Iron deficiency is a major risk factor for anemia among pregnant women in Senegal

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SUMMARY

Anemia during pregnancy is highly prevalent in Senegal. For effective intervention, its causes must be known. We determined the prevalence of anemia and the relative contribution of various risk factors in a cohort of 480 women in Dakar. Hemoglobin (Hb), erythrocyte protoporphyrin (EP), serum ferritin (SF), malaria and helminthes infection, Hb phenotype, and dietary iron intake were assessed. Overall, 39% of women were anemic (Hb<110 g/L), 70% were iron deficient (EP>70µmol/mol heme or SF<15µg/L), and 33% had iron deficiency anemia. Twelve percent were infected with P. falciparum; 13% had intestinal helminthes, most of which resided in suburban Dakar. About 7% had sickle cell trait (Hb AS). Women consumed heme-iron containing foods more frequently than non-heme iron foods; however, they also consumed iron absorption inhibitors at high frequency. Iron deficiency more than tripled the risk of anemia. Malaria parasitemia, helminthes infection and Hb AS also increased the risk of anemia, but not significantly. Our findings indicate that for effective control of anemia during pregnancy in Senegal, iron supplementation is needed in addition to education of women about better food choices. Antimalarial chemoprophylaxis should be made available to all women and populations at risk of helminthes infections should be screened and treated.

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Introduction

Anemia of pregnancy is highly prevalent in Senegal (West Africa). Although no recent survey has been conducted, it is estimated that >50% of pregnant women in that country are anemic [1-2]. Anemia, specifically iron deficiency anemia early in pregnancy has adverse consequences on pregnancy outcome, including low birth weight, preterm birth, and small-for-gestational age, which are the strongest predictors of perinatal mortality; in severe cases, anemia increases the risk of maternal death at the time of delivery [3-7]. In Senegal the prevalence of low birth weight is at least 15%; maternal and infant mortality rates are high at 560/100,000 and 58/1,000, respectively. The proportions of these rates attributable to anemia are unknown; however, studies suggest that they are significant [8].

There are multiple causes of anemia in tropical developing countries such as Senegal. More than half of the cases are generally due to dietary iron deficiency often resulting from a diet poor in bioavailable iron but rich in iron-absorption inhibitors such as phytates in cereals and polyphenols in coffee and tea. In addition, nutritional deficiencies of folate, vitamin B12, and vitamin A can also cause anemia. Other coexisting causes include malaria parasitemia, intestinal parasite infections and to a lesser extent hemoglobinopathies such as sickle cell (Hb S) [9-10].

As part of its new national health strategic plan the government of Senegal has taken steps to improve maternal health, including reducing anemia. Since >80% of women aged 20-34 years seek prenatal care and that the majority of those (83%) obtain it in the government-run health centers, improvement efforts have mainly been concentrated on these centers [11]. The government’s program to reduce anemia can be summarized as follows: when women go to their first
prenatal visit, they are given a prescription to purchase iron/folic acid tablets (65 mg elemental iron and 250 µg folic acid) and malaria chemoprophylaxis. The efficacy, effectiveness, and cost-effectiveness of this program, which has been in place for the past twenty years, are not known although maternal mortality rate has decreased from 1200 to 560/100,000 live births between 1990 and 2005 [11].

An effective program to combat anemia should address all the major causes of anemia. One of the first steps in designing such a program for a specific country is to investigate the contribution of each of the known causes of anemia in that country. Thus the purpose of this study was to determine the prevalence and major risk factors for anemia in a cohort of pregnant women in urban Senegal and more specifically the relative contributions of iron status, malaria parasitemia, helminthes infection, and Hb S to anemia in order to make recommendations that could improve the current program in Senegal.

Materials and Methods

The study was conducted in the capital city, Dakar, which is home to 80% of the urban population of Senegal. The country’s fertility rate results in approximately 450,000 pregnancies annually [11]. Dakar is subdivided into 8 health districts, which have a total of 11 health centers. Each district represents a different geographical area. Subjects were recruited from the 6 “reference” health centers, which are larger than the others and offer more services, such as surgery and radiography. Two of the selected health centers were located in the South health district; the remaining 4 were each located in the Center, West, Pikine, and Guediawaye health districts. Each health center covers a population of about 180,000 [12].

The subjects were participating in a randomized intervention trial of the effect of free iron/folic acid tablets versus a prescription to purchase the tablets on compliance. All women who registered for routine prenatal care and fulfilled the following inclusion criteria were invited to participate after giving informed consent: 1) healthy according to physical examination, 2) in their second trimester of gestation according to fundal height and date of the last menstrual period (this criterion was included because 69.5% of women in Dakar do not seek prenatal care before this stage of gestation [11], 3) residing in Dakar or its suburbs, and 4) not having received iron/folic acid supplements prior to enrollment. For adequate statistical power in the randomized study, 480 subjects were enrolled, i.e. 80 women per center.

Socio-demographic, socio-economic and health survey

Women were interviewed at enrollment using structured questionnaires that were pre-tested on 10 non-study participants at each center for face validity and the necessary changes were made prior to data collection. Characteristics such as age, education level, employment status, and household possessions were collected. Data on parity, known diagnosis of disease, and general perception of health were also collected. Weight was measured to the nearest 0.1 kg on a calibrated beam balance scale. Height was measured to the nearest 0.1 cm with a stationary height board affixed to the wall.

Anemia, iron, and infection status

Two venous blood samples were collected from each subject: one in an EDTA-treated vacutainer tube and another in an evacuated non-treated tube. The samples were packaged in dry ice for transport to the laboratory where analyses were performed. Anemia status was assessed by measuring hemoglobin (Hb) concentration using the HemoCue photometer (HemoCue, Angelholm, Sweden); each sample was analyzed in duplicate and calibration of the photometer was checked daily using the control cuvette provided by the manufacturer. The Pearson correlation between the 2 Hb measurements was .998 (P<.001). Anemia was defined according to WHO guidelines as Hb < 110 g/L, moderate to severe anemia as Hb <90 g/L, and severe anemia as Hb <80 g/L. This last cut-off was used instead of the traditional <70 g/L because only a few women (n =14) had Hb concentrations that low [13].

Iron status was assessed using two indicators, erythrocyte protoporphyrin (EP) and serum ferritin (SF). EP was measured in duplicate with a front-face hemato fluorescence meter (Aviv Biomedical, Lakewood, NJ). Calibration of the hematofluorometer was checked daily using control solutions provided by the manufacturer. The Pearson correlation between the 2 EP measurements was .997 (P<.001). EP concentration was used as an indicator of Fe-deficient erythropoiesis. Values indicative of iron deficiency (ID) were defined as EP >70 µmol/mol heme [14]. Blood collected from the evacuated tubes was used for SF analysis. The blood was centrifuged (481 x g, 8 min, 28°C).
The resulting serum was then frozen at -20 ºC. Later, it was thawed in a refrigerator (2-8ºC) for no longer than 12 hours before being analyzed by enzyme-linked immunoassay with monoclonal antibodies using a kit and the Mini-Vidas (Biomerieux, France). An SF concentration <15 µg/L was indicative of depleted iron stores [14].

Iron deficiency anemia (IDA) was defined as Hb<110 g/L and EP>70µmol/mol heme or SF <15 µg/L.

C-reactive protein (CRP) was measured from the serum as an indicator of infection or inflammation, which can affect Hb, EP, and SF concentrations, by latex-enhanced immunonephelometry on a BN II Analyzer (Dade Behring, Newark, DE). A cutoff value of > 6 mg/L was used [15].

Malaria and intestinal parasitic infection
Thick and thin blood films were collected and fixed and stained with Giemsa to detect malaria parasitemia. Malaria parasites were counted as a ratio to leukocytes by an experienced parasitologist. The calculation of parasite density was based on 8000 leukocytes per µL of blood and all species were identified as P. falciparum. Densities >5,000 parasites/µL blood were considered evidence of clinical malaria [16].

To assess helminthes infection, women were asked to produce a stool specimen in containers provided by the researchers on the morning of their visit. When they were unable to do so, they were asked to try again that evening or the following morning and to return the sample to the health center. The samples were conserved in 40% formaldehyde solution until analyses could be performed. They were stained using the Kato Katz method and read within one hour of staining by a trained microscopist for presence of A. duodenale, N. americanus, A. lumbricoides, and T. trichuria. Parasite density was expressed in number of eggs per gram of stool [17].

Hemoglobin S
Blood samples were screened for Hb S within a few hours of collection using the sodium metabisulfite reduction test. All samples that were positive for Hb S were re-analyzed by hemoglobin electrophoresis of a red blood cell hemolysate on cellulose acetate plates to confirm the phenotype [18].

Dietary evaluation
A modified non-quantitative food frequency questionnaire (FFQ) was used to estimate dietary intake of iron (Fe). The 45-item FFQ was constructed after reviewing the food list of the Worldfood Dietary Assessment System (WDAS), which was developed at the University of California at Berkeley in collaboration with the Food and Agriculture Organization; it is designed primarily for dietary research projects in developing countries. The database contains a list of 1800 foods reported from 6 countries, including Senegal. The nutrient composition of foods that were reported as frequently consumed in that country was reviewed using the International Minilist (IML) food composition table, which is built into the WDAS. For each food on the IML, there are values for 52 constituents: the data are taken from published food composition tables or imputed where no analytic data are available [19]. Foods were included in the FFQ if they contribute significant amounts of Fe in the Senegalese diet, or are non-heme Fe absorption enhancers (due to their high content of ascorbic acid and citric acid), or are non-heme Fe absorption inhibitors (due to their high content of phytate, calcium, polyphenols, and tannins). For intake of heme-Fe, only foods of animal origin were included. For non-heme Fe intake, only plant foods containing >0.35 mg Fe per serving were included. Foods were considered important contributors of vitamin C if they contain >24 mg of vitamin C per serving. Foods rich in phytate, tannins, and calcium were identified on the basis of the IML and published values. Study participants were asked to indicate how often they consumed each item on the FFQ over the 12-month period preceding the interview.

Statistical analysis
Multinomial logistic regression models were performed to estimate the adjusted odds ratios (AOR) and 95% confidence intervals (CI) for anemia, iron-deficient erythropoiesis, and depleted iron stores. Since EP and SF were skewed, they were log-transformed for analysis. Adjusted mean differences in Hb, EP, and SF were calculated with forward selection multiple linear regression. All regression models included variables for malaria parasitemia, intestinal parasite infection, CRP, Hb S, stage of gestation, time elapsed between the previous and current pregnancies (birth interval), socio-economic, demographic, and anthropometric data. Variables were retained in the models only if statistically significant. Since the intensities of malaria parasitemia and parasitic infection were relatively low in the population that was studied, the data were entered as present or absent. Differences in the prevalence of anemia and/or iron
deficiency were assessed using chi-square for dichotomous variables. Differences in Hb, EP, and SF concentrations were ascertained by Student t test and ANOVA for categorical variables. Where appropriate, Dunnett’s C test was used for post-hoc comparisons for samples with unequal variance.

Foods in the FFQ were grouped into 4 categories: sources of heme-Fe, sources of non-heme Fe, sources of Fe absorption enhancers, and sources of Fe absorption inhibitors. Mean frequencies of consumption were computed and coded to reflect the following 3 categories: almost never/a few times a month, several times a week, and several times a day.

An index of socio-economic status (SES) was created from 4 binary indicators: paid employment, home ownership, refrigerator ownership, and literacy. Subjects were assigned a score of 0 to 4 depending on how they scored on each of the indicators. All data were analyzed using SPSS (version 15.0) and statistical significance was defined as a P value <0.05.

Results

Characteristics of the study sample (Table 1)
The mean age of the sample was 25.7±5.9 years with a range of 15-43 years. Most women were aged between 20 and 29 years (55%). Only 18% could read and write and 68% were unemployed. About 35% were primipares and very few had 5 or more children (6%). For 49% of the non-primipares, the time elapsed between the previous and current pregnancy was of at least 24 months. Most of the women (81%) had never been diagnosed with a serious illness such as HIV/AIDS, diabetes, or cancer; the remainder reported diagnoses of chronic heartburn, respiratory disorders, and migraines. Most described their current state of health as either good or excellent (51%). Mean weight and height were 60.40±12.7 kg and 1.64±0.6 m, respectively. Mean SES score was 1.6±1.1 on a scale of 4.0 and on average, women spent <$1 per day on food (mean = $.99±.98). Mean stage of gestation at enrollment was 12.4±4.7 weeks.

Prevalence of anemia, iron deficiency, and iron deficiency anemia (Table 2 & 3)
Overall, 39% of the women were anemic, of which only 7% suffered from severe anemia (Hb <80 g/L). Around 70% were iron deficient; 63% had elevated EP and 40% had low SF. The prevalence of iron deficiency anemia was 33%.

Malaria
Malaria parasitemia was detected in only 12% of women (n = 433; 47 blood films were unreadable at the time of analysis). P. falciparum was the only species detected. Mean parasite density was low at 342.4±2091.9/mm³; only 5 women had parasite densities indicative of clinical malaria (>5,000/mm³). Mean Hb, EP, and SF were not significantly different between women with and without malaria parasitemia.

Helminth infection
Parasitic infection was assessed for a sub-sample of 298 women; the remainder of the women either did not provide a stool sample or the sample that they provided was deteriorated at the time of analysis. Overall, only 13% (n = 63) tested positive for intestinal helminthes. Most (82% n = 52) were infected with A. lumbricoides with a mean density of 866 (S.E 120.6) eggs/g; 13% (n = 8) were infected with T. trichiura with a mean density of 262.5 (76.6) eggs/g. About 5% (n = 3) were infected with A. duodenale with a mean density of 48.0 (13.8) eggs/g. Sixty two percent of infections were found among women who resided around and visited the two suburban health centers. Mean Hb, EP, and SF were not significantly different between women with and without parasitic infections.

Hb S analysis
The sodium metabisulfite screening test was performed on 415 subjects (65 samples were missing from women who were enrolled in the study before the test was available). Only 6.5% tested positive (n = 27) and were all heterozygote for sickle cell trait according to cellulose acetate electrophoresis.
Dietary intake of heme and non-heme iron, iron absorption enhancers and inhibitors (Table 4)

Approximately 35% of women reported consuming heme-Fe containing foods several times a day; 25% consumed non-heme Fe containing foods at that frequency; 34% and 40% reported consuming foods containing Fe absorption enhancers and foods containing Fe absorption inhibitors, respectively, several times a day. Mean Hb concentration was significantly higher among women who consumed Fe inhibitors only several times a month as opposed to several times per day (P<.05). Mean Hb, EP, and SF did not differ significantly across frequencies of consumption of heme-Fe, non-heme Fe, Fe enhancers and inhibitors; however, there was a general trend of increasing mean Hb and SF with increased consumption of heme-Fe, non-heme Fe, and enhancers and decreased consumption of inhibitors. There was also a trend of decreasing EP concentration with increased consumption of heme-Fe, non-heme Fe, and enhancers and decreased consumption of inhibitors.

Table 2: Anemia and iron status indicators in the sample of Senegalese pregnant women

<table>
<thead>
<tr>
<th>Hematological status</th>
<th>%</th>
<th>Hb, g/L</th>
<th>EP, µmol/mol heme</th>
<th>SF, µg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (Hb≥110)</td>
<td>61</td>
<td>121.1 (5)</td>
<td>81.2 (2.9)</td>
<td>37.5 (2.4)</td>
</tr>
<tr>
<td>Anemic (Hb&lt;110)</td>
<td>26</td>
<td>101.6 (4)</td>
<td>110.7 (5.5)</td>
<td>29.5 (3.3)</td>
</tr>
<tr>
<td>Moderately to severely anemic (Hb&lt;90)</td>
<td>6</td>
<td>85.6 (5)</td>
<td>205.4 (22.6)</td>
<td>11.4 (2.3)</td>
</tr>
<tr>
<td>Severely anemic (Hb&lt;80)</td>
<td>7</td>
<td>68.0 (1.9)</td>
<td>271.6 (26.5)</td>
<td>15.9 (3.9)</td>
</tr>
</tbody>
</table>

1 Significantly different from anemia, moderate to severe, & severe anemia, ANOVA, P<.05
2 Significantly different from moderate to severe & severe anemia, ANOVA, P<.05
3 Not significantly different from moderate to severe anemia, ANOVA
4 Significantly different from moderate to severe & severe anemia, ANOVA, P<.05
5 Significantly different from moderate to severe anemia, ANOVA, P<.05

Table 3: Prevalence of iron deficiency in the sample of Senegalese pregnant women

<table>
<thead>
<tr>
<th>EP, µmol/mol heme(n)</th>
<th>%</th>
<th>Mean (SE)</th>
<th>SF, µg/L(n)</th>
<th>%</th>
<th>Mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤70 (167)</td>
<td>36.9</td>
<td>42.3 (1.3)</td>
<td>&lt;15 (186)</td>
<td>59.8</td>
<td>48.2 (2.6)</td>
</tr>
<tr>
<td>&gt;70 (285)</td>
<td>63.1</td>
<td>149.1 (5.1)</td>
<td>≥15 (277)</td>
<td>40.2</td>
<td>8.3 (3.3)</td>
</tr>
</tbody>
</table>

Table 4: Dietary intake of heme and non-heme iron (Fe), iron absorption enhancers and inhibitors in the sample of Senegalese pregnant women

<table>
<thead>
<tr>
<th>Frequency of consumption</th>
<th>%1</th>
<th>Heme-Fe N = 480</th>
<th>Non-heme FeN = 480</th>
<th>Fe absorption Enhancers Fe N = 480</th>
<th>Fe absorption Inhibitors N = 480</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Hb2</td>
<td>EP3</td>
<td>SF4</td>
<td>Hb</td>
</tr>
<tr>
<td>Few times/month</td>
<td>26</td>
<td>108.1</td>
<td>115.0</td>
<td>29.8</td>
<td>44.8</td>
</tr>
<tr>
<td></td>
<td>(1.6)</td>
<td>(7.8)</td>
<td>(3.2)</td>
<td>(1.2)</td>
<td>(1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>109.5</td>
<td>107.9</td>
<td>42.5</td>
<td>29.8</td>
</tr>
<tr>
<td></td>
<td>(1.3)</td>
<td>(5.9)</td>
<td>(3.2)</td>
<td>(1.7)</td>
<td>(1.7)</td>
</tr>
<tr>
<td>Several times/month</td>
<td>38.8</td>
<td>111.3</td>
<td>108.0</td>
<td>36.7</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td>(1.5)</td>
<td>(7.8)</td>
<td>(2.9)</td>
<td>(1.5)</td>
<td>(1.5)</td>
</tr>
<tr>
<td>Several times/day</td>
<td>35.2</td>
<td>111.3</td>
<td>108.0</td>
<td>36.7</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td>(1.5)</td>
<td>(7.8)</td>
<td>(2.9)</td>
<td>(1.5)</td>
<td>(1.5)</td>
</tr>
</tbody>
</table>

1 Percent sample (N = 480)
2 Mean hemoglobin (g/L) (standard error)
3 Mean erythrocyte protoporphyrin (µmol/mol heme) (standard error)
4 Mean serum ferritin (µg/L) (standard error)
5 Significantly different, Student t test, P<.05

Relation of anemia to iron deficiency, malaria parasitemia, parasitic infection, and Hb AS

In the multinomial logistic regression, the adjusted odds ratio (AOR) of anemia associated with the combination of elevated EP and low SF was 3.55 (95% CI 1.96 – 6.43). The AORs for Hb AS, malaria parasitemia, and parasitic infection were 1.79 (95% CI .52 – 6.24), 2.11 (95% CI .89 – 5.02), and 1.53 (95% CI .80 – 2.93). The association between anemia and these last three factors is not significant since the confidence intervals include 1.

A stepwise multiple linear regression analysis was conducted with forward selection to predict Hb concentration from iron status indicators while controlling for various factors:

Block 1 included: the intensity of parasitic infection, malaria parasitemia, Hb AS, and CRP. Block 2 included: stage of gestation, age, weight, height, and SES score. Block 3 included: log EP and log SF. The first block of predictors accounted for a significant amount of Hb variability with an R2 = .057 (P = 0.014). The second block, controlling for the first, also accounted for a significant amount of Hb variability, R2 change was .11 (P <.001). The third block, controlling for the first two, accounted for the largest Hb variability with R2 change of .26 (P < 0.001).

Relation of anemia with other factors

The prevalence of anemia was not associated with age category, parity, birth interval, or SES score (Chi-square tests, P>.05). Neither iron-deficient erythropoiesis nor depleted iron stores or the combination of the indicators were associated with the three maternal characteristics mentioned above.

Discussion

Anemia among pregnant women is a major public health problem in Senegal. This is the first study in recent years to investigate the multiple risk factors for anemia of pregnancy among low-income urban women. This study can provide a framework for recommendations for effective prevention and treatment.

We found that almost 40% of women in a cohort of pregnant women in Dakar were anemic. This prevalence is somewhat lower than WHO estimates of anemia in West Africa [20]. It is also lower than previous estimates in Senegal [1-2]. The fact that all women in our sample were recruited in the beginning of the second trimester of gestation may explain these discrepancies; the stage of gestation at which women were sampled to generate the WHO and other data is unclear. If a large proportion of women in those samples were at more advanced stages of gestation, we would expect their hemoglobin concentration to be lower because of plasma volume expansion [21]. We recruited women at the start of the second trimester for two reasons: 1) it is the stage at which most women go to their first prenatal visit (11) and 2) it is when expansion of blood volume begins and when iron needs rise dramatically [21].

Iron deficiency was very prevalent at 70%; however, serum ferritin concentrations were not as low as expected, suggesting that most women did not enter pregnancy with depleted iron stores. Thirty three percent of cases of anemia were attributable to iron deficiency. Iron deficiency more than tripled the odds of anemia after controlling for other causes; serum ferritin and erythrocyte protoporphyrin accounted for 26% of the variability in hemoglobin concentration. Analysis of the food frequency questionnaire showed that women consumed heme-iron foods more frequently than non-heme iron foods; however their consumption of absorption inhibitors was more frequent. These inhibitors included rice, millet, and maize, which contain phytates, which all women consumed at least once a day because they are staples in Senegal. These inhibitors also included a local black tea and coffee which contain phenolic compounds and were consumed several times a day by 40% of the women. Our findings indicate that dietary iron, although available to this population, is hindered by the consumption of absorption inhibitors. Furthermore, the 2005 Senegal Demographic and Health Survey (DHS) reported that only 7% of mothers of children <5 years of age are undernourished in Dakar whereas 40% are over-nourished as indicated by body mass index [11]. This, again, suggests that inadequate iron intake in this population is more related to poor food choices than to the unavailability of food.

Our findings support the current policy of universal iron/folic acid supplementation for pregnant women who visit public health centers for prenatal care. DHS reports that 95% of women in Dakar receive a prescription to purchase supplements at their first prenatal visit; however there is no data available to suggest that women actually purchase the tablets and comply with daily supplementation. Women also need to be educated about better food choices so that they consciously increase bioavailable iron intake and
are home to many of the low-income migrants who come from rural areas of the country where parasitic infections are more prevalent. They often reside in cramped houses where sanitary conditions are poor and conducive to helminthes transmission. Malaria parasitemia was detected in 12% of women and the only species found was P. falciparum. This is consistent with the findings of a survey involving 2,583 individuals in Dakar where P. falciparum was the only parasite observed in all age groups (1 to 80 years). Infection rates were greatest between October and December, the period that immediately follows the rainy season. The annual incidence of parasitemia in the sample was 5% [25]. Women were enrolled in our study between February 2005 and March 2006, which covers the period of greatest infection rates. Although WHO defines severe malarial anemia as Hb concentration < 50 g/L in the presence of a normocytic blood film and P. falciparum parasitemia > 10,000 parasites/μL of whole blood, in practice, severe malarial anemia is defined at the level of Hb concentration cited above, but in the presence of any P. falciparum parasitemia [25]. We found that only 2 women in our sample had malarial anemia according to this definition. Malaria parasitemia more than doubled the risk of anemia after controlling for other causes; however the confidence intervals included 1. Currently, 91% of women who visit health centers receive a prescription to purchase antimalarial drugs; however, only 8% receive the very effective intermittent preventive treatment (Fansidar) during the prenatal visit [11]. As a result of untreated mild forms of malaria in malaria endemic areas, adult women become semi-immune to the disease so that many malarial infections are asymptomatic. However, these forms of infection can contribute to mild to severe maternal anemia depending on the level of acquired immunity prior to pregnancy and the efficacy of immune responses during pregnancy; and this anemia attributable to malaria leads to negative perinatal outcomes [26]. Much improvement is therefore needed in the delivery of antimalarial chemoprophylaxis in health centers. We chose to investigate the Hb variant form that would be most common in the population that was studied, Hb S. In Senegal, the Hb S gene frequency is > 0.02 [27]. For the homozygous form, Hb SS, the amino acid mutation in Hb causes Hb S to aggregate into filaments when deoxygenated. These filaments are of sufficient size and stiffness to give red blood cells an irregular crescent-like shape (or sickled shape) that
causes vaso-occlusion and their destruction, hence the term sickle cell anemia. The heterozygous state for sickle cell, Hb AS, often results in a milder form of sickle cell anemia [28]. We found that 6.5% of the women in our sample had Hb AS, which almost doubled the risk of anemia; however, the confidence intervals included 1. Even though, Hb S was not a major risk factor for anemia in this sample, a careful screening of women should be done at the time of the prenatal visit. A simple sodium metabisulfite test can be performed. The test is currently performed on only 79% of women who seek prenatal care [11].

Recommendations

Since iron deficiency was very prevalent in this population and was the strongest risk factor for anemia, we recommend that public health efforts to control anemia in Senegal include two phases during the prenatal visit: 1) the education of pregnant women about making better food choices to limit the consumption of iron absorption inhibitors and 2) an effective iron supplementation program. The current program which consists of writing a prescription for women to purchase supplements has not been evaluated. Since helminthes infection was not prevalent and was not a significant risk factor for anemia, systematic anthelminthic therapy may not be necessary for this population. However, we do recommend that women who reside in areas where the incidence of infection is generally high to undergo stool analysis. The analysis is available at almost all health center laboratories. A single course of anthelminthic therapy coupled with iron/folic acid supplementation can dramatically improve hemoglobin and iron status [29]. Malarial chemoprophylaxis should be made available to all pregnant women. Efforts should be made to significantly increase the proportion of women who receive the actual treatment instead of a prescription to purchase it.

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