/dl) or non-anemic (hb ≥ 10.5 g/dl) categories, a T-test was used to determine whether the mean age of introduction of fish is different between groups.

The second hypothesis is that children who consume the *diogonal* (afternoon meal), when this meal is defined by fewer than 5 people at the bowl and the presence of some adult supervision, will have better hemoglobin levels than children who do not consume this meal, or consume this meal with 5 or more people at the bowl and no adult supervision. For this hypothesis, a Chi-square analysis was used where anemia status (anemic vs. non-anemic where anemic = hb<10.5) and number of eaters present at the *diogonal* bowl was used. The range for the number of eaters is from 0-10. Based on the distribution of this variable as well as theoretical concerns (i.e. whether the child having the bowl to himself was important rather than a shared bowl), the categories were 0 (no *diogonal* eaten), 1 person at bowl, 2-4 eaters at bowl, and 5 or more eaters at bowl.

In addition to the quantitative analysis, examples are presented to provide a better understanding of the caring behaviors present or absent at different meals, as recorded during the home observations.

iii. Paper 3 (Chapter 6)

A T-test for the equality of means with picture test (time 1) between two groups (anemic and non-anemic) was calculated.

Since the hypothesis concerns the impact of stimulation on anemic children, the analysis was run twice: the first time with the whole sample and the second time with only those children with hemoglobin < 10.5 g/dl included in the analysis. Control variables of age and occupational rank (as a proxy for SES) were included in the model to provide a more complete picture. The following equation was used to test the hypothesis:

Picture test score (time 1) = constant + B_1[Anemic] + B_2[Psychosocial Stimulation] + B_3[Psychosocial Stimulation]*[Anemic] + B_4[Age] + B_5[Occupational Rank]

The regression equation used to test the second hypothesis in paper 3 was:

Reading level score (time 2) = constant + B_1[Picture test score] + B_2[age] + B_3[Pyschosocial Stimulation] + B_4[Occupational Rank]

G. Discussion of methods and study limitations

The data used in this thesis was obtained through a complex survey instrument that included several different questionnaires, a 12-hour home observation, and cognitive outcome measures at two different points in time. It seems prudent to comment on the advantages and limitations of this process, both in the data collection itself and in the subsequent data analysis that was utilized for this thesis.

i. Questionnaire

The main questionnaire used in this study began with basic sociodemographic information on the child and the household and then went on to the child's health history and age of introduction of specific foods into his diet. These items are generally not considered controversial and in many ways offer an entry into the homes and a common basis for understanding certain practices and behaviors. In this case, the questionnaire was also a time for the families to observe the researcher, and this familiarity was useful during the later home observations.

ii. Observation

The organic evolution of the observation method was based on advice from a seasoned expert and the intuition of an enthusiastic novice. At the time of the initial round of this study (1998-1999), there were very few descriptions in the literature pertaining to the daily life and activities of iron deficient children in their home setting. The observations allowed for both a better understanding of these children's lives as well as a necessary piece of formative research for the subsequent design of an appropriate intervention. After the completion of these 75 12-hour observations and the subsequent analysis of the data collected, it became clear why certain people would want to devote their careers to the development of a method for obtaining key information in the home (i.e. R. Bradley and B. Caldwell with their HOME Inventory): there is such an abundance of information available during observations that being able to distill the most important events or key interactions that are related to outcomes of interest takes years of study and refinement to understand.

iii. Cognitive outcome measures

The cognitive measures used in this survey were standardized within the study, and were similar to but not identical to other tests used in this field.[18] Ideally, these

[18] See Grantham-McGregor & Ani (2001) for a review of the studies that look at the effect of iron deficiency on cognitive development in children, including summary tables of outcome measures.

measures could have been tested for validity and reliability, but this was not done. Another ideal would have been to use one of the standardized testing kits available (i.e. Raven's Progressive Matrices or the Peabody Picture Vocabulary Test), but that was not an option based on our time and budget allocations.

The picture vocabulary test was administered using a set of laminated cards showing pictures of various items that would be familiar to children in the village. These cards were part of a preschool project that was going on in a different neighborhood in the village. The children were tested on their knowledge of both Wolof and French names for these items, and then the card was left at the home for a period of one week after which the tester returned to see what the children had learned. There was not a lot of instruction given to the parents on what to do with the card, but they did know that someone would be returning in a week to test the child again.

Reading level was obtained by using specific marked pages in two readers used in the Senegalese public schools. The older child was asked to read passages and to answer simple comprehension questions before progressing to the next marked page. A local graduate student, who had previously worked with young children, assisted in this task. There is at least one other study that has utilized local school tests for assessing the older child's cognitive ability (Pollitt et al., 1989).

H. References

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4. Paper 1: Iron-deficient children are less physically and mentally active than iron-replete peers

A. Abstract

Early childhood is a time of increased iron needs due to rapid growth and, unfortunately, also a time when many children are not receiving enough of the iron-rich foods their bodies need. Iron status affects both physical activity and cognitive development of the growing child. The study was conducted between February and September of 1999 in the village of Yoff in Senegal. There were 74 children in this sample in total, with 81% (N=61) having hemoglobin values less than 10.5 g/dl. There were no statistical differences between the anemic and non-anemic children for sex, age, anthropometic Z-scores (based on the 2005 WHO standards), or duration of breastfeeding. Likewise, there were no statistical differences between the two groups in maternal age, education and BMI; paternal education and occupation ranking; family possession score; or rough Caldwell HOME Inventory estimate. Children with higher hemoglobin levels spent more time in focused activity (35.2% vs. 21.8%), especially low energy focused activities (32.5% vs. 20.5%) than the children in the lower hemoglobin group. These two groups participated relatively equally in important activities such as errands, dancing, and housework, the anemic children were more likely to engage in bad behavior and the non-anemic children were more likely to make visits outside of the family compound. Anemic children spent less time engaging in imitative, physical, and exploratory play than their non-anemic peers.

Keywords: iron deficiency, anemia, children, behavioral observations, physical activity, Senegal, qualitative analysis, event observation

B. Introduction

Early childhood is a time of increased iron needs due to rapid growth and, unfortunately, also a time when many children are not receiving enough of the iron-rich foods their bodies need (Beaton, Corey & Steele, 1989; Black et al., 2004; Stoltzfus, Heidkamp, Kenkel & Habicht, 2007). While iron deficiency does not have the overt physical symptoms of many other micronutrient deficiencies, this "hidden hunger" can have long term consequences for a child's physical and mental development. Iron deficiency that occurs during the major brain growth spurt around ages 12-24 months can lead to impairment in the myelination of the developing neurons (McCann & Ames, 2007; Beard & Connor, 2003; Gordon, 2003; Guesry, 1998; Youdim, Ben-Shachar & Yehuda, 1989).

Most studies of the impact of iron deficiency on children's physical and cognitive development have focused on infants and toddlers between the ages 6 and 24 months (Angulo-Kinzler et al., 2002a; Black et al., 2004; Czajka-Narins, Haddy & Kallen, 1978; Harahap et al., 2000; Heywood, Oppenheimer, Heywood & Jolley, 1989; Jahari, Saco-Pollitt, Husaini & Pollitt, 2000; Kariger et al., 2005; Lozoff et al., 1998; Lozoff, Klein & Prabucki, 1986; Pollitt et al., 2000; Shafir et al., 2008; Lozoff et al., 1982; Walter, 1989; Walter, de Andraca, Chadud & Perales, 1989). This age range is when the prevalence of iron deficiency is thought to be highest for the growing child and is an important time for physical and cognitive development (de Andraca, Castillo, & Walter, 1997). Fewer studies have looked at the impact of iron deficiency on pre-school or school aged children, and these include longitudinal studies that began when the subjects were infants

(Hurtado, Claussen & Scott, 1989; Johnson et al., 1992; Oyarzun, Aliaga, Cieciwa & Lopez, 1993; Palti, Pevsner & Adler, 1983; Seshadri & Golpadas, 1989; Soewondo, Husaini & Pollitt, 1989; Walka et al., 2000; Walter et al., 1990)

Two of the important external stimuli for cognitive development in children are physical activity and interaction with their environment (Campos et al., 2000). Young children need to be active in order to develop physically and mentally (Kariger et al., 2005; Olney et al., 2007), yet iron-deficient children are more lethargic, less likely to respond to environmental cues, and may be less likely to elicit interactions effectively with other people around them (Black et al., 2004; Honig & Oski, 1984; Lozoff et al., 1998; Lozoff et al., 1986). Several studies have shown decreased activity in the anemic child compared to non-anemic counterparts (Olney et al., 2007; Honig & Oski, 1984; Jahari, Saco-Pollitt, Husaini & Pollitt, 2000; Lozoff et al., 1998). Anemic children have a poorer quality of attention during a critical time in their development when they are learning about the world around them. Thus it is not only their physical activity, but also their ability to concentrate on an object or task at hand, or “focused activity”, that is affected by iron deficiency. This loss of attentiveness has both short-term and long-term consequences for the growing child.

This study complements previous studies that have looked at activity levels in anemic children (Kordas et al., 2007; Olney et al., 2007; Angulo-Kinzer et al., 2002a; Angulo-Kinzer et al., 2002b; Lozoff et al., 1998; Lozoff, Klein & Prabucki, 1986). There are not many studies that have observed the activity of anemic children in their home setting (Angulo-Kinzler et al., 2002a; Black et al., 2004; Harahap et al., 2000; Olney et al., 2007), and none for the 12-hour duration of time that was used in this study. Most often, the Caldwell HOME Inventory[19], which includes a questionnaire and observation time of around 40 minutes (Black et al., 2004; Idjradinata & Pollitt, 1993), is used. Other attempts to study motor activity in anemic children have used leg actigraphs (a small device attached to ankle that records movement), rather than observation, so that results are difficult to interpret (Angulo-Kinzler et al., 2002a; Angulo-Kinzler et al., 2002b). The previous studies also have much shorter observation times, starting at 15 minutes (Lozoff et al., 1998). Olney and colleagues (2007) found less physical activity and locomotion for young iron-deficient children when using 2-4 hour home observations.

The aim of this paper is to address two related hypotheses:

H_1: Children with low hemoglobin levels spend less time engaged in physical activity, than the children with higher hemoglobin levels.

H_2: Children with low hemoglobin levels spend less time in focused activity than the children with higher hemoglobin levels.

C. Methods

This study includes both a survey and home observation, providing more depth and explanatory power to the results. We chose this longer 12-hour observation time (compared to the Caldwell 40 minute observation) as an opportunity for capturing and describing infrequent, but important, events over the course of the child's day, and in

[19] The Caldwell HOME Inventory is a checklist of interactions and environmental variables that are associated with child growth and cognitive development (Caldwell & Bradley, 1984).

order to be able to detect repeating sequences of behavior.

i. Population

The study was conducted between February and September of 1999 in the village of Yoff, an ancient fishing village, now a part of the capital city of Dakar, in the country of Senegal. Children between the ages of 24 and 42 months in the neighborhood of Tonghor were selected using a previous survey done in this traditional neighborhood by the staff of the Yoff EcoCommunity Program for ENDA-TM[20]. The age range was chosen due to the fact that most Senegalese women breastfeed until 18-24 months (the Koran advises breastfeeding until 2 years of age, and 95% of the Senegalese population identifies as Muslim; Yoff is a particularly homogeneous population in terms of religious affiliation). Since daily food intake was one of the variables being calculated in the study, it was decided that children who were no longer consuming breastmilk would be chosen.

The children were identified by the first author and a Senegalese assistant in house visits, with a total of 78 children meeting the age criterion. A verbal explanation of the study design - a simple blood test to determine hemoglobin level, height and weight measures, a questionnaire on health and diet history and a possible 12-hour home observation - in the local language (Wolof) was given to a parent or caretaker, usually the mother, as well as a written document in French to be kept at the household. All requested families agreed to be a part of the study. Despite the initial agreement from all

[20] ENDA-TM (Environmental and Development Action in the Third World) is an international non-profit organization based in Dakar which contracts with local organizations for various programs related to health and the environment.

families, data are available on 74 households/children from the first round of the study (95%) due to extended travel or permanent moves by the family or child in four households.

ii. Physical and Biochemical Measurement

Two sets of anthropometric measures were taken on each child six months apart.

The blood test for the hemoglobin value was performed using a HemoCue[21] machine which was transported from house to house. Hemoglobin values were obtained at two different time points, 6 months apart. This helped to control for possible seasonal variation in hemoglobin level (this variation was not detected, data not presented). For the purposes of the analysis, the hemoglobin value that was taken closest to the event observation was the value used.

Weights were calculated by using a spring scale with accuracy to 0.5 kilograms. Heights were obtained by having the child stand with heels against a wall, a sturdy box placed on top of the head for a 90^{o} angle and tape measure with readings to the nearest millimeter using the standard WHO instructions (WHO, 1995).

Heights and weights of the parents of the child were also measured using the same method (spring scale and box/tape measure).

iii. Questionnaire

The main questionnaire, developed over several months of pretesting in other Yoff

[21] The HemoCue is a portable hemoglobinometer which utilizes pre-calibrated microcuvettes into which a drop of blood from a finger prick has been added to calculate a value of hemoglobin (see Cohen & Seidl-Friedman, 1988; http://www.hemocue.com/international/Products/Hemoglobin/References-1158.html)

neighborhoods, was given to the mother, or child-care provider in two cases. A native Yoff resident administered this survey, translating from the French questionnaire into Wolof. The investigator, also fluent in Wolof, was present for the first twenty interviews. Questions were mainly closed-ended with some open-ended questions for qualifications (for example, “how many?” or “why?” in response to some health practices or to specify responses to the category “other”). Child health history since birth as well as in the two weeks prior to the interview were obtained, followed by the month of introduction of various foods for the infant and feeding behaviors when the child is ill. Socioeconomic variables were probed and monthly expenditures for various categories were also estimated. All responses were self-reported by the respondent.

Questionnaire contents:

- Health history (both for last year and last 2 weeks)
- Breastfeeding duration (months) and method of cessation
- Age of introduction for 39 most common foods
- Household distribution of cooking and feeding tasks (who prepares meals and with whom the child eats)
- Strategies for when child refuses to eat, during illness or otherwise
- Socioeconomic data - type of housing, source of water for drinking and washing, whether mother engages in work for pay, household possessions (television, refrigerator, telephone, car), monthly expenditures (for list of 10 items), education of parents (level completed), and principal employment of father

During the observation, a brief questionnaire was given to the mother or household cook on the frequency of different meals prepared in the household (in a society that describes meals as a complete dish prepared rather than the individual ingredients contained within the dish served, the questionnaire asked about frequency per week and per month of 33 specific dishes as well as weekly frequency of common snacks and some beverages) (see Appendix A for full questionnaire).

iv. Development and Pretesting of Observational Methods

Twelve-hour event observations (one per child) were carried out for all the children in the study.

The principal investigator developed the event observation methods used in this study during several months of informal, semi-structured observations during home visits in non-surveyed neighborhoods of Yoff. Rather than pre-coding events, she used an unobtrusive child-following approach to record an uninterrupted narrative describing the index child's environment and all his/her interactions with the environment and all persons present. Throughout this research, periods during which the child was relatively immobile, sleeping, or engaged in the same quiet activity, permitted the observer to complete the recording process.

The approach to measuring the children's activity, states and moods evolved together with each event observation. These narrative event observations were triggered by change in activity, physical state, emotional state/mood of the child in order to expand beyond what could be recorded on the form. At the end of each hour, the investigator estimated and recorded hourly percentages of time the child spent in a list of different activity levels and psychological states (See Table 4.1). She validated these time percentages against the start and end times of the events occurring during each hour.

Table 4.1. Categories for hourly percentages of time spent.

Activity	State	Mood
running walking standing sitting lying down being carried backed	sleeping awake drowsy low-energy diffuse low-energy focused high-energy diffuse high-energy focused	happy neutral sad angry teasing/mischievous whiny/needy loud crying

This study was not blinded (the same investigator who obtained the hemoglobin measurements was also the non-participant observer in all households); however, all efforts were made to limit the bias that could exist. Since the nature of this study was exploratory, there were not clear expectations about what would be observed. The hypotheses were that the anemic child would be less active and less interactive, but how this actually played out in the home environment had not been described in the literature. The long time period of the event observation (12 hours) allowed for a variety of interactions and opportunities usually from the time that the child awoke in the morning until s/he went to bed at night.

v. Statistical analysis

The data for testing these hypotheses come from both the quantitative questionnaire and the hourly summary of activity and psychological state data from the

12-hour event observations. The quantitative data for this study were analyzed with SPSS 15.0. A t-test of the difference in means for two groups, dividing the children into anemic (Hb < 10.5 g/dl) and non-anemic (Hb ≥ 10.5 g/dl)[22], was used to test the main hypothesis.

The qualitative data were coded for analysis using Atlas.ti. The analysis was a multi-step iterative process. Key words or phrases were marked based on both pre-determined codes (for illustrative purposes of the hourly activity levels and psychological states) and on interactions of interest. For this analysis, "general activities" and "type of play" codes were used.

The general activities included the activities around the house such as the child being sent on an errand and the child engaging in housework. Social activities included greetings and visiting, while care activities included grooming and bathing. Dancing, singing, watching people or objects, watching television, and bad behavior[23] were also some of the most frequent activities observed. Differences in the number of these activities by category and the child's anemia status were calculated with a Chi-square test.

The types of play that the children engaged in were coded into four categories: imitative, imaginative, physical, and exploratory. "Imitative play" was used to code play activities that were direct imitation of household members or other people the children could observe, most often of common household tasks (washing clothes, sweeping, cleaning dishes, caring for a "baby", etc.) "Imaginative play" was used to code play

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22 The cut-off of 10.5 g/dl was determined based on the literature (Palti, 1985; Lozoff, 1989; Lozoff et al., 1982; Idjadinata & Pollitt, 1993; Seshadri & Gopaldas, 1989) and cut-point analysis of the sample.

23 "Bad behavior" was the code used for behaviors that were accompanied by scolding from the caregiver, or would have been had the caregiver been attentive. Examples include hitting, kicking, or pinching other children.

activities that were outside the direct observation or experience of the child, where the child had to pretend (imitating a lion, driving a pretend car, etc.). "Physical play" included running, tug-of-war, wrestling, and swinging from the arms of adults. "Exploratory play" was used to tag instances where the child was actively engaged in learning about an object in his environment. A T-test for the equality of means was used to test the differences for each play category between the anemic and non-anemic groups.

D. Results

i. Description of the population

There were 74 children in this sample, with 81% (N=61) having hemoglobin values less than 10.5 g/dl. There were no statistically significant differences between the anemic and non-anemic children in means for sex, age, anthropometric Z-scores, or duration of breastfeeding (see Table 4.2), although the non-anemic children had slightly better anthropometric scores and were slightly older. Likewise, there were not any statistical differences between the two groups in the family characteristics of interest: maternal age, education and BMI; paternal education and occupation ranking; family possession score; or rough Caldwell HOME Inventory estimate (see Table 4.2). These results help us to interpret the following differences in physical and mental activity with more confidence that the differences seen are due to iron status rather than other variables.

ii. Overall Activity and State Levels

When the mean percentages of time for activity levels and moods were calculated for each child over the 12 hour event observation period, there were some very clear differences between the two groups. The non-anemic children spent more time running (5.0% vs. 2.0%) and walking (18.6% vs. 13.7%) and less time standing (20.3% vs. 35.4%) than their anemic counterparts over the 12-hour observation period. The children with higher hemoglobin levels spent a greater percentage of time in a happy mood (29.3% vs. 19.7%), while the children with lower hemoglobin levels spent a greater percentage of time in a neutral mood (76.3% vs. 65.6%). The anemic children spent twice as much time being whiny (1.6% vs. 0.8%). (See Table 4.3.)

Table 4.2. Mean values for child and family characteristics.

	Anemic, Hb $<$ 10.5 g/dl	Non-anemic, Hb $\geq$ 10.5 g/dl	N (anemic/nonanemic)
sex (% female)	65%	64%	60/14
age (months)	32.9	34.9	60/14
WAZ	-1.40	-1.00	60/14
HAZ	-1.68	-1.22	60/14
WHZ	-0.70	-0.47	60/14
hemoglobin, g/dl*	8.4	11.4	60/14
duration of breastfeeding (months)	20.4	23.9	60/14
maternal age (years)	32.0	33.2	56/14[24]
maternal education	1.2	1.2	55/13
maternal BMI	24.1	24.4	56/14
paternal education	2.3	2.5	55/13
paternal occupation ranking	1.8	1.9	60/14
family possession score	0.7	0.8	58/12
Caldwell score	14.8	11.8	60/14

*Statistical significance <.001.

[24] The N is lower here because there was one case where the mother was recently deceased, and other cases where the mother was not available to answer these additional questions.

Table 4.3. Mean percentage time for overall activity and mood levels.

	Anemic, Hb < 10.5 g/dl	Non-anemic, Hb ≥ 10.5 g/dl	P
N	61	14	
running*	**2.0**	**5.0**	**.004**
walking	13.7	18.6	.101
standing	**35.2**	**20.3**	**<.001**
sitting	38.0	43.8	.233
lying down	9.8	10.9	.692
carried	0.9	0.6	.511
backed	0.4	0.6	.696
happy	**19.9**	**29.3**	**.083**
neutral	**75.9**	**65.6**	**.084**
sad	0.2	1.2	.148
angry	0.1	0.2	.147
teasing/ mischievous	1.3	1.9	.332
whiny	**1.6**	**0.8**	**.036**
crying	1.1	1.0	.825

* Bolded rows show variables that are statistically significant, or that are approaching significance, and are discussed further in the text.

iii. Focused and diffuse activity levels

Children with higher hemoglobin levels spent more time in focused activity (35.2% vs. 21.9%), especially in low energy focused activities (32.5% vs. 20.6%) than the children in the lower hemoglobin group (See Table 4.4). These figures are based on an average percentage of time spent in each state over each of 12 consecutive one-hour time increments. Even for 24-42 month old children, the majority of their days were spent in low energy activities, described in more detail in the following section. The non-anemic children spent a total of 6.0% of their day in high energy activities compared to anemic children, who spent 2.5% of their day in such activities.. All of these differences were highly statistically significant.

Table 4.4. Mean percentage time for activity state.

	Hb < 10.5 g/dl	Hb ≥ 10.5 g/dl	P
N	60	14	
High energy focused	**1.3**	**2.7**	**<.001**
High energy diffuse	**1.2**	**3.3**	**.029**
Low energy focused	**20.6**	**32.5**	**.014**
Low energy diffuse	**69.9**	**53.1**	**.001**
drowsy	1.0	1.0	.957
sleeping	6.0	7.5	.522

iv. Activities and types of play

Table 4.3 gives us a quantitative look at the time in minutes these children spent in overall activity and mood categories. Table 4.5 presents a list of the actual activities the children were engaged in, with a comparison of the anemic and non-anemic children in frequency of engagement in these activities. Table 4.6 presents the different types of play observed.

In the sample (N=74), the anemic children (with a hemoglobin value <10.5 g/dl) made up 81.1% of the group (N=60) and the non-anemic children represented 18.9% (N=14). If they engaged in these general activities equally, the percentage of instances of each activity would equal the representation of the group (the anemic children would be sent on 81.1% of the errands and the non-anemic children would be sent on 18.9%) of the errands. As expected, the groups were not equally represented. Four variables show statistically significant differences based on anemic status using a Chi-square analysis.

The non-anemic child engages in more visits outside the home and is also more likely to spend time watching TV[25]. The anemic child receives more baths (this may be due to compensatory care or is just a factor of spending more time around the house and close to mother) and also engages in more bad behavior, as hypothesized earlier.

Table 4.5. Comparison of number of general activities* over 12 hours by anemia status (anemic=hemoglobin<10.5 g/dl).

Activity	Total	Anemic (N=60, 81.1%)	Non-Anemic (N=14, 18.9%)	Difference from expected (%)**
errand	462	370 (80.1%)	92 (19.9%)	-1.0
housework	92	78 (84.8%)	13 (15.2%)	3.7
greeting	81	69 (85.2%)	12 (14.8%)	4.1
visit	**31**	**17 (54.8%)**	**14 (55.2%)**	**-26.3**
grooming	316	261 (82.6%)	55 (17.4%)	1.5
bathing* **	**117**	**101 (86.3%)**	**16 (13.7%)**	**5.2**
dance	215	172 (80.0%)	43 (20.0%)	-1.1
singing	79	67 (84.8%)	12 (15.2%)	3.7
watches person/thing	165	129 (78.2%)	36 (21.8%)	-2.9
watches TV	**83**	**57 (68.7%)**	**26 (31.3%)**	**-12.4**
bad behavior[26]	**93**	**84 (90.3%)**	**9 (9.7%)**	**9.3**

* This table presents the number of coded activities undertaken by all children over the 12 hour observation period.
** Positive numbers indicate that the anemic children had higher than expected numbers of instances of these activities; negative numbers indicate that the anemic children had lower than expected instances of these activities.
*** Chi-square analysis was used to test the significance of the differences and rows in bold indicate those differences with P-values <0.05.

25 This unexpected result may be due to different factors. The non-anemic child may be in a household with higher socioeconomic status, and higher SES households are more likely to have a TV and more likely to have the TV on during the day. Also, the non-anemic child has a longer attention span and is able to join the older kids in watching a complete episode of television programming whereas the anemic child leaves the room after a few minutes.

26 “Bad behavior” was the code used for behaviors that were accompanied by scolding from the caregiver, or would have been had the caregiver been attentive. Examples include hitting, kicking, or pinching other children.

There is a trend for the non-anemic child to "watch" more often (more engaged with environment), while the anemic child may be engaged in more greetings, singing and housework (all three may be factors of the child not leaving the family compound as frequently, hovering closer to mother). However, these differences were not statistically significant.

For all of these children, performing errands for the adult members of their household was the most frequent activity undertaken on a given day. This is an example of a focused activity where the child has a goal that s/he is encouraged to reach by adults s/he interacts with. In this society in particular, the errands run by toddlers are an important teaching tool used by the parent and an important milestone used by parents to judge their child's development. Anemic children were not observed to be sent on fewer errands than their non-anemic counterparts in this sample.

The following examples illustrate the types of errands that children of this age would be requested to carry out. In the first example (Obs2), the child is asked by an older relative to fetch an item from the house to bring out to the yard and the task is completed as expected. The second example (Obs3) is an errand which involves buying an item from a nearby vendor and the mother specifically wants the child to perform this without the help of her sister. The third example (Obs4) is an example of a message being sent from one part of the house to another. In the fourth example (Obs5), the child is asked to both fetch and return a cup of water. In the final example (Obs9), the mother uses the errand as a strategy for redirecting the child. The children in three of these examples had normal hemoglobin levels, while two of them would be considered severely anemic.

Obs2, Index child=W, age=41 months, Hb=11.1 g/dl:
(10:00) Uncle asks [W] to fetch some clothespins from in the house which she does. She returns to the yard and stands by him, handing the clothespins as he needs them.

Obs3, Index child=A, age=41 months, Hb=11.2 g/dl:
(13:51) Mom gives her money to buy mint. A leaves room and calls for B, but Mom yells for her to go by herself. She comes back with a bunch of mint, followed by Astou. She drops off mint and then goes out of the room...

Obs4, Index child=F, age=37 months, Hb=7.3 g/dl:
(16:51) Mom sends F to give a message to O in other room. They return together a minute later.

Obs8, Index child=MF, age=30 months, Hb=7.1 g/dl:
(14:48) An older man asks MF to get him some water to drink. MF goes into the bedroom, returning with a cup of water. MF then returns cup to the bedroom.

Obs9, Index child=MF, age=32 months, Hb=13.0 g/dl:
(12:55) MF has started scraping the wall with a piece of wood. Mom yells for her to stop, but she doesn't. Mom changes her strategy and asks MF to come do something for her. MF walks out.
(12:58) She is at the boutique across the street buying some more laundry soap.
(13:00) MF comes back and gives the soap to Mom, then runs around in the courtyard.

"Housework" may go along with "errand", where the child engages in a helpful activity for the household. This housework may be self-motivated, such as the toddler who picks up a broom and proceeds to sweep off a porch, or may be directed, such as the child being instructed to wash their clothes while other women are washing in the courtyard. These would be considered necessary teaching activities and are important in the child's early learning at the home.

Obs6, Index child=G, age=38 months, Hb=10.9 g/dl:
(18:36) He goes up the stairs and stands by Grandma. She encourages him to sweep foyer. She directs him and gives him pointers on form, he looks up for approval. He is slow and thorough.
(18:43) When he is done with the foyer, G moves to sweep the steps.
(18:46) He sweeps the foyer again. Mom teases him for doing a girl's job. He smiles and continues.
(18:48) G picks up sand and throws it in foyer so he sweeps more.

Obs16, Index child=E, age=24 months, Hb=10.8 g/dl:
(11:09) E stands on ledge, walks over to foyer and urges some sheep to leave. Then he sweeps top step.
(11:12) He stands looking at tree, then walks to stand by Mom who is washing some clothes.

Obs20, Index child=M, age=38 months, Hb=10.7 g/dl:
(10:31) M runs across yard, then sits by young woman washing clothes. Then he stands and holds clothes for her.

Obs27, Index child=K, age=30 months, Hb=9.3 g/dl:
(10:00) Aunt tells K to sit and clean rice. She moves bowl to the floor and K sits, cleans, eats some.

Obs28, Index child=A, age=30 months, Hb=9.6 g/dl:
(10:14) A sits on the bucket. He watches Grandma sift some henna.
(10:32) The girls come in and help Grandma bag the henna. A sits and watches.
(10:35) A picks up a bag and tries to open it, mimicking the girls. He gives Grandma the bag, then doesn't get another.
(10:40) A picks up an opened bag and holds it, asking Grandma to fill it. She does one with him then tells him to stop because he is going to stain his clothes.

Obs38, Index child=F, age=31 months, Hb=7.7 g/dl:
(12:27) F walks around then runs to kitchen.
(12:29) She is given a plate of white rice which she carries on her head out to other kids.
(12:31) She sits and hands rice to P. She eats some, then tries to give some to A who refuses.

Obs52, Index child=O, age=42 months, Hb=11.6 g/dl:
(14:06) [O] walks to kitchen with L and F. They help bring dishes out to yard to be washed.

Table 4.6. Comparison of types of play observed by anemia status (anemic=hemoglobin<10.5 g/dl).

Type of play	**Total number of instances observed**	**Anemic (N=61, 81.3%)**	**Non-Anemic (N=14, 18.7%)**	**Difference from expected (%)**	**P-value from T test for equality of means**
imitative	**84**	**51 (60.7%)**	**33 (39.3%)**	**-20.6**	**.05**
imaginative	82	69 (84.1%)	13 (15.9%)	2.8	.17
physical	30	20 (66.7%)	10 (33.3%)	-14.6	.30
exploratory	14	9 (64.3%)	5 (35.7%)	-17.0	.35

Imitative and imaginative play were the most frequently observed in both groups of children, which makes sense for this age group. The anemic child was much less likely to engage in the imitative, physical, and exploratory play. This was especially apparent with the imitative play, which would be implicated in quality of attention where the child observes what is happening around him and is then able to mimic these behaviors themselves. The physical and exploratory play also involves both stamina and interest in objects and his surroundings.

The following examples illustrate some of the different types of imitative and illustrative play that were observed. In these instances, several children are playing together. In the first two examples (Obs19 and Obs36), it is the index child who is initiating the play and another child joins in or asks questions to elucidate what is going on. In the next two examples (Obs11 and Obs41), an older child is organizing the play and the index child is joining in. The last two examples (Obs34 and Obs6) find two similarly aged children engaged in imaginative play using found objects.

Obs19, Index child=B, age=33 months, Hb=8.0 g/dl, Imitative play:
(13:09) When B walks by with pot of sand, M (sister, age 7 y) asks him what he is doing: "cooking lunch". A (sister, age 5 y) sits next to him while he "cooks". He sits in a styrofoam box.
(13:17) B and A continue playing with sand and styrofoam box, seated.

Obs36, Index child=C, age=30 months, Hb=10.2 g/dl, Imitative play:
(12:25) C talks to everyone passing by. She gets a drink of water from Grandma then gets up and walks around in yard. She picks up a small white bucket with cover. She sits back down with S (cousin, age 4 y). S asks her what she is selling - "churai (incense)" she replies. "How much?" S asks. "Fukki duorum."

Obs11, Index child=K, age=38 months, Hb=11.6 g/dl, Imitative play:
(13:05) K plays under blanket with one of the older boys and A. Another boy (~10 y) positions all the kids on a plastic prayer mat and covers them with blanket. They repeat "Allah akbar" over and over.
(13:14) When the blanket gets rearranged, K runs around the yard and hits one of the boys with a plastic tube. Then they sit down again and continue playing "mosque".

Obs41, Index child=F, age=42 months, Hb=11.2 g/dl, Imitative play:
(16:12) She sits back down, watching AM (age 7 y) prepare something in cooking pot. S (age 8 y) is still working on doll.
(16:16) AM sends F to get an "ingredient". F stands, confirms request and walks out to street and returns with some small rocks. She sits and watches AM.
(16:22) F laughs as she pretends to eat soupy sand. Then AM washes her hand off, as if after a meal.
(16:24) F walks to main yard and gets a piece of plastic wrap, then walks to living room. She returns to side yard and helps AM to "wash" dishes.

Obs34, Index child=E, age=43 months, Hb=10.2 g/dl, Imaginative play:
(15:44) [E and D(age 4 y)] use a small bench as a car, moving and making motor noise. They take turns with who is sitting "in front".

Obs6, Index child=G, age=38 months, Hb=10.9 g/dl, Imaginative play:
(12:29) His cousin (age 4 y) starts playing with a metal frame of some sort. The two boys turn it around, move it and then pretend it is a motorcycle. G holds on to the back and assists in sound effects.

E. Discussion

The anemic child is spending less time in focused activity, including less time in the types of imitative play that provide the child with the chance to try out the behaviors they have observed themselves. Walka and colleagues (2000) looked at the quality of play of undernourished children in Indonesia and found increased “functional” play after an energy and micronutrient supplement. Attention deficit in the anemic child, due to changes in neurometabolism and neurotransmitter function, has been put forth as a hypothesis to explain the poor performance in cognitive and behavioral tests (Liu & Raine, 2006; Lozoff et al., 2006; Nokes, van den Bosch & Bundy, 1998). Early nutritional deficits are also correlated with lower motor coordination in later childhood (Bénéfice, Foueré & Malina, 1999).

These results are important in the larger picture of understanding the anemic child and how he interacts with his environment. There is a growing body of literature focusing on the early child development and the need for early intervention. In the case of iron-deficiency anemia, one of the most prevalent nutritional deficiencies in the world, the case for early intervention cannot be made often and loudly enough. This intervention should be a combination of both preventive iron supplementation of the infant and psychosocial care training aimed at caregivers (Engle & Ricciuti, 1995; Gordon, 2003).

It would be expected that “bad behavior” such as hitting, kicking, or pinching would be more frequent among the anemic child, which would correspond with irritable or anti-social behavior seen in other descriptions of the anemic child.

The separation of activities into focused and diffuse is a useful contribution, as it may help to either explain or illustrate some of the cognitive deficit issues that have been described in the literature (Kordas et al., 2007). This distinction differs from the more common high versus low energy labels, which do not qualify the level of cognitive engagement the child is exhibiting.

i. Study Limitations

Having a single observer for all cases does eliminate the need to control for inter-rater variability. The Hawthorne effect, whereby subjects modified their behavior due to the fact that they were in the study or were being observed, was a distinct possibility. The observer had spent time with each of the families before the day of the observation and the explanation for what she would be observing was sufficiently vague that the adults wouldn't be aware of what behaviors should be modified. In some cases, the mother may have asked the child to stay closer to the family compound or may have discouraged eating at a neighbor's home on the day of the observation. These types of changes would possibly had some impact on the child's activity levels and overall daily routine, but were likely to occur equally for the anemic and non-anemic child.

ii. Conclusion

One of the values of the qualitative aspect of the study is that it allows the researcher and the reader to gain a more in-depth understanding of the lives of these children. The qualitative information gained in the home observations can help inform our understanding of how anemia affects cognitive development. The decreased physical and mental activity of the anemia child has been well-documented to a point, and this research gives a clearer picture of how this plays out in the child's daily life.

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5. Paper 2: Two key child feeding practices that protect against iron deficiency anemia in a predominantly laissez-faire eating environment

A. Abstract

The author of this study recorded 12-hour parent-child observations, measured hemoglobin and anthropometry, and collected nutrition, health and socio-demographic data on 75 24-42 month old Senegalese children in a low income fishing neighborhood outside of Dakar. Differences in iron deficiency anemia were found between ages of introducing fish and for consumption of an early evening children's meal, the *diogonal*. The mean reported age for introduction of fish was 7.2 months for the non-anemic children compared to 11.5 months for the anemic children (p=.002). Ninety-one percent of the children who did not consume the *diogonal* were anemic. Among the 32 children eating the *diogonal*, anemia rates differed significantly according to the number of people sharing this meal from the common bowl: 72% for individual bowls; 53% for 2-4 per bowl; and 60% at bowls feeding 5-10 children. (p=.013). The quality of the meal also made a difference; the inclusion of fish as well as the more traditional supervision and responsive feeding at this meal led to statistically significant differences in hemoglobin, bringing the mean values from 8.3g/dl to 10.4g/dl (ANOVA p=.034). The observations revealed a cultural laissez-faire approach to feeding and infrequent speech to children, yet show genuinely creative non-verbal responsive feeding practices.

Keywords: iron deficiency, anemia, children, behavioral observations, active feeding, care, Senegal, qualitative analysis

B. Introduction

Iron deficiency is a global problem with well-documented detrimental impact on early childhood cognitive development (Liu et al., 2003; Lozoff, Jiminez & Smith, 2006; Pollitt, 1993; Pollitt et al., 1986; Scrimshaw, 1984; Stoltzfus, 2001; Walter et al., 1990). Diet and health are key factors for the adequate absorption and utilization of iron by the body (Hallberg, 1989; Lozoff, 2007). Availability of iron-rich foods in the household does not always translate into the adequate access by all members of the family (Engle, Menon & Haddad, 1999), and frequent infections increase the body's demands for this vital oxygen-carrying micronutrient (Scrimshaw, 1984). Early research has pointed to associations between child iron status and caring behaviors (Werkman, Shifman, & Skelly, 1964).

Care can provide a crucial link between diet and health (Engle, Bentley & Pelto, 2000; Pelto, Dickin & Engle, 1999). In the case of iron nutriture, active feeding practices can ensure that when high quality foods are available, a child is encouraged to consume these foods, and the eating environment is monitored to enable adequate intake. This type of care can enhance the intake of iron as well as the intake of foods known to promote iron absorption. At the same time, social interaction and environmental stimulation can help to encourage brain growth and cognitive development. This includes verbal interaction. Children with low iron stores may be more lethargic or less interested in interacting with their environment at a crucial time in their brain development (Lozoff, 2007; Pollitt, 1993), making it even more necessary for caregivers to practice more active feeding to ensure these kids consume the food they need.

Engle, Bentley & Pelto (2000) describe the range of care practices around child feeding styles that fall into three main categories: controlling, responsive, and laissez-faire. Of these styles, laissez-faire (letting the child decide for himself if he is hungry and when he is full) is correlated with higher rates of malnutrition (Engle et al., 2000). Responsive feeding includes encouraging, cajoling, offering more helpings, talking to the children while eating, and monitoring what the child eats. It should be noted that the majority of these behaviors include verbal interaction, or at least having the mother talk to the child while he is eating (Engle & Zeitlin, 1996). Modeling the eating of healthy foods and understanding hunger cues are also a part of responsive feeding (Engle et al., 2000). However, there have not been many studies that have empirically examined the relationship between responsive feeding and child nutrition outcomes (Pelto, 2000). A recent review found 21 studies that addressed this issue, only 12 of which had data based on observation, and the authors concluded that a positive association between responsive feeding and child nutritional status had not been demonstrated (Bentley, Wasser, & Creed-Kanashiro, 2011).

For example, Dearden and colleagues (2009) used videotaped interactions of two different meals for 179 mother-child pairs in Vietnam and found that verbal encouragement did increase the likelihood of the child, age 12 or 17 months, accepting a bite of food offered. This cross-sectional study does not consider the nutritional status of the child, but makes an assumption that more bites will lead to improved nutritional status. Analysis of observed complementary feeding in Bangladesh found no correlation between responsive feeding behaviors and child weight (Moore, Akhter & Aboud, 2006).

An issue that also comes up when looking at these studies is the range of socio-cultural practices related to feeding children, whether it be prevalence of force feeding young children or age of introduction of nutrient-dense foods. There is a diversity of definitions for what active feeding or responsive feeding means in different studies, which makes it difficult to make conclusions across studies or across cultures.

There are a few studies that have explored some of the issues of care and health in Senegal and other countries in West Africa. Simondon and Simondon (1995, 1997) looked at age of introduction of complementary feeding and the impact on physical growth for a cohort of children less than one year of age in rural Senegal using 24-hour recalls and diet/health history. Dettwyler (1986) took an ethnographic approach to describing infant feeding in Mali. She used three categories for “maternal attitude” in describing care behaviors around feeding: above average (proactive), average, and below average (extreme laissez-faire). These were significantly related to the child's growth, where children with proactive mothers fared better.

There has been little discussion in the literature on the possible benefits or drawbacks from eating from a shared plate, despite its prevalence in many cultures. In one example from Nepal, the researchers found that more food groups were represented in the shared meals compared to meals that the child ate by himself which led to increased nutrient intake, and that sharing with the mother was more beneficial than sharing a meal with the father (Shankar et al., 1998). The reason for the latter finding may have been that the mother was more responsive to cues from the child and provided more care during the meal compared to the father.

There are conflicting conclusions in the literature regarding the influence of socioeconomic variables on child health (Wachs et al., 2005), which may in part be due to the nuances of the relationship between the variables and the outcome of interest. For example, Fotso and Kuate-Defo (2006) used Demographic and Health Survey data from five African countries (Burkina-Faso, Cameroon, Egypt, Kenya and Zimbabwe) to look at correlations between SES measures and child stunting and found SES to be a statistically significant predictor of stunting at both the household and community level. A longitudinal study in Costa Rica found a widening gap over time in cognitive test scores for children who had chronic iron deficiency in infancy from low-SES families compared to those from higher-SES families (Lozoff, Jiminez & Smith, 2006). This points to the interaction between SES and the impact of iron deficiency, whereby lower SES can exacerbate the cognitive deficits incurred from early iron deficiency. However, in a study from rural Senegal, it was the parents with higher education levels, often a variable used in determining SES, who introduced solid foods to infants at earlier ages (2-3 months) and subsequently had children with poorer nutritional status (Simondon & Simondon, 1997). This can be contrasted with findings from Uganda where lower maternal education, but not lower paternal education, was the best predictor of child stunting (Wamani et al., 2004).

Socioeconomic variables may play a more distal role compared to variables of a more proximal nature, such as care behaviors and attitudes toward child parenting, in relation to child health and development (Terrisse et al., 1998). Ruel and colleagues (1999) found that good care practices protected against poor child nutritional status in households with low SES and low maternal education. According to the current thinking around positive deviance, behaviors and practices that are being used right now in a community are the key to the solution to pervasive problems, such as child undernutrition and iron deficiency anemia (Pascale, Sternin & Sternin, 2010). These behaviors and practices are possible despite deficits in educational systems, infrastructure, and economic development. Behaviors and practices can be learned by anyone in the community, which makes this modern definition of positive deviance extremely powerful. The focus on behaviors and practices is different from earlier definitions and uses of positive deviance which included individual and family characteristics that could not be acted on immediately (such as income, family structure, and parental education levels (Zeitlin, 1996)).

Iron deficiency anemia has significant impact on a child's health and development, reaching long past the nutritional deficit in infancy and early childhood (Liu et al., 2004; Lozoff et al., 2000). The availability of iron in a child's diet is due in part to its availability to the household, but this needs to be balanced with the care practices provided by the mother and other adults in the household that enable these foods to be consumed by the child. In a population where a laissez-faire feeding style is the cultural norm, age-appropriate feeding practices including monitoring of eating, verbal and nonverbal encouragement to eat more, responding to cues for hunger and providing more food, and facilitating the eating environment are going to be important predictors or determinants of a child's iron status, regardless of the socioeconomic status of the household. These mothers who practice more responsive feeding styles would be considered “positive deviants” in a culture where laissez-faire feeding is the norm.

In Senegal, families eat their main meal (lunch) from a common bowl, with the youngest child often sitting on the lap of his/her mother until he/she shows interest in sitting on his/her own (usually around age 24 months). Mothers are expected to feed the child, or at least to portion out bits of fish and vegetable within the child's reach. Dinner is also often eaten this way, usually consisting of a dense rice porridge or millet couscous served with a sauce, although there are more variations in this setting (individual cups of millet porridge can be given to each family member (including the young child) and consumed, or individual sandwiches of fish or fish balls with sauce). In large families or extended family compounds, children eat at a bowl separate from the adults. The men in a household will often eat from a separate bowl, sometimes in another room. Access to the protein and vegetable portion of the meal (placed in the center of the bowl) is determined by status within the household, with the young children being considered of least importance and having the least opportunities to choose from these parts of the meal if at all. There are important societal lessons being given at the bowl beyond etiquette and nutrition. In Senegal, many taboos exist around spoiling a child through food, especially the food that we would consider the most important for growth and development (eggs, fish). This is consistent with the beliefs of other ethnic groups in West Africa (Setiloane-Babatunde, 1995). Talking at the bowl is kept to a minimum and cues to the child are mostly nonverbal.

Beyond the three typical family meals, young children often receive another meal in the late afternoon which consists of the leftovers from the lunch meal. When this meal is specifically fed to the youngest children of the house under the supervision of the mother or other caregiver, it is called the *diogonal* in the local language. There are two concepts at play with the *diogonal* meal. One involves organization in the kitchen so that the mother or food preparer sets aside a bowl containing all or most parts of the meal before the lunch is served. It also involves the mother or other caregiver heating up this dish or otherwise serving the meal to the youngest children in the household at a time when the older children (as well as many adults) are away from the house.

In the traditional extended family compounds seen in Senegal, it is not unusual to find multiple alternate caretakers for young children, including grandmothers and older siblings. The effect these caregivers have on the child's health and nutritional status may have both positive and negative impacts (Aubel, Toure & Diagne, 2004; Stansbury, Leonard, & DeWalt, 2000; Reyes et al., 2004).

While there was one reference in the literature which doubted the susceptibility of Lebou children to iron deficiency anemia due to their high intake of fish (Fall et al., 1982), iron deficiency was certainly prevalent in children at the time of this study. More recent surveys of iron deficiency anemia in African children have also seen high prevalence rates (Ehrhardt et al., 2006). This study examines two feeding behaviors that are protective against iron deficiency in this vulnerable population, drawing on behaviors that are already present within the community. The first one is the age of introduction of fish, the main source of heme iron in the diet. Earlier introduction of animal source foods was positively associated with growth status and mental development index (MDI) in Nigeria (Zeitlin, 1996). The second feeding behavior is the serving and consumption of the *diogonal*, a traditionally child-centered meal, which is fading from practice due to rapid modernization in Senegal, but may be a key factor in increasing the likelihood of sufficient iron intake and good nutritional status.

C. Methods

i. Population

The study began in February 1999 in the traditional fishing village of Yoff, now a part of the capital city of Dakar, Senegal. Households in the survey were selected based on the presence of a child aged 24-42 months at the time of the first data collection. All households in one of the seven traditional neighborhoods of Yoff that met this criterion were approached to be included in the survey. All households agreed to participate after an explanation of the steps and purpose of the survey. There were 78 households in the study at the beginning of this research, with 74 households included in the analysis.[27] Complete data are not available for all households due to change of address or extended travel by the family between data collection points.

ii. Physical and biochemical measurement

Two sets of anthropometric measures were taken on each child, six months apart. Hemoglobin values were obtained at the same time as the physical measurements, using a portable HemoCue machine which was transported from house to house. For the purposes of the analysis, the hemoglobin value that was taken closest to the event

[27] Complete data are not available for all households due to change of address or extended travel by the family between data collection points.

observation was the value used for the analyses.

Weight was measured using a spring scale with accuracy to 0.5 kilograms. Height was measured by having the child stand with heels against a wall, placing a rectangular box parallel to the floor on top of the head, for a 90° angle, marking the wall at the lower intersection of the box, and measuring in millimeters, using a tape measure, following standard WHO instructions at the time (WHO, 1995).

iii. Questionnaire

The main questionnaire, developed over several months of pretesting in other Yoff neighborhoods, was given to the mother, or child-care provider in two cases. A native Yoff resident administered this survey, translating verbally from the French questionnaire into Wolof. The investigator, also fluent in Wolof, was present for the first twenty interviews. Most questions were pre-coded and complemented with open-ended questions for qualification (for example, "what? who?" or "why?" in response to some health practices, or to specify responses to the category "other"). All responses were self-reported.

Mothers were asked to state the age, in months, when they gave their child specific foods, starting with the components of the typical weaning porridges on through the introduction of solid foods.

The questionnaire contained items on child health history as well as socioeconomic variables for the household. These variables included type of housing, source of water for drinking and washing, whether mother engages in work for pay, household possessions (television, refrigerator, telephone, car), monthly expenditures (for list of 10 items), education of parents (level completed), and principal employment of father. Education level attained by parents was recorded on a 6 point scale with 0 being no formal education, 1= being literate (for this population, this was the proxy for either some primary education or for completion of adult literacy courses), 2 = completed primary school, 3 = completed middle school, 4 = completed secondary school, 5 = completed some level of higher education (please see Appendix for complete questionnaire).

iv. Development and Pretesting of Observational Methods

The investigator developed the event observation methods used in this study during several months of informal, semi-structured observations during home visits in non-surveyed neighborhoods of Yoff. Rather than pre-coding events, an unobtrusive child-following approach to record an uninterrupted narrative describing the index child's environment and all his/her interactions with the environment and all persons present was used. Later, the narratives were coded in the qualitative data analysis software Atlas.ti according to key dimensions of the study and areas of possible interest.

The approach to measuring the children's activity, states and moods evolved together with each event observation. A continuous 12-hour narrative was created for each child, including start times for each observation entry. The starting points for the narratives were triggered by changes in the child's activity, physical state, or observed emotional state/mood. At the end of each hour, the investigator estimated and recorded hourly percentages of time the child spent in a list of different activity levels and psychological states. These time percentages were validated against the start and end times of the events occurring during each hour.

This study was not blinded (the investigator who obtained the hemoglobin measurements was the non-participant observer in all households); however, all efforts were made to limit the bias that could exist. Since the majority of the children were anemic, the investigator entered each household as if she were watching an anemic child. Also, since the nature of this study was exploratory, there were not clear expectations about what would be observed. Inevitably there could have been episodes or activities that were missed or were misinterpreted, but these would be random and should not affect the results. The long time period of the event observation (12 hours) allowed for a variety of interactions and opportunities, usually from the time that the child awoke in the morning until s/he went to bed at night.

v. Statistical Analysis

Data were analyzed using SPSS 15.0 and IBM SPSS 20. The narrative accounts from the observations were coded in Atlas.ti, with counts from selected codes exported into the SPSS data set. For each case, extractions of each narrative related to meals and snacks were prepared for qualitative analysis. Z scores were calculated using ANTHRO (CDC, 2005). The significance of the differences in mean values of demographic characteristics between anemic and non-anemic children were calculated by T-test.

The first two hypotheses concern fish: H1 is that children who begin to consume animal protein (fish in the case of these fishing families, as almost no meat was eaten and eggs are not served to young children) at an earlier age will have better hemoglobin levels at age 24-42 months than children who begin fish consumption at a later age. The subjects are grouped into anemic (hb < 10.5 g/dl) or non-anemic (hb ≥ 10.5 g/dl) categories, and a T-test was used to determine whether the mean age of introduction of fish is different between groups. H2 is that the presence of fish in a child's *diogonal* meal will be associated with better hemoglobin levels than children who receive no *diogonal* at all or only left over rice. A one-way ANOVA (Table 5.3) was used to compare hemoglobin levels of children with no diogonal (33), with only left-over rice (13), receiving left-over rice with fish (33) and an intentionally prepared and served *diogonal* with fish (8).

The third hypothesis concerns the relative iron status of all children by number of children sharing a common bowl serve themselves. H3 is that fewer children eating at the same bowl and more adult supervision are associated with better iron status. For this hypothesis, a Chi-square analysis was used where anemia status (anemic vs. non-anemic where anemic = hb<10.5) and number of eaters present at the *diogonal* bowl were used as categorical variables. The range for the number of eaters is from 1-10. Based on the distribution of this variable as well as theoretical concerns (separating out the own bowl from the shared bowl), the categories were 0 (no *diogonal* eaten), 1 person at bowl, 2-4 eaters at bowl, and 5 or more eaters at bowl.

In addition to the quantitative analysis, examples are presented to provide a better understanding of the caring behaviors present or absent at different meals, as recorded during the home observations.

D. Results

Table 5.1 provides a summary of key characteristics of the population. The mean hemoglobin value of 9.1 g/dl is quite low, which highlights the problem of iron deficiency anemia for this age group. The anthropometric Z scores are lower than the international norms (WHO, 1995), and the anemic children are shorter than their non-anemic peers, which may be related to chronic iron deficiency, since iron deficiency is an independent risk factor for stunting (Krebs, 2000) as well as the fact that there is a correlation between an iron-deficient diet and a generally poor diet (lacking in protein, calories and other essential micronutrients). Other than hemoglobin and HAZ, there are no significant differences between the anemic and non-anemic children and their families. Weight-for-age and weight-for-height Z scores are not significantly different between anemic and non-anemic children. This suggests that differences between the caloric intakes were minimal, compared to the differences between them in the micronutrient content of their diets. While there was a difference in parental educational attainment (the average mother had only finished the first few grades of school, while most fathers had completed more than primary school), these education levels did not differ by child's hemoglobin status. Looking at the mean values, there is also no statistical difference in the father's occupational rank and household possession scores between the anemic and non-anemic children.

Since the mean values of these variables (presented in Table 5.1) did not differ by hemoglobin status, only the totals are shown here. Parental education levels, especially maternal education levels, were found to be significant predictors of iron status in many studies of child care and nutrition. For this population, however, there was little variation in maternal educational attainment; more variation was seen in the paternal education, but paternal education did not predict iron status. Due to the fact that so few mothers in this sample had more than a primary education, we would not expect to see differences based on this variable for this sample size. While fathers with anemic children have lower education than those with non-anemic children, this difference is not statistically significant. Occupational rank is our proxy for socioeconomic status, another key indicator in child health and nutrition studies, and while there is some variation in the sample, it does not differ by child's hemoglobin status.

Table 5.1. Description of sample, N=74 (mean and s.d.).

Variable	Total (N=74)	Hb<10.5 g/dl (N=58)	Hb≥10.5 g/dl (N=16)	*P*-value
Age, months	39 (7)	38 (7)	41 (8)	.112
Birthweight, g	3153 (545)	3108 (576)	3300 (416)	.270
Hemoglobin, g/dl	**9.1 (1.8)**	**8.5 (1.4)**	**11.4 (0.9)**	**<.001**
HAZ	**-1.44 (1.10)**	**-1.60 (1.10)**	**-0.79 (0.83)**	**.009**
WAZ	-1.35 (1.00)	-1.43 (1.02)	-1.06 (0.86)	.203
WHZ	-0.80 (1.13)	-0.76 (1.15)	-0.94 (1.05)	.592
Mother's age, years	32 (7)	32 (7)	32 (6)	.694
Mother's education	1.1 (1.1)	1.1 (1.2)	1.1 (1.1)	.865
Father's age, years	44 (10)	44 (10)	46 (6)	.413
Father's education	2.4 (1.5)	2.3 (1.5)	2.8 (1.4)	.217
Father's occupation rank	1.5 (0.9)	1.5 (0.9)	1.6 (0.9)	.473
Household possession score	0.7 (1.0)	0.8 (1.0)	0.5 (0.7)	.391

There is a more than a four month age difference in the mean age of introduction of fish between anemic and non-anemic children (Figure 5.1), with mothers reporting that they introduce fish earlier into the diets of children who are subsequently non-anemic. The difference between the two groups is statistically significant (P=.002) using a T-test for equality of means. This makes physiological sense as well, since breast milk ceases to be a sufficient source of dietary iron by age 6 months, and in this population fish is the main source of heme iron introduced into the infant's diet. Vegetable (non-heme) sources of iron are consumed in very low quantities, iron-enriched cereals or grains are virtually non-existent, and other sources of heme iron such as chicken or mutton are rarely consumed by these households and are even more rarely given to children.

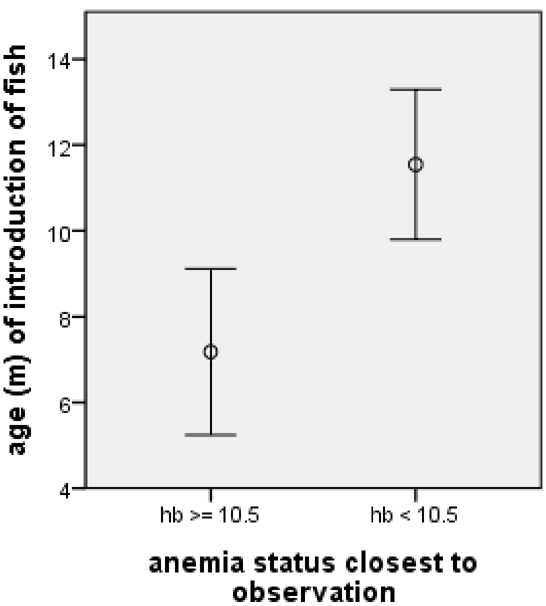

Figure 5.1. Bar chart for age of introduction of fish and child's anemia status (anemic= Hb < 10.5 g/dl) at age 24-42 months. Mean age of introduction of fish for non-anemic children (n=17) was 7.2 months vs. 11.5 months for anemic children (n=57). Error bars show 95% CI of mean.

Table 5.2. Cross tabulation of anemia status and number of eaters at *diogonal* bowl (Pearson Chi Square P=.013). Cells show percent of total sample of children (N=74).

	Non-anemic (hb ≥ 10.5)	Anemic (hb < 10.5)
Did not eat meal, % (N)	9 (4)	91 (38)
1 eater at bowl, % (N)	29 (4)	72 (6)
2-4 eaters at bowl, % (N)	47 (7)	53 (8)
5-10 eaters at bowl, % (N)	40 (2)	60 (5)
Total, % (N)	23 (17)	77 (57)

Several notable statistics are seen in Table 5.2. First, we see that 42 children in the sample (57%) did not eat the leftover rice meal and of these children, 91% were anemic. While having the child have his own plate (one eater at the bowl) would seem preferable in terms of responsive feeding behaviors, this is not the case in this population. Having 2-4 eaters at the *diogonal* bowl seems to be the most protective for iron status, and this may be because this size bowl is found to be more intentionally prepared for the youngest members of the household. For the bowl with only one child, there were several cases where the bowl only contained rice, no fish or vegetables. Table 5.3 presents mean hemoglobin levels at different levels of leftover rice quality: leftover rice which does not contain fish (or other animal products), leftover rice with fish, and the more specific *diogonal* which includes fish and has fewer numbers at the bowl. If we compare the cases where there is adult supervision of the child or children eating at the *diogonal* bowl with cases that do not have such supervision (data not shown), we find that there is a trend for better iron status at the supervised bowl, but this difference is not statistically significant at this sample size.

Table 5.3. ANOVA for quality of afternoon meal to look at mean values for hemoglobin closest to the observation (F=3.06, P=.034).

	Mean	N	S.D.
Did not eat	9.0	32	1.3
Leftover rice	8.3	13	2.0
Leftover rice with fish	9.5	21	1.8
Intentionally prepared *diogonal*	10.4	8	1.9
Total	9.2	74	1.7

The following examples illustrate some typical meals as observed during the household observations, and demonstrate the variability even within the generally laissez faire style of meal time. In the first example (Obs27), there are two women, three brothers, and the index child at the lunch bowl. The mother and the aunt have different approaches to feeding the child, one being more verbal and other being non-verbal but still supportive. The child ends the meal when she wants, even though more food is still available and other people continue to eat. In the second example (Obs48), there is even less verbal interaction at the bowl, with the child selecting the bits that she wants to eat without other people at the bowl adding to what was available directly in front of her. Again, the child ends the meal before it is formally concluded, prompting the one verbal interaction at the meal, when her mother asks if she is finished. In the third example (Obs61), the child does her own selection from the food options at the bowl but this is supplemented by bits actively given to her by her mother and older sister. The child's departure from the bowl is not remarked upon, although her mother is ready to give her a glass of water after handwashing. The last example (Obs75) shows a similar pattern, with twelve people eating from the bowl and the child both selecting what parts of the meal she would like to consume and concluding the meal on her own.

Obs27 (K=Index child; S=older brother):

13:10 Mom brings in the bowl of tieb bu xonq. She hands the boys spoons (K is the only girl).

13:12 Aunt tells K to go wash her spoon. K eats a few spoonfuls before everyone. She gets yelled at to sit correctly. Aunt gives her fish.

13:17 Aunt asks K what she wants - carrot, fish potato. Mom also throws her some fish.

13:19 She puts her spoon down and Aunt asks if she is full. "Keep eating." K plays with the lighter. Then she takes one more spoonful before getting up.

13:20 She washes spoon then stands by Mom.

13:25 K sits on mat with Aunt and S who are still eating. She drinks some water.

Obs48 (MB=Index child; SS=older sister):

13:45 Everyone gathers around bowl. SS drops in fish, cabbage, eggplant, sweet potato and okra into tiebou xonq. All eat with hands. MB takes sweet potato and fish.

13:50 MB stands. Mom asks "You're not eating lunch?" MB walks to steps, stands.

13:53 She washes her hand then walks into room.

Obs61 (A=Index child; F=older sister):

13:33 F picks her up and brings her to other foyer. A sits at bowl with other kids. She uses spoon. A picks sweet potato for herself, then D gives her some. Mom also gives her some. She only takes tiny spoons of saucy rice.

13:43 A leaves bowl and nobody says anything. F carries her over to their house where Mom pours her some water to drink.

Obs75 (F=Index child):

13:36 Everyone is called to eat lunch, served in foyer - Mafe.

13:38 F sits by bowl, hand not washed. She starts eating before others - just some rice. 2 men, Aby, other girl, 7 women around bowl.

13:43 F asks for a drink and Mom gives her some water. F just eats rice with sauce.

13:47 F stands, walks away from bowl. Mom tells her to wash her hands. She stands around in foyer.

We can see from the above examples that the child is the one who usually ends the meal for herself, despite the fact that other family members continue eating and food is still available. In Observation 27, both the mother and aunt provide appropriate-sized portions of the fish and vegetables to the child, and the aunt even asks the child which vegetables she would like. In Observation 48, the child takes his own bits from the center of the bowl and there are no verbalizations at the meal. In Observation 61, we can see how the nonverbal interaction at the bowl allowed the child to receive more of the vegetable than she was interested in eating. The last example shows how the mother talks to the child only after she has left the bowl.

In addition to the main meals, many between-meal snacks were consumed with other children and family members unsupervised by the mother, which may contribute positively or negatively to the child's nutritional status. Like the *diogonal,* these provide a supplement to the food provided at the family bowl, although often on a much smaller scale. Unlike the *diogonal,* these snacks are more often provided by other family members besides the child's mother. The number of snacks by themselves was not related to the child's hemoglobin status. The following examples illustrate this point. The first example (Obs54), a relative visiting the household briefly hands the child a small snack. In this case it was a beignet (small doughnut/fried dough) although often it may be some grilled peanuts, local fruit in season, or a portion of a sandwich. The second example (Obs59) shows the distribution of a snack to a large number of children. The third example (Obs69) is a more substantial snack provided by the child's grandmother, including an invitation to come eat and responsive feeding behaviors.

Obs54 (MA=Index child):

> 9:59 Aunt comes over on her way to the market and gives MA a beignet [fried dough ball].

Obs59 (A=Index child):

> 18:39 A woman just came home with a grilled fish. Kids crowd around her for some. A gets a small piece (1 cm3), then walks to foyer1, out to street.

Obs69 (B=Index child):

> 8:30 Grandma calls B to come into her room and the two of them eat [millet porridge with peanut sauce] together. She feeds him by spoon.
> 8:34G tells him he is finished since he hasn't eaten breakfast yet, although she gives him a few more spoonfuls.

These next examples illustrate the different ways in which the *diogonal* is organized and served in the households. The variety in strategies used in the households all promote the same thing: increased intake by the child. However, they are successful to different degrees depending on the approach taken.

In the first example (Obs3), we see the mother responding to her child's hunger cue by asking her older daughter to bring out the set-aside bowl of leftovers from lunch. The child eats with two older siblings who take responsibility for ensuring the younger child's intake. The mother in this example is not involved with this meal beyond the initial command for procuring the food. The children are allowed and expected to eat what they want. This is an example of the laissez-faire attitude taken by most mothers.

Obs3 (A=Index child):
17:03 A tells Mom that she is hungry. Mom tells Astou to bring in the leftovers bowl. Astou, Omar and A eat together, each with a spoon. Both Astou and Omar give pieces of fish to A.
17:10 A gets up and leaves. Astou and Omar continue to eat. A comes back and finishes off bowl with Astou (O has left) and then the two of them run off.

In the second example (Obs20), two young boys are actually eating at the second round of the *diogonal*; they were sent away from the bedroom where the toddlers were eating about ten minutes before. This may be a beneficial action because there are fewer children at the bowl at a time, and the children at the bowl are of the same age range and able to compete for the food equally. The mother of the two boys supervises their eating and ensures a nutritious snack by adding beans and fish, but does not use any verbal commands or encouragements. This mother was more active in her feeding style, although verbalization was not a part of her strategy.

Obser20 (M=Index child):
18:30 He walks into Dad's room after Mom. She gives M bowl with rice. She spoons sauce with beans and fish. He and Ousin eat with hands not washed. Mom stands over, watching them.
18:36 She washes their hands when they finish and they walk back outside, play with sand pile, return to house.

In this next case (Obs27), we see a nicely prepared bowl is brought to the child with an invitation from her mother to eat. However, the mother leaves it up to the child to consume what she wants, with minimal supervision during the meal itself. An older brother then takes the bowl after his sister has finished and has his snack, along with the mother who is sitting nearby. The mother doesn't comment on the small amount that the younger child consumed, but has obviously noticed and nonverbally gets the child to eat a few chunks of fish by handing them to her. Again, we see that non-verbalization around feeding does not mean that the mother is not paying attention.

Obs27 (K=Index child; S=older brother):

18:00 Mom then calls K to come eat. Mom has brought out a bowl of rice into which she puts a big chunk of fish, okra, carrot, cabbage and manioc. She gives K a spoon and brings out a bench. K starts eating.

18:03 K turns and calls Mom to come eat. Mom says "thank you", sits on mat. Nobody supervises K's eating and she only takes rice.

18:08 She puts her spoon down and eats a few green cherries that are still in her hand. Then she eats some more rice.

18:10 When she gets up, Mom asks her if she if full. K shakes her head "yes" and sits down.

18:14 S brings bowl over to mat and he eats with Mom. K lays over Mom's legs and grabs a chunk of fish that Mom has cut off for her.

In the last example (Obs53), there are two young cousins and the mother of one of the boys (aunt of the index child) at this meal. In this case, the mother invites the boys to eat, facilitating the eating environment, and also providing a vitamin-rich sauce made from leafy greens and citrus juice (which aid in the absorption of non-heme iron found in the meal). However, once the boys sit down, there are no more verbal interactions with the caregiver, and in just a few minutes the child of interest walks away with no attempt to keep him at the bowl. The *diogonal* was served much later in this household than in other households, and the child subsequently fell asleep before the evening meal was served. In this case, it may be that the *diogonal* was a substitute for the evening meal. However, further analysis of the number of meals (data not shown) found that the *diogonal* served as an additional meal in the majority of the cases.

Obs53 (AD=Index child; AD=aunt; D=cousin/close in age):
19:27 AD calls kids to come in to eat rice. S runs to get his spoon. Small bowl is shared by AD, D, and S. S sits on small bench. There is a big chunk of fish. All use spoons, AD squeezes lime on all spots.
19:31 She puts some byssop sauce out for boys.
19:35 S gets up and walks away. He walks out other door to yard. He walks around.

E. Discussion

One of the main findings of this research, a key positive deviant behavior, was how the consumption of an enriched *diogonal*, or afternoon meal of leftover rice with fish, was protective against iron deficiency. Often this was directly supervised by the mother or another caregiver. Children who consumed this meal were less likely to be anemic than those children who did not. Several things that were observed were that this meal provided an opportunity for more responsive feeding practices (encouragement to eat more, responding to child's cues for more food, etc.) by the caregiver aimed at the child, leading to higher consumption of nutrient-rich foods which may have been neglected at the noon/lunch meal bowl. Most of these interactions were non-verbal, in contrast to the recommended norms, despite the mother being responsive to the child's intake. The *diogonal* bowl also had fewer children around it, which means less competition for the slow or distracted eater. The mother was more likely to provide more food and effectively encourage the child to eat, often through a non-verbal response to something the child asks for or through observation of what the child is or is not eating.

The verbal interactions around the *diogonal* bowl are highly significant in a population where verbalization directed at children under 5 years of age is kept at a minimum. However, due to the extreme lack of verbalization observed, it may be that actions speak louder than words in the case of young child nutrition. Both the earlier introduction of fish and the serving of the *diogonal* do not rely on verbalization directed at the child.[28] However, the more typical definition of responsive feeding behaviors, as referred to in the introduction, which are highly skewed towards verbal mothers, does not seem to be appropriate for this population. The nutritional role of the *diogonal* is not dependent on verbal interaction, but the successful consumption of this meal requires a mother who is practicing a more active form of feeding compared to the usual laissez-faire tradition that is the expected norm.

This points the way to the design of a possible intervention to improve caregiving behaviors around eating episodes in a way that does not interfere with the culturally sacred lunch meal. An example of this would be a meeting/information exchange scheduled for later in the afternoon (*diogonal* time) when mothers would be expected to contribute to a meal to be shared by them and the children during which key behaviors could be demonstrated and practiced. This may be one of the strategies used in a positive deviance approach to addressing the problem of micronutrient malnutrition. Since only 43% of the families observed served this meal and took this time to be with their children, this intervention would be a way to begin a new habit of providing the *diogonal* as well as learning from other mothers the strategies for doing this successfully.

In the case of the *diogonal*, having more than one but fewer than five eaters at the bowl was most beneficial in terms of iron status for the child. The lone child was most often just given the leftover rice without the other key ingredients from the meal. The presence of too many children led to increased competition, but 2-4 children seemed to

[28]That being said, maternal verbalization is extremely important for the cognitive development of the child irrespective of the relevance to nutrition and should not be disregarded.

strike the right balance for the mother's attention and provision of nutritious foods.

There is evidence from the qualitative analysis that alternative caregivers play a role in the child's nutritional intake, often by providing snacks. The influence of other caretakers, including grandmothers and older siblings, has been noted elsewhere (Aubel, Toure & Diagne, 2004; Stansbury, Leonard, & DeWalt, 2000; Reyes et al., 2004), which may have implications for their consideration and inclusion in policy and program design. These results also suggest that the role of alternative caregivers should be taken into account in nutrition education programs; mothers should not be the only recipients of interventions designed to improve caring practices that influence child health and nutrition.

A clear understanding is needed of what is a practice that is due to material poverty and what is based on shared values of a community. Often poor care behaviors are blamed on low socioeconomic status or poor parental education, but it may be that the behaviors of interest are culturally determined, and not related to material wealth. While the issue of whether the behaviors and practices are culturally determined or economically determined does not change the relationships of these variables, it has relevance for policy and intervention strategies. In this study, we were working in a relatively homogeneous community in terms of shared values, with limited variation in terms of socioeconomic status (SES). Therefore, the relationships identified are much more likely to be due to cultural beliefs rather than SES, and deviations from the common behaviors which may be protective for the child would be accessible to all members of the community. In other words, there was a variation in practices around child feeding observed in the households that was not related to SES, and therefore SES would not be a barrier to enacting the changes seen in the "positive deviant" households.

i. Study Limitations

One of the limitations of the observational method used in this study is that, while obtaining a rich amount of information for one day for each child, there may be variation over the course of the week or month such that observation over a longer period would provide even better information, especially in terms of eating habits and caregivers available to the child. For reasons of logistics and funding, it was not feasible to have multiple 12-hour observations per subject. However, the sample size was relatively large for observations of this duration, which does provide within-group variation.

ii. Summary

Being able to observe these children in their home environment was crucial in determining the type of care they were receiving around meal times and snacks. The observation period lasted the entire day, though, giving insight into care beyond meal time and opportunities to record interactions around informal food procurement by the children. Gittelsohn and colleagues (1999) found that direct observation of food intake by trained observers not only provided information on intake that was just as accurate as 24-recall or other estimates of food intake, but allowed for measurement of food consumed outside of meal times, which may be more difficult for care providers to estimate. It was through these home observations that it became clear that the *diogonal* should be a meal of interest. Since it doesn't fit into the standard breakfast/lunch/dinner triad usually considered in dietary surveys, it might have been overlooked in a more traditional survey.

Looking at the relationship between child feeding during a late afternoon children's meal and the child's anemia status provides a prime example of the importance of direct observation to the detection of the simplest ways in which mothers might assure better iron status outcomes in their 24-42 month old children.

In conclusion, it was found that in a population with a high prevalence of iron deficiency anemia, the earlier introduction of fish into the child's diet as well as the inclusion of a late afternoon meal between lunch and dinner (*diogonal* in the local language) were protective behaviors currently being practiced within the community. While any consumption of the *diogonal* was found to have a positive effect on the child's hemoglobin status, the quality of the meal and the supervision around the meal also played important roles. Household socioeconomic status and parental education levels were not correlated with the serving of the diogonal, nor with the child's iron status.

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G. Appendix

Table 5.4. Educational attainment of parents.

Education level completed	Mother, n (%)	Father, n (%)
None	27 (39)	7 (10)
Literate	16 (23)	17 (24)
Primary	18 (26)	14 (20)
Middle	6 (9)	15 (21)
Secondary	2 (3)	11 (16)
University	0 (0)	6 (9)

Table 5.5. Distribution of father's occupation rank.

Father's occupation rank	N (%)
Unemployed	6 (8)
Basic labor	39 (51)
Skilled labor	18 (24)
Service sector/business	13 (17)

Table 5.6. Description of key variables for defining "active feeding" and other variables related to care and food consumption; mean (s.d.).

Variable	Hb<10.5 g/dl	Hb≥10.5 g/dl	*P*-value
Number of caregivers (CG)	2.7 (1.2)	3.0 (1.0)	.389
Father involvement	0.7 (0.8)	0.8 (0.8)	.650
Consumption of leftover rice	0.5 (0.5)	0.8 (0.5)	.065
CG encourages eating	0.7 (1.2)	0.8 (1.1)	.980
CG monitors intake	0.1 (0.3)	0.2 (0.4)	.314
CG gives more food	0.3 (0.6)	0.3 (0.6)	.960
CG facilitates eating	0.4 (0.7)	0.2 (0.4)	.160
Number of snacks	11.1 (4.6)	9.8 (4.4)	.309
Number of meals	3.0 (0.5)	2.8 (0.4)	.120
Number of different foods consumed	14.4 (3.0)	14.6 (3.0)	.812
Meal organization	1.1 (0.5)	1.1 (0.6)	.964

6. Paper 3: Iron deficiency anemia predicts early vocabulary learning which is linked to later school success

A. Abstract

The aim of this paper is to demonstrate the relative importance of iron deficiency and parent-child interaction in early childhood in determining cognitive outcomes measured by early language ability and later school performance. The data come from a longitudinal study of the relationship between early parent-child interactions with Senegalese 24-42 month olds and their subsequent school attendance and reading levels seven years later at age 10-11 years. Anemic children had a mean picture test score at age 24-42 months that was less than 50% of the mean of their non-anemic peers. When controlling for age and family SES, the picture test at age 24-42 mo was the strongest predictor of reading level at age 10-11 years ($P<.001$). Psychosocial stimulation as measured through direct observation, had a small positive benefit on children's vocabulary score outcomes at time 1, but this was overwhelmed by the negative impact of iron deficiency on the child's learning. The psychosocial stimulation was an important factor at time 2 when looking at the reading levels of these children. Anemic children who received stimulation had higher reading levels than their non-anemic peers not receiving stimulation.

Keywords: School performance, early education, children, maternal-child interaction, longitudinal study, iron deficiency, cognitive development, Senegal

B. Introduction

The aim of this paper is to demonstrate the relative importance of iron deficiency and parent-child interaction in early childhood in determining cognitive outcomes measured by early language ability and later school performance. The results provide evidence that psychosocial stimulation is not able to counteract the detrimental effects of iron deficiency at time 1, but that early psychosocial stimulation does play a positive role in later reading level. As shown in paper 1, anemic children 24-42 months old have lower levels of energy and less focused attention than non anemic children. The hypotheses tested in this paper are:

> 1) Anemic children have significantly lower scores on a vocabulary test than their non-anemic peers. The anemic children who receive more psychosocial attention from their main caregiver will have a higher early language ability as assessed by performance on the vocabulary test than anemic children receiving less psychosocial stimulation.
>
> 2) Anemic children receiving higher psychosocial stimulation at age 24-42 months will have better performance and greater similarity in performance to non-anemic children in school at age 10-11 years than anemic children receiving less stimulation.

The relationship of iron status to cognitive growth and development has been studied extensively (Lozoff et al., 2006; Akman et al., 2004; Liu et al., 2003; Halterman et al,; 2001; Lozoff et al., 2000; Hurtado, Clausen & Scott, 1999; Walter et al., 1990; Deinard et al., 1986; Pollitt et al., 1986), even though the mechanisms are not exactly clear (McCann & Ames, 2007; Pollitt, 2000; Hallberg, 1989; Pollitt et al., 1989). It has been shown that iron deficiency can have long-term impacts on the child's ability to learn (Lozoff, Jiminez, & Smith, 2006; Gordon, 2003; Lozoff et al., 2000; Pollitt, 1997;

Soewondo, Husaini, & Pollitt, 1989; Palti, Meijer, & Adler, 1985). However, it is the care given during the pre-school age that seems to have the most impact on a child's later school achievement, with child's improved language ability being one of the key mediators (Raviv, Kessinich, & Morrison, 2004; Bradley & Caldwell, 1984). This relationship is particularly important in developing countries where access to learning materials and extracurricular activities is limited (Leslie & Jamison, 1990; Grantham-McGregor et al., 1991). Yet even in the US, studies have shown that intensive early psychosocial intervention can positively alter the cognitive developmental trajectories of socially and biologically vulnerable young children (Landry et al., 2000; Ramey & Ramey, 1998).

There have been a few randomized controlled studies testing the interaction of psychosocial stimulation with supplemental protein and calories (Grantham-McGregor et al., 1991; Hamadani et al., 2006) and supplemental zinc (Gardner et al., 2005), but none that used iron. These studies have shown an additive impact of the combined interventions (supplementation with psychosocial stimulation) on cognitive outcomes. Often, though, health and nutrition are not considered in studies of the effects of care and home environment on cognitive development (Hirsh-Pasek & Burchinal, 2006; Kolobe, 2004; Landry et al., 2000; Berlin et al., 1995; Kirsh, Crnic, & Greenberg, 1995; Hart & Risley, 1992).

Paxson and Schady (2007) argue that the influence of cognitive development at young ages on later school performance has received little attention in developing countries. Health and nutrition rather than care and home environment have been the main subjects of research and interventions looking at cognitive development in these settings. The few cross sectional studies of school performance in Africa and South America have demonstrated the importance of mother's education (Abidoye & Eze, 2000) and economic status (Paxson & Schady, 2007) in addition to child’s health and nutritional status in determining cognitive development. Sigman and colleagues (1988) found an association between verbal stimulation and developmental status in a cohort of 110 young children in Kenya. Fewer studies have been longitudinal (Liu et al., 2003; Lozoff et al. 2000; Walter et al., 1990). The longitudinal studies that have taken place in the United States were looking at the predictive value of the HOME Inventory, a measure of stimulation in the home environment, on later school behavior and achievement (Bradley, Caldwell, & Rock, 1988; Bradley & Caldwell, 1984; vanDoorninck et al., 1981). A more recent study of low-income Latino families in the United States found that families having more books in the home read aloud to their children more frequently, lowering the need for early interventions (Tomopoulos et al., 2006).

While most research and policy is aimed at mothers as the main care provider to children, other family members are implicated in early child development and care. Tamis-LeMonda and her colleagues also stress the importance of fathers in child development (2004). Fathers and alternate caregivers are mentioned by Engle and colleagues (1999) in their framework for measuring care and nutrition. McGill-Evans and Harrison also found the father's interactions to be predictive of later language development (2001). Paternal literacy was associated with toddler cognitive development in an observational study of home interactions and child development in

Kenya (Sigman et al., 1988). In Senegalese society, grandmothers influence maternal care practices and child nutrition (Aubel, Touré & Diagne, 2004). A more broadly defined "social support" has been shown to be correlated with caregiver behavior and subsequent child height-for-age (Begin, Frongillo & Delisle, 1999).

Iron deficiency remains one of the most common micronutrient deficiencies in the world and affects 40-60% of the infants in Sub-Saharan Africa (Garcia, Virata & Dunkelberg, 2008). For Senegal, the rate of anemia (Hb $<$ 11.0 µg/dl) was estimated at 82.6% for all preschool aged children (ages 6 months to 5 years) and 68.8% for those in the Dakar region in 2005 (WHO, 2007). While efforts to reduce disease and infection, improve diets, and increase supplementation or fortification are necessary, there is also a role for psychosocial stimulation in the home in order to have the most impact on cognitive outcomes. In 1999, Bénéfice and her colleagues reported on a study of children in another region of Senegal (near Thiès) and hypothesized that "marginal nutritional circumstances were compromised by a poor non-stimulating environment." In this paper, we present longitudinal data measuring the impact of early iron deficiency on short- and long-term cognitive outcomes (a picture vocabulary test at time 1 and a reading level for time 2) for children in Senegal, along with the interaction of the role of parent-child interaction with manifestations of iron deficiency in the home setting.

C. Methods

i. Overview

This study employed a longitudinal design with two rounds of data collection.

The first round of data collection was in 1999 (time 1) and included 12-hour observations of all subjects (age 24-42 months). The second round was in 2007 (time 2) and focused on school performance (age 10-11 years).

ii. Population

The study began in February 1999 in the village of Yoff, a traditional fishing village that is now a part of the capital city of Dakar, Senegal. Households in the survey were selected based on the presence of a child aged 24-42 months at the time of the first data collection. All households in one of the seven traditional neighborhoods of Yoff that met this criterion were approached to be included in the survey. All households agreed to participate after an explanation of the steps and purpose of the survey. There were 78 households in the study at the beginning of this research. Complete data are not available for all households, however, due to change of address or extended travel by the family between data collection points. One family was not able to produce a health card to verify the child's date of birth. Two children were significantly older than the intended age range and were not included in the analysis. Data are available on 74 households/children from the first round of the study (95%) and on 68 children from the second round (91% of the original sample).

iii. Physical and Biochemical Measurement

During the first round of data collection, two sets of anthropometric measures were taken on each child six months apart with the exception of 4 children who had either moved to a different region or were on an extended vacation at the time of the second set of measurements.

Hemoglobin values were obtained at two different time points in the first round of the study, also six months apart, using a portable HemoCue machine which was transported from house to house. For the purposes of the analysis, the hemoglobin value that was taken closest to the event observation was the value used for the analyses.

Weight was measured using a spring scale with accuracy to 0.5 kilograms. Height was measured by having the child stand with heels against a wall, placing a rectangular box parallel to the floor on top of the head, for a 90^{o} angle, marking the wall at the lower intersection of the box, and measuring in millimeters, using a tape measure, following standard WHO instructions at the time (WHO, 1995).

During the second round of data collection, hemoglobin, weight and height were measured again with the same methods (at a single data collection point).

iv. Questionnaire

The main questionnaire, developed over several months of pretesting in other Yoff neighborhoods, was given to the mother, or child-care provider in two cases. A native Yoff resident administered this survey, translating verbally from the French questionnaire into Wolof. The study investigator, also fluent in Wolof, was present for the first twenty interviews. Most questions were pre-coded and complemented with open-ended questions for qualification (for example, "what? who?" or "why?" in response to some health practices, or to specify responses to the category "other"). All responses were reported by the mother or primary caregiver.

The questionnaire contained items on child health history as well as socioeconomic variables for the household. These variables included type of housing, source of water for drinking and washing, whether mother engages in work for pay, household possessions (television, refrigerator, telephone, car), monthly expenditures (for list of 10 items), education of parents (level completed), and principal employment of father. However, in the children's large extended and polygamous households, the status of individual mother-child dyads was not reliably related to the presence of amenities, such as refrigerators or cars nor to the mothers reported monthly expenses. Education level attained by parents was recorded on a 6 point scale with 0 being no formal education, 1= some primary education or completion of an adult literacy course, 2 = completed primary school, 3 = completed middle school, 4 = completed secondary school, 5 = completed some level of higher education.

A picture test was used to assess the child's learning ability and vocabulary at age 24-42 months. During the initial round of the study, a male field worker brought to each family the simple picture-word sheet used in testing the children's vocabulary learning (a single photocopied and laminated A4 sheet of paper showing 14 familiar pictures, labeled in Wolof and French). This field worker tested the children's picture recognition, with responses recorded in Wolof and French. The paper was left with the family with the instructions to use this picture card together during the next week. After one week, the child was tested again for the number of pictures s/he could name.

Eight years after the initial questionnaire and observation, the same group of children was surveyed, this time with questions focusing more on their current school performance. In the follow-up study, when children were now aged 10-11 years old, the questionnaire contained items on attendance at preschool, whether currently in school, grade level and grade point average (given as a number between 0 and 10) and the number of repetitions, if any. The investigator also tested each child's ability to read a series of brief, increasingly difficult passages taken from beginner and second level local school readers (Ami and Remi and Sidi and Rama and a Jules Verne novel simplified for children and taught in the higher grades).

v. Development and Pretesting of Observational Methods

The investigator developed the event observation methods used in this study during several months of informal, semi-structured observations during home visits in non-surveyed neighborhoods of Yoff. Rather than pre-coding events, an unobtrusive child-following approach was used to record an uninterrupted narrative describing the index child's environment and all his/her interactions with the environment and all persons present.

At the end of each hour, the investigator estimated and recorded hourly percentages of time the child spent in a list of different activity levels and psychological states. These time percentages were validated against the start and end times of the events occurring during each hour. The starting and ending points of each narrative event were triggered by changes in the child's activity, physical state, or emotional state/mood.

These observations were obtained for all children in the study.

This study was not blinded (the investigator who obtained the hemoglobin measurements was the non-participant observer in all households). The long time period of the event observation (12 hours) allowed for a variety of interactions and opportunities, usually from the time that the child awoke in the morning until they went to bed at night.

vi. Statistical Analysis

The following variables are used in the statistical analyses used to test the hypotheses of this paper:

At time 1:

- Anemia (yes/no with a cut off of Hb<10.5 g/dl) and hemoglobin (continuous)
- Picture test score
- Height-for-age Z-score
- "Psychosocial stimulation", defined by a dichotomous variable determined through reliability analysis on a set of maternal care variables coded from the observation data. This variable is the sum of [mother x conjoined attention] + [mother x question/answer] + [mother x structured play] + [mother x watch]. These variables were independently positively correlated with the reading score (time 2). Due the lack of psychosocial attention as the cultural norm in the population, this variable was distributed most equally when used as "none" or "any" (0/1). Approximately 50% of these children received no psychosocial stimulation based on these variables on the observation day.
- A variable was created to show the four different conditions of anemia and stimulation for use in ANOVA: anemic with stimulation (anem*stim), non-anemic with stimulation (nonanem*stim), anemic without stimulation (anem*nostim), and non-anemic without stimulation (nonanem*stim)
- Occupational rank of the father is our proxy variable for family SES.

At time 2:

- In school (yes/no)
- Grade level (below, at, or above expected for age)
- Reading level, measured by test of ability to read increasingly difficult school book passages
- Anemia (yes/no with a cutoff of Hb<10.5g/dl) and hemoglobin (continuous)
- Height-for-age Z-score

The hypotheses tested in this paper are the following:

1) Anemic children have significantly lower scores on a picture test (time 1) as compared to their non-anemic peers. Members of this sample who are anemic and who receive more psychosocial attention from their main caregiver (time 1) will have a higher early language ability as assessed by performance on the picture test (time 1) compared to anemic children receiving less psychosocial stimulation, controlling for age and SES (father's occupational rank used as the proxy for SES).

First, a T-test for the equality of means with picture test (time 1) between two groups (anemic and non-anemic) was calculated.

Since our hypothesis is concerned with the impact of stimulation on anemic children, the analysis was run twice: the first time with the whole sample and the second time with only those children with hemoglobin < 10.5 g/dl included in the analysis.

The regression equation used to test the hypothesis was:

$$\text{Picture test score (time 1)} = \text{constant} + B_1[\text{Anemic}] + B_2[\text{Psychosocial Stimulation}] + B_3[\text{Psychosocial Stimulation}]*[\text{Anemic}] + B_4[\text{age}] + B_5[\text{SES}]$$

An ANOVA for the picture test score broken down by the different anemia and stimulation conditions is presented graphically, and was compared to the results for the reading levels in the analysis of hypothesis 3 below.

2) This group receiving higher psychosocial care at age 24-42 months will have better performance and greater similarity in performance to non-anemic children in school at age 10-11 years compared to anemic children receiving less stimulation at time 1.

Children not in school now were not included in the analysis, because the outcome of interest is a reading level score that is age-appropriate for in-school grade levels.

The regression equation used to test this hypothesis was:

$$\text{Reading level score (time 2)} = \text{constant} + B_1[\text{Picture test score}] + B_2[\text{age}] + B_3[\text{Pyscho.Stim.}] + B_4[\text{SES}]$$

In addition to the regression, an ANOVA on the reading levels broken down by different anemic and stimulation states is presented graphically.

The quantitative data for this study were analyzed with SPSS 15.0 and IBM SPSS 20. The narrative observation data were coded for analysis using Atlas.ti. The analysis was a multi-step iterative process. Key words or phrases were marked based both on pre-determined codes and on observed interactions of interest identified during the analysis.

D. Results

Table 6.1 gives a brief description of the study subjects. Mean age at time of the first observation was 33.4 months, and birthweights were normal (mean of 3160g with standard deviation of 550g). Their overall nutritional status, as measured by height-for-age, weight-for-age, and weight-for-height Z scores (HAZ, WAZ, and WHZ) was about one SD lower than international norms (WHO, 2005). What is most remarkable for this cohort of 74 children is their mean hemoglobin levels at 9.2 g/dl. This is well below what would be expected in a healthy population, and over 80% of this sample would be classified as having iron deficiency anemia[29] based on a cut off of 10.5 g/dl (as per Lozoff et al., 1982; Lozoff et al., 1986; Lozoff et al., 1998).

The mothers of these children had a mean age of 32 years, with a standard deviation of almost 7 years. Their BMI is in the high-normal range. While most mothers were literate, very few had completed primary school. Fathers were more likely to have completed primary school, but few had gone beyond that (Table 6.2). Father's educational attainment was significantly positively correlated with the child's picture test score (time 1)[30], but not significantly so for the reading level (time 2). This may point to the importance of the father's involvement with the child during the child's early years which becomes less important as the child ages and is influenced by a wider range of adults in his/her life (i.e. teachers, other family members).

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[29] Often in the literature there is some confusion between the terms anemia and iron deficiency anemia. Ideally, we would have been able to take multiple blood measures to confirm the diagnosis, but low hemoglobin levels are a standard measure for determining iron deficiency anemia.

[30] This relationship held up in a regression including child's age and hemoglobin.

Table 6.1. Description of subjects.

	Total			Anemic (hb≤10.5)			Non-anemic (hb>10.5)		
	N	Mean	s.d.	N	Mean	s.d.	N	Mean	s.d.
Age (months)	73	33.5	7.1	59	32.7	6.8	14	36.8	7.5
HAZ	73	-1.2	1.5	59	-1.3	1.4	14	-1.0	1.7
WAZ	73	-1.5	1.0	59	-1.6	1.0	14	-1.1	0.9
WHZ	73	-0.9	1.1	59	-0.9	1.0	14	-0.6	1.3
Birthweight (g)	56	3160	550	45	3130	570	11	3300	470
Hemoglobin - Round 1 (g/dl)*	73	9.2	1.7	59	8.6	1.4	14	11.5	0.9
Hemoglobin - Round 2 (g/dl)	74	9.0	1.6	61	8.7	1.6	13	10.6	0.5
Mother's age (years)	69	32.3	6.7	55	32.4	7.0	14	32.0	5.6
Mother's BMI	69	24.2	5.8	55	23.9	6.1	14	25.3	4.4
Mother's education	65	1.1	1.1	52	1.1	1.2	13	1.3	1.0
Father's education	64	2.4	1.5	51	2.4	1.5	13	2.6	1.5

* The only statistically significant difference between the mean values for the anemic and non-anemic group is for hemoglobin at round 1.

Table 6.2. Education levels completed by parents.

Education Levels	Mother (percent)	Father (percent)
No education = 0	26 (40%)	6 (9.4)
Literate = 1	15 (23%)	15 (23.4)
Primary school = 2	16 (25%)	12 (18.8)
Middle school = 3	6 (9%)	14 (21.9)
Secondary school = 4	2 (3%)	11 (17.2)
Higher education = 5	0 (0%)	6 (9.4)

As expected, father's education level was highly correlated with his occupation rank, but the occupation rank has a stronger positive relationship with the child cognitive outcome measures (picture test score and reading level). Occupation rank is a proxy for family socioeconomic status (SES) and is used as a control variable in the regression equations.

Table 6.3. T-test for equality of means for picture test score (time1) by anemia status.

	Hb < 10.5 g/dl (N=52)	Hb ≥ 10.5 g/dl (N=12)	P
Mean picture test score	4.6	10.0	.001

Table 6.4. Linear regression of picture test score (time1) by anemia status and psychosocial stimulation and the interaction between hemoglobin and psychosocial stimulation controlling for age.[1]

Variable	B	Standardized Coefficients Beta	t	P
Anemia status	-.485	-.038	-.183	.855
Psychosocial stim.	5.892	.553	2.008	.049
Anem*stim	-4.869	-.459	-1.551	.126
Age at observation	.308	.426	3.488	.001

[1] Dependent variable: picture test score, R Sq = 0.305, Adj. R Sq = 0.257, F=6.364, P<.001.

The presence of psychosocial stimulation by itself does not change the effect of anemia on the picture test score and it does not have a significant effect of its own. However, when an interaction term is added into the equation, it shows that there is a positive impact of the stimulation, but that it is not big enough to counteract the impact of anemia. Figure 6.1 shows the difference that stimulation plays for the non-anemic children, with an almost doubling of their picture test score in the presence of some sort of psychosocial stimulation. The mean values for the anemic children, with and without stimulation, are the same.

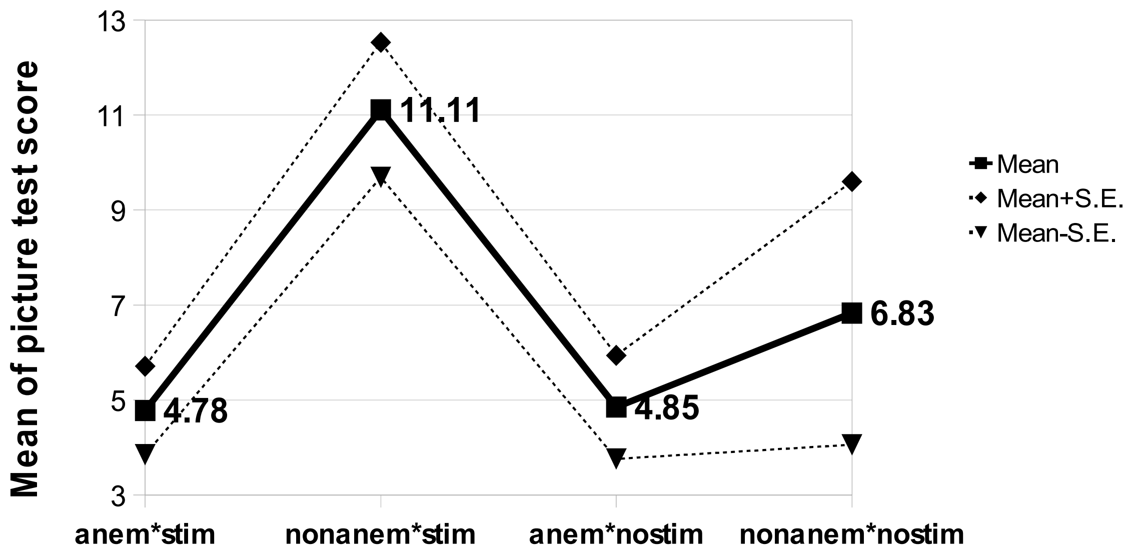


Figure 6.1. Mean picture test score (time 1) for different states of stimulation and anemia (ANOVA F=4.244, sig.=.009).

Table 6.5. Linear regressions for picture test (time 1) as predicted by anemia status and psychosocial stimulation controlling for age and family SES for entire cohort and subset of anemic children.[1]

	Full cohort[2]				Anemic subset (Hb < 10.5 g/dl)[3]			
Variable	B	Standardized Coefficients Beta	t	P	B	Standardized Coefficients Beta	t	P
Anemia status	-3.406	-0.270	-2.62	.011	-	-	-	-
Psychosocial stim.	1.735	0.163	1.54	.128	1.111	0.112	0.889	.379
Age	0.180	0.249	2.26	.028	0.180	0.180	1.924	.061
SES	2.540	.412	3.93	<.001	2.473	0.427	3.254	.002

[1] Dependent variable: picture test score.
[2] R Square=0.428, Adjusted R Square=0.389, F=10.870, P<.001.
[3] R Square=0.315, Adjusted R Square=0.269, F=6.889, P=.001.

Table 6.5 presents the results from two linear regressions for the picture test (time 1) as predicted by psychosocial stimulation controlling for anemia status (in the full cohort), age of child, and family SES. The second regression uses only the anemic children in the analysis to look for differences in the variables for this subset. Psychosocial stimulation does have a positive effect, but it is quite small.

Table 6.6. Linear regression for reading level (time 2) as predicted by picture test (time 1) and psychosocial stimulation controlling for age and family SES.[1,2]

Variable	B	Standardized Coefficients Beta	t	P
Picture test score	.274	.569	3.777	.001
Psychosocial stim.	1.542	.289	2.340	.025
Age	-.016	-.041	-.329	.744
SES	.075	.025	.181	.857

[1] Dependent variable: reading level, R Square=0.522, Adjusted R Square=0.473, F=10.632, P<.001
[2] N=48; children not in school at time 2 were not included in the analysis

Looking at the predictors of the later reading test score (Table 6.6), the earlier picture test is statistically significant, even with psychosocial stimulation in the model. The psychosocial stimulation at age 24-42 months is also a statistically significant predictor of reading test score. Age and SES are not significant determinants. When this equation was run with anemia status at time 1 replacing the picture test score (Table 6.7), anemia status was not a statistically significant predictor of reading test score, but psychosocial stimulation and SES became more important in statistical terms. Tests of models that predicted the picture test score and psychosocial stimulation separately, controlling for age and SES (data not shown), found the same relative values for the coefficients, with the model that includes both picture test score and psychosocial stimulation to be the strongest (highest adjusted R square).

Table 6.7. Linear regression for reading level (time 2) as predicted by anemia status (time 1) and psychosocial stimulation controlling for age and family SES.[1,2]

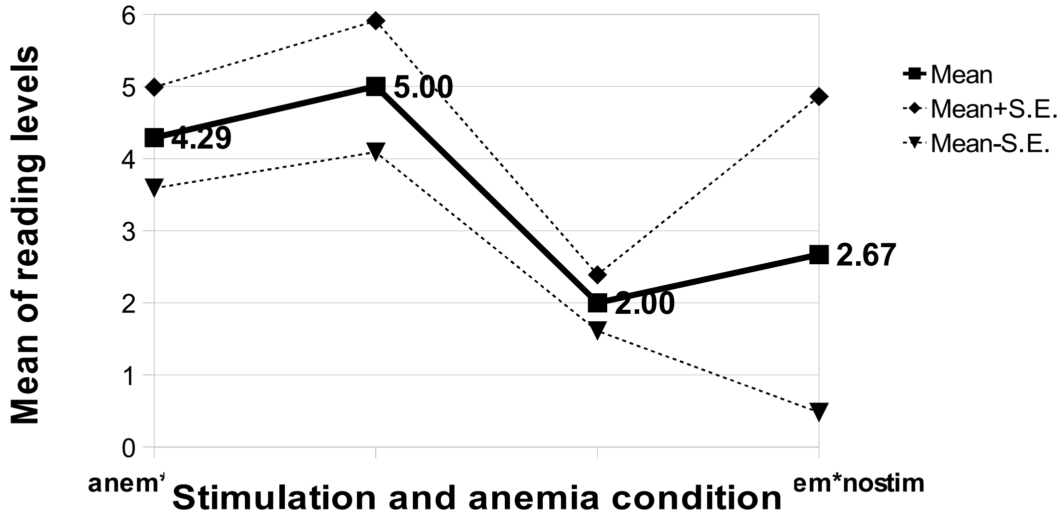
Variable	B	Standardized Coefficients Beta	t	P
Anemia status	0.122	.021	.157	.876
Psychosocial stim.	2.459	.472	3.701	.001
Age	0.060	.167	1.239	.222
SES	0.779	.258	1.938	.059

[1] Dependent variable: reading level, R Square=0.350, Adjusted R Square=0.290, F=5.790, P=.001
[2] N=49; children not in school at time 2 were not included in the analysis

Figure 6.2 presents the differential impact of early psychosocial stimulation on the child's reading level at time 2. The children who received some stimulation, both anemic and non-anemic, had higher reading scores than their counterparts who did not receive such stimulation. The children who were anemic at time 1 and who received stimulation were indistinguishable from their non-anemic peers who also received stimulation.

The 9 children who were no longer in school at time 2 did differ from the children currently in school in several ways. Their mean hemoglobin at time 1 was lower (8.1 g/dl vs. 9.4 g.dl; T-test P=.026), all of the children who had dropped out of school were anemic at time 1 compared to 71% of the children currently in school, and the mean education level of the mothers of the children who had dropped out was lower than the mother's whose children were still in school (0.56 vs. 1.37; T-test P=.015). Paternal educational achievement and occupation rank were not statistically different for the two groups.

Figure 6.2. Mean reading levels (time 2) for different states of stimulation and anemia (time 1).



ANOVA F=4.619, sig.=.007.

E. Discussion

Iron deficiency anemia in early childhood is a strong predictor of the picture test score. While it was hypothesized that psychosocial stimulation would be able to mediate this relationship, the data show that stimulation was effective only for the non-anemic children. The effects of anemia at time 1 were just too strong to be counteracted by a minimal level of stimulation at that same time. However, the picture test score at time 1 does predict the reading level at time 2, as does psychosocial stimulation. This has implications on the long-term impact of both the detrimental impact of iron deficiency anemia and the positive impact of early childhood psychosocial stimulation on cognitive outcomes for the older child.

As indicated in the 12-hour observations at time 1, these children normally had minimal verbal interactions with their caregivers. There were only 10 instances of naming, with 7 of these not being related to pictures of people, for the entire set of 12-hour observations. While there were 82 instances of "question/answer" coded in the data, only 1 was the child asking the question and getting a response from adult. Since learning materials were not available in the homes, these picture cards and the teaching behaviors requested by the researcher were a novelty.

The main question that arises around the high correlation between the children's scores on the picture test and their reading levels 8 years later concern both the magnitude and statistical significance of these results in an environment in which parents and children have very low verbal interactions as measured by the psychosocial stimulation variable. Despite the small sample size and related low power to detect differences, the observed effect of the picture test on subsequent reading levels was large enough to be statistically significant.

At the time of the second round of the study, iron deficiency was almost non-existent for this group (see Table 6.1). We do not know the duration of the iron deficiency, yet the snapshot provided by the first round of data collection still seems to provide a strong correlation with later school performance in the way that it affected early learning.

The 12-hour observations were rich experiences in being able to catch a glimpse of the lives of these children and their families. It was a chance to record interactions that occurred as well as to reflect on the moments in each day where a learning opportunity was passed by. At this age (24-42 months), children are still spending most of the day in the family compound, surrounded by many family members with a large range of ages and experiences. In several cases, grandparents were available to be the primary caregiver when the mother needed to leave the household for work or an errand. Fathers, aunts, uncles, and cousins were playmates and caregivers as well.

Educational attainment is one of the key factors for later success for these children, especially in the rapidly urbanizing capital regions in the developing world (Garcia, Virata & Dunkelberg, 2008), and research agendas in health and nutrition should be reflecting this. Early iron deficiency sets the stage for decreased learning potential for the child. However, these results suggest that psychosocial stimulation at an early age can have a long term positive impact that mitigates the negative effect of anemia.

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G. Appendix

Table 6.8 presents a comparison of several variables related to adult-child interactions from the sample of Senegalese children and a previous study of American children in the same age group. Senegalese parents were much less likely to respond verbally to their child's initiations and also less likely to ask questions to the child. The percentage of verbal prohibitions was about the same between the groups.

Table 6.8. Comparison of ranges (Low-high) and means for selected parenting variables between Hart and Risley (1992) sample and Senegal sample.

	Low-high values of parenting variables		Mean values of parenting variables		Senegalese / US means
Parenting variables	US, 28-36m N=40	Senegal, 24-42m, N=73	US, 28-36m N=40	Senegal, 24-42m, N=73	
Responds to initiations (% child initiations)	42-77	0-9.5	70	2.6	4%
Questions (% parent utterances to child)	17-45	0-28.4	31	2.4	7%
Prohibitions (% parent utterances to child)	0-20	0-29.4	4	6.5	163%

Table 6.9. Correlations between parenting variables and family and child status variables averaged across ages 24-42 months (T=Total, A=Anemic).

Variable	1. Responds		2. Prohibitions		3. Questions		4. SES		5. Father's ed		6. Mother's ed		7. Picture Test	
	T	A	T	A	T	A	T	A	T	A	T	A	T	A
1.Responds	-	-												
2. Prohib.	-.005	.111	-	-										
3. Questions	-.091	.037	-.165	-.150	-	-								
4. SES	.088	.024	.134	.232	.020	-.173	-	-						
5. Father's ed	.146	.031	.211	.118	-.238	-.212	.490**	.539**	-	-				
6. Mother's ed	.240	.391**	.298*	.319*	.100	.134	.346*	.356*	.036	-.029	-	-		
7. Picture test	.140	.123	.140	.289	.164	-.184	.623**	.683**	.403**	.445**	.137	.153	-	-
8. Vocab test	.056	.075	-.035	.145	.292*	.104	.339*	.321	.203	.260	.130	.173	.682**	.598**

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Correlations of key variables, for both the total sample and for the subgroup of anemic children, are presented in Table 6.6. First, we see that the correlation is strongest between the picture test score and the reading level. The next strongest correlation is between father's education and picture test. Socioeconomic status, as measured by the father's occupational rank, was significantly correlated with the child's picture test score, but mattered less for reading level. Maternal education may modify the verbal relationship with the anemic child, as seen in the correlation with her responses to the child.

7. Summary and Discussion

A. Summary of findings from three papers

The three papers that make up the core of this thesis look at different aspects of the social and physiological manifestations of iron deficiency anemia in a cohort of young children in Senegal. The first paper explores the child's physical and mental activity levels compared to non-anemic peers. The second paper looks at some of the care behaviors that are implicated in the etiology of iron deficiency. The final paper discusses both short- and long-term impacts of iron deficiency anemia and psychosocial stimulation on the child's ability to learn, using results from a picture test score at age 24-42 months and a reading level score at age 9-10 years. Together, these papers provide a relatively coherent view of how iron deficiency anemia can impact a child's life at a crucial time in his development.

i. Anemic children are less active both physically and mentally

The first paper looks at child behavior as summarized by hourly percentages in different activities, states, and moods drawn from 12-hour observations. As seen in previous studies, the anemic child spends less time active physically and more time at rest. The anemic child spends more time whining and crying. Importantly, the anemic child spends less time in low-energy focused activities compared to children with higher hemoglobin levels. This focused time is crucial for early learning at a time when the brain is programmed for connecting the growing synapses.

It is not known at what point in development these children became iron deficient, but the high prevalence of iron deficiency anemia in the cohort starting at 24 months of age leads us to believe that this deficiency might have begun much earlier. What we can see from this study, however, is that there are differences in affect and behavior between the anemic child and the non anemic child, and these differences have implications for cognitive development. This interaction is occurring at a crucial time in neurological development and may have a profound effect on the child's cognitive development.

ii. Responsive feeding behaviors and afternoon meal implicated in better iron status

In the case of iron deficiency, there are behaviors by caregivers that may have contributed to the development of the deficiency, and there are also ways in which the caregiver can prevent iron deficiency from occurring (i.e. responsive feeding). In this particular population, the style of eating (from a family bowl) may be an impediment to optimal child nutrition, but there are already culturally acceptable ways to improve a child's diet, specifically the late afternoon meal (the *diogonal*) which is a traditional meal for the youngest children in the household using leftover food from the lunch meal. The *diogonal* is also a time where verbal and nonverbal responsive feeding can be practiced, as was observed in many of the households where this meal was served. The timing of the introduction of key foods into the diet, such as fish, also play a role and the mothers who introduce this important food at an earlier age have children who have better hemoglobin status than those who introduce it later.

iii. IDA correlated with short-term cognitive outcome (picture test) which is then correlated with long-term cognitive outcome (reading level)

The findings from the third paper are perhaps easy to summarize, but more difficult to interpret. Lower hemoglobin levels in early childhood are correlated with lower cognitive test score, in this case a picture vocabulary learning test, when controlling for child's age, socioeconomic status of the household, and the amount of psychosocial stimulation received by the child. In turn, this picture vocabulary learning test score at age 2-3 years is one of the strongest predictors of later school outcomes, reading level, at age 10-11 years.

B. Policy and program implications

i. Understanding the etiology of iron deficiency in a specific population

While IDA is one of the most prevalent nutritional deficiencies worldwide (and one of the most studied), the etiology of the deficiency is going to vary by population and therefore the solutions to this problem need to be tailored to the specific causes in the community. This may be one of the reasons that ID and IDA is so difficult to combat. In the situation being analyzed here, while a very high prevalence of IDA in the 24-42 month age group was found, IDA was almost non-existent in these children seven years later. While the timing of the correction is not known, it can be surmised that it happened when these children were able to better fend for themselves at the family bowl and were able to procure their own nutritious snacks (for example, when the young boys could grill the fish that they were catching themselves). Food scarcity was not a big issue in this community, but rather, it was intra-household food distribution that was the main contributing factor to iron deficiency in the younger children.

Large scale fortification of infant weaning foods would probably not be helpful in this population since the vast majority of households did not buy such products. However, bread is bought daily from centralized bakeries, so fortification at this level may be useful.

ii. Community involvement in planning a behavior change intervention

Behavior change is going to be involved when iron deficiency is being targeted, whether it means consuming a fortified food or including some sort of supplement into a daily regimen. Finding appropriate venues or vehicles for enhancing iron status in young children needs to involve people from the communities themselves in the planning process. This research did not directly address this issue, although it was used to inform a subsequent intervention which was organized around the *diogonal* meal.

iii. The contribution this thesis brings to the debate

Perhaps the "hidden hunger" aspect of iron deficiency should be referring to the fact that this is all around us and many communities do not see the toll that the lack of dietary iron has on child growth and development. In a community where more than 80% of the 24-42 month old children would be considered iron-deficient anemia, it is indeed the iron deficient child who is the norm, rather than the non-anemic child. This has particular relevance as we consider the future lives of these children and the ability for their parents to prepare them for eventual school achievement and later social success.

Early iron deficiency leads to a child not interacting with his environment and may mediate the behaviors of caregivers, since this child will elicit less attention in many cases. The child needs the stimulation from both activities he can engage with by himself and through shared time with his caregivers, both verbally and non-verbally. It may be that added psychosocial stimulation from caregivers can aid in preventing some of the cognitive deficits that lack of iron may cause. This added stimulation also has the benefit of being something that can be implemented right now in the child's life, even if iron supplementation is ongoing since it will take some months before hematological correction is achieved. However, the results in this dissertation show that the negative impact of iron deficiency overwhelms the small positive difference psychosocial stimulation makes on children's early cognitive skills. This result may be exaggerated, though, due to the dearth of psychosocial stimulation, particularly verbalization, by caregivers targeted towards the young child.

Even after the iron deficiency is corrected, whether by supplementation or natural mechanisms due to decreased physiological needs and increased consumption of iron-rich foods, the consequences last well beyond the toddler years. The school deficits seen in this research should be used as advocacy for early intervention, both nutritionally and psychosocially, if we want our investments in primary education to be most effective. Early iron deficiency sets the stage for decreased learning potential for the child, and this is most evident in a community where verbal stimulation is low.

C. Future research directions

i. Further use of existing database

One of the advantages of a large qualitative data set is that there is the possibility for continued analysis using the same data with new hypotheses. Also, in the course of refining the hypotheses used for this dissertation, there were aspects of the quantitative questionnaire which were not fully explored. These provide a natural opportunity for future research directions that I hope to undertake.

Areas of research that would be of interest include: in-depth analysis of child errands; verbal vs. non-verbal psychosocial stimulation; dietary intake and meal patterns that relate to good nutritional outcomes, including snacks.

A methods paper which describes in more detail the non-participant observation approach and strategy used would be another contribution to the field.

ii. New data collection

Other research directions would involve the collection of additional data. Building on the base of information collected in 1999, it would be interesting to compare more current diet and nutritional care practices for toddlers and young children in the same community. Another avenue for research that was remarked upon in this dissertation was the role of pyschosocial stimulation

This is a community in flux, as the traditional fishing village is now part of the expanding capital city of Dakar. The Lebou fishing families, once thought to be at less risk for iron deficiency anemia because of the quality of their diet, are seen here as having a very severe problem with iron status among the youngest members of their population. It would be interesting to see in what ways this transition is affecting diets, especially the diets of the youngest members of the family.

The traditional curriculum followed by the parents in this study includes the use of errands and commands for tasks which assist the household, but do not necessarily prepare the child for school. Children are taught words on a need-to-know basis rather than through exploration and explanation. In most cases, the parents or other caregivers do not respond to children's questions that naturally form from the children's interaction with the world around them. In fact, it seems that by the age of 3 years or so, these children stop asking many questions to the adults around them. It would be interesting to design a longitudinal study using an intervention that modifies the traditional curriculum to include more school-readiness activities, along with regular measurement of health and nutritional variables.

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List of Appendices

Appendix A. Questionnaire (English, round 1, 1999).

Date (Day, Month, Year)
Household number
Name of Family Head
Name of child

1. Since the past cold season, has your child had any of these illnesses?
0 = no, 1 = had in the last 6 months, 2 = has currently

- 1.1 whooping cough
- 1.2 pneumonia
- 1.3 sickness with high fever
- 1.4 other high fever
- 1.5 severe and/or continual diarrhea or dysentery
- 1.6 parasites or worms
- 1.7 measles
- 1.8 kwashiorkor or edema
- 1.9 marasmus or very thin
- 1.10 repeated convulsions when the child is sick
- 1.11 severe skin or body infections
- 1.12 other, specify

2. In the last two weeks, has your child had: 0=no, 1=yes

- 2.1 runny nose or cough
- 2.2 diarrhea
- 2.3 fever
- 2.4 other, specify

3. How many months was your child breastfed? 00 = never breastfed, 88 = still breastfeeding

4. How did you know that your child was old enough to stop breastfeeding?

- 4.1 child stopped himself
- 4.2 because of new pregnancy
- 4.3 big enough (18 months +)
- 4.4 lack of milk
- 4.5 the marabout recommended
- 4.6 other, specify

5. At what age did you begin giving your child these foods:

- Porridges
  - millet porridge with sugar
  - millet porridge with butter
  - millet porridge couscous with fermented millet
  - millet porridge with powdered egg
  - millet porridge with baobob fruit
  - millet porridge with rice
  - millet porridge with powdered milk
  - millet porridge with condensed milk
  - millet pasta with yogurt
  - millet pasta with peanut sauce
  - millet pasta
- Starchy tubers

potato
manioc
sweet potato
Rice/Grains
white, boiled
white, soft, cooked in soup
red, (white rice cooked in tomato-based sauce)
millet couscous
Vegetables
carrot
turnip
eggplant
cabbage
okra
Fruits
banana
mango
orange
watermelon
lime
baobob
Bread
Cowpeas (black-eyed peas)
Egg
Milk for drinking
powdered
thin yogurt
Fish
Meat (goat or sheep)
Chicken
Peanuts
Donuts
Sweets, candies, cookies

6. Did your child refuse to eat certain foods?
6.1 If yes, which one(s)?

7. And now, are there certain foods the child refuses to eat?
7.1 If yes, which one(s)?

8. Who does the cooking in this household?
8.1. only the mother of the child
8.2. someone else always
8.3. the mother is part of a rotation
8.4. other, specify

9. Usually, the child eats with:
9.1 his father
9.1.1 How many times per week?
9.2 his grandmother
9.2.1 How many times per week?

10. If the child does not want to eat when you serve the meal, what do you do?
    10.1 leave the child alone
    10.2 try to make the child eat
    10.3 give the child another food he likes
    10.4 think that the child is sick and give him medicine
    10.5 forcefeed

11. Sometimes do you have to stop your child from eating too much of something?
If yes, what foods?
Why?

12. How would you describe your child's appetite? 0=bad, 1=acceptable, 2=good

13. When your child is sick, do you do anything different with his feeding?

SES
1. Type of housing: 1=concession (traditional attached rooms around a courtyard), 2=detached house, 3=multifloor apartment

2. Number of households in the building

3. Household status: 1=owner, 2=renter, 3=co-renter, 4=sub-lease, 5=housing through job, 6=housing through family, 7=other

4. How many years have you lived here?

5. Water source:
    5.1 Water faucet in house or courtyard location
    5.2 Faucet at neighbor's or other
    5.3 Tubewell
    5.4 Household well
    5.5 External well
    5.6 Buy water from vender
    5.7 Buy water from local woman

6. Are you involved in any money-earning activities?
    6.1 If yes, what is the first or main source
    6.2 What is the second activity

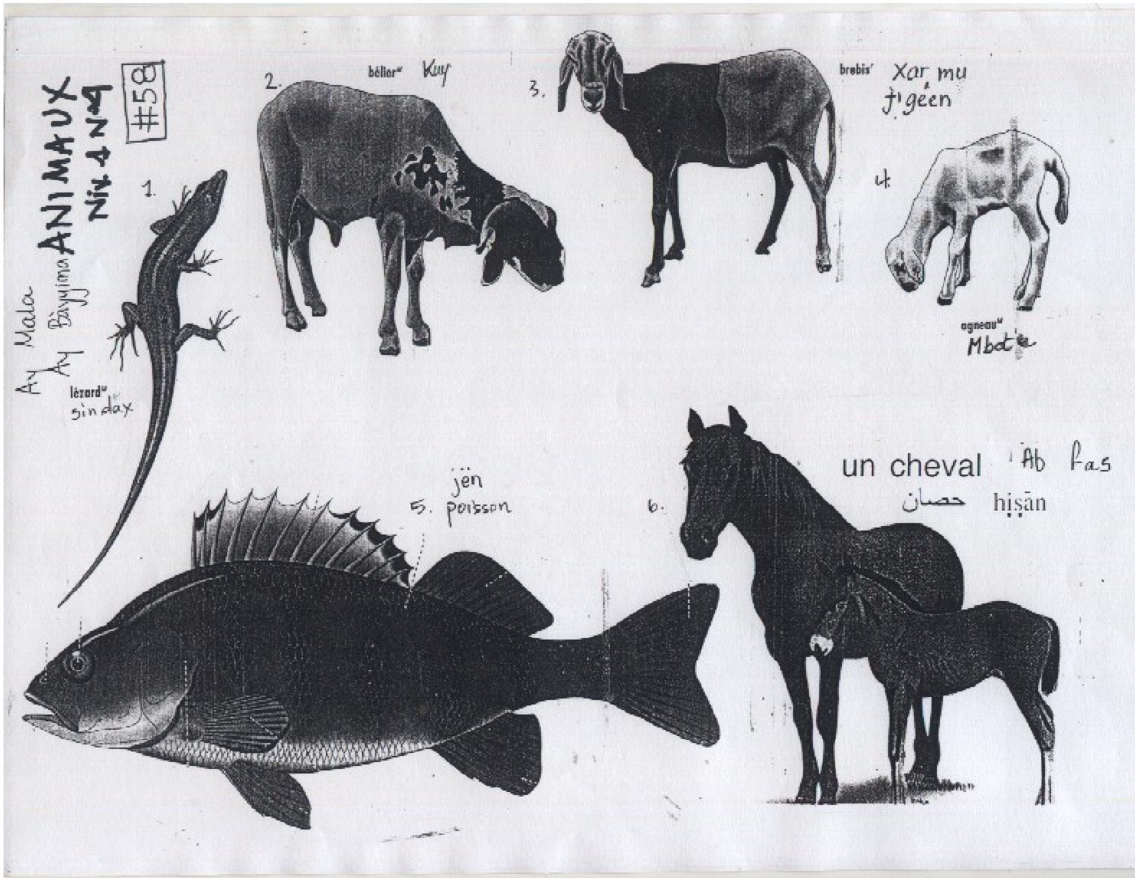
7. How much would you estimate that you earn each month? 1=<25 000, 2=de 25 000 à 50 000. 3= de 50 000 à 100 000, 4 = de 100 000 à 200 000, 5 = de 200 000 à 500 000, 6 = de 500 000 à 1 000 000, 7 = plus d'un million, 9 = NSP

8. Does your family posess (0=no, 1=yes):
    8.1 a television?
    8.2 a refrigerator?
    8.3 a telephone?
    8.4 a car?

9. How much do you spend each month on:

    9.1 water (look at the bill for the last two months)
    9.2 electricity (look at the bill for the last two months)
    9.3 food
    9.4 clothing
    9.5 education
    9.6 leisure/ceremonies
    9.7 transportation
    9.8 if applicable, telephone (look at bill for last 2 months)
    9.9 telecenter
    9.9 if applicable, rent

Appendix B. Sample picture test card.



Appendix C. Observation activity/state/mood sheet.

Hour 1
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy,____loud crying

Hour 2
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 3
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 4
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 5
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 6
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 7
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy,____loud crying

Hour 8
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 9
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 10
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 11
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Hour 12
% of time child spent: ____running, ____walking, ____standing, ____sitting, ____laying down, ____being carried, ____backed
% in state: ____sleeping, ____awake drowsy, ____awake lo-activity diff, ____awake lo-act foc, ____hi-act diff, ____hi-act foc
% in mood: ____happy, ____neutral, ____sad, ____angry, ____teasing/mischievous, ____whiny/needy, ____loud crying

Appendix D. Sample narrative.

Observations #27

Index child: Khary Kane Mbengue

Time of entry to HH: 7:56

8:00 Freshly washed and dressed, K sits on the couch in the living room, talking with brother. In the room are her four older brothers and a younger cousin. Smiling, she goes over and pats the baby, talking to her in a sing-song voice, then sits back down. Mom comes in from her bath and K walks into her room after her. She walks back out to the living room and sits.

8:04 She runs out into the foyer after one of the boys, then back in. She climbs on the couch.

8:06 The baby is put on the floor and K dances around her. K returns to the couch and lies down, kicking her legs.

8:08 Dad walks through and she runs after him, stands at the doorway then walks into Mom's room, asks a question. Mom responds. Mom gives her some bread, which she brings to another room, then she returns. K asks Mom for 5F. Mom gives her another command and K walks out back.

8:12 K returns from the boutique with brother Aziz, holding a bag of milk. Mom tells her to go buy chocolate for her bread with the change. K walks around the room then sits on the couch.

8:15 She bites off the end of the milk bag, A tells on her and she hides the bag behind her back. Mom is preparing breakfast in her room. K gives some powdered milk to A and another brother tries to get some. Milk is spilled on the couch. Mom comes out and tells K to eat outside, guides her to the back steps. K and A stand near Aunt who is washing dishes.

8:19 They walk inside where K sits on a bucket just inside the doorway. She is holding an 1/8 of bread and eating milk.

8:21 Mom brings K into her room and sits her down to eat. K walks into the other room. Mom comes out with her cup of milk and sees that K didn't get chocolate for her bread. She asks if she still has the 10F and K shows her. Mom finds her sandals and sends K off to the boutique.

8:24 K runs back and walks into Mom's room. Mom asks her if she bought the chocolate and K shakes her head in affirmation. Mom tells her to go sit with her milk which is in the living room. K sits for a minute, then walks out to the foyer to join brothers.

8:30 K asks A to give her the paper on the floor which she uses to fan her milk. She puts the bread down on top of the cup and hums, talking to A who continues eating. Then she eats.

8:36 K stands to watch what Dad is doing outside, then sits down again, still eating. A finishes and leaves, K stays seated in the foyer eating.

8:39 Mom walks through and sings K's name. K tells her she is full, hands Mom her bread. K stands up and walks over to the front steps, stands for a moment, then sits down with milk cup. A leaves for school.

8:42 K walks into the house and gives Mom the cup with only a little milk left. K stands out in the back where an older girl is holding the baby. The woman takes the baby and the girl walks with K.

8:45 She half-runs/half-walks to the front steps and then walks to the doorway of the living room. K walks into Mom's room and talks with her. She lies on the bed while Mom straightens up the room.

8:47	K walks out to the foyer. Her Aunt in the next room calls her and K walks into the room. Aunt tries to get K to invite me into the room, but K just stands quietly at the door. Then she asks Aunt questions, watching her.

8:52	K walks out to the foyer with Aunt to talk with another aunt, Rokhaya. They walk back into the room, then K walks to the living room and out back. She runs over to the steps of the other house, asks Mom a question, then walks over to her.

8:55	Aunt comes out and asks K to buy her chocolate for her bread. Aunt explains which boutique to go to and gives K her bread wrapped in a scarf. K walks to the boutique across the street.

8:57	She stands at the window with a group of women. R is there and asks K what she is buying. R takes the bread and tells the vendor whiles K stands quietly.

8:59	K walks back to the house.

9:00	K stands in the living room with Aunt, walks into Mom's room. Then she follows Aunt into her room. K skips in the foyer, brings Mom a cup, then runs back to Aunt's room.

9:03	K walks into the living room with a bag of cakes, sits down. Aunt comes in to eat and tells me that she makes the cakes to sell.

9:08	K stands up, walks into Mom's room. She runs across the yard to catch up with Mom who is going to another boutique, on the corner.

9:10	K stands next to Mom while she buys rice and oil plus other things for lunch.

9:13	K sits on a rice bag.

9:15	She stands again, a minute later, they walk back home. Mom calls to K to follow.

9:18	K stands next to Mom, then goes to fetch a fan for Mom when asked. She returns and stands next to Mom. Aunt asks K about the boutique purchases. Then K exits to greet her Uncle at the next house.

9:20	The baby is his child. The woman washing dishes, his wife. K stands next to the baby, eats some of the cake given to her by Aunt. She feeds some to the baby.

9:22	K sits on the floor with the baby and the woman leaves the room. K makes faces and the baby laughs.

9:26	K stands up and walks out. She skips after woman, walks into living room. Mom is cleaning rice and talking with Aunt.

9:29	K sits on the floor next to Mom. Aunt encourages her to play with the baby. After a minute, she stands, peering into the rice bowl. Mom sends her to get something from the room, she returns and stands by Mom.

9:39	A few people come in (cousin, neighbor and Yade) without formal greetings. K stays silently by Mom. Then one of her brothers (Sarry) comes in and talks to K. S is making a net and K watches.

9:49	K sits on the couch with Aunt. Mom is walking around.

9:55	K stands in the middle of the room with a pillow over her head, then stands next to Aunt. Aunt sends her somewhere, K leaves the room, returns a few seconds later with Aunt's radio. Then Aunt sends her on another errand. K skips into Mom's room and walks out back, around the house, returning to the room. Aunt asks her why she doesn't have the matches. K doesn't respond. Aunt gives her another place to look and tells her to go. K stands playing with the radio antenna. Aunt tells her to stop. K sticks hand in the rice bowl.

10:00 Aunt tells K to sit and clean rice. She moves bowl to the floor and K sits, clean, eats some.

10:08 K starts looking at the bag of cake, leaves rice bowl. She gets up and walks out to the foyer, follows Aunt back in, then stands at the doorway. She walks around the foyer, to Aunt's room.

10:11 K walks back into the living room with a set of keys and stands next to the couch. She leaves the keys, takes the cake, walks out, back in, back out. Aunt tells her to wait in the living room.

10:15 K stands at the doorway to the back, walks to the foyer and stands at the doorway there.

10:18 She follows Mom to the back and they walk into Mom's room. K follows Aunt out.

10:20 Back in the living room, Aunt asks K to buy some ice. Mom gives her a pitcher and money. Aunt repeats instructions and K walks out to do the errand.

10:24 She stands at a wall, waiting for a cousin with a basket who is also buying ice. K stands while cousin does the buying. Still carrying the bag of cake, she eats another piece.

10:27 Cousin Arame gives K the basket and change, they walk home. Cousin takes the basket, seeing that K is struggling. K gives her a chunk of cake.

10:29 At the doorway, Arame gives everything to K to carry into the house. Aunt and Mom compliment her on doing a good job. K stands, walks around the room.

10:32 She runs out to the back then walks back in. She walks after Mom.

10:36 K stands in the living room.

10:43 Aunt sends her to get a mirror from Mom's room. K does the task, stands by Aunt.

10:45 Woman from next house comes to the door and calls K to bring something into the house. K does this, then walks out back. She sits near Mom who is cleaning fish for lunch. K asks Mom questions, after a couple repetitions, Mom responds. Mom sings K's name.

10:49 Mom asks K questions - "Can you clean fish?" - to which K answers "Yes". Mom asks her to explain how she does it. Then she sends K to go into the room to get some soap. K takes her time and Mom repeats. K remains sitting.

10:52 Again Mom asks and K runs around front and then into house to get money for the boutique. She walks to the boutique and returns with a bag of soap. She walks into the living room, gives Mom the soap.

10:56 She returns to the back.

10:59 K sits in the back and washes dishes.

11:01 She stands up, Mom continues with dishes. K sits back down.

11:03 She stands up, leaning against the canari.

11:06 K walks around back, then stands by Mom.

11:10 She joins S and cousin Khady at the doorway. S continues his net. K stands next to Khady silently.

11:12 K sits, then stands, tries to get Mom's attention by calling her name. After several repetitions, she skips over to the kitchen. K asks Mom to buy something. Mom responds. K washes hands in bucket.

11:16 She returns to standing at the doorway with Khady. They are silent.

11:18 The girls sit for a few seconds, then stand again.

11:20 K sits on the steps, playing.

11:25 She walks to the front and stands next to Aunt who is talking to a cloth vendor and a photographer. Some other kids are running around the yard.

11:32 She sits next to an older cousin.

11:36 K runs to the back by herself. Mom follows her into the house and K asks for a drink. Mom pours her some water. K drinks, then walks around with the cup.

11:40 K returns to the living room and sits, looking in a mirror.

11:42 She gets down and runs out to the yard, stands with Aunt who is discussing animatedly with the photographer.

11:44 K runs and plays with S. They walk to the boutique at the corner. After standing a minute, S carries her back to the main tree where everyone is sitting. S gives K a chunk of bread, she stands and eats it.

11:48 She follows S over to the steps and sits next to him.

11:51 K runs into the living room, then to back yard where Mom is. K walks back to the front. She walks around with S.

11:54 They sit on the steps together. K watches as S draws on himself with a marker. She wants to check out the marker, but he tells her to wait. After a minute, he stands up, tells K to sit. She laughs and runs after him.

11:57 Back into the house, standing in back by Mom. Mom is washing rice, K watches, gets chided a few times for sticking her hand in the bowl.

11:59 K whines to Mom, "Yaye? Yaye?". Mom takes her time in responding.

12:00 K walks away, then back to Mom.

12:03 Again she whines to Mom. Mom continues with her work.

12:06 Aunt calls to her through the window, K walks around after Mom, still whining. Then she goes and whines to Aunt - she is hungry, wants lunch.

12:08 She comes into the living room with Aunt, stands next to Mom who is sitting. Mom gets up to buy her some bread, K follows her.

12:11 Mom leaves K at the boutique to buy the bread. She is by herself, stretching up to give the vendor money.

12:13 K runs back with her chocolate bread (1/4 loaf). Aunt asks for some - she takes a little piece and says "merci". K stands by Mom.

12:16 She tries to climb on Mom's lap, but Mom tells her it is too hot. Mom sings to K about how she likes bread.

12:18 S gets yelled at by Aunt about the marker tatoos on his arm and leg. When he leaves, K repeats Mom's chide ("dange fooey" - effronter). Mom laughs. S throws the marker in the room and K gives it to Aunt when asked. K stands next to Mom.

12:24 Mom gets up to check on lunch. K walks over to Aunt. Aunt teases her that if she eats all the bread, she won't eat lunch.

12:26 K walks out after Uncle, then returns to living room with a cup. K has eaten about ½ the bread. Aunt wipes off her face and hands. She sends K to fill the cup with water. She drinks, then is sent to the other house with the water.

12:29 K returns. Aunt tells her to bring more water to put in the ice pitcher. K takes the bread back. She stands in front of Aunt.

12:32 Aunt sends K to get a rag from her room. Then she uses it to wipe K's nose. When K starts walking out, Aunt asks her where she is going. "To see Mom". K walks out.

12:34 K sits with a woman on front steps, continuing to eat bread.

12:41 She stands, calls with the woman to a young boy who is taking a bath by another house.

12:44 She walks around to the back of house, through the living room and out to the foyer with Aunt, then back to the living room. She stands leaning on Aunt.

12:48 K sits down on the chair between Mom and Aunt, then climbs on Mom's chair.

12:51 She sits on top of Mom's chair. Oldest brother tells her to get down. She remains up there, legs resting on Mom's shoulders.

12:53 Mom pulls her down and K lies on the floor, hanging on to Mom. After a minute, Mom gets up to check on the rice and K plays with older brother, sitting on his feet, leaning on his legs.

12:57 K sits on the floor.

13:00 She sits on Mom's lap for a minute, then is back on the floor.

13:02 K stands and whines at Mom. Mom checks on lunch.

13:04 K sits on the floor. She walks around, then sits on older brother's lap.

13:07 K stands in front of him, then climbs onto chair arms. She is checking out a lighter.

13:10 Mom brings in the bowl of tieb bu xonq. She hands the boys spoons (K is the only girl).

13:12 Aunt tells K to go wash her spoon. K eats a few spoonfuls before everyone. She gets yelled at to sit correctly. Aunt gives her fish.

13:17 Aunts asks K what she wants - carrot, fish potato. Mom also throws her some fish.

13:19 She puts her spoon down and Aunt asks if she is full. "Keep eating." K plays with the lighter. Then she takes one more spoonful before getting up.

13:20 She washes spoon then stands by Mom.

13:25 K sits on mat with Aunt and S who are still eating. She drinks some water.

13:29 K climbs on chair next to Mom, then sits on arm of chairs. Everyone, except Aunt, is lounging on chairs, quietly digesting.

13:30 K gets down and sits with A, stands up, lays on him, stands next to him. Mom tells K to behave. K sits in front of her.

13:32 A is given bowl to return, K follows him, stands at doorway.

13:34 She walks outside and helps Mom to wash. She follows Aunt to doorway where Aunt is still eating. K stands for a minute, then walks inside. She stands in Mom's room. Older brother is going to make tea.

13:39 K stands in the living room and is given a piece of candy by S. She sits on the couch and opens it. Oldest brother asks for some and she says "bay ma", pulls away. He takes a photo album out of a drawer and hands it to K. She smiles, points out pictures of brothers. Brothers look at the album with her.

13:49 Brother asks her to get him a cloth but she refuses.

13:55 She walks out to the foyer with A then returns to the living room. She calls to Mom, "Yaye, uyoo-ma!" She doesn't get a response. Mom goes to take a shower.

13:57 Mom calls to her and asks her to find her sandals. Then Mom takes off her clothes in order to bathe her first.

14:02 K walks back to room, wet and naked. She dresses herself, has a little trouble. She comes out to the living room with another dress and Aunt helps her. K returns to room where Mom puts on her underwear.

14:09 She returns to the living room and stands by Aunt. Aunt fixes a chain on K's dress.

14:14 Aunt walks outside and calls K to follow her. K stands at the top of steps. Aunt asks her to sit on the mat in sand, but K doesn't reply. She walks to the living room door.

14:17 K sits on the couch with A. One of the boys has gotten a small bag of bouye and adds water to it. K looks at her chain.

14:19 Mom comes in and lays K on the couch. She looks sleepy, although after a minute, she gets up and walks to Mom. She whines a little, leans on her. She gets some sweet orange drink from Mom. She drink ~1 cup then reaches to Mom to be picked up. She lies down in her arms, whines about something.

14:24 She gets down and draws on the chalkboard next to A. She sits next to Mom who encourages her. K asks for affirmation - "Yaye, holal!" Mom looks and smiles. Then K compares "notes" with A. Mom has K repeat Arabic letters. Older brother calls her over, but she stays seated by Mom.

14:31 K gets down and Mom tells her to give chalkboard to A. She stands for a minute then walks outside. She sits on the step next to Aunt who is getting her hair braided. The other little girl is sitting next to her.

14:33 Aunt yells at K to keep board on the step since she is getting pink chalk on her dress. Mom calls her from the living room, but K doesn't answer. The two girls talk together about studying.

14:36 Aunt asks for chalk and K gives her one of her tiny pieces. Then she gets up and walks into the living room. She brings board and other piece of chalk with her. She stands by Mom for a minute, then walks back outside.

14:39 K returns inside, sits on the floor.

14:40 She lies down, kicks at Mom, stands up. She walks out back after A.

14:44 K walks into the bedroom, gets A's chalkboard and goes back outside, again returns inside with A. Back outside, she stands next to A, then sits on ledge near plants.

14:48 K stands up and walks around. She watches A who is throwing a fruit from the tree next to them. Then they start teasing each other with the chalkboard.

14:50 A is sent on an errand for Uncle and K walks into Uncle's house then to the living room. She puts the chalkboard away, but then takes it back out. She walks to the front steps, follows A into the house.

14:53 She walks to the back and sits with A. Uncle shaves A's head and K sits on ledge. Mom works on getting flies out of the living room.

14:57 K walks around her freshly bald brother. She picks up the razor and cuts her finger.

14:59 K walks into Uncle's house with him and he cleans up the wound.

15:01 K walks into living room to show Mom. Uncle comes in and tells Mom what happened. Mom is laying on the couch. K stands next to her.

15:04 Mom rips up a cloth to give K another dressing over her finger. Then she walks out to the front. Aunt tries to convince K to go visit her grandmother. K doesn't respond. She stands for a minute, then walks back into the living room. She returns with keys for Aunt who again tries to get K to go visit Grandma. K stands silently in front of her. A young man comes in, greets K by patting her head and asks her where her father is.

15:11 K returns to the living room and sits on Mom. Mom talks with her and K laughs, rocking back and forth.

15:15 Mom asks her to get down and take a nap. K lies on the couch when Mom sits up, but then Ngone (braiding Aunt's hair) calls K to come return tea cups. K pauses, but then does the task.

15:19 After being harassed by Aunt again, K returns and lies on the couch. Mom gets up and after half a minute, K gets down and follows her. They stand at the top of the steps together. Mom talks with Aunt.

15:21 Mom makes A and K go visit Grandma. They reluctantly walk across the yard. K doesn't say anything, stands by G's bed. [G has been room-bound for over a year after she broke her leg. She speaks pretty good French since she used to work for some toubabs when she was young.]

15:29 G talks to me and K leaves. She sits on the step with Mom who is talking with Aunt and a friend.

15:34 K whines and Mom picks her up into her lap.

15:36 Mom encourages her to sleep on mat in sand and K gets off her lap, lies down.

15:38 K sits up. The other girl sits on the mat with her. They play together at first, but then they fight over the keys. K is straight-faced while not letting go of the keys, the other girl cries. Mom gets up and picks K up, bringing her over to the steps.

15:41 K sits on Mom's lap. She teases A. Mom tells her to sit still. She talks to the other girl.

15:46 K takes bandage off her finger with her mouth. She has the red stuff all over her teeth. Mom checks out the wound, tells her to keep it out of her mouth.

15:49 K stands and yells at A who tries to take her plastic fish. Then she whines at Mom. K gets down and walks into the foyer, then she stands at the doorway.

15:52 She walks over to Aunt, then walks to the steps. A fool (friend of Yade's) is bothering me and doesn't leave when both I and Aunt ask him to leave. So we just ignore him.

15:54 K sits on Mom's lap. Fool tells the "story of this family" in French. The women laugh, tell him to go to the beach. K whines at Mom, shows her wounded finger. Fool keeps talking.

15:58 K is standing, leaning on Mom.

16:00 Fool talks, but nobody listens. K leans on Mom.

16:05 Aunt tells us to go inside and maybe the fool will leave.

16:07 Older brother carries K into the living room and sits her down. Mom tells me that the man is possessed by a spirit.

16:09 K gets down and whines when A teases her. She sits on top of Mom who is lying on the couch.

16:17 Mom asks K to get down and go to sleep, but K remains seated on Mom.

16:20 Mom picks K up and sets her on the ground, tells her to sit in a chair. K says "may bun" and climbs on Mom. She lies on her for a moment, Mom laughs then stands up. K follows her to the doorway, stands for a few seconds, then walks out to the front.

16:22 She sits on a mat in the sand with an older female cousin.

16:25 The cousin gets up, but K remains seated. She is looking at cousin's watch. Aunt, returning from her bath, laughs at K and asks her what time she has. No response.

16:27 K stands up and walks over to Mom, sits on her legs.

16:33 Mom is sewing a boubou for Aunt, K is wrapping a small plastic doll in Mom's skirt. She talks to herself, Mom is silent.

16:36 Mom moves K to the step. K sits for a moment, then stands next to Mom. K goes to see Aunt who asks her to go gets something from Ngone. K walks out and stands by Mom.

16:38 She lays her head on Mom's lap who tells her to sit up. K leans on Mom.

16:40 A walks in eating a mango. K stands up. Mom asks him where he got it, tells him to eat it out back after washing up. K gets up, walks to the living room and through the back door. Mom calls her but K doesn't pay attention.

16:42 She asks for some mango and he lets her take a bite while he holds the fruit. She asks again and he bites a piece off for her.

16:44 K cries and Mom asks what is going on. A tells her that K wants more mango. She yells at him to go wash. They walk to back. A washes his hand and face then K's.

16:47 K walks through the living room. She stands by the bed. Aunt talks to her.

16:49 K walks into Mom's room, whines about something. Mom responds, then K follows Mom out of the room. Mom lays mats outside and K sits down. Mom goes inside.

16:52 She lies down yet again.

16:54 K sits up, arranging mats, then walks around to back. Mom has closed the door after getting flies out so K knocks.

16:56 A griot comes by and announces upcoming baptisms. K sits with Mom on mat. She is looking at her chalkboard again.

17:00 Mom prays. K remains seated, plays with Mom's beads.

17:07 Cousin comes out and asks for watch. K tries to hide behind Mom and laughs. She lies down and Mom takes the watch off. Mom puts her underwear that she has kicked off back on and K laughs. She remains lying down.

17:13 K sits up while Mom kills some ants on the mat, then she lies down in Mom's lap. Mom talks quietly with Aunt. After a minute, K sits up. Aunt teases her, she smiles. She compliments K on her pretty bracelet.

17:16 K whines to Mom who continues talking with Aunt.

17:18 She lies on Mom, still whining ("Yaye?"), then she sits up.

17:22 K follows Aunt into her room, quietly whining.

17:24 She comes out with one of Aunt's cakes, returns to Mom and sits down with her.

17:28 Talking quietly together, K lies on Mom's lap, sharing her cake.

17:33 She sits up. Mom asks her to see where the smoke is coming from and K stands up, walks, point and returns to Mom, sitting on her legs.

17:36 S comes home and K gets up, walks around, then sits down next to him.

17:42 Aunt is going to Rufisque and she says goodbye to K. No reaction.

17:45 Older brother comes home and calls to K. She responds, but stays seated. He puts his paint cans away then walks out to back. He leaves the yard.

17:52 S has left, but K remains seated on mat, playing with chalkboard now broken in three pieces instead of two. Mom is lying down, trying to teach K "merci". Yet, she only repeats, not giving the translation.

17:56 Mom gets up to heat the leftover rice. K stays seated for a minute, then gets up. She walks over to S who is picking green cherries off the tree. He jumps onto mat and lies down. K runs and jumps after him, laughs, then also lies down.

18:00 S teasingly hits her with his stick and she laughs, then sits up. Mom then calls K to come eat. Mom has brought out a bowl of rice into which she puts a big chunk of fish, okra, carrot, cabbage and manioc. She gives K a spoon and brings out a bench. K starts eating.

18:03 K turns and calls Mom to come eat. Mom says "thank you", sits on mat. Nobody supervises her eating and she only takes rice.

18:08 She puts her spoon down and eats a few green cherries that are still in her hand. Then she eats some more rice.

18:10 When she gets up, Mom asks her if she if full. K shakes her head "yes" and sits down.

18:14 S brings bowl over to mat and he eats with Mom. K lays over Mom's legs and grabs a chunk of fish that Mom has cut off for her.

18:17 She lies on Mom's lap.

18:19 She sits up. Mom finishes eating and S continues. Mom talks with her, K smiles.

18:21 Mom takes one of the green cherries out of her hand saying they are bad. K whines, Mom gives it back. K smiles and lies down in her lap.

18:23 She stands up when Mom sweeps rice off mat. S sits back down and the three of them talk, laugh.

18:26 Mom asks K where different body parts are and K points. When she is slow, S helps her. She smiles, enjoying this game. Then they go on to saying Arabic letters.

18:29 K asks Mom to buy a bag so she can go to school. Mom laughs "you want to go to school?" "Wow", K replies. Then K lies in her lap, still talking. She sits at the edge of the mat and picks up some stones.

18:32 The three of them take turns throwing stones up and catching them, picking up stones between throws. K is throwing stones all over, but nobody says anything negative.

18:39 Play continues. When S takes too many of K's stones, she whines a little, but they continue. Mom chides S. K stays mostly focussed, although she turns her attention to other things from time to time.

18:49 S is lying down and K turns her attention to him, still playing with the rocks.

18:51 The woman, Ndeye Ndiaye, returns. She and K repeat each others' names while she walks across the yard. K goes back to playing with rocks, S sits up.

18:53 NN puts baby (Codou) down next to K. NN talks to Mom. K plays with rocks.

18:58 Mom and K play with C. Mom occasionally tells K to be a little gentler.

19:00 They continue. S returns.

19:03 NN sits down and K stands up behind her, playing with her hair. NN sends her on an errand. K walks to the boutique to buy matches.

19:06 She stands there. Man and girl ask K what she wants to buy. No answer. Girl makes her purchase. Then man gives K some cookies and she walks out. S goes to buy the matches.

19:09 K sits next to Mom who asks her who bought her the cookies. K sits down, says nothing. K shares the cookies with everyone.

19:11 K lies down on mat eating cookies. After a minute, she sits up.

19:14 Mom lies down and asks K to join her. After half a minute, she does. S is also lying down on the other side of Mom. C sits next to him.

19:16 K points to something in sky and asks Mom to look. Mom makes a comment, K responds.

19:17 She sits up and makes noises with C. K continues eating her cookies.

19:22 K gets up and walks into the house with S. They get a cup which K gives to NN. Then they run back to the mat.

19:24 K lies on Mom, then sits on her.

19:26 K runs to mat under trees where two older girls are lying down. K stands and talks with them. Then she sits down.

19:28 K lies down with them. They giggle together. K and one girl sit up. S, A and Omar are running around with a ball made out of plastic bags.

19:31 The girls watch and laugh. K gets up to join in, then runs back to the mat. Then she runs around with the boys.

19:33 She sits back on the mat. After a minute, she stands and runs again. The two other girls also start running around.

19:36 The girls all lie down. Boys are throwing ball as hard as they can at each other and loving it.

19:37 K gets up and walks around. She plays with one of the girls' scarves. Mom calls to her and gets no response. She runs with boys again, then she walks out to the street.

19:39 K runs in the street, scarf dragging behind her. She stands at the doorway of another house, then runs back. Again Mom yells to her, K doesn't answer. Then she stands on the bench outside of the door. O comes to get her, but she whines "may bun".

19:41 Mom tells the oldest boy to go get A and K - it's "timis". He picks K up over his shoulder and carries her to Mom. She laughs.

19:43 K squirms a bit, then sits on Mom's legs. She walks over to NN and stands next to her. NN is preparing rouillie for the baby.

19:46 K sits down and is given ¼ cup. She takes the spoon from the bigger cup then refuses to hand it back. Mom and NN tease her. They ask me to take the spoon since I'm closer.

19:50 S talks to K who is drinking her rouillie, not sharing. When she wants, she gives the rest to S.

19:52 K gets up and walks over to Mom who is washing for prayer. Then K runs around, teases Mom by taking her scarf.

19:54 K runs around the house and comes to older brother from the other side. She stands next to him. She moves to NN who tells her to sit down. K walks to Mom.

19:57 K sits down by NN and S, plays with C.

20:00 K, S and C remain sitting on the mat.

20:29 Mom brings out a dish of cere sime. They are eating outside, by flashlight since there is a power outage. K only eats two spoonfuls then walks away.

Aunt is more active feeder/encourager for K.
Mom responds to requests.
few nutritious snacks
verbal child

Appendix E. Questionnaire (English, round 2, 2007).

1. Administrative data
   Date (day/month/year)
   Building number
   Name of head of family
   Name of child's mother
   Name of child's father
   Name of child
   Respondent

2. Child index: reference data, nutritional status and health history
   Child's sex, M=1, F=2
   Date of child's birth (year, month, day)
   Information from Health Card? yes=1, no=0, 2=birth notice, 3=school report card
   Weight in kg (nearest .1)
   Height in mm
   Child's hemoglobin
   How would you qualify your child's health? 0=bad, 1=average, 2=good, 3=excellent
   Since our last visit, how many times has the child been hospitalized (spent the night at the hospital)? For what reason(s)?

3. Preschool
   How many years did your child go to a daara (Koranic school)?
   How many years at a preschool center or “mother school”? Which one?

4. Primary school
   Has your child been to French school? 0=no, 1=yes
   Or Franco-Arab school?
   If non, why has he not gone to school?
   What does he do now?
   What year did your child start school?
   Is your child in school now? 0=no, 1=yes
   If he is no longer in school, why did he stop?
   What is the name of the school where your child attends?
   What grade level is your child in now?
   Has your child ever needed to repeat a class? 0=no, 1=yes
   If yes, how many times?
   How many students are in your child's class?

5. Grades
   Do you have your child's grades from December? 0=no, 1=yes
   Can I see them?

What is your child's average mark?
If you don't have the grades at the house, can we go see them at the school? 0=no, 1=yes

6. Other questions on the primary school
What is the name of the director of the school?
Who is your child's teacher?
Are you a member of the Parent-Teacher Association? 0=no, 1=yes

7. Supplementary courses and homework help
Does your child attend a supplementary course for reinforcement or to learn better? 0=no, 1=yes
If yes, how many hours per week?
With what system? 1= class at school in the afternoon; 2=your child goes to the home of his teacher or elsewhere; 3=a tutor comes to your home
Does your child have an older sibling who can help him with his homework? 0=no, 1=yes

8. Education of parents
Have you attended French school? 0=no, 1=yes
If yes, until what level?
Did the child's father attend French school? 0=no, 1=yes
If yes, until what level?

9. Family structure
Total number of people who share the space at the concession, house or building (number of households)
Does the child's father live with this family? 1=full time, 2=more than half the time, 3= less than half the time, 4=rarely or never
How many wives does the father have? (99=divorce)
How many children does the father have?

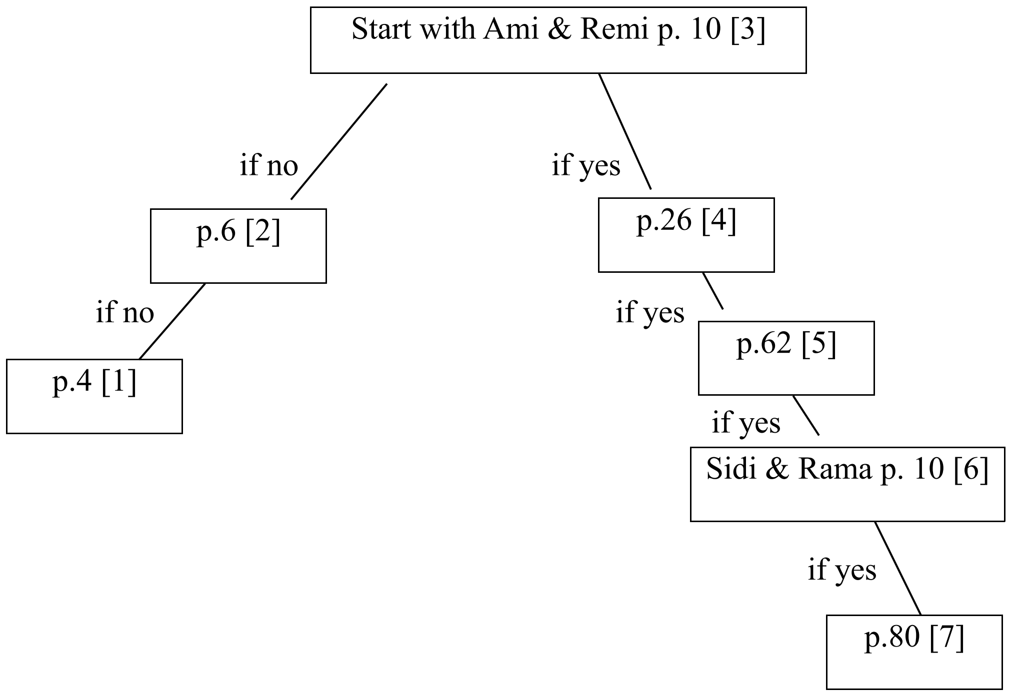
10. How many of the following items does your household own? (99=not in working order)

Televisions	Fishing boats
Radios	Fishing nets
Cassette players	Freezers
DVD players	Cars
Refrigerators	Sewing machines
Telephone lines	Bikes or motor scooters
Cell phones	Horse carts

Appendix F. Reading level calculator.

Score based on highest level completed.

[0] = Can not read



Appendix G. Results of regressions for responsive feeding variables, with and without interactions.

The adjusted R^2 of each of the models is quite low, and most are not statistically significant. Occupation rank, our proxy for SES, is usually the only independent variable approaching significance, which in and of itself disproves half of my hypothesis? Table B shows the results of a regression where the model is statistically significant and it looks like the significance is driven by the interaction of SES and supervision of the diogonal. How do you interpret the negative R^2 for this regression? The coefficient for the interaction between SES and supervision of the diogonal is positive, so there is some sort of positive relationship between these two variables so that families with higher SES are more likely to supervise the diogonal. Age, or interaction of the responsive feeding variables and age, are never significant in any of the models. Table C is approaching significance and the variable of interest in this regression is caregiver facilitating the eating environment. However, the significance disappears when interactions are entered into the equation. Table H shows another regression of interest, including the interactions for caregiver providing more food, and again it is the interaction between SES and CG providing more food that is significant rather than CG providing more food by itself.

Table A. Results of regression of hemoglobin as predicted by supervision at diogonal when controlling for SES and current age (adjusted R^2=.028, model significance=.172).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.151	1.085		7.512	.000
	Supervision at diogonal	.450	.431	.121	1.045	.299
	occupation rank	.454	.242	.231	1.873	.065
	age in months: second round	.005	.029	.020	.166	.869

a. Dependent Variable: hb closest to observation

Table B. Results of regression of hemoglobin as predicted by supervision at diogonal, with interactions (adjusted R^2=-.117, model significance=.019).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.508	1.291		5.817	.000
	Supervision at diogonal	1.365	2.179	.367	.626	.533
	occupation rank	-.060	.287	-.031	-.209	.835
	superDio_occ	1.445	.489	.693	2.955	.004
	age in months: second round	.042	.036	.177	1.172	.245
	superDio_age2	-.078	.057	-.852	-1.367	.176

a. Dependent Variable: hb closest to observation

Table C. Results of regression of hemoglobin as predicted by caregiver (CG) facilitating eating environment when controlling for SES and current age (adjusted R^2=.054, model significance=.077).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.806	1.119		7.871	.000
	CG facilitates eating environment	-.565	.326	-.204	-1.731	.088
	occupation rank	.365	.241	.185	1.510	.135
	age in months: second round	-2.1E-005	.029	.000	-.001	.999

a. Dependent Variable: hb closest to observation

Table D. Results of regression of hemoglobin as predicted by caregiver facilitating the eating environment, with interactions (adjusted R^2=.050, model significance=.130).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.117	1.283		6.328	.000
	CG facilitates eating environment	1.380	1.901	.499	.726	.470
	occupation rank	.193	.290	.098	.665	.508
	eatingenv_occ	.361	.387	.201	.932	.355
	age in months: second round	.025	.035	.103	.703	.484
	eatingenv_age2	-.066	.055	-.869	-1.205	.232

a. Dependent Variable: hb closest to observation

Table E. Results of regression of hemoglobin as predicted by caregiver (CG) providing food when controlling for SES and current age (adjusted R^2=.016, model significance=.250).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.915	1.291		6.129	.000
	CG provides food	.028	.062	.055	.455	.650
	occupation rank	.432	.243	.220	1.781	.079
	age in months: second round	.011	.031	.047	.367	.715

a. Dependent Variable: hb closest to observation

Table F. Results of regression of hemoglobin as predicted by caregiver providing food, with interactions (adjusted R^2=-.001, model significance=.436).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.331	2.377		3.504	.001
	CG provides food	-.051	.363	-.100	-.140	.889
	occupation rank	.741	.457	.377	1.621	.110
	CGfood_occ	-.061	.076	-.245	-.798	.427
	age in months: second round	-.012	.060	-.052	-.207	.837
	CGfood_age2	.005	.010	.324	.480	.633

a. Dependent Variable: hb closest to observation

Table G. Results of regression of hemoglobin as predicted by caregiver (CG) provides more food when controlling for SES and current age (adjusted R^2=.019, model significance=.229).

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.467	1.147		7.380	.000
	CG gives more food	-.225	.347	-.078	-.649	.518
	occupation rank	.421	.243	.214	1.733	.087
	age in months: second round	.003	.030	.013	.102	.919

a. Dependent Variable: hb closest to observation

Table H. Results of regression of hemoglobin as predicted by caregiver provides more food, with interactions (adjusted R^2=.064, model significance=.090).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.705	1.183		7.359	.000
	CG gives more food	-1.958	2.398	-.677	-.817	.417
	occupation rank	.676	.262	.344	2.577	.012
	givesmore_occ	-.886	.389	-.471	-2.275	.026
	age in months: second round	-.013	.031	-.056	-.426	.671
	givesmore_age2	.083	.073	.976	1.139	.259

a. Dependent Variable: hb closest to observation

Table I. Results of regression of hemoglobin as predicted by caregiver (CG) encourages eating when controlling for SES and current age (adjusted R^2=.027, model significance=.181).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.450	1.106		7.642	.000
	CG encourages eating	-.169	.171	-.116	-.989	.326
	occupation rank	.463	.243	.235	1.901	.061
	age in months: second round	.004	.029	.015	.124	.902

a. Dependent Variable: hb closest to observation

Table J. Results of regression of hemoglobin as predicted by caregiver encourages eating, with interactions (adjusted R^2=.019, model significance=.284).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	7.781	1.371		5.675	.000
	CG encourages eating	.762	1.139	.521	.669	.506
	occupation rank	.586	.281	.298	2.086	.041
	enceat_occ	-.152	.175	-.238	-.867	.389
	age in months: second round	.016	.037	.066	.425	.672
	enceat_age2	-.017	.032	-.441	-.547	.586

a. Dependent Variable: hb closest to observation

Table K. Results of regression of hemoglobin as predicted by positive active feeding behaviors when controlling for SES and current age (adjusted R^2=.023, model significance=.201).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.700	1.217		7.149	.000
	Positive active feeding behaviors	-.089	.105	-.104	-.852	.397
	occupation rank	.471	.246	.239	1.913	.060
	age in months: second round	-.001	.031	-.003	-.021	.983

a. Dependent Variable: hb closest to observation

Table L. Results of regression of hemoglobin as predicted by positive active feeding behaviors, with interactions (adjusted R^2=-.001, model significance=.437).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	9.270	1.868		4.963	.000
	Positive active feeding behaviors	-.357	.625	-.415	-.570	.570
	occupation rank	.533	.366	.271	1.457	.150
	posAF_occ	-.037	.124	-.092	-.296	.768
	age in months: second round	-.018	.048	-.077	-.381	.705
	posAF_age2	.009	.018	.376	.498	.620

a. Dependent Variable: hb closest to observation

Table M. Results of regression of hemoglobin as predicted by CG encourages eating and CG gives more food when controlling for SES and current age (adjusted R^2=.017, model significance=.275).

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	8.630	1.162		7.424	.000
	CG encourages eating	-.158	.173	-.108	-.910	.366
	CG gives more food	-.185	.351	-.064	-.528	.599
	occupation rank	.452	.246	.230	1.838	.070
	age in months: second round	.000	.030	.002	.015	.988

a. Dependent Variable: hb closest to observation

Appendix H. Coding process for the qualitative data.

The narratives from the observations were transcribed from the field notebooks into plain text (.txt) files and then entered into Atlas.ti for coding. Each observation became a primary document, with its title coming from the observation number. (Appendix D presents a sample of one observation as transcribed.) It was possible to mark certain sections of text through keyword searches related to the relevant code. For example, the rough coding for child activity and state (i.e. run, walk, stand, carried, sleep, etc.) The coding of interactions with adults and others was a series of nesting codes, first identifying the relationship of the person the child was interacting with and then coding the type of interaction and who initiated this interaction. "Super codes" were created using the query tool which combined codes of interest (i.e. "adult interaction" and "mother" and "conjoined attention" reduced to "*MAT conjoined attention"). The full set of codes used is listed in Appendix I.

Some coding involved more nuanced judgment on which code was appropriate for the particular case. For this dissertation, inter-coder reliability was not an issue because there was only one person coding (who also happened to be the investigator who conducted all of the observations). However, there was occasional discussion with committee members, both during committee meetings and also in one-on-one analysis meetings, where "rules" or "concepts" for the codes and coding was clarified.

The following table presents an example of how the observation data were coded for one such nuanced case, using the coding for "type of play" which was composed of four codes, "imitative play", "imaginative play", "physical play", and "exploratory play".

Table N. Coding example for "Type of Play".

Domain	Concepts	Quotations
Imitative Play	- acting out scenarios from daily life - mimicking adult behavior	"[A.] pretends to read a paper she is holding, mimicking Astou."
		"P. decides to start "cleaning" so he tosses some rice out of the bowl. Aunt laughs then tells him to put rice in her hand first."
		"When M.T. is done with the mirror, K. looks at it - copying her sister by holding it in one hand and working chew stick with the other."
		"G. stands on porch, playing with a stick brought over by an older boy. He starts teasing boy and hitting him with stick. Then he pretends to be teaching in a daara [koranic school] - hitting wall and saying letters."
Imaginative Play	- pretending - make-believe - giving found objects a different meaning	"I. calls [N.] to see a car he has drawn in the sand. She sits down with him, watches what he is doing and then starts to participate in the artwork. They pretend to drive the car, complete with sound effects."
		"G "drives" a broken board around in foyer."
		"[B.] follows girls into l.r. and they play together. B pretends he is a sheep. M ties him to bed post and he "baas"."
		"[S.] climbs into a box with Ablaye. They pretend they are in a car."
Physical Play	- running - jumping - games such as tag or catch - climbing trees or other objects - wrestling	"[W.] starts running around with one of the young men then back to G."
		"Three-way tug-of-war commences. Another older boy/cousin joins in."
		"S. sits for a moment, then stands, watching C. get swung around by the woman. She asks for a turn and is also swung."
		"O. starts wrestling with a boy a little older than him."
Exploratory Play	- discovering properties of a found object - examining physical surroundings or things	"T. comes back with a tub 1/3 full of small fish. F. comes and checks them out, sticking her hand in the water."
		"Then [M.] gets up and walks down the street, checking out an old tire."
		"O. stands by L. and F., looking at some plants. L. and O. each break off a branch."
		"[A.K.] picks up a beetle and checks it out."

Reports were generated for individual codes (i.e. “failed errand”) and groups of codes (i.e. “FA - alone”, “FA - adult”, “FA - group”, and “FA - other”) to see as a group the series of quotations that were coded for these different variables across observations. Counts for the various codes were then exported to Excel and then into SPSS for analysis with the summary data in conjunction with the data collected through the quantitative questionnaire.

Appendix I. List of codes used, number of occurrences, and categories for related terms.

Caldwell code hierarchy:

Caldwell

- **Acceptance (311)**
  - **CG annoyed/hostile (12)**
  - **CG scolds (147)**
  - **CG shouts (37)**
  - **CG slaps (28)**
- **Involvement (53)**
  - **CG pays attention to toys (0)**
  - **CG structures play (22)**
  - **CG talks while working (2)**
  - **CG watches (30)**
- **Learning materials (59)**
  - **Book (15)**
  - **CG-provided toy (1)**
  - **Toy-complex (9)**
  - **Toy-cuddly (9)**
  - **Toy-muscle (0)**
  - **Toy-push/pull (12)**
  - **Toy-simple (13)**
  - **Wheeled conveyance (0)**
- **Organization (29)**
  - **Child's toy box (0)**
  - **Unsafe item (29)**
- **Responsivity (607)**
  - **CG names (10)**
  - **CG responds (406)**
  - **CG speaks (141)**
  - **CG talkative (4)**
  - **Physical affection (39)**
  - **Positive voice (19)**
  - **Praise (16)**
- **Variety (14)**
  - **CG reads story (0)**
  - **Eating with CG (67)**
  - **Father care (14)**
  - **Visit (32)**

Other playthings codes:

ball (77)
chalkboard (4)
drum (167)
photo album (67)
toy-figure (16)
toy-found object (78)

Other caregiver (CG) interaction codes:

CG delegates (23)
CG hits (4)
CG monitors (8)
CG pays attention to toys (0)
CG provides challenge (2)
CG provides challenging toy (0)
CG restricts (83)
CG shoves (1)
CG tells story (1)
CG threatens (15)

Other psychosocial care codes:

adult-init[-iated] **(488)**
adult interaction (4446)
bowl etiquette (10)
child-init[-iated] **(703)**
child asks (37)
comforting (47)
command (718)
CompMatCare[31] (34)
conjoined attention (107)
conversation (11)
discussion (6)
EXPANDS (6)
explanation (33)
humor (50)
modeling behavior (2)
no response (108)
no response child (126)
nonverbal (759)
nonverbal response (164)
question/answer (82)
repetition-adult (30)
repetition-child (28)
teaching (67)
verbal response (230)

Nutritional care codes:

active feeding (475)
assuring adequate intake (0)
CG encourages eating (55)
CG facilitates eating (25)
CG gives more (19)
CG monitors eating (6)
CG provides food (428)
hand feeds (8)
spoon (34)

Meal and snack codes:

attaya[32] (62)
bean snack (6)
beignet snack (27)
biscuit snack (12)
bread plus snack (45)
bread snack (65)
breakfast (75)
candy (50)
candy snack (11)
coconut snack (25)
cola nut (5)
cookie snack (33)
dinner (65)
diogonal (8)
dry rice snack (1)
egg snack (2)
fataya[33] snack (19)
fish snack (42)
Food (948)
frozen snack (28)
fruit snack (99)
juice snack (10)
leftover rice (43)
lunch (78)
meal (216)
meat snack (3)
milk snack (27)
millet peanut snack (4)
millet snack (13)
pasta snack (3)
peanut snack (68)
plain rice snack (25)
porridge snack (41)
rice plus snack (16)
seafood snack (31)
snack (732)
soda (25)
soda snack (5)
starchy veg snack (17)
vegetable sauce snack (4)
vegetable snack (0)
water (328)
yogurt snack (29)

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31 CompMatCare = Compensatory Maternal Care

32 Attaya is the traditional afternoon tea: highly sweetened, strong green tea.

33 Fataya is a fried snack of spicy fish encased in pastry.

Child activity/behavior/state codes:
angry (5)
backed (65)
bad behavior (93)
bathing (117)
carried (284)
crying (501)
DA[34]-adult (0)
DA-alone (3)
DA-group (6)
DA-other (0)
dance (215)
diaper (8)
drowsy (48)
errand (462)
exploratory play (14)
FA[35]-adult (15)
FA-alone (144)
FA-group (63)
FA-other (75)
failed command (176)
failed errand (45)
first aid (13)
greeting (81)
grooming (316)
happy (550)
high energy (23)
housework (92)
imaginative play (81)
imitative play (85)
laying (867)
low energy (24)
money (105)
neutral (7)
physical play (30)
physically sick (2)
pica? (4)
pottying (215)
run (1641)
sad (4)
school (3)
selling fish (5)
singing (79)
sit (4670)
sleep (73)
stand (5548)
teasing (245)
teasing play (71)
walk (6099)
watch (165)
watches TV (83)
whiny (692)

[34] DA=diffuse activity
[35] FA=focused activity

Relationship to child codes:
adult CG (1)
adult cousin CG (1)
alternate CG (17)
aunt (52)
aunt CG (1)
aunts (6)
brother (1)
brother CG (1)
cousin (38)
cousin CG (1)
father (430)
grandparent (312)
grandparent CG (1)
man in compound (170)
man outside compound (81)
men in compound (11)
mother (2331)
people in compound (2)
people outside compound (1)
sister (6)
sister CG (13)
teacher (5)
uncle (152)
woman in compound (325)
woman outside compound (79)
women in compound (32)
women outside compound (3)
younger sib (29)

Handwashing/sanitation codes:
after defecation (0)
after meal (90)
before meal (57)
handwash (197)
Sanitary Behaviors (323)
warning about "dirty" place/thing (9)
sheep (69)
sheep dung (4)
sheep urine (1)

Traditional values/practices codes:
Adherence to Tradition (24)
timis[36] (14)
traditional medicine (4)

[36] "Timis" is the Wolof word for dusk. This is considered a time for the spirits to be wandering about and young children should stay in the family compound.

Direct quote descriptions of child:
"bandit" (3)
"Baye Fall" (2)
"chatte" (1)
"crazy" (1)
"dirty" (7)
"greedy eater" (2)
"impolite" (1)
"loves to eat" (1)
"oepel" (3)
"rude" (6)
"shy" (1)
"sop" (1)
"special" (1)
"sy-sy" (3)
"tease" (1)
"too curious" (1)
"turbulent" (1)
"ugly" (3)

Query tool codes combining maternal interactions (MAT) with other variables:
***MAT bathing (17)**
***MAT comforting (8)**
***MAT command (433)**
***MAT conjoined attention (36)**
***MAT errand (184)**
***MAT explanation (20)**
***MAT failed command (87)**
***MAT failed errand (34)**
***MAT grooming (235)**
***MAT monitors (4)**
***MAT names (6)**
***MAT no response (84)**
***MAT nonverbal (427)**
***MAT nonverbal response (110)**
***MAT Physical affection (17)**
***MAT Positive voice (9)**
***MAT Praise (5)**
***MAT question/answer (37)**
***MAT restricts (51)**
***MAT scolds (83)**
***MAT shouts (27)**
***MAT singing (4)**
***MAT structures play (8)**
***MAT teaching (21)**
***MAT verbal response (157)**
***MAT watches (11)**
***MATadult-init (173)**