NUTRITIONAL, DEMOGRAPHIC, AND BEHAVIORAL DIFFERENCES BETWEEN
SUBJECTS FROM TWO SIMILAR WIC CLINICS WITH
DIFFERENT PREVALENCES OF ANEMIA

THESIS

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

By

Damon J. Vidrine, B.A.

Denton, Texas

December, 1997
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The purpose of the study was to determine what nutritional, demographic, and behavioral differences existed between children one year of age from two similar WIC clinics with different prevalences of anemia. Children from the higher-prevalence site were found to consume significantly ($p < .05$) more B12, C, copper, fiber, folate, total kilocalories, and riboflavin than did children from the lower-prevalence site. Family income and maternal weight gain were significantly ($p < .05$) higher in the lower-prevalence group as compared to the higher-prevalence group. In addition, children from the higher-prevalence site were enrolled in the WIC program at a significantly ($p < .05$) younger age than were children from the lower-prevalence site.
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CHAPTER I

INTRODUCTION

Anemia, defined as a low level of hemoglobin or hematocrit concentration, is among the most widespread public health problems in the world. Infants and children are among the most frequent victims (Hercberg & Galan, 1992). During childhood this condition is associated with numerous adverse health consequences. Children with anemia demonstrate lower physical and psychomotor functioning than children with normal iron status (Aukett, Parks, Scott, & Wharton, 1986). Cognitive and behavioral development are also adversely affected (Deinard, List, Lindgren, Hunt, & Chang, 1986; Driva, Kafatos, & Solman, 1985). Although many of these developmental delays can be improved quickly with better nutrition or iron supplementation, there is evidence that mental and motor developmental disadvantages among children diagnosed with anemia in infancy are long-term (Lozoff, Jimenez, & Wolf, 1991).

The current study examined factors commonly associated with anemia among children 12 to 13 months of age at two inner city nutritional clinics located in San Antonio, Texas. The clinics provide the Special Supplemental Food
Program for Women, Infants, and Children (WIC). Despite numerous similarities between the two clinics, the prevalence of anemia among children in one clinic (57.7%) was more than double the rate of the other clinic (22.1%). The purpose of the study was to determine what nutritional, demographic, and behavioral differences existed between subjects from the two clinics. Nutritional variables considered included intake of vitamin B12, vitamin C, copper, dietary fiber, folate, iron, kilocalories, protein, and riboflavin. Other variables considered included family income, family size, maternal weight gain during pregnancy, number of weeks breast-fed, child's birth weight, and the age at which the child began the WIC program.

The Centers for Disease Control and Prevention (CDC) criteria were used to define anemia. For children 12 to 24 months of age, a hematocrit less than or equal to 33% or hemoglobin less than or equal to 11.0 g/dl was considered anemic (CDC, 1989) (see Table 1).

Statement of Problems

This study examined differences between children, 12 to 13 months of age, from two similar clinics providing the Special Supplemental Food Program for Women, Infants, and Children (WIC). One clinic had a prevalence of anemia more than double that of the other (57.7% vs. 22.1%). Variables
examined have been shown to influence the prevalence of anemia in infants and children. Nutritional variables included intake of vitamin B12, vitamin C, copper, dietary fiber, folate, iron, kilocalories, protein, and riboflavin. Other variables considered included family income, family size, maternal weight gain during pregnancy, number of weeks breast-fed, child's birth weight, and the age at which the child began the WIC program.

Significance of the Study

Anemia in childhood has been established as a significant public health concern. Although much improvement has been made in the United States, the condition still poses a significant threat to children from low socioeconomic status (SES) families. The Special Supplemental Food Program for Women, Infants, and Children (WIC) was established by the United States Department of Agriculture (USDA) in part to combat this condition in low SES families (USDA, 1994).

In several areas of Texas, the prevalence of anemia among children 12 to 13 months of age on the WIC program remains well above the national average (Texas Department of Health [TDH], 1995). Because of the adverse mental and motor developmental effects of anemia in this period of life, it is important that an attempt be made to determine
factors that could possibly be associated with the elevated rates. If the cause is dietary, the approach taken by the Texas WIC program may need to be modified to better meet the needs of the WIC population. If the cause is not dietary, additional public health efforts may be warranted to investigate possible environmental or biological causes.

Hypotheses

For the purposes of this study, the following hypotheses are submitted:

1. Children from the WIC clinic with the lower prevalence of anemia consume more vitamin B12, vitamin C, copper, folate, iron, kilocalories, protein, and riboflavin than children do from the WIC clinic with the higher prevalence of anemia.

2. Children from the WIC clinic with the lower prevalence of anemia consume less dietary fiber than do children from the WIC clinic with the higher prevalence of anemia.

3. Children from the WIC clinic with the lower prevalence of anemia have a smaller family size than do children from the WIC clinic with the higher prevalence of anemia.

4. Children from the WIC clinic with the lower prevalence of anemia have higher family income per member
than do children from the WIC clinic with the higher prevalence of anemia.

5. Children from the WIC clinic with the lower prevalence of anemia have a younger certification age (the age at which the subject began the WIC program) than do children from the WIC clinic with the higher prevalence of anemia.

6. Mothers of children from the WIC clinic with the lower prevalence of anemia have higher maternal weight gain than do mothers of children from the WIC clinic with the higher prevalence of anemia.

7. Children from the WIC clinic with the lower prevalence of anemia were breast-fed longer than were children from the WIC clinic with the higher prevalence of anemia.

8. Children from the WIC clinic with the lower prevalence of anemia have a higher birth weight than do children from the WIC clinic with the higher prevalence of anemia.

Definitions of Terms

24-Hour Diet Recall: Diet recall taken at the child certification period in which all food and drink consumed by the child in the previous 24 hours is verbally reported by
the child's guardian to a nutritionist trained in diet recall procedures.

**Anemia:** For children 12 to 24 months of age, either a hematocrit less than or equal to 33% or a hemoglobin less than or equal to 11.0 g/dl (CDC, 1989).

**Birth Weight:** Birth weight, in ounces, of the child.

**Certification Age:** Age at which the subject began the WIC program.

**Child Certification Period:** Time at which infant certification expires and the WIC client is considered a Child; occurs at 12-13 months of age.

**Family Income:** Total income of all individuals living in the same household as the child.

**Family Income Per Member:** Total household income divided by the number of individuals living in the household.

**Family Size:** Number of individuals living in the household.

**Hematocrit:** Test that measures the percentage of red blood cells (RBC) in a sample of whole blood. Scores typically range from 29% to 40% (Pearson & Horkey, 1992).

**Hemoglobin:** Test that measures the concentration of hemoglobin in a sample of whole blood. Scores typically
range from 8 to 15 grams per deciliters (g/dl) (Pearson & Horkey, 1992).

Infant Certification Period: Period from birth to 12 months of age in which a subject participating in the WIC program is considered an infant.

Iron Status: Child's score on either hematocrit or hemoglobin as measured at the time of child certification.

Maternal Weight Gain: Estimated amount of weight gained (lbs) by the child's mother during pregnancy. This estimation is recorded at the infant certification period.

Project: Administrative divisions of the Texas WIC program.

Weeks Breast-Fed: Estimated number of weeks in which the child was exclusively breast-fed. This estimation is recorded at the infant certification period.

WIC: The Special Supplemental Food Program for Women, Infants, and Children; designed to provide supplemental foods, nutrition education, and referrals to other health care and social services to income-eligible (< 185% of poverty level) pregnant, postpartum (up to 6 months), and breast-feeding women as well as to infants and children up to 5 years of age (USDA, 1994).
CHAPTER II

REVIEW OF LITERATURE

Worldwide, iron-deficiency anemia is among the most prevalent public health problems. This type of anemia can result from a nutritional deficiency, an excessive iron loss, or an increased metabolic requirement. The most common nutritional deficiencies resulting in anemia are iron, folate, B12, copper, riboflavin, and protein (Hercberg & Galan, 1992). While the diagnostic criteria has been the object of debate, the CDC has set the most commonly used diagnostic criteria (CDC, 1989) (see Table 1). The purpose of the study was to determine what nutritional, demographic, and behavioral differences existed between subjects from two similar WIC clinics. The prevalence of anemia among children from one clinic was more than double the prevalence from the other (57.7% vs. 22.1%). The nutritional variables considered included intake of vitamin B12, vitamin C, copper, dietary fiber, folate, iron, kilocalories, protein, and riboflavin. Other variables considered included family income, family size, maternal weight gain during pregnancy, number of weeks breast-fed, child's birth weight, and the age at which the child began the WIC program.
The Special Supplemental Food Program for Women, Infants, and Children (WIC) is designed to combat nutritional inadequacies among eligible clients by providing supplemental foods, nutrition education, and referrals to other health care and social services. The program is available to pregnant, postpartum (up to 6 months), and breast-feeding women as well as to infants and children up to 5 years of age. Clients must meet income and nutritional risk criteria prior to acceptance in the WIC program (USDA, 1994). In Texas, the WIC program is divided into 81 administrative districts referred to as projects. Projects in rural parts of the state may span several counties and include several clinics, whereas large cities may contain numerous projects. Projects in large cities may contain only one or two full-time clinics (TDH, 1995).

Table 1

CDC Diagnostic Criteria for Anemia

<table>
<thead>
<tr>
<th>Age in months</th>
<th>Hemoglobin (g/dl)</th>
<th>Hematocrit (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children (12-24)</td>
<td>&lt; 11.0</td>
<td>&lt; 33.0</td>
</tr>
<tr>
<td>Children (24-60)</td>
<td>&lt; 11.2</td>
<td>&lt; 34.0</td>
</tr>
</tbody>
</table>
Iron plays a crucial role in the metabolic function. In the body, most iron is present in hemoglobin and myoglobin (compounds that supply oxygen to tissues throughout the body) (Hercberg & Galan, 1989). The remainder is typically stored as ferritin (a large iron-storage protein) and hemosiderin (a molecule that consists of components derived from ferritin). These compounds are typically stored in the liver and spleen (Lauffer, 1992). If iron intake is either insufficient to replenish daily iron losses, insufficient to permit metabolic iron utilization, or insufficient to maintain the proper level of iron stores, the body typically goes through three stages of deficiency. The first stage is iron depletion. In this stage iron stores are exhausted, but there is not yet a decrease in the iron supply to red blood cells. The second stage is iron-deficient erythropoiesis. During this stage, an inadequate amount of iron is available for erythrocyte production, but the amount of hemoglobin circulating in the body is not yet significantly reduced. The final stage is overt anemia. In this stage there is a significant reduction in the amount of hemoglobin, thus an inadequate amount of oxygen is being circulated throughout the body (Cook, 1982).
Although no population is free from the risk of anemia, this condition usually afflicts infants, young children, menstruating women, or pregnant women. The additional nutritional requirements of these populations significantly increases the risk of an iron-deficient condition. To confound this situation among infants and children, the presence of iron deficiency and anemia is associated with reduced scores on physical and psychomotor scales (Aukett et al., 1986). Other reported findings of the adverse health consequences of iron deficiency and anemia in children have also been found. Deinard et al. (1986) found that children with iron deficiency showed significant cognitive impairment as compared to children with adequate iron levels.

Many of these deficits can be remedied by the administration of oral iron therapy, but some cases may be more enduring. Lozoff et al. (1991) found long-term sequelae associated with iron-deficiency anemia in childhood. In this study, 5-year-old children with iron-deficiency anemia were assessed with a battery of developmental tests (intelligence, educational, visual-motor, and motor proficiency). The children had been diagnosed as anemic during infancy and subsequently treated with iron supplementation. By their 5th year, all of the children were determined to have an appropriate hematologic
status and average growth rates. Their scores on the battery of developmental tests, however, were significantly lower than those of children from families of similar socioeconomic status (SES) with no history of anemia. Lozoff et al. claimed that the results demonstrate that iron-deficiency anemia in infancy is associated with long-term developmental delays. The validity of these findings has been questioned because of the lack of information about possible lead intoxication of the subjects. High blood-lead levels have been shown to cause the same developmental delays (Marcus, 1992; Petrone, 1992). Other long-term effects of iron deficiency in childhood or infancy include an impairment in ability to concentrate, poor coordination, and an increase in hyperactivity (Cantwell, 1974).

Assessment of Iron Status

Various methods are available to assess iron status. The two most common tests are hematocrit percentage and hemoglobin level. While both of these tests are inexpensive and have proven to be reliable screening methods for anemia, the hematocrit test is not as sensitive as the hemoglobin test in diagnosing anemia. If both tests were administered to the same population, the results of the hematocrit test would indicate a lower prevalence of anemia than would the
results of the hemoglobin test (Graitcer, Goldsby, & Nichaman, 1981).

The hematocrit test measures the percentage of red blood cells (RBC) in a sample of whole blood. To measure hematocrit percentage, a tube of whole blood is placed in a centrifuge and spun, packing all RBCs in the bottom of the tube. After the spin cycle is completed, the RBCs are packed on the bottom of the tube, with clear plasma resting on top. The formula, hematocrit \(\% = \left(\frac{\text{volume of packed RBC}}{\text{volume of whole blood}}\right) \times 100\), gives the hematocrit value (Pearson & Horkey, 1993).

The hemoglobin test measures the concentration of hemoglobin (iron-containing protein in blood) in a sample of whole blood. Hemoglobin levels are attained by treating the blood sample with a special reagent which break open the RBCs releasing the hemoglobin. A hemoglobinometer then assesses the amount of hemoglobin in the sample and displays the value (g/dl) (Pearson & Horkey, 1993).

Prevalence Estimates

As the number of children living in poverty continues to climb, the risk of anemia also climbs (Children's Defense Fund, 1992). According to conservative estimates, worldwide as many as 700 million people have iron-deficiency anemia (Hercberg & Galan, 1992). Driva et al. (1985) estimated
that as much as 20% of the world's population suffers from iron deficiency. Children in developing countries are frequently afflicted; approximately 51% of children ages 0 to 4 years living in such countries are anemic. Studies looking at select populations in developing countries have found rates as high as 77% to 80% (El-Sahn, 1992; Kuvibidila, Yu, Ode, Mbele, & Warrier, 1993). Estimates for children in North America are around 8% (Demaeyer & Adiels-Tegman, 1985; Levin, Pollitt, Galloway, & McGuire, 1993) (see Table 2).

Estimates of the prevalence of anemia in North America may be misleading. Children from low SES families have substantially higher rates. According to data collected through the Pediatric Nutrition Surveillance System (PedNSS) (Head Start, Early and Periodic Screening, Diagnosis, and Treatment Program [EPSDT], and WIC), the prevalence of anemia in children 24 months or younger was between 20% and 30%. Of these cases, approximately 80-90% could be attributed to inadequate iron intake (Yip et al., 1992). Despite reports from Yip, Binkin, Fleshood, and Trowbridge (1987) that prevalence of anemia was declining in the United States, more recent findings indicate that the rate is actually increasing among some minority populations (Pollitt, 1994).
Table 2

Prevalence of Anemia in Children

<table>
<thead>
<tr>
<th>Population</th>
<th>Age</th>
<th>Total (millions)</th>
<th>Number anemic</th>
<th>Percent anemic</th>
<th>Criteria for anemia</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hemoglobin g/dl</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Hematocrit) %</td>
</tr>
</tbody>
</table>

World 0-4 yrs. 445.10 193.50 43 < 11.0
North 0-4 yrs. 19.60 1.60 8 < 11.0
America
U.S. < 24 mos. 2.28 0.57 20-30 < 11.0
(PedNSS) (< 33)
National 12-24 mos. 1.20 0.18 14.7 < 11.0
WIC (< 33)
Texas 12-24 mos. 0.17 0.05 31.3 < 11.0
WIC (< 33)

According to national data from the WIC program, prevalence of anemia among children from 1 to 4 years of age is approximately 15.5% (USDA, 1992). In the state of Texas, the problem of childhood anemia among WIC participants may
be more severe. Almost half (48.3%) of the children ages 1 to 4 years on WIC meet the diagnostic criteria for anemia (TDH, 1995).

Causes of Anemia and Iron Deficiency

Nutritional Deficits

The most common cause of anemia and iron deficiency is inadequate dietary intake of iron. Because an increased amount of iron is needed for an expanding red blood cell mass and the increased oxygen needs of growing tissue, infants and children are particularly at risk. If iron intake is not satisfactory, the growing child is at risk of becoming anemic. Nutritional deficiencies of folic acid, vitamin B12, vitamin C, copper, riboflavin, and protein can also lead to anemia. These nutrients play important roles in the uptake and utilization of iron in the body (Hercberg & Galan, 1992).

An excess of dietary fiber can also lead to anemia. Too much fiber in the diet decreases iron absorbability. In infants, this decreased absorbability can lead to anemia (Bushnell et al., 1992).

The use of whole cow's milk before 1 year of age has also been linked to anemia. Many infants are not able to digest intact whole cow's milk proteins. As these undigested proteins pass into the infant's digestive tract,
gastrointestinal bleeding occurs, which can lead to anemia. Whole cow's milk also does not contain an adequate level of iron for the growing infant (Committee on Nutrition, 1992). In addition, the iron that it contains is poorly absorbed. Another problem is that the consumption of whole cow's milk impairs the infants ability to absorb iron from other foods (Buchanan, 1996).

Lactose intolerance may result in blood loss leading to anemia. Lactose intolerance is especially prevalent in minority populations (Committee on Nutrition, 1992).

Toxins

Certain medications and environmental toxins have been linked to anemia in children. For example, regular use of nonsteroidal anti-inflammatory medication, such as aspirin, can cause gastrointestinal blood loss which may lead to anemia (Brigden, 1993).

Aluminum has also been linked to anemia. Elevated levels of this element can usually be traced to medications, such as antacids and treatment for kidney disease. Other less common sources of elevated aluminum levels include drinking tap water high in aluminum levels, eating or drinking foods prepared in aluminum cookware, and eating or drinking foods stored in aluminum containers (Andreoli, Bergstein, & Sherrard, 1984; Sedman, Wilkening, Warady, Lum,

Lead has received more attention than all other anemia-causing toxins. Estimates of prevalence of anemia among children with elevated lead levels range from 30% to 80% (Yip, Norris, & Anderson, 1981). Research suggests that low iron levels increase risk of elevated blood-lead levels, whereas elevated blood-lead levels increase risk of low iron levels. Although it is not clear if one condition directly causes the other, it is clear that the conditions frequently exist simultaneously. Treatment of one of these conditions often improves the other condition (Bellinger et al., 1991; Mahaffey, 1982; Markowitz, Rosen, & Bijur, 1990).

Behavioral

A commonly seen cause of iron deficiency-anemia in infants is unsupplemented breast or formula feeding. Although children who are breast-fed are not as likely to be anemic (iron in breast milk is more readily absorbed than iron in formula), if not given supplementation by 4 to 6 months of age, they are still at risk (Brigden, 1993).

Demographic

Studies designed to assess demographic characteristics of specific populations have led to conflicting results. For
example, Kuvibidila et al. (1993) identified several person factors that influence the prevalence of anemia in a group of children from Bas-Zaire. These factors included the following: Boys tend to have higher hemoglobin counts than girls; children between 12 and 24 months of age are most at risk for anemia; and a child's hemoglobin level tends to be positively correlated with the educational level of the mother. Grant (1990) utilized a similar study design to determine prevalence of iron-deficiency anemia in preschool children in Ireland. Neither sex, birth order, social class, nor breast-feeding history was correlated with iron status.

There is also evidence that ethnicity may influence hemoglobin status. Black children may have lower hemoglobin levels than white children, thus putting them more at risk of fulfilling the current diagnostic criteria for anemia. In the future it may be necessary to develop separate criteria for racially diverse populations (Jackson, 1990).

Another group of children at risk for anemia are those born prematurely. Preterm infants are not able to produce erythropoietin from the peritubular cells, as are term infants. This lack of production can result in temporary anemia in the infant (Ohls, Li, Trautman, & Christensen, 1994).
Infection

Parasitic infection. Although nutritional deficits are one cause of anemia, pathological iron loss is another contributor. Parasitic infection is one of the most common reasons for blood loss from the gastrointestinal tract. The malaria-causing *Plasmodium falciparum* is one of the most common parasitic causes of anemia in tropical regions of the world (Kasili, 1990). In Texas, however, malaria is not often reported. In 1994, only 43 cases of malaria were seen in the state (CDC, 1995a).

Affecting millions of people worldwide, hookworm is another commonly seen parasite in anemic individuals inhabiting tropical regions. Unlike *P. falciparum*, which is usually transmitted in the rainy season, hookworm transmission takes place year-round. It usually results from walking barefoot on soil polluted by larvae of the parasite (Hercberg & Galan, 1992). Most cases of hookworm seen in the United States are likely not endemic (Kappus, Lundgren, Juranek, Roberts, & Spencer, 1994).

**Bacterial infection.** Severe bacterial infection is a well-recognized cause of anemia (Olivares, Walter, Osorio, Chadud, & Schlesinger, 1989). This type of infection usually results in an acute but severe anemic condition. *Hemophilus influenzae*, usually associated with bacterial
meningitis, has been shown to cause this condition (Shurin, Anderson, Zollinger, & Rathbun, 1986). Prior to the availability of a vaccine in 1988, *H. influenzae* was the most common cause of bacteria meningitis in the United States. In 1987 there were 41 cases of *H. influenzae* infection per 100,000 children age 5 years and younger. By 1994 that rate had dropped to 1.7 per 100,000 (CDC, 1995b).

Bloody diarrhea caused by *Escherichia coli*, a common bacteria, has also been shown to cause anemia in infected individuals (Ornt, Griffin, Wells, & Powell, 1992). Evidence suggests that there has been an increase in the number of cases of *E. coli* in the past 10 years. At present, however, there are no reporting laws, so accurate prevalence rates are not available (Berkelman, 1993).

Although bacterial-induced anemia is thought to be a relatively rare condition, it should not be overlooked. Because of easy transmission (food, water, and person to person), it may be a threat to people living in close proximity to each other (i.e., siblings) (Pennings, Seitz, Karch, & Lenard, 1994).

**Viral infection.** Like the previously mentioned bacterial infections, severe viral infections such as influenza, herpes simplex, and mononucleosis can cause anemia by altering iron metabolism in an otherwise healthy
individual (Baranski & Young, 1987). It has become apparent over the last few years that mild viral infections often encountered in childhood may also cause anemia.

Olivares et al. (1989) examined the effects that a mild viral infection would have on healthy 12-month old children. Regularly scheduled measles vaccination (with live attenuated measles virus) was used to simulate the effects of a viral infection. Approximately 25% of the children in the study group became anemic by day 14 post-inoculation. This temporary anemic condition disappeared by day 30 post-inoculation.

Cemeroglu and Ozsoylu (1994) also studied children with viral infections and their subsequent iron status. In their investigation, all children (median age 6 years) seeking treatment at a local hospital for either chicken pox or mumps viral infections were given blood tests so that their iron status could be determined. At the time of initial examination, 59.2% of the children had serum iron levels below 30 micrograms/dl. Most of the patients returned to normal iron levels by 21 days after initial examination.

Also implicated as a cause of iron deficiency is the B19 parvovirus. This common virus has been shown to cause a slow decrease in hemoglobin. Although this decrease is usually slight (1-2g/dl), the result can be severe anemia in
some children (Murray, Gresik, Leger, & McClain, 1993). While mild viral infections, caused by either vaccinations or common viruses, are usually not considered as causes of anemia, these studies suggest they should be. If not, recently infected children may be exposed unnecessarily to the risks involved in iron treatment (Berkovitch, Matsui, Lamm, Rosa, & Koren, 1994).
CHAPTER III

RESEARCH METHODOLOGY

Site Selection

Data from each of the 81 WIC projects located in the state of Texas were examined. These data were retrieved by accessing a computerized database referred to as the Teradata. This database is located at the Texas Department of Health main complex in Austin. Each WIC project in the state regularly downloads data into the Teradata via modem.

From each project only data on children born in 1993, enrolled in the WIC program before 12 months of age, and still active in the WIC program at age 12 to 13 months were considered. A mean hematocrit percentage or a mean hemoglobin (g/dl) was computed for this group of subjects, 12 to 13 months of age, from each WIC project. Ten projects with a prevalence of anemia as defined by the CDC (1989) of > 50% were identified (see Table 3 and Figure 1). From this group of 10 projects, project 59, located in San Antonio, Texas, was selected as the site for the investigation. In 1994 the prevalence of anemia among clients 12 to 13 months of age from project 59 was 57.7%.
Project 73, also located in San Antonio, was selected as a control group. Both projects 73 and 59 have only one

Table 3

WIC Projects With High Prevalences of Anemia Among Children 1 Year of Age

<table>
<thead>
<tr>
<th>Project</th>
<th>Number</th>
<th>Percent</th>
<th>Counties served</th>
</tr>
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<tr>
<td></td>
<td>anemic</td>
<td>anemic</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>730</td>
<td>50.6</td>
<td>Kinny, Maverick</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td>Goliad, Jackson,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Victoria</td>
</tr>
<tr>
<td>39</td>
<td>596</td>
<td>56.0</td>
<td>Cherokee, Smith</td>
</tr>
<tr>
<td>58</td>
<td>377</td>
<td>60.6</td>
<td>Angelina</td>
</tr>
<tr>
<td>59</td>
<td>593</td>
<td>55.5</td>
<td>Bexar</td>
</tr>
<tr>
<td>61</td>
<td>362</td>
<td>59.7</td>
<td>Jasper, Newton,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sabine, San</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Augustine</td>
</tr>
<tr>
<td>63</td>
<td>172</td>
<td>53.8</td>
<td>Hardin</td>
</tr>
<tr>
<td>Project</td>
<td>Number</td>
<td>Percent</td>
<td>Counties served</td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>---------</td>
<td>-----------------</td>
</tr>
<tr>
<td>anemic</td>
<td>anemic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>113</td>
<td>50.4</td>
<td>Brazoria, Fort Bend, Harris</td>
</tr>
<tr>
<td>79</td>
<td>4</td>
<td>66.7</td>
<td>Hardin, Jefferson, Orange</td>
</tr>
</tbody>
</table>

Figure 1. WIC projects with prevalences of anemia greater than 50% among children 12 to 13 months of age.
Legend

<table>
<thead>
<tr>
<th>Project</th>
<th>Counties Served</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Kinny, Maverick</td>
</tr>
<tr>
<td>32</td>
<td>Brazos, Grimes, Leon, Madison, Robertson</td>
</tr>
<tr>
<td>37</td>
<td>Calhoun, Dewitt, Goliad, Jackson, Victoria</td>
</tr>
<tr>
<td>39</td>
<td>Cherokee, Smith</td>
</tr>
<tr>
<td>58</td>
<td>Angelina</td>
</tr>
<tr>
<td>59</td>
<td>Bexar</td>
</tr>
<tr>
<td>61</td>
<td>Jasper, Newton, Sabine, San Augustine</td>
</tr>
<tr>
<td>63</td>
<td>Hardin</td>
</tr>
<tr>
<td>77</td>
<td>Brazoria, Fort Bend, Harris</td>
</tr>
<tr>
<td>79</td>
<td>Hardin, Jefferson, Orange</td>
</tr>
</tbody>
</table>

The project 59 clinic is located west of downtown San Antonio, and the project 73 clinic is located southwest of downtown. These two clinics are located approximately 10 miles apart, and they served a similar number of predominantly Hispanic clients in 1994 (see Table 4 and Table 5). Despite these similarities, the prevalence of anemia among 12- to 13-month old clients from project 73 in 1994 was less than 25%. This rate is far below that of project 59 (57.7%) (see Figure 2).
Figure 2. Prevalence of anemia among children 12 to 13 months of age, born in 1993.

Table 4

Clients Served by Projects 59 and 73

<table>
<thead>
<tr>
<th>Project</th>
<th>Number of clients</th>
<th>Number of 1-year old clients</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>3806</td>
<td>1069</td>
</tr>
<tr>
<td>73</td>
<td>3906</td>
<td>1146</td>
</tr>
</tbody>
</table>

Subject Selection

The sample for this study was comprised of WIC clients from two projects, 59 (higher prevalence of anemia) and 73 (lower prevalence of anemia). All subjects were born in
1993, were enrolled in the WIC program before they were 12 months of age, and were still active in the WIC program at age 12 to 13 months.

Table 5

<table>
<thead>
<tr>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>59</td>
</tr>
<tr>
<td>73</td>
</tr>
</tbody>
</table>

All WIC clients from project 59 fulfilling the above selection criteria were selected (approximately 350 subjects). One hundred and fifty qualifying subjects were randomly selected from project 73. Random selection was made using SPSS for Windows 6.1.3 software (SPSS Inc., 1995).

Procedure

After gaining consent of the project directors from both sites, the 24-hour diet recall was collected from each subject's file. The 24-hour diet recall was completed while
the child was between the ages of 12 and 13 months. Twenty-four-hour diet recalls have been shown to be a valid representation of the nutritional intake of a group (Karvetti & Knuts, 1985).

The 24-hour diet recalls were performed by WIC nutritionists (registered and licensed dietitians) at each clinic site at the time of WIC certification as a child (between ages 12 and 13 months). The nutritionist instructed the child's guardian to list all foods and drinks consumed by the child on the preceding day. The nutritionists utilized samples of portion size with the aid of cups, glasses, and bowls to obtain accurate reports of quantities consumed. Each WIC nutritionist followed this procedure when collecting recalls as outlined in state policy NO.:CS:04.6 (TDH, 1994).

The 24-hour diet recalls were analyzed with Nutritionist IV for Windows (First DataBank, 1994). Food types and quantities were transferred into this computer application exactly as they appeared on the 24-hour diet recall. A separate report providing the approximate intake levels of kilocalories (Kc), protein (g), iron (mg), copper (mg), riboflavin (mg), folate (mg), B12 (mg), vitamin C, and dietary fiber (g) was then generated for each subject.
Iron status as measured at age 12 to 13 months was used to determine prevalence of anemia in each project. Iron status was measured as hematocrit percentage at project 59 and as hemoglobin (g/dl) at project 73. This measure was collected at the same time as the 24-hour diet recall. Procedures for obtaining both of these measures are described in the WIC training guide, Testing for Hematocrit and Hemoglobin Values (Pearson & Horkey, 1992) (see Appendix A for a complete description). These measures were collected from Teradata.

Values for kilocalories (Kc), protein (g), iron (mg), copper (mg), Riboflavin (mg), folate (mg), B12 (mg), vitamin C, and dietary fiber (g) as obtained from the Nutritionist IV report of the 24-hour diet recall served as the nutritional variables.

Other variables collected from Teradata include birth weight—birth weight, in ounces, of the child; certification age—age at which the child began the WIC program; family income—total income of all individuals living in the same household as the child; family income per member—total family income divided by the number of individuals living in the household; family size—number of individuals living in the household with the child; maternal weight gain—amount of weight gained by the child's mother during pregnancy;
weeks breast fed—number of weeks in which the child was exclusively breast-fed; language—the language the child’s guardian preferred to speak; and sex—the sex of the child. These data were collected by staff at each of the two sites at the time of child certification at 12 to 13 months of age.

**Statistical Analysis**

Chi square analysis was performed to determine whether the difference in prevalence of anemia between subjects at the two WIC projects was significant \((p < .05)\). To determine whether significant differences \((p < .05)\) in the mean value for each dependent variable existed between subjects of the two projects, analysis of variance was performed. All statistical procedures were conducted using SPSS for Windows 6.1.3 software (SPSS Inc., 1995).

**Limitations**

1. No data were available concerning medications that the subjects were taking at the time of child certification. As discussed in the review of literature, certain medications have been shown to cause anemia in children. It is assumed that no group differences exist in types and amount of medication taken.

2. No data were available concerning possible aluminum toxicity. Reports of aluminum poisoning, other
than individuals undergoing dialysis are rare (Tsou et al., 1991).

3. No data were available concerning blood-lead levels. This should be addressed in future research.

4. Data on the type of formula the child was given were not collected. However, because all children in the WIC program are provided only with iron-supplemented formula (unless medically contraindicated), it is assumed that no group differences exist.

5. Data on amount of whole cow's milk consumed and age at which child was first given whole cow's milk were not collected. Whole cow's milk has been shown to interfere with iron absorption (Buchanan, 1996). This should be addressed in future research.

6. Prevalence of lactose intolerance in each group is unknown. However, because the ethnicity of each group was the approximately the same (predominately Hispanic), it is assumed that no group differences exist.

7. Data on number of preterm infants in each group were not available. Because preterm infants often have low birth weights, the birth-weight variable is assumed to account for any influence that preterm births may have.

8. Data on recent infections (parasitic, viral, and bacterial) were not available. Most of the discussed
infections are rarely seen in the United States. In addition, all children on WIC are required to be up to date on all immunizations (must be documented) prior to child certification. It is possible, however, that a localized outbreak of a common viral infection could have occurred.

9. Date of immunization was not collected. Because all Texas WIC clinics follow the same immunization schedule, the effects of recent immunizations on iron status were assumed to be no different between the groups.

10. Assessment of iron status was made using different techniques in the two projects (hemoglobin g/dl in project 73 and hematocrit % in project 59). Ideally, the two groups should have used the same test.
CHAPTER IV
RESULTS

Data was collected from the records of 486 children. 352 were from project 59 (high-prevalence site) and 134 were from project 73 (low-prevalence site). The records of 26 children (10 from project 59 and 16 from project 73) were unavailable at the time of data collection. All subjects were Hispanic.

Chi square analysis showed a significant difference in prevalence of anemia between the two projects ($X^2(1, N = 481) = 41.71, p < .001$). Prevalence of anemia was 55% among children from project 59 and 22% among children from project 73.

Several differences in nutrient intake between the two groups were observed. According to the 24-hour diet recalls, children from project 59 (high-prevalence site) consumed more vitamin B12, $F(1, 439) = 4.24, p < .05$; more vitamin C, $F(1, 439) = 6.56, p < .05$; more copper, $F(1, 439) = 8.45, p < .05$; more dietary fiber, $F(1, 439) = 5.12, p < .05$; more folate, $F(1, 439) = 63.05, p < .05$; more total kilocalories, $F(1, 439) = 7.68, p < .05$; and more riboflavin $F(1, 439) = 3.94, p < .05$ than children from project 73.
(low-prevalence site). Significant differences were not observed between the two groups in intake of iron or protein (see Table 6).

In addition to the nutritional differences, several other important demographic and behavioral differences were noted between the two groups (see Table 7). Children from Table 6

**Nutrient Intake Means**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Project 59 Mean (SD)</th>
<th>Project 73 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B12 (mg)</td>
<td>2.8 (1.4)</td>
<td>2.5 (1.0)</td>
</tr>
<tr>
<td>C (mg)</td>
<td>69.6 (70.5)</td>
<td>52.1 (49.8)</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>1.3 (0.7)</td>
<td>1.1 (0.5)</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>4.3 (4.1)</td>
<td>3.4 (2.7)</td>
</tr>
<tr>
<td>Folate (mg)</td>
<td>146.5 (96.2)</td>
<td>123.5 (66.7)</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>4.2 (3.2)</td>
<td>4.5 (2.3)</td>
</tr>
<tr>
<td>Kcal</td>
<td>872.8 (365.0)</td>
<td>774.7 (253.6)</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>39.7 (15.2)</td>
<td>36.7 (13.1)</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>1.4 (0.7)</td>
<td>1.2 (0.6)</td>
</tr>
</tbody>
</table>

project 73 (low-prevalence site) were found to have a significantly higher income per member than the children from project 59 (high-prevalence site), $F(1, 443) = 12.61$, p
< .001 ($2,578 vs. $1,923). Maternal weight gain was also found to be significantly higher in the group from project 73 (low-prevalence site), $F(1, 476) = 7.29, p < .05$ (30.72 lb vs. 27.2 lb).

Table 7

Demographic and Behavioral Means

<table>
<thead>
<tr>
<th></th>
<th>Project 59</th>
<th>Project 73</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (oz)</td>
<td>116.8 (20.9)</td>
<td>117.0 (18.86)</td>
</tr>
<tr>
<td>Family income</td>
<td>7898 (7125)</td>
<td>10864 (6465)</td>
</tr>
<tr>
<td>Income per member</td>
<td>1923 (1861)</td>
<td>2578 (1600)</td>
</tr>
<tr>
<td>Family size</td>
<td>4.4 (1.6)</td>
<td>4.5 (1.6)</td>
</tr>
<tr>
<td>Maternal wt gain (lb)</td>
<td>27.2 (12.0)</td>
<td>30.72 (14.5)</td>
</tr>
<tr>
<td>Certification age (days)</td>
<td>22.5 (35.2)</td>
<td>33.87 (61.6)</td>
</tr>
<tr>
<td>Weeks breast-fed</td>
<td>4.1 (11.4)</td>
<td>4.2 (12.0)</td>
</tr>
</tbody>
</table>

Certification age was found to be significantly different between the two groups. Subjects from project 73 (low-prevalence site) were enrolled in the WIC program at a significantly older age than were subjects from project 59 (high-prevalence site), $F(1, 476) = 6.47, p < .05$.

Significant differences between the two groups were not
observed in birth weight, weeks breast-fed, or family size.
See Table 8 for a display of descriptive statistics.

Table 8
Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Project 59</th>
<th>Project 73</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spanish-speaking (%)</td>
<td>28</td>
<td>16</td>
</tr>
<tr>
<td>English-speaking (%)</td>
<td>72</td>
<td>84</td>
</tr>
<tr>
<td>Male (%)</td>
<td>51</td>
<td>52</td>
</tr>
<tr>
<td>Female (%)</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>Hispanic (%)</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
CHAPTER V

DISCUSSION

Although all individuals participating in the WIC program must meet income eligibility requirements (< 185% of the poverty level), children from project 59 (high-prevalence site) were found to come from families with significantly less income as compared to children from project 73 (low-prevalence site). Numerous studies have demonstrated the relationship between income and child health. Low-SES children have higher morbidity and mortality rates than high-SES children (Singh & Yu, 1995). More specifically, prevalence of anemia in children has been shown to be higher in low-SES populations (Looker, Dallman, Carroll, Gunter, & Johnson, C. L., 1997).

The present study found that, even within this low-SES population, differences in income may play a role in child health. To better serve the WIC population it may be necessary to provide additional benefits to those individuals at the lower end of the income spectrum rather than to consider all eligible participants equivalent. Those at the lower end may in fact benefit from additional foods and educational sessions. Future research efforts
would be needed to identify the income level at which these initial benefits would prove efficacious.

Several unexpected differences were found in nutrient intake between children from the two projects. As a general trend, children from project 59 (high-prevalence site) consumed more nutrients than did the children from project 73 (low-prevalence site). The intakes of vitamin B12, vitamin C, copper, folate, total kilocalories, riboflavin, and dietary fiber were significantly ($p < .05$) higher in the group from project 59. With the exception of dietary fiber, for which there is no Recommended Dietary Allowance (RDA) value, both groups exceeded the RDA (National Academy of Sciences, 1989) (see Table 9).

As hypothesized, children from project 59 did consume more dietary fiber. Consumption of fiber has been associated with gastrointestinal blood loss, which in extreme cases may lead to anemia (Bushnell et al., 1992). In the present study, however, it is doubtful that intake of excessive fiber is related to the discrepancy in anemia rates. This difference, with children from project 59 (high-prevalence site) consuming more than children from project 73 (low-prevalence site), is not out of line with the other dietary differences observed between the two sites.
The other hypotheses concerning dietary difference between the two WIC projects were rejected. However, the possibility of dietary differences playing a role in the difference in prevalence of anemia between the two projects remains. Although the 24-hour dietary recalls performed in the two projects were done according to state protocol and this method has been shown by Karvetti and Knuts (1985) to be a valid method for assessing group nutritional status, several possible sources of bias do exist.

Table 9

Recommended Dietary Allowances for Children 12 Months of Age

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g)</td>
<td>13</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>6</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>30</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>.4</td>
</tr>
<tr>
<td>Folate (mg)</td>
<td>25</td>
</tr>
<tr>
<td>Vitamin B12 (mg)</td>
<td>.3</td>
</tr>
<tr>
<td>Copper (mg)</td>
<td>.4</td>
</tr>
<tr>
<td>Kilocalories (Kcal)</td>
<td>650</td>
</tr>
</tbody>
</table>
The 24-hour dietary recalls were not conducted by a single nutritionist. Although all WIC nutritionists complete identical training sessions, they typically work only at a single site. Thus, different nutritionists at the two sites conducted the 24-hour diet recalls. A better study design would have been to have had all diet recalls conducted by the same nutritionist.

Secondly, a dietary history of the child was not collected. Information such as the age at which the child was introduced to whole cow's milk and the amount of whole cow's milk typically consumed would be valuable. Excess intake of whole cow's milk has been associated with decreased hemoglobin levels in children (Pizarro et al., 1991). The use of a brief dietary history has been shown to be an effective and inexpensive screening device for iron deficiency (Boutry & Needlman, 1996). The WIC program may find the adoption of such a technique beneficial.

The final area to be addressed in regard to dietary differences is acculturation. Although both groups examined in the current study were exclusively Hispanic, a difference in acculturation may have existed. While acculturation was not assessed in the current study, a difference in language preference was observed (see Table 8). Language has been shown to be a measure of acculturation (November, 1993). A
difference in acculturation may be associated with different dietary behavior not detected in the 24-hour dietary recalls. It may also result in different communication patterns between the WIC client and the nutritionist (Cassidy, 1994). Future efforts would be required to determine whether or not acculturation could be affecting nutrient intake in the WIC population.

The final two differences of note include differences in maternal weight gain during pregnancy and original certification age (the age at which the child was enrolled in the WIC program). Maternal weight gain was found to be greater in the group from project 73 (low-prevalence site) than in the group from project 59 (high-prevalence site) (30.72 lb vs. 27.2 lb). Both groups met the weight-gain recommendations of the American Academy of Pediatrics (1993). For this reason, it is doubtful that maternal weight gain during pregnancy influenced the discrepancy in prevalences of anemia between the two sites.

Surprisingly, children from project 59 were enrolled in the WIC program, on average, 11 days earlier than were children from project 73. Both projects were successfully enrolling children near 1 month of age, 23 days versus 34 days.
Subsequent researchers may need to explore the mother's behavior prior to giving birth. Income-eligible (≤ 185% of the poverty level) women are able to enroll in the WIC program during pregnancy. It may be beneficial to focus WIC marketing on this population. Research has shown that women with nutritionally inadequate diets during pregnancy are more likely to have preterm deliveries and give birth to low-birth-weight babies. These babies are then more likely to suffer from increased morbidity (Scholl, Hediger, Fischer, & Shearer, 1992).

In summary, the present study showed that two similar WIC projects within close proximity to one another have significantly different prevalences of anemia. One important area in which the projects varied—income—was identified. Whether or not differences in income level could be responsible for the difference in anemia rates was beyond the scope of this study. Another area that needs to be addressed is the environment. It may be beneficial to investigate possible neighborhood and housing differences between the sites. For example, it is possible that children from the high-prevalence site were exposed to unsafe lead levels.

The WIC program was established, in part, to combat childhood anemia. Although great progress has been made
over the years, several areas in Texas still have unacceptably high rates. Due to the adverse health consequences of anemia in infancy and early childhood, more investigation is needed to identify the causes in order to design efficacious interventions.
APPENDIX

PROCEDURE FOR TAKING BLOOD SAMPLES
PROCEDURE FOR TAKING BLOOD SAMPLES

(Texas Department of Health. (1994). Texas WIC Policy No. CS:01.1 (Available from the Texas Department of Health 1100 West 49th Street, Austin, TX 78756.).)

How to Perform a Finger Stick

1. Increase the blood flow to the person's hand by either rubbing it briskly or have the parent or guardian open and close the child's hand into a fist several times. Hold hand downward.

2. Have the parent hold the child's arm firmly at the elbow during the finger stick.

3. Cleanse the skin with a 70% alcohol swab. Allow to air dry before puncturing. Do not blow dry. The selected puncture site must not be swollen or infected.

4. Using a sterile, disposable lancet, make a quick but firm jab puncturing the finger just to the side of the finger pad. Be prepared for the client to respond by jerking her hand. Puncture the skin deeply enough to allow blood to flow freely.

5. Wipe away the first drop of blood with dry gauze or cotton ball.
6. Wait for a spontaneous flow of blood and collect the blood. Place the capillary tube to the edge of the drop of blood and fill with one continuous draw. Do not break contact with the drop of blood, or this could cause air bubbles. If the blood does not flow freely, puncture a different finger. Do not milk or squeeze the puncture as this may cause tissue fluids to mix with the blood and dilute the sample. Whenever possible, take two samples.

7. When collection is complete, press a sterile gauze pad or cotton ball to the puncture site until bleeding has stopped. An adhesive bandage should be used if there is excessive bleeding. However, in very young children the danger of aspiration from a bandage, especially the patch type, is serious. For this reason, explain to the parent or guardian the importance of removing the bandage as soon as the bleeding stops. (pp. 15-18)

Using a Centrifuge Machine

1. After obtaining blood samples, grasp both ends of the capillary tube between the thumb and the pointer finger and gently rotate the tube five to ten times to mix the heparin (anticoagulant in the tube with the blood.

2. To seal, hold the tube in the middle and press one end of the tube into plastic clay, twisting gently to seal.
3. Open the cover of the centrifuge machine and remove (by unscrewing) the head cover of the machine. Place the capillary tubes in the numbered channels with the clay-sealed end toward the outer rim of the head (against the rubber gasket). Balance each tube with another tube another tube. (Note: Some machines do not require balancing of the tubes. Always check manufacturer’s instructions.)

4. If blood samples for more than one person are placed in the channels, be sure to record each name with its respective channel number.

5. Secure both covers and set time limits to spin the length of time specified by the manufacturer.

6. Although heparinized capillary tubes can be held up to four hours (preferably refrigerated before centrifuging), blood samples should be spun as soon as possible.

7. Remove the capillary tubes as soon as the centrifuge stops spinning. Do not attempt to stop manually stop the centrifuge. If the tubes have bubbles after they finish spinning, discard the tube and take another blood sample if necessary.

Measuring Hematocrit Levels Using a Criptocaps Card
1. Line the bottom line of the blood in the tube (where the red blood cells and plastic clay meet) with the zero mark on the card.

2. Move the tube along the scale until the top line of the plasma is lined up with the 100 mark on the card.

3. Read the number on the scale where the plasma and packed red blood cells meet. This is the hematocrit level; record measurement immediately. (pp. 22-24)

Using a HemoCue

1. If your clinic uses a HemoCue to measure hemoglobin, then the blood will be collected in a microvette. A separate vial of reagent is not needed, as dry reagent is stored in the microvette.

2. Place the tip of the microvette in the middle of the drop of blood, not the edge of the drop as would be done with capillary tubes. Fill the microvette in one continuous draw. Do not break contact with the drop of blood, as this would cause air bubbles.

3. Fill the microvette. Wipe off any excess blood on the tip of the microvette and then place it in the HemoCue. The hemoglobin value will be displayed in about 45 seconds.

4. Write down this number in the client's record or on a piece of paper, transferring the information to the client's record as soon as possible. (pp. 29-30)
REFERENCES


Driva, A., Kafatos, A., & Solman, M. (1985). Iron deficiency and the cognitive and psychomotor development of
children: A pilot study with institutionalized children. 

*Early Child Development and Care, 22, 73-82.*


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