Senegal

National Nutrition Survey 2018

Survey report

Evaluation of food fortification on the nutritional status of children aged 6-59 months and women of childbearing age: detailed analysis of the 2018 nutrition survey and comparative analysis with the 2010 nutrition survey

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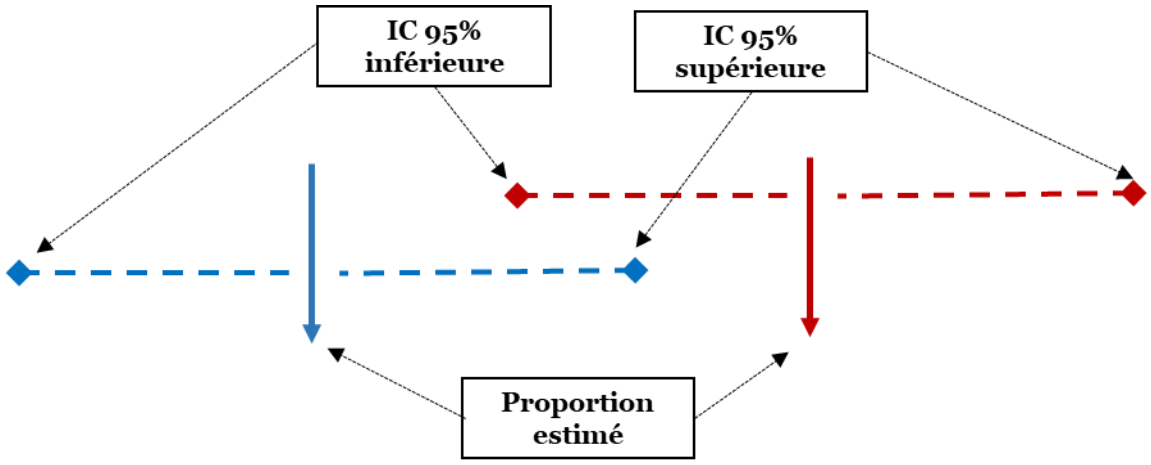
Abbreviations

AGP	α-1-acid glycoprotein
ANSD	Agence Nationale de Statistique et de la Démographie
BMI	Body mass index
BRINDA	Biomarkers Reflecting Inflammation and Nutritional Determinants of Anemia
CI	Confidence interval
CNDN	Conseil National de Développement de la Nutrition
COSFAM	Comité Sénégalais pour la Fortification des Aliments en Micronutriments
CRP	C-reactive protein
DHS	Demographic and Health Survey
ELISA	Enzyme linked immunosorbent assay
EQC	External Quality Control
HAZ	Height-for-age z-score
HPLC	High performance liquid chromatography
ITA	Institut de Technologie Alimentaire
IQC	Internal Quality Control
IYCF	Infant and Young Child Feeding
MUAC	Mid-upper arm circumference
NI	Nutrition International
NPW	Non-pregnant women (15-49 years)
ODK	Open Data Kit
PSC	Pre-school children, aged 12-59 months
PSU	Primary sampling unit
PW	Pregnant women
QC	Quality control
SD	Standard deviation
SUN	Scaling-up Nutrition
VAD	Vitamin A deficiency
WAZ	Weight-for-age z-score
WHO	World Health Organization
WHZ	Weight-for-height z-score

Interpretation of tables in this report

This report contains many different styles of tables. The simplest tables present a frequency distribution of values for a specific characteristic. An example is given in **Table 5** which presents the proportion of children aged 12-59 months who belong to different subgroups defined by various characteristics. For example, children are separated into groups according to whether they live in urban or rural areas; 46.5% of children, as shown in column 3, live in urban areas. These tables do not contain p-values because the results are not compared between two groups. However, to give the reader an indication of the precision of each estimate, these tables include 95% confidence intervals (95% CIs) calculated taking into account the complex sampling used in the 2018 survey.

The comparison of the prevalence of each primary outcome between different subgroups is presented in a second type of table. An example is **Table 6** which gives the cumulative prevalence of fever, diarrhea, respiratory infection, and point prevalence of inflammation in various demographic subgroups of children. The same demographic characteristics are included in all such tables. A specific p-value gives the probability that the observed or greater difference between different subgroups may be due solely to sampling error, and thus does not reflect a true difference in the population. If there are more than two values for a characteristic, for example a stratum, a significant p-value indicates only that the outcome in at least one of the strata is statistically significantly more or less frequent than in the other strata. The best way to know which subgroups are different is to look at the point estimates, not the p-values. To get this information with some degree of certainty, it is best to compare the estimates and their 95% Confidence Intervals (95% CIs): if the 95% CIs of two percentages do not pass the estimated percentage of the other variable, and vice versa, it is very likely that the two groups are different, as shown below:



Each primary outcome is also analyzed for other risk factors. **Table *13*** provides an example. The prevalence of anemia is calculated in subgroups defined by several different characteristics. For example, the prevalence of anemia is much higher in children with iron deficiency than in those without, and the very small p-value in the last column of the table indicates that this difference is statistically significant.

The last type of table in this report presents the comparison between the 2010 and 2018 nutrition surveys. The p-values in these tables present the statistical significance of the differences between these two surveys. As with other subgroup analyses, if the characteristic has more than two levels (e.g., anemia severity), the p-value only demonstrates that the distribution of these levels differs between the two surveys; there is no way to tell which value of the characteristic is significantly different between the two surveys.

Executive summary

Introduction

Despite sustained economic growth and reductions in some forms of malnutrition, progress on reducing micronutrient deficiencies has been mixed in Senegal. In the past decade, several surveys assessed the prevalence of anemia and found that around two thirds of children under five years of age were affected, and around half of the women of reproductive age. The most recent survey from 2010 reported that the prevalence rates of iron, zinc and vitamin A deficiencies are high in pre-school children, while for non-pregnant women of reproductive age iron, zinc and folate deficiencies were at high levels. To address the issue of micronutrient deficiency, Senegal has a longstanding policy of salt iodization. More recently, in 2009, it established a flour and vegetable oil fortification program.

As a country going through 'nutritional transition' (i.e. evolving from undernutrition to adequate or over-nutrition), Senegal experiences the increasing problem of the double burden of malnutrition, where in a population undernutrition and overnutrition occur concomitantly.

Objectives

The 2018 micronutrient survey ('Evaluation de l'impact du programme de fortification des aliments en micronutriments sur le statute en fer, acide folique et vitamin A des enfants 12-59 mois et des femmes en âge de procréer au Sénégal', hereafter referred to as the '2018 micronutrient survey') presented in this report had a twofold aim: a) to provide a comprehensive assessment of various forms of malnutrition in Senegal as well as an evaluation of various risk factors for malnutrition, particularly micronutrient deficiencies (iron, folic acid, vitamin A) in non-pregnant women 15-49 years of age, pregnant women 15-49 years of age and pre- school children 12-59 months of age; and b) to assess trends for key micronutrient indicators by comparison of the 2018 micronutrient survey with the 2010 national nutrition survey for women of reproductive age and pre- school children. Sampling was designed to provide useful estimates at the national level and for each of the four strata: Dakar, other urban, rural south, and rural north.

The key indicators assessed in the 2018 survey are listed in **Table 1**, which gives the summary of nationwide results for 2018, while in **Table 2**, a temporal comparison of the 2010 and 2018 national estimates is provided.

Survey plan

The 2018 nutrition survey was designed as a national cross-sectional survey with four strata. In total, 192 primary sampling units (PSUs) were selected with probability proportional to size from lists of census districts from the 2013 Senegal census. Sampling was done separately in each of the strata. In each selected PSU, a household listing was conducted by teams from the Agence Nationale de Statistique et de

la Démographie (ANSD) in order to provide an updated sampling frame for household selection. In each selected PSU, 7 households were selected with random sampling and equal probability. This resulted in a planned sample size of 2304 households in total.

Following a complete training of the teams, the data collection took place in the household starting with the interviews of the participants once the written informed consent had been provided, followed by the anthropometric measurements and the venous blood samples. A cold chain was established to ensure proper conditions after collection and processing of the samples (centrifugation) and during storage until analysis in the laboratory. The laboratory analysis was organized by the Institut Pasteur Sénégal in Dakar.

After data entry and purification and merging of the different databases, a bivariate analysis was used to test the association between the variables, with a chi-square adjusted P value <0.05 being considered statistically significant. Precision of estimates was indicated by 95% confidence intervals. All statistical analyses took into account the complex sampling design including adequate sample weighting.

Results

Table 1 provides an overview of selected key results from the 2018 micronutrient survey conducted in Senegal, while **Table 2** compares key results between the 2010 and 2018 micronutrient surveys.

NB: For results by stratum or urban/rural residence area, other tables referenced below are available.

Table 1: Summary results of the Senegal Nutrition survey 2018

Population	Indicator[a]	%	Table[b]
Pre-school children 12-59 months (unless indicated differently)			
	Anemia	34.8%	Table 10
	Mild anemia	19.4%	Table 11
	Moderate anemia	14.8%	Table 11
	Severe anemia	0.6%	Table 11
	Iron deficiency	56.3%	Table 10
	Iron deficiency anemia	27.6%	Table 10
	Vitamin A deficiency	12.1%	Table 12
	Stunting	13.9%	Table 9
	Wasting	13.0%	Table 9
	Underweight	10.8%	Table 9
	Overweight or obese	1.7%	Table 9
	Overweight	1.0%	
	Obesity	0.7%	
	Ever breastfed (12-23 months of age)	97.6%	-
	Early initiation of breastfeeding (12-23 months of age)	61.5%	Table 7
	Consumes micronutrient powders	4.3%	Table 7
	Consumes 5+ food groups[c]	34.3%	Table 7
	Currently taking iron supplements	2.6%	Figure 1
	Currently taking vitamin A supplements	8.0%	Figure 1
Non-pregnant women 15-49 years			
	Anemia	28.9%	Table 19

	Mild anemia	17.6%	Table 20
	Moderate anemia	10.0%	Table 20
	Severe anemia	1.1%	Table 20
	Iron deficiency	42.3%	Table 19
	Iron deficiency anemia	18.5%	Table 19
	Vitamin A deficiency	2.8%	Table 21
	Folate deficiency	50.2%	Table 22
	Currently lactating	24.0%	Figure 9
	Currently taking iron supplements	13.8%	Table 18
	Household oil labelled 'fortified' with vitamin A	50.7%	Table 18
	Household flour labelled 'fortified' with iron and folate	25.4%	Table 18
	Familiar with vitamin A	33.8%	Figure 8
	Knows foods fortified with vitamin A	6.8%	Figure 8
	Knows importance of iron and folate	72.2%	Figure 8
	Knows food fortified with iron and folate	12.2%	Figure 8
Pregnant women			
	Anemia	31.0%	Table 29
	Mild anemia	23.1%	Table 29
	Moderate anemia	7.3%	Table 29
	Severe anemia	0.5%	Table 29
	Iron deficiency	55.9%	Table 29
	Iron deficiency anemia	16.1%	Table 29
	Vitamin A deficiency	8.2%	Table 29
	Folate deficiency	37.0%	Table 29

[a] See text of method section for case definitions.
[b] Refer to the table indicated for more detailed analysis of the outcome, including group-specific results by age, region, wealth quintiles and other analyses.
[c] This is a modified indicator. Data do not allow calculation of standard WHO/UNICEF indicator for minimum dietary diversity in children 6 – 23 months of age, partly because only children 12-59 months were included and partly because some questions were not phrased accordingly. See text for definition.

Table 2: Comparison of key findings from the 2010 and 2018 nutrition surveys in Senegal

Indicator	2010		2018		
	N	%[a]	N	%[a]	*p-value* [b]
Children 12-59 months of age					
Anemia	962	66.0%	210	34.8%	<0.001
Iron deficiency	1005	70.9	326	56.3%	<0.001
Iron deficiency anemia	753	53.1%	166	27.6%	<0.001
Vitamin A deficiency	194	14.4%	60	12.1%	0.415
Non-pregnant women 15-49 years of age					
Anemia	442	47.2%	547	28.9%	<0.001
Iron deficiency	553	56.6%	818	42.3%	<0.001
Iron deficiency anemia	325	32.7%	364	18.5%	<0.001
Vitamin A deficiency	22	2.1%	58	2.8%	0.468
Folate deficiency	491	49.6%	963	50.2%	0.887
Pregnant women 15-49 years of age					
Anemia	51	55.9%	35	31.0%	<0.01
Iron deficiency	63	62.1%	60	55.9%	0.458
Iron deficiency anemia	36	34.3%	22	16.1%	<0.05
Vitamin A deficiency	5	3.4%	10	8.2%	0.164
Folate deficiency	50	52.2%	43	37.0%	0.112

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
b The p value <0.05 indicates that the difference between the 2010 and 2018 results is statistically significant.

Discussion

Both anemia and iron deficiency are common in women and children in Senegal. These conditions are more prevalent in rural areas, particularly in the rural South stratum. These higher prevalences in rural areas may be due to socioeconomic and agroecologic factors that lead to higher exposure and severity of communicable diseases and infections in these areas. There has been a substantial decline in the prevalence of both anemia and iron deficiency in both women and children since the 2010 survey, but this survey did not show an association between household flour labelled as fortified and anemia in women; in contrast, the prevalence of iron deficiency was lower in women from households with flour labelled as "fortified". The presence of a fortification logo was used as a proxy indicator for whether the food was adequately fortified, and no data were collected on amounts of the product typically consumed.

The prevalence of anemia is significantly lower in this 2018 survey than in the 2017 DHS (as the prevalence of anemia was recalculated by excluding children in the 6 -11 month range), however the reasons for the substantial decrease in the prevalence of anemia remain to be determined.

Iron deficiency has been identified in this survey as a strong putative risk factor for anemia in different population groups. These findings indicate that iron deficiency does indeed contribute to anemia in both women and children; however, it does not explain the majority of cases of anemia in either population group. In this survey, vitamin A deficiency was positively associated with both anemia and iron deficiency,

while consuming oil labelled as vitamin A-fortified or consumption of vitamin A supplements suggests a possible 'protective' effect of adequate vitamin A status or additional vitamin A intake.

Vitamin A deficiency in non-pregnant women is not considered a public health problem in Senegal, and this has not changed since 2010. Among children, vitamin A deficiency is categorized as being of 'moderate' public health concern according to WHO criteria. It is higher in children living in rural areas and is positively associated with underlying inflammation. The prevalence of vitamin A deficiency has remained relatively stable between 2010 and 2018. Population knowledge of vitamin A is relatively poor; only one third of women reported being familiar with vitamin A, and very few knew about foods which were fortified with vitamin A.

Folate deficiency is very common in women and has not changed significantly since the 2010 survey, and remains a concern. Almost two thirds of pregnant women consumed iron supplements during their pregnancy; since the majority of iron-containing pre-natal supplements used worldwide contain folic acid, the coverage estimate for iron supplementation and folic acid supplementation are likely similar. Increased folic acid intake before pregnancy is very important to support foetal development and reduce the risk of neural tube defects. But because neural tube closing occurs very early in the pregnancy (i.e. at about 4 weeks gestational age), before most women are aware of their pregnancy, adequate pre-conception folate status is fundamental. In other contexts, cereal grains fortification with folic acid has been demonstrated to be an effective public health intervention to increase women's folic acid intake and substantially decreased the incidence of neural tube defects.

The strengths of this survey include the high comparability of the 2010 and the 2018 surveys, the quality of anthropometric measurements, and the response rate for laboratory results in women, and for anthropometry results in children. The limitations relate to a sub-optimal match between the survey sample and recent census data, the absence of household-level information (household wealth, hygiene, women's status in the household, etc.), the use of 'presence of fortification logo' to determine fortification coverage rather than actual nutrient content analysis, and the non-standard collection for child feeding indicators.

Recommendations

The discrepancy in anemia prevalence estimates between this survey and DHS merits further investigation by the stakeholders involved in the respective surveys. Further, a future anemia assessment should include hemoglobin measurements using a reference method and careful pre-analytics to validate hemoglobin concentrations measured by a field-friendly device. Although iron deficiency was identified as an important putative risk factor for anemia in this survey, a more in-depth assessment of the etiology of anemia should be conducted to understand the nutritional and non-nutritional factors associated with anemia in Senegalese women and children.

Future assessements of the coverage of fortified foods should be done using quantitative methods to enable the estimation of fortification adequacy and intra-household consumption patterns to determine whether or not the fortification program needs strengthening. As several program components can be enhanced to increase the coverage of fortified foods, the systems currently in place should be revisited to identify any shortcomings, such as the fortification technology used at the level of the mills, access to premix, regulatory monitoring and enforcement, and inspection at points of importation and of

wholesalers. A market assessment may be needed to investigate flour brands and their market share along with fortification adequacy to identify common brands with sub-optimal fortification adherence. An assessment of the iron fortificant used should also be conducted and if needed, a focus should be put on increasing the use of more bioavailable forms. Regarding the fortification of vegetable oil, future fortification coverage assessments should also extend beyond observing the logo to include analysis of the retinyl palmitate content of oil samples obtained from the households. If done in conjunction with oil consumption estimates, this would allow a correlation analysis between vitamin A intake from oil and vitamin A status. To increase demand for fortified foods, public awareness of fortification and the use of the logo 'enrichi' should be enhanced through social marketing.

Child feeding practices, such as improving early breastfeeding, decreasing the proportion of children who consume other foods before their first breast feed, and increasing dietary diversity among children 6 to 23 months of age, should be implemented to the extent possible in Senegal. In addition, use of micronutrient powders or other fortified foods in children 6-23 months should be considered and this program could potentially reduce iron deficiency in children less than 24 months of age.

There is room for improvement regarding coverage of vitamin A supplementation, and a programmatic assessment may enable the identification of barriers to increased supplementation coverage. Senegal's recent shift from supplementing children using twice-annual health campaigns to routine delivery of vitamin A supplements should be assessed. As vaccination coverage is nearly universal in children, there is a clear opportunity to deliver vitamin A supplements along with vaccinations. Vitamin A supplementation is of particular importance in young children, since their additional vitamin A intake from fortified oil may be limited due to the small quantities of food consumed compared to their nutrient needs.

Due to the persistingly high prevalence of folate deficiency, in addition to strengthening the wheat flour fortification program and understanding folic acid intake from fortified wheat flour, folic acid supplementation coverage during pregnancy should be increased. Further, additional measures to improve women's folate status prior to conception should be discussed.

1 Introduction and objectives

1.1 Country overview and nutritional situation

Senegal is a coastal country in West Africa. It is bordered by Mauritania in the north, Mali to the east, Guinea to the southeast, and Guinea-Bissau to the southwest; further, it nearly surrounds The Gambia, a country occupying a narrow sliver of land along the banks of the Gambia River. Its total population in 2019 was estimated to be 16.3 million [1]. The urbanization rate has been steadily increasing from 43% to 48% between 2010 and 2020 [2]. Economically, Senegal is categorized as a lower middle income country by the World Bank and has had a relatively stable average per capita gross domestic product of 1,260 US Dollars [2].

Senegal is a relatively stable African democracy with high economic growth forecasts [3], despite its high unemployment and fertility rates; the COVID pandemic has recently had an impact on economic growth[4]. However, it faces the challenges of having not only a large youth population, but also high levels of poverty and low levels of social protection, all of which have implications for gender equality. The country has implemented legal frameworks to ensure women's equality, including the 2010 Parity Law that amends the Constitution to mandate parity between men and women [5], and it has adopted the National Strategy for Equity and Gender Equality 2016-26, introduced by the Ministry of Women, Family and Childhood [6]. Despite legal frameworks in place and progress made with regard to reduced gender gaps in, for example, literacy rate and primary and secondary enrollment, disparities in tertiary education, and employment continue to exist [7].

In 2019, life expectancy at birth was at 68.6 years, up from 64.2 years in 2010 [1]. Similarly, infant mortality has decreased from 47 per thousand live births in 2010 to 27 per thousand in 2019 [8]. These levels are low in comparison with other countries of sub-Saharan Africa. Maternal mortality has also declined but remains at a worrying level, with over 230 cases/100,000 live births, and is off track to meet the sustainable development goal of a ratio <70/100,000 [9] . Access to safe water has improved considerably but sanitation remains problematic, and there are important urban vs. rural disparities related to water and sanitation but also for access to health care [8].

The Senegalese diet is predominantly based on cereals (rice, millet, sorghum), but also contains insufficient vegetables, meet and fish. Cereals represent about two-thirds of the dietary energy supply. The consumption of rice has increased because of growing urbanization. While the share of protein in the total energy supply remains low, that of lipids is increasing, likely contributing to the ongoing nutrition transition. Difficulties in the agricultural sector combined with poverty are the main causes of household food insecurity [10].

Breastfeeding is a common practice but early initiation remains infrequent. Despite significant progress, only a third of children under six months of age are exclusively breastfed. Complementary feeding practices also need to be improved. Progress in pregnancy surveillance, exclusive breastfeeding, access to safe water and immunization coverage may explain the decrease in the prevalence of stunting among young children over the last two decades. However, since 2015, the prevalence of stunting has been stagnant according to the latest DHS [8].

Senegal is characterized by chronic vulnerabilities and seasonal risks, particularly in the northern and eastern regions of the country where acute malnutrition and food insecurity rates regularly exceed emergency thresholds. In the area of food security, the country has established four food insecurity response plans to assist populations residing in departments classified as crisis phase of the Harmonized Framework. In 2016, approximately 17% of households had inadequate food consumption [11] and according to the latest results of the 2021 harmonized framework, the situation remains at this level[12].

The evolution of nutritional status, specifically anemia, wasting, stunting, and overweight/obesity, in children under 5 years of age in Senegal has been regularly documented by recurrent Demographic and Health Surveys (DHS). The prevalence of anemia in children was very high in 2005 (84%) [13] and slightly dropped thereafter but remained persistently high at 60-76% between 2010 and 2017 [14]. Similarly, child stunting and wasting remain relatively unaltered since 2010, with stunting stabilized at just below 20% and wasting between 6-10%. Young child overweight and obesity have repeatedly been reported to be below 3% by the DHS. Prior to the national micronutrient survey conducted in 2010 [15], micronutrient data at the national level was mostly absent and based on estimations from smaller studies. The 2010 survey found that almost two thirds of children 12-59 months had low iron stores, almost 40% had low zinc levels and about 15% were affected by vitamin A deficiency.

Among women of reproductive age, data are less frequent but prior to 2010 the prevalence of anemia was around 60% with a slight decrease thereafter (55% in 2010, 54% in 2017) according to DHS reports. Overweight and obesity (BMI≥ 25) among women of reproductive age were last reported in the 2010 DHS and affected 21% of women, while 22% were underweight (BMI<18.5). The national micronutrient survey of 2010 [13] found that almost half of non-pregnant women 15-49 years were anemic (47.4%), and pregnant women were slightly more affected (56%); just below half of the women (43.3%) had low iron stores, while a bit over half (54.8%) were folate deficient. Vitamin A deficiency was only found in about 2% of the women, while suboptimal vitamin A status was reported for almost one fifth of women (15.3%).

Iodine status was last assessed in 2010 [16] among school-aged children; the median urinary iodine concentration was 104 µg/L, classifying the country as having 'adequate' status, albeit at the lower end of the recommended range of 100-199 µg/L.

According to the latest global nutrition report, Senegal is on course to reach the sustainable development goals with regards to maintaining child overweight prevalence at a low level and has made some progress on reducing low birth weight, child stunting, and women's anemia [17]. In contrast, the report does not ascribe sufficient progress to child wasting, exclusive breastfeeding, or adult overweight and obesity.

1.2 Strategies and programs to combat micronutrient deficiencies in Senegal

To support improvements in micronutrient status, Senegal has taken steps to create an enabling policy environment, but also developed strategies and programs. Micronutrient deficiencies can be addressed through several strategies including supplementation, dietary diversification, public health measures, and fortification. A short overview of strategies and programs in place in the recent past is provided in this section.

Salt iodization is mandatory in Senegal [18] and iodized salt coverage has increased since the law was enacted in 2001; since 2010, there has been a small but steady increase in household coverage of iodized salt from 43% to 65% [7]. A stand-alone salt coverage assessment even reported coverage with iodized salt of 80%, but the same study also found that less than 40% of households had access to adequately iodized salt [18]. Reasons for this discrepancy were ascribed to the salt production landscape with many small-scale salt producers, quality control issues during production, and inconsistent supply of potassium iodate.

To better coordinate efforts to tackle malnutrition, the 'Cellule de Lutte contre la Malnutrition' –currently named 'Conseil National de Développement de la Nutrition' (CNDN) - was established in 2002, following the presidential decree Nº 2001-770 of 5 October 2001. One of the CNDN's flagship projects has been the 'Programme de Renforcement Nutritionnel' aiming at integrating actors from the various sectors to align for better coordination. The CNDN also coordinates vitamin A supplementation progras to children and iron and folic acid supplementation to pregnant women.

To coordinate fortification efforts, a national alliance for food fortification was founded, the 'Comité Sénégalais pour la Fortification des Aliments en Micronutriments' (COSFAM). One of COSFAM's mission includes creating an enabling environment to enact mandatory fortification of wheat flour and refined vegetable oil, laws for which were passed in 2009. Data on the coverage with fortified wheat flour and refined vegetable oil has been collected at the national level in 2014 and it found that just over half of the wheat flour and about one third of the vegetable oil was fortified [19], which is a considerable coverage for such a young program; unfortunately, no more recent coverage assessment at the national level has been conducted.

In 2011, Senegal joined the 'Scaling Up Nutrition' movement and has since made demonstrated progress in creating an enabling environment for nutrition by establishing platforms to bring actors from different sectors together, ensuring coherent policy and legal frameworks, and aligning actions for common results frameworks; with regards to financial tracking and resource mobilization, progress has been made, but at present, funds allocated are deemed insufficient.

1.3 Objectives

The main objectives of this report are to:

1) Present the prevalence of nutritional anthropometry-related indicators for children 12-59 months of age for 2018: wasting, stunting, and overweight; where possible and useful, disaggregated by certain demographic variables;
2) Present the anemia prevalence for children 12-59 months of age, non-pregnant women 15-49 years of age, and pregnant women 15-49 years of age for 2018; where possible and useful, disaggregated by certain demographic variables;
3) Present the prevalence of key micronutrient deficiencies for children and women for 2018; where possible and useful, disaggregated by certain demographic variables:
    a. Iron and vitamin A deficiency for children 12-59 months of age;
    b. Iron, vitamin A and folate deficiency for non-pregnant women 15-49 years of age and pregnant women 15-49 years of age;

4) Identify putative risk factors factors for anemia, iron deficiency, vitamin A deficiency, and (in women only) folate deficiency for 2018;
5) Present other proximal nutrition indicators (morbidity, dietary patterns) for 2018;
6) Compare main results of the 2018 micronutrient survey with a baseline survey conducted in 2010.

2 Methodology - 2018 survey

2.1 Survey design and sampling procedure

The 2018 micronutrient survey targeted two groups: children 12-59 months of age and women 15-49 years of age. The primary sampling unit (PSU) was the census district (zone de dénombrement). The desired number of PSUs was selected with probability proportional to the size, with the measurement of size being the number of households in each PSU. Separate samples of PSUs were drawn in each of the four strata:

1) Dakar and environs (including the Départements de Dakar, Guédiawaye et de Pikine in the region of Dakar as well as the Département de Rufisque
2) Other urban areas of Senegal
3) Rural areas in the south (regions of Kolda, Tambacounda, Ziguinchor Kédougou, and Sédhiou)
4) Rural areas in the north (rural areas of Dakar region and the regions of Diourbel, Fatick, Kaolack, Louga, Matam, Saint Louis, Thiès and Kaffrine).

Each selected PSU then underwent a new household listing to ensure an accurate sampling frame for the second stage of sampling. From this new list of households, households were selected with equal probability of selection. Households were then visited by a survey team which sought verbal consent from the household head or another adult member the household for survey data collection activities. In each selected household, all women 15-49 years of age and all children 12-59 months of age who were considered to be household members were eligible for recruitment into the survey sample as long as appropriate written consent was given and the individual showed no signs of serious illness, such as high temperature or being bedridden. Data collection included an interview with all consenting and eligible women about themselves and an interview with the caretaker of all eligible children living in the household. Blood was collected from women and children and tested on site with a portable hemoglobinometer for hemoglobin concentration. In addition, blood was collected for laboratory testing of micronutrient biomarkers.

2.2 Description of sample size calculation

The sample size was calculated to obtain the desired precision around a point estimate of the prevalence of iron deficiency in women 15-49 years of age using the formula shown below:

$$n = \frac{2^2 * p * (1-p)}{e^2 * pb_h * tm_h * tr} * d$$

Where n is the minimum number of households desired for the survey sample, p the expected prevalence, d the design effect, e the error margins (or ½ confidence interval), pb_h the proportion of the stratum h population made up of women 15-49 years, tm_h the mean household size in the stratum h, and tr is the household response rate.

The assumed prevalence of iron deficiency was 39%, the assumed design effect was 2.9, and the assumed response rate was 95%. The required number of women was converted to households by accounting for

the proportion of the entire population made of target women and the average household size in each of the four strata. The minimum number of women 15-49 years of age and children 12-59 months of age resulting from the sample size calculation was 2554 and 1371, respectively.

2.3 Survey population

The sampling consisted of all households resident in Senegal at the time of survey data collection. Institutional populations, such as prison inmates and residents of military bases, were not included.

Inclusion criteria were as follows:

1) NPW: residing in a selected household, having signed written informed consent, being aged 15-49 years by self-report, and not having signs of acute disease or not being bedridden;

2) PSC: residing in a selected household, parent having signed written informed consent, being aged 12-59 months as reported by caregiver, and not having signs of acute disease or not being bedridden.

Exclusion criteria were absence of any of the above inclusion criteria.

2.4 Field work and data collection

2.4.1 Interviewer training and survey pre-testing

Prior to data collection, team members were trained on all aspects of the survey. The training consisted of classroom instruction and practice and of field testing of all survey procedures.

The first part of the training consisted of understanding the overall survey procedures, including:

1) Roles and responsibilities of each team member;
2) The sampling frame, number of clusters, total number of households to survey in total and per cluster;
3) Identification of PSUs and households within selected PSUs: information and sensitization of local authorities, identification of boundaries and selecting households;
4) General approach to conduct interviews: communication with participants, help respondents to understand the question without providing response hints (unless where applicable) and general attitude with respondents;
5) Questionnaire training: all questions were reviewed in detail, followed by role plays to practice the questionnaire administration and discuss observations made;
6) Training on the use of smartphones and ODK with regards to record, save, and upload data obtained during the survey;
7) Use of anthropometry equipment and correct measurement of anthropometric indicators: equipment was introduced and interviewers were given the opportunity to use the equipment with the use of dummies;
8) Anthropometry standardization: on 10 measuring stations, 50 mother-child pairs were repeatedly measured and results were compared between the interviewers and against the trainers' results.

On day 4 of the training of interviewers, the field test was conducted. To do so, a census district in Dakar which was not part of the 2018 micronutrient survey was selected and the interviewers conducted interviewers and anthropometric measurements.

The nurses were trained separately on correct venepuncture techniques, the use of the Hemocue 301 device, centrifugation and aliquotation of obtained samples, as well as the cold chain during the field work. This training lasted 3 days, and the fourth day was used to prepare all the materials and equipment for the field work.

2.4.2 Field work organization

Field work took place between 8 April and 7 May 2018. Interviews were conducted first, after having obtained written informed consent from the responding women or the caregivers of the children. Anthropometry was conducted thereafter, followed by phlebotomy. All reasonable attempts were made to recruit selected households. At least two repeat visits were made before dismissing a household as non-responding.

Data collection was done by 10 teams, each comprised of 2 interviewers (one of which was team leader), 1 nurse/phlebotomist, and a medical doctor for clinical examination.

2.4.3 Interviews

For data collection, paper-based questionnaires were used initially, but interviewers entered the responses on smartphones on the same or following day using Open Data Kit (ODK). Interviewers administered the woman questionnaire first, followed by the pre- school child one. Household and individual questionnaires were available in French. Interviews were conducted in the interviewee's preferred language.

At the end of each day, the team leader reviewed and collated the different forms and questionnaires. Interviewers were notified of any errors and/or omissions, whereupon they were instructed to make the necessary corrections, when possible.

2.4.4 Anthropometry measurements

Following the interviews, one interviewer, assisted by the second interviewer, proceeded to take anthropometric measures, weight and length/height of PSC and NPW and mid-upper arm circumference of PSC.

Length/height and weight measurements were taken using standard methods [20] on a SECA scale (877, SECA, Hamburg, Germany). For children who could not stand by themselves, the mother or caregiver was first measured alone, the scaled tared, and the child handed to the mother. As a result, the child's weight was obtained by automated subtraction using tared scales. Children's height or length was measured by using a standard wooden height board (UNICEF, #S0114540). MUAC was measured following standard procedures and using a non-elastique MUAC measuring tape (UNICEF, # S0145620). Anthropometry results were initially recorded on a paper form and later entered into ODK.

2.4.5 Blood sampling, processing and storage

Phlebotomy was done in the household following interviews and anthropometric measures. First, the blood collection tubes were labelled with a unique identifier assigned to each survey subject. For both PSC and NPW, two 10 mL EDTA tubes (EK-colorlife healthcare, K 800701). During phlebotomy, hygiene precautions were respected and only single-use material was used to minimize the risk of contamination.

Following blood collection, the tubes were gently inverted to homogeneize the sample with the anticoagulant. Tubes were closed, wrapped in aluminum foil and placed in a cool box containing cold packs to ensure they are stored cold but not frozen at ~4°C and in the dark until further processing later the same day.

Within 4 hours of obtaining the blood sample, samples were processed at the nearest appropriate health facility. First, a few drops of whole blood were extracted from one tube using a disposable plastic pipette for hemoglobin measurements. The remaining whole blood was centrifuged and the resulting plasma aliquoted in 2 mL cryotubes, which were then placed in cryoboxes and frozen at -18°C in portable freezers until regular transport to Dakar using vehicles equipped with mobile freezers. In Dakar, samples were stored at -80°C until laboratory analysis.

2.5 Definition of indicators and thresholds used

Table 3 provides an overview of the laboratory tests used for the 2018 survey to measure blood biomarkers, as well as the cut-offs applied to define a nutritional deficiency or otherwise abnormal concentration.

Table 3: Analysis, cut-offs, and laboratory tests used to measure biomarkers, Senegal 2018

Variables	Analysis	Cut-off defining deficiency or abnormal	Laboratory test
Children			
Anemia	Hemoglobin	<110 g/L [21]	HemoCue 301
Iron deficiency	Ferritin	Adjusted level <12 µg/L [22]	ABBOTT Architect c4000/i1000
Inflammation	CRP	≥5 mg/L [23]	ABBOTT Architect c4000/i1000
	AGP	≥ 1 g/L [23]	
Vitamin A deficiency	Retinol	<0.7 µmol/L [24]	High performance liquid chromatography
Non-pregnant women			
Anemia	Hemoglobin	<12 g/L [21]	HemoCue 301
Iron deficiency	Ferritin	Adjusted level <15 µg/L [22]	ABBOTT Architect c4000/i1000
Inflammation	CRP	≥5 mg/L [23]	ABBOTT Architect c4000/i1000
	AGP	≥ 1 g/L [23]	
Vitamin A deficiency	Retinol	<0.7 µmol/L [24]	High performance liquid chromatography
Folate deficiency	Plasma folate	<10 nmol/L [25]	ABBOTT Architect c4000/i1000
Pregnant women			
Anemia	Hemoglobin	<11 g/L [21]	HemoCue 301
Iron deficiency	Ferritin	Adjusted level <15 µg/L [22]	ABBOTT Architect c4000/i1000
Inflammation	CRP	≥5 mg/L [23]	ABBOTT Architect c4000/i1000
	AGP	≥ 1 g/L [23]	
Vitamin A deficiency	Retinol	<0.7 µmol/L [24]	High performance liquid chromatography
Folate deficiency	Plasma folate	<10 nmol/L [25]	ABBOTT Architect c4000/i1000

Anthropometric indices in children 12-59 months of age were calculated in both the 2010 and 2018 surveys from the anthropometric measurements, age, and sex using SPSS syntax published by the World Health Organization. These calculations used the WHO Child Growth Standard. Children with z-scores < -3 were defined as severely malnourished, those with with z-scores ≥ -3 and <-2 were defined as moderate, and those with z-scores ≥ -2 and < +2 were considered normal. These categories apply equally to stunting, wasting, and underweight. Children with weight-for-height z-scores ≥ +2 were considered overweight or obese [26].

Feeding indicators in children 12-59 months of age were defined, as far as possible, using definitions similar to those given by the WHO-UNICEF recommendations for measuring infant and young child feeding (IYCF) indicators [27]. However, the data collected on child feeding cannot be used to calculate

the standard WHO-UNICEF infant and young child feeding (IYCF) indicators. One problem is that the target group in the both surveys was children 12 - 59 months, thus making it impossible to calculate those standard IYCF indicators defined for children <6 months of age, children <24 months of age, and children 6 - 23 months of age. In addition, the questions about consumption of food groups do not allow calculation of minimum dietary diversity, minimum feeding frequency, or minimum adequate diet because the questions about consumption of liquids were non-standard, and there were no questions about the frequency of feeding. In addition, it should be noted that the question regarding current iron supplementation among children is based on voluntary preventive use, as there is currently no iron supplementation program in this group. Similarly, the question 'current vitamin A intake' does not differentiate the intake of supplements distributed by the health system with any other voluntary intake.

2.6 Laboratory analysis

Hemoglobin measurements were conducted using the HemoCue Hb301 (HemoCue, Ångelholm, Sweden); each blood sample was analyzed in duplicate and to do this duplicate, the second tube was used to conduct the second measurement. Quality control was done using a quality control sample with the 'normal' level (Eurotrol, Ede, Netherlands) at the beginning of fieldwork.

Laboratory tests for ferritin, serum folate, AGP and CRP were performed by the Institut Pasteur in Dakar (Senegal), on ABBOTT Architect c4000/i1000 automated instruments. To validate the series, the laboratory performed independent BioRad internal quality controls (IQC) twice daily, except for the CRP which used the IQC of the instrument supplier.

Results were automatically transferred to the laboratory information system (LIS), further minimizing human transcription errors. The laboratory is registered and participates regularly throughout the year in external quality controls (EQC) provided by the French organization PROBIOQUAL ('association pour la promotion du contrôle de qualité en Biologie Médicale') accredited by COFRAC. The excellent results obtained in these EQCs during the study period attest to the accuracy of the results.

Retinol was measured by the Eurofins-Biomnis laboratory in Lyon (France) by high performance liquid chromatography (HPLC) with UV detection on the WATERS UPLC chain (Milford, USA). The laboratory participates in an external quality control program provided by ASQUALAB, with a successful performance in 2019/20, the sample analysis period. The laboratory is also accredited to ISO15189 for vitamin A analysis.

2.7 Data entry and analysis

2.7.1 Data entry

Data was initially recorded on paper-based questionnaires and forms, but was entered into ODK while in the field. A second data entry from the paper-based questionnaires was conducted upon completion of

field work and the entries compared. In case of discrepancies, the paper-based forms were consulted to double-check the entered information.

2.7.2 Data analysis

Databases for both the 2010 and 2018 surveys were received in STATA format from collaborators in Dakar. Two databases were received for each survey: one for children 12-59 months of age and one for women 15-49 months of age. The 2010 survey data contained no variable or value labels, while the 2018 survey data did contain this information about each variable. Because no data keys accompanied the databases, new data keys were constructed by attempting to match the questions in the questionnaires used in each survey to the variable names in the databases.

The databases did contain variables identifying the complex sampling parameters, including stratum, cluster, and sampling weights. After confirming the method of calculation for the sampling weights, they were used as contained in the databases.

- The databases were translated into SPSS format for analysis in SPSS version 27. Frequency distribution of the values contained in selected variables were used to describe the survey sample.

-

Table *3* above shows the cut-off values used to dichotomize continuous laboratory results to define deficiency.

No adjustment of hemoglobin values for altitude of residence or smoking status was necessary because the highest altitude in Senegal is 648 meters [28] and only 0.4% of Senegalese women smoke tobacco[29]. Ferritin values were adjusted in children and women for the presence of inflammation using the method described by Namaste et al [30,31]. In summary, the association between serum ferritin concentration and individual markers of inflammation (CRP and AGP) was measured by constructing a model with serum ferritin as the outcome and CRP and AGP as independent variables. The beta coefficients for each marker were used to calculate the ferritin concentration in the absence of inflammation if and only if that marker of inflammation was above the 10th percentile using the distribution of values in the 2018 survey data. For example, if an individual's CRP value is below the 10th percentile of CRP values, but that individual's AGP value is above the 10th percentile of AGP values, only the AGP beta coefficient is used to calculate an adjusted ferritin concentration. Both the derivation of the original linear regression model and the calculation of adjusted ferritin were performed using ln-transformed values for ferritin and biomarkers of inflammation to meet the normality requirements of linear regression modeling.

Retinol values in children were similarly adjusted for the presence of inflammation. As recommended by the BRINDA publications, retinol values in females were not adjusted for inflammation because in this target group, retinol values are inconsistently associated with markers of inflammation without statistical significance [31].

For children whose date of birth could be obtained from the birth certificate, age was calculated by subtracting the date of birth from the date of the interview.

For children without dates of birth, the mother's reported age was used. Self-reported age in years was used for women survey subjects.

Most variables, including both putative risk factors and outcomes, were categorized for analysis. Bivariate analysis was used to test the association between variables, with an adjusted chi-square P value <0.05 considered statistically significant. The precision of estimates was indicated by 95% confidence intervals.

The comparison of the 2010 and 2018 surveys demonstrated that the samples in these two surveys differed by urban/rural residence and age. For this reason, generalized linear models were used to minimize confounding and measure the independent effect of the independent variable survey. All models included the micronutrient deficiency as the dichotomous outcome; independent variables included age as a continuous variable and urban/rural residence.

Standard measures of data quality were calculated according to the recommendations of the WHO [32]. These include inspection of the distribution of anthropometric scores and calculation of the standard deviation for each z-score without accounting for the complex sampling. In addition, histograms of child and woman ages were inspected for rounding. The distribution of decimals or final digits of anthropometric measurements were displayed in histograms, and the Myers unblended index provides a summary measure of digit heaping. Finally, standard anthropometry flags were routinely calculated when z-scores were calculated.

2.8 Ethical considerations

In order to ensure that the survey follows principles to protect respondents and prevent unnecessary risk to survey respondents, ethical approval for the study was obtained from the 'Comité National d'Ethique pour la Recherche en Santé (CNERS) du Ministère de la Santé et de l'Action Sociale' (approval dated 6 February 2018, #V/L N° 00252/ITA/COSFAM).

For household interviews, oral consent was first sought from the household head or in his/her absence, from another adult household member. The selected women and child caregivers were asked to provide written informed consent for themselves and their participating children. If any consenting survey participants were unable to read and write, the consent form was read out loud to them and a thumbprint or fingerprint was taken as evidence of consent in lieu of a signature. The respondents were also told that they are free to withdraw from participation in the survey at any time, even after written consent had been given.

Confidentiality of information from the respondents was upheld with utmost care throughout data collection, processing and analysis. Identifying records, in both electronic and paper formats, are stored under lock and key (or password) at all times and access granted only to specifically identified survey personnel. Specific identifying information was stripped from all electronic databases used by the survey management team for data analysis.

Participants diagnosed with severe acute malnutrition or severe anemia were referred to a nearby health facility for follow-up.

3 Results – 2018 survey

3.1 Survey sample sizes

The data sets do not include the final results of the data collection visit to each household. As a result, the response rates for households or any individual target group cannot be calculated, and reasons for non-response are unknown. **Table 4** below presents the actual sample size for each target group. The decrease in the number of biological data is mainly due to a refusal rate and insufficient volume of blood samples. The decrease in the number of biological data is mainly due to a refusal rate and insufficient volume of blood samples.

Table 4: Actual sample sizes, Senegal 2018

Target group and type of data	Actual sample size
Children 12-59 months of age	
Questionnaire data (age)	696
Biomarker data (ferritin)	574
Women 15-49 years of age	
Questionnaire data (age)	1916
Biomarker data (ferritin)	1865
Non-pregnant, non-lactating women	
Questionnaire data (age)	1461
Biomarker data (ferritin)	1414
Non-pregnant, lactating women	
Questionnaire data (age)	455
Biomarker data (ferritin)	451
Pregnant women	
Questionnaire data (age)	105
Biomarker data (ferritin)	103

3.2 Children 12-59 months of age

3.2.1 Child characteristics

Table 5 below describes the demographic characteristics of children who participated in the Senegal micronutrient survey. About one-half of children lived in urban areas, which is somewhat larger than the proportion on the Senegal population. Approximately one quarter of the sample came from each stratum. Children were somewhat disproportionately older, with almost one third of children being 48-59 months of age. The M:F sex ratio is 0.87.

Table 5: Description of sampled children 12-59 months of age, Senegal 2018

	Proportion of children aged 12-59 months in the 2018 survey sample		Proportion of children aged 12-59 months in Senegal population
Characteristic	**N**	**% [a]**	% [33]
TOTAL	696	100%	
Urban/rural			
Urban	347	46.5%	37.5%
Rural	349	53.5%	62.5%
Stratum			
Dakar	152	24.4%	17.9%
Other urban	195	27.9%	19.6%
Rural south	150	20.7%	15.2%
Rural north	199	27.0%	47.3%
Age (in months)			
12-23	124	15.3%	26.2%
24-35	159	23.9%	25.4%
36-47	209	28.0%	24.6%
48-59	204	32.8%	23.9%
Sex			
Male	330	46.6%	51.1%
Female	366	53.4%	48.9%

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection.

3.2.2 Recent illness and health indicators

Table 6 below shows various recent illnesses as reported by the caregiver.

There were no statistically significant differences in the proportion of children with fever, diarrhea, or respiratory difficulty in the past 15 days by urban/rural status, stratum of residence, age group, or sex. On the other hand, current inflammation was more common in the youngest age group and in girls.

Table 6: Proportion of children 12-59 months with various forms of morbidity in the past 15 days and inflammation status, by various demographic characteristics, Senegal 2018

Characteristic	Fever				Diarrhea				Cough and/or respiratory difficulty				Any inflammation [d]			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*
TOTAL	687	14.9%	(11.0, 19.9)		686	7.1%	(4.9, 10.3)		688	7.7%	(5.6, 10.4)		508	9.8%	(7.3, 13.1)	
Urban/rural				0.418				0.366				0.774				0.806
Urban	340	13.0%	(8.4, 19.7)		340	5.9%	(3.8, 9.0)		342	8.0%	(5.2, 2.2)		262	10.2%	(6.9, 14.8)	
Rural	347	16.6%	(11.0, 24.2)		346	8.1%	(4.6, 13.9)		346	7.3%	(4.5, 11.6)		246	9.5%	(6.0, 14.7)	
Stratum				0.685				0.699				0.552				0.452
Dakar	147	10.0%	(5.5, 17.6)		147	7.3%	(4.2, 12.4)		148	7.1%	(3.6, 13.8)		113	12.8%	(7.9, 20.2)	
Other urban	193	14.8%	(8.6, 24.3)		193	4.5%	(2.0, 9.8)		194	9.8%	(5.8, 15.9)		149	9.3%	(5.2, 16.0)	
Rural south	149	15.6%	(9.6, 24.3)		149	6.3%	(3.1, 12.4)		149	11.0%	(5.6, 20.7)		93	15.3%	(9.4, 23.9)	
Rural north	198	15.2%	(8.9, 24.7)		197	7.9%	(3.7, 15.8)		197	6.4%	(3.7, 11.0)		153	9.6%	(5.9, 15.4)	
Age group in months				0.788				0.353				0.728				0.015
12-23	124	17.3%	(8.9, 30.7)		124	12.3%	(6.1, 23.5)		124	8.4%	(4.6, 15.0)		86	20.5%	(12.8, 31.4)	
24-35	157	16.1%	9.9, 25.2)		157	6.8%	3.0, 14.6)		157	9.3%	(5.1, 16.4)		109	9.6%	(5.2, 17.2)	
36-47	206	15.2%	(9.7, 23.1)		205	5.9%	(3.3, 10.30		206	6.3%	(3.8, 10.3)		151	10.1%	(6.1, 16.4)	
48-59	200	12.7%	(8.0, 19.6)		200	5.8%	(2.6, 12.4)		201	7.2%	(4.3, 11.8)		162	5.6%	(2.5, 11.9)	
Sex				0.787				0.914				0.627				0.040
Male	324	14.4%	(10.3, 19.9)		323	7.2%	(4.6, 11.2)		324	8.2%	(5.4, 12.4)		241	6.5%	(3.9, 10.8)	
Female	363	15.4%	(10.2, 22.5)		363	7.0%	(4.3, 11.3)		364	7.2%	(4.6, 10.9)		267	12.8%	(8.7, 18.3)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.
d Defined as AGP, CRP or high AGP/CRP

3.2.3 Breastfeeding and other feeding indicators

Overall, 639 of 659 (97.6%) children had been breast-fed at some point in their lives. Because of this near universal exposure, no subgroup analysis was done for this factor. **Table 7** provides results of various other child feeding indicators by sub-groups. Early breastfeeding was reported in more than half of children with no statistically significant differences by stratum, urban/rural residence, or child sex. Relatively few children had consumed micronutrient powders, and although not statistically significant, the proportion was higher in urban children. There was little difference between age groups or between sexes. Overall, about one third of children 12-23 months of age had consumed five or more food groups in the prior 24 hours, and there was no statistically significant differences by stratum, urban/rural residence, or child sex.

Table 8 shows the proportion of children who consumed iron-rich or vitamin A-rich foods, respectively, during the previous survey day. About two-thirds of children reportedly consumed iron-rich food and vitamin A-rich food, with little variation across residence (urban/rural) and child's gender. There is only a statistically significant difference by stratum for iron-rich foods, with the rural South having less widespread intake.

Table 7: Proportion of children with other feeding indicators, by various demographic characteristics, Senegal 2018

Characteristic	Early breastfeeding (12-23 months of age)				Consuming micronutrient powder (12-59 months of age)				Consuming 5+ food groups [d] (12-23 months of age)			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p- value [c]*
TOTAL	119	61.5%	(48.6, 73.0)		682	4.3%	(2.6, 6.9)		124	34.3%	(23.9, 46.5)	
Urban/rural				0.523				0.077				0.205
Urban	58	65.6%	(49.6, 78.6)		337	6.3%	(3.5, 11.3)		62	27.3%	(16.4, 41.7)	
Rural	61	57.7%	(38.3, 75.0)		345	2.5%	(1.0, 6.0)		62	41.3%	(25.2, 59.5)	
Stratum				0.575				0.182				0.497
Dakar	26	50.5%	(26.2, 74.5)		145	6.4%	(2.6, 15.0)		29	31.6%	(13.2, 58.3)	
Other urban	32	72.6%	(50.8, 87.1)		192	5.9%	(2.2, 14.4)		33	22.5%	(10.8, 41.0)	
Rural south	38	58.8%	(39.2, 76.0)		147	0.9%	(0.1, 6.3)		39	34.6%	(16.7, 58.3)	
Rural north	23	57.1%	(31.0, 79.7)		198	2.6%	(1.0, 6.6)		23	48.1%	(25.6, 71.4)	
Age (in months)								0.965				
12-23	119	61.5%	(48.6, 73.0)		119	3.3%	(1.0, 10.6)		41	34.3%	(23.9, 46.5)	
24-35					158	4.2%	(1.9, 8.9)					
36-47					204	4.7%	(1.9, 11.1)					
48-59					201	4.4%	(2.0, 9.3)					
Sex				0.851				0.974				0.747
Male	60	60.7%	(45.1, 74.5)		320	4.3%	(2.2, 8.3)		65	32.9%	(20.4, 48.4)	
Female	59	62.2%	(47.2, 75.3)		362	4.2%	(2.4, 7.3)		59	35.8%	(22.8, 51.3)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.
[d] Data do not allow calculation of standard WHO/UNICEF indicator for minimum dietary diversity in children 6-23 months of age. See text for definition of this modified indicator.

Table 8: Proportion of children consuming iron-and-vitamin A-rich foods, by various demographic characteristics, Senegal 2018

		Consumption of iron-rich foods (12-59 months) [a]			Consumption of vitamin A-rich foods (12-59 months) [b]			
Characteristics	*N*	*% [c]*	*IC 95%[d]*	*valeur p [e]*	*N*	*% [c]*	*IC 95%[d]*	*valeur p [e]*
TOTAL	696	68.3%	(61.6; 74.3)		696	67.3%	(59.5; 74.3)	
Urban/rural				0,114				0.179
Urban	253	73.4%	(67.0; 78.9)		347	72.5%	(63.9; 79.7)	
Rural	204	63.8%	(52.5; 73.8)		349	62.8%	(50.1; 73.9)	
Stratum				0,026				0.368
Dakar	152	67.5%	(55.7; 77.5)		152	67.2%	(50.8; 80.3)	
Other urban	195	74.4%	(65.3; 81.8)		195	71.3%	(59.2; 81.0)	
Rural south	150	48,1%	(35.1; 61.4)		150	54.1%	(39.1; 68.4)	
Rural north	199	62.9%	(48.1; 75.6)		199	60.0%	(43.3; 74.7)	
Gender				0,905				0.940
Male	330	68.5%	(60.6; 75.5)		330	67.2%	(58.2; 75.0)	
Female	366	68.0%	(60.3; 74.9)		366	67.4%	(59.0; 74.9)	

Note : Note: N's are denominators for a specific subgroup.
a Defined by aggregating the consumption of meat, fish, fortified infant cereals, or micronutrient powders in the previous 24 hours.
b Defined by aggregating consumption of vitamin A-rich fruits and vegetables in the previous 24 hours.
c All percentages, except for estimates by region, are weighted to account for unequal probability of selection across strata.
d CI=confidence interval calculated taking into account the complex sampling design.
e P value <0.05 indicates that at least one subgroup is statistically different from the others.

3.2.4 Supplement consumption

As shown in **Figure 1** below, even though relatively few children were taking iron or vitamin A supplements, a higher proportion of boys than girls were taking iron supplements ($p<0.05$). On the other hand, the proportion of boys and girls taking vitamin A supplements was almost identical.

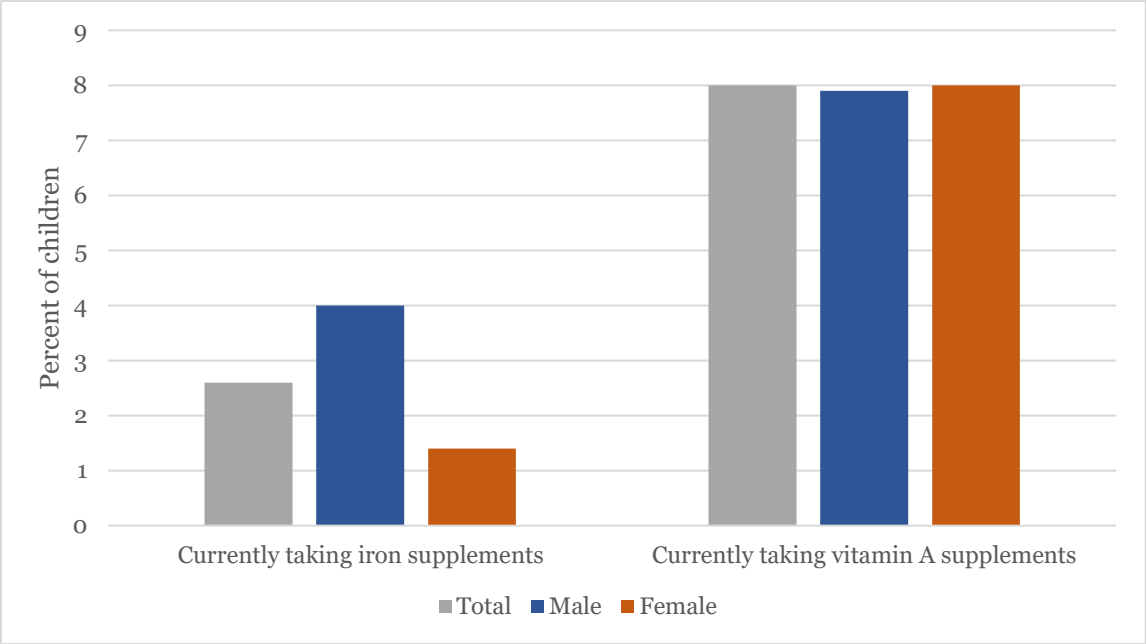


Figure 1: Proportion of children 12-59 months of age consuming supplements, by sex, Senegal 2018

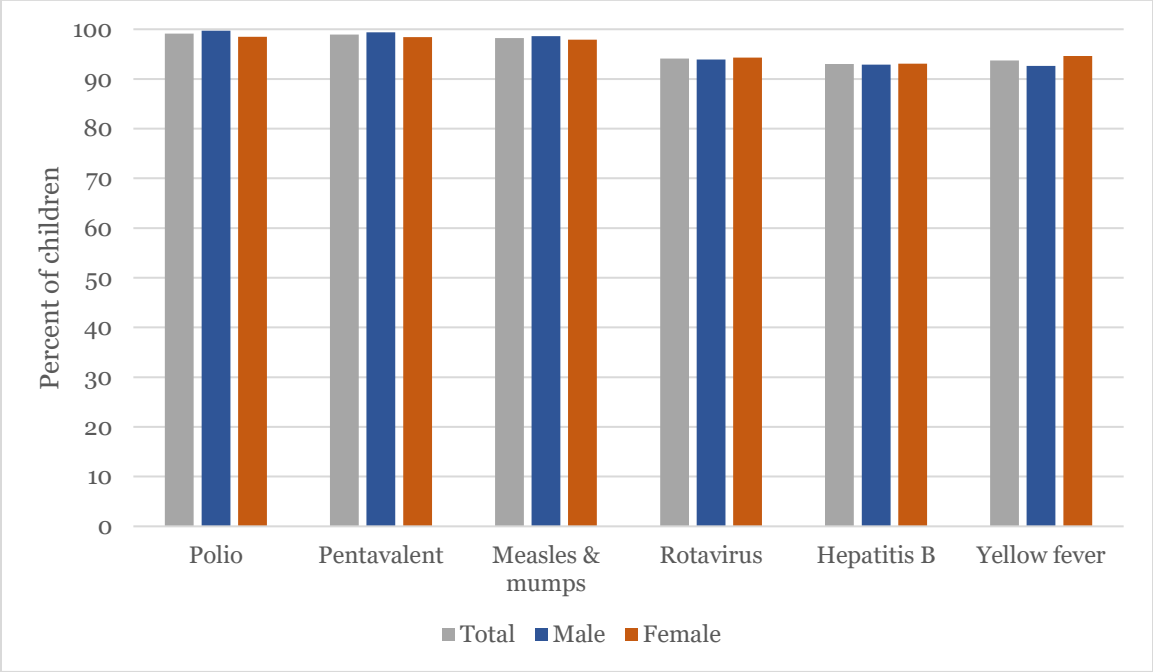


Figure 2: Proportion of children 12-59 months of age vaccinated for selected diseases, Senegal 2018

3.2.5 Anthropometry

The charts below show the distributions of HAZ, WHZ, and WAZ in the survey sample (colored bars) and the WHO Child Growth Standard (dotted line). These distributions are all reasonably normal. The implications of the standard deviations of these z-scores is discussed more fully in Appendix section 8.4 Data quality checks. All indices show a shift to the left with the mean z-score being a negative number, indicating some degree of each type of malnutrition. Additional assessment of the quality of the anthropometric measurements are provided in the appendix, as cited above.

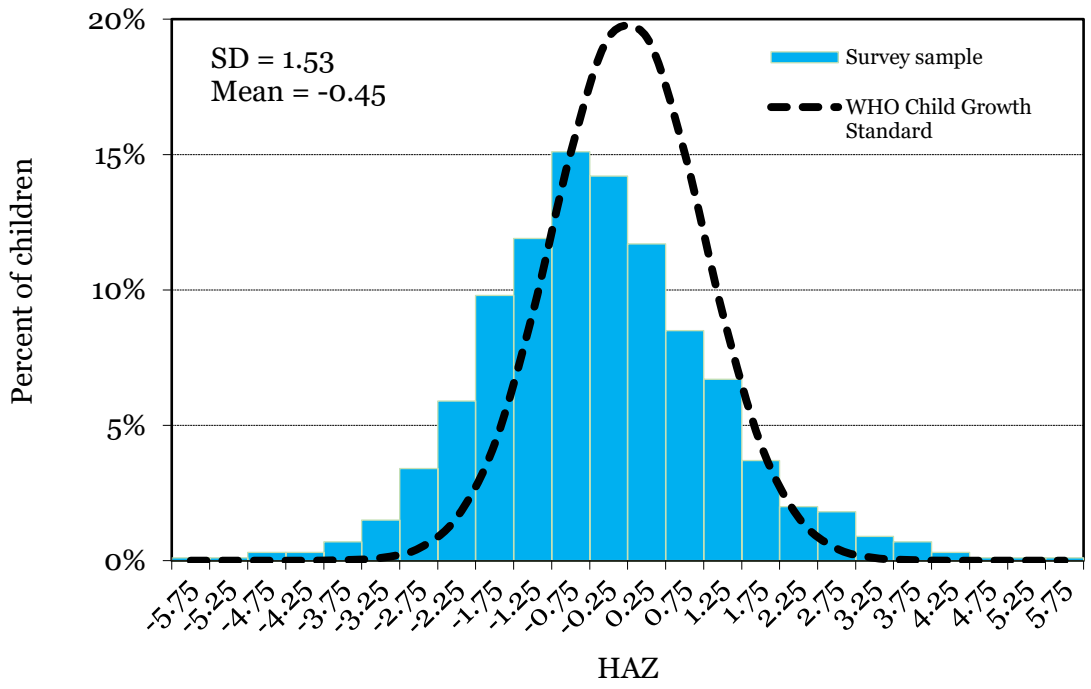


Figure 3: Distribution of height-for-age z-scores and standard deviation in children 12-59 months of age, Senegal 2018

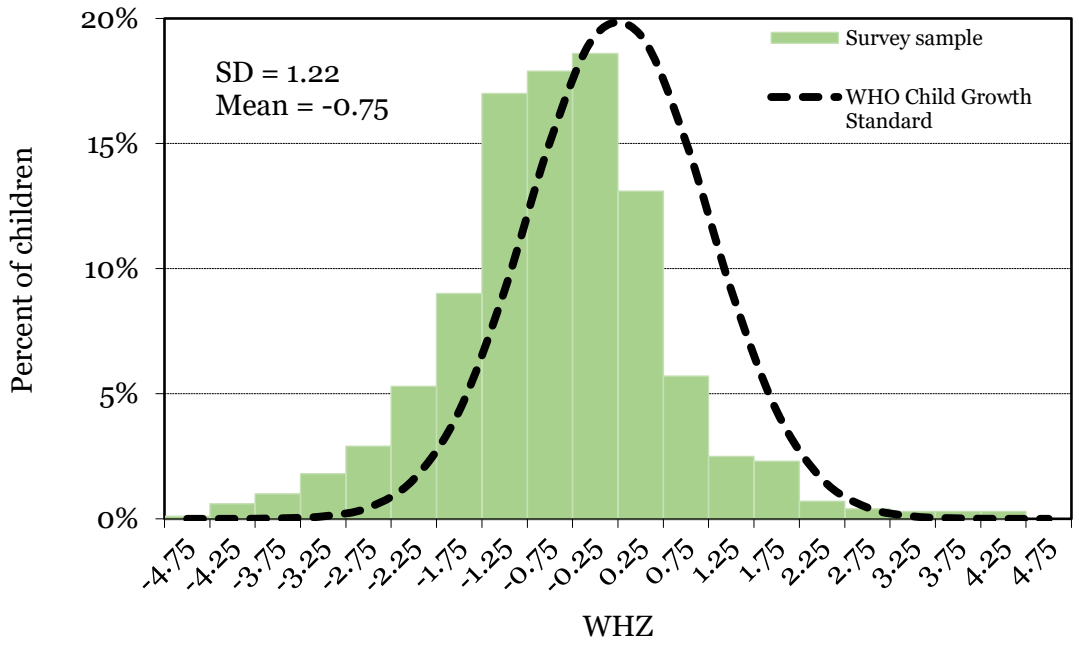


Figure 4: Distribution of weight-for-height z-scores and standard deviation in children 12-59 months of age, Senegal 2018

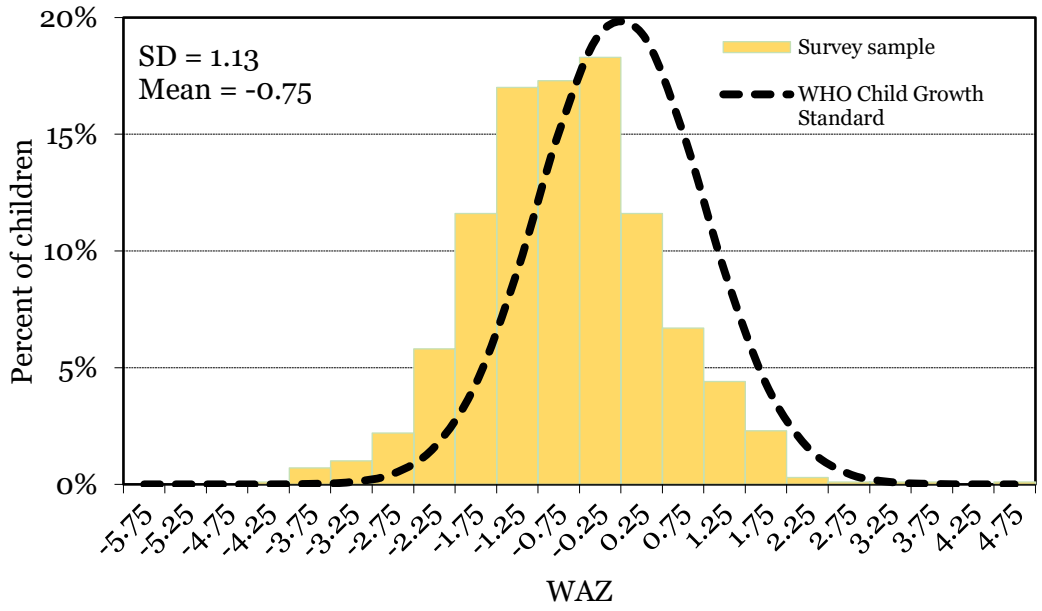


Figure 5: Distribution of weight-for-age z-scores and standard deviation in children 12-59 months of age, Senegal 2018

The prevalence of stunting, wasting, underweight, and overweight or obesity are presented in Table 9**.** Overall, the prevalence of stunting is somewhat elevated and would be classified as 'medium' according to recent WHO recommendations [26]. The prevalence of stunting is substantially higher in the rural areas, especially in the rural north stratum, and this difference is statistically significant. However, there is no statistically significant difference in the prevalence of stunting by age or sex. The prevalence of

wasting is almost the same as that of stunting and would be classified as ‘high’ [26]. As with stunting, the prevalence of wasting is higher in rural areas, but without statistical significance. The lowest prevalence of wasting is in the Dakar stratum, and the other three strata show more similar prevalences. he prevalence of wasting is higher in the older age group and among girls, but neither of these differences is statistically significant. The prevalence of underweight mirrors the trends observed for wasting. Prevalence is lower in the Dakar stratum and higher in rural areas. Underweight is more common in children aged 36 months and older than in children aged 12 to 35 months, and there is little difference by gender. The prevalence of overweight is 1.0% nationally, and obesity is 0.7%. These prevalences would be classified as "very low" [26]. Due to the low prevalence, these two categories were combined for all analyses. The prevalence of overweight/obesity did not differ significantly by urban/rural residence, stratum or gender. However, the prevalence of overweight/obesity was statistically significantly related to age, with the highest prevalence observed in the youngest age group, 12-23 months.

Table 9: Prevalence of selected types of malnutrition in children 12-59 months, by various demographic characteristics, Senegal 2018 survey

Characteristic	Stunted				Wasted				Underweight				Overweight or obese			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*
TOTAL	683	13.9%	(11.2, 17.2)		681	13.0%	(10.1, 16.7)		688	10.8%	(8.4, 13.9)		681	1.7%	(0.9, 3.0)	
Urban/rural				0.017				0.180				0.002				0.414
Urban	340	10.2%	(7.3, 14.1)		339	10.6%	(7.0, 15.8)		341	6.3%	(3.9, 9.9)		339	1.2%	(0.5, 3.0)	
Rural	343	17.1%	(13.0, 22.3)		342	15.1%	(10.8, 20.6)		347	14.7%	(11.0, 19.5)		342	2.0%	(0.9, 4.2)	
Stratum				0.022				0.048				0.013				0.195
Dakar	145	8.2%	(5.0, 13.4)		146	4.8%	(2.3, 9.8)		147	3.7%	(1.6, 8.0)		146	3.0%	(1.1, 8.2)	
Other urban	195	11.0%	(7.0, 17.0)		193	13.3%	(8.5, 20.3)		194	8.6%	(4.9, 14.6)		193	0.4%	(0.0, 2.6)	
Rural south	147	9.8%	(5.9, 15.8)		146	11.7%	(7.3, 18.3)		150	9.8%	(5.9, 16.1)		146	3.5%	(1.4, 8.7)	
Rural north	196	18.8%	(12.9, 26.6)		196	16.0%	(9.6, 25.3)		197	14.6%	(9.8, 21.3)		196	2.2%	(0.8, 5.6)	
Age group in months				0.495				0.069				0.022				0.008
12-23	120	18.0%	(11.3, 27.4)		121	11.2%	(6.3, 19.3)		122	5.7%	(2.4, 13.1)		121	5.0%	(2.0, 12.2)	
24-35	158	11.0%	(6.8, 17.4)		157	10.2%	(6.2, 16.5)		158	5.9%	(3.2, 10.7)		157	0.9%	(0.2, 3.7)	
36-47	204	14.6%	(9.8, 21.2)		203	9.9%	(6.1, 15.7)		206	13.4%	(9.1, 19.3)		203	2.2%	(0.8, 5.9)	
48-59	201	13.6%	(9.6, 19.0)		200	18.6%	(12.5, 26.7)		202	14.7%	(9.8, 21.4)		200	0.2%	(0.0, 1.5)	
Sex				0.574				0.288				0.833				0.597
Male	325	14.9%	(11.0, 19.9)		321	11.3%	(7.9, 15.7)		324	10.6%	(7.4, 14.9)		321	1.9%	(0.9, 4.1)	
Female	358	13.0%	(9.3, 18.1)		360	14.6%	(10.2, 20.3)		364	11.1%	(8.1, 14.9)		360	1.4%	(0.6, 3.5)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.2.6 Anemia, iron deficiency, and iron deficiency anemia

Figure 5 below shows the distribution of hemoglobin values for children 12-59 months of age. Many children fall below the cut off defining anemia of 110 g/L. Few children have hemoglobin values of 140 g/L or higher. The weighted mean hemoglobin concentration is 112.6 g/L, and the standard deviation calculated without accounting for complex sampling is 14.6.

Figure 6: Unweighted distribution of hemoglobin concentrations in children 12-59 months of age, Senegal 2018

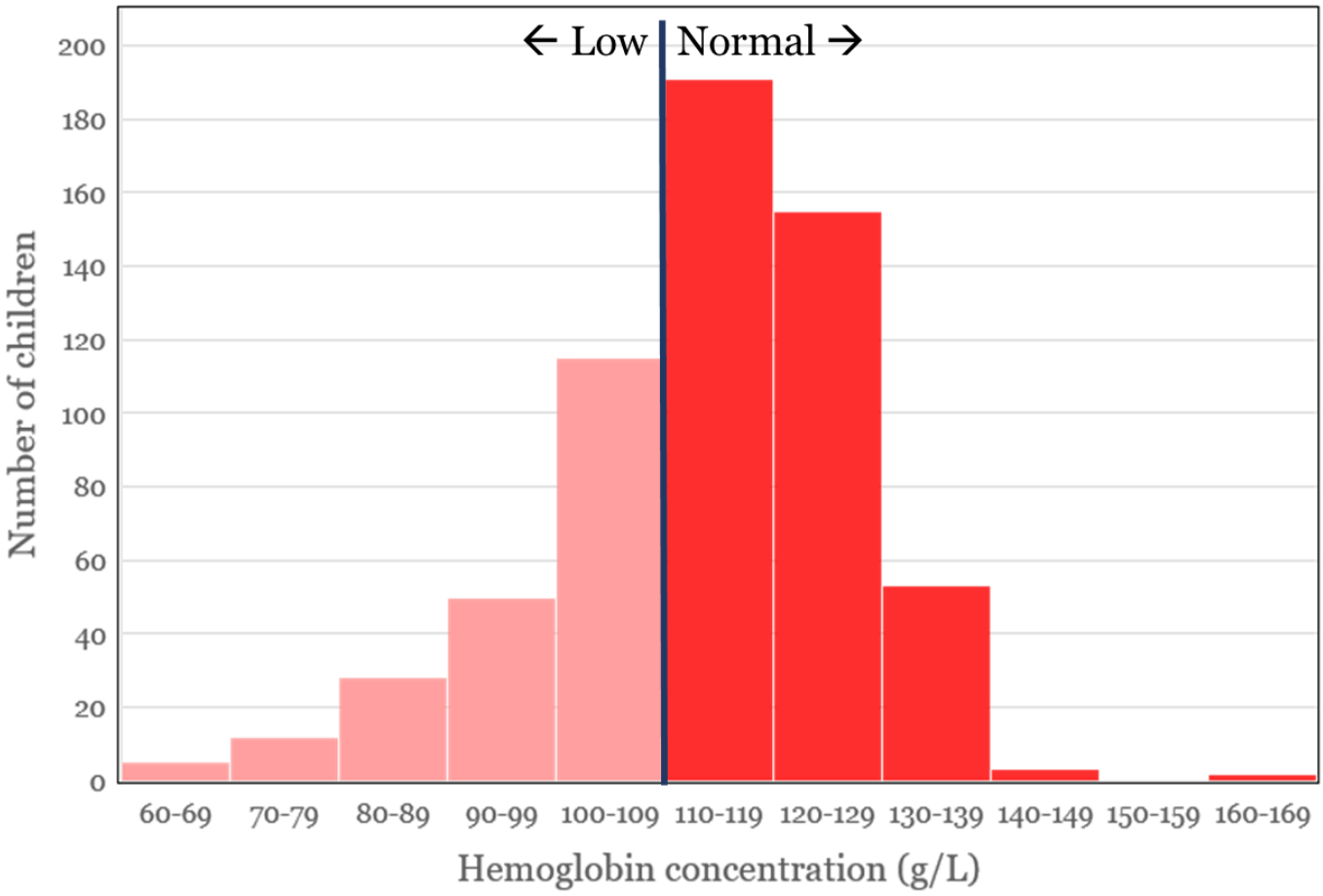


Figure 7 visualizes the proportion of children with concomitant iron deficiency and anemia, often referred to as iron deficiency anemia. It shows that for these children, a large proportion of anemia is accompanied by iron deficiency.

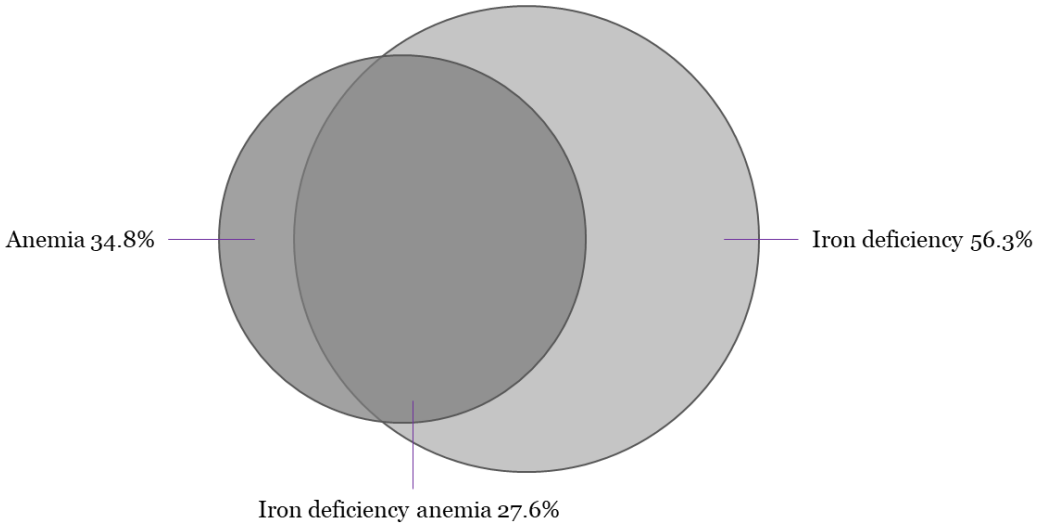


Figure 7: Venn diagram showing overlap between anemia and iron deficiency in children 12-59 months of age, Senegal 2018

As shown in**Table 10** below, about one third of children 12-59 months of age in Senegal have anemia. This prevalence would be classified as 'moderate' by the WHO [34]. The prevalence of anemia is highest in rural areas and lowest in Dakar, although these differences are not statistically significant. The prevalence of anemia drops with age, but is not statistically significantly different in boys and girls. More than one-half of children have iron deficiency, and this prevalence would be classified as 'high' by the WHO [35]. Iron deficiency is more common in rural areas and in Dakar compared to other urban areas. As with anemia, the prevalence of iron deficiency drops with age. In contrast, the prevalence is statistically significantly higher in boys than in the girls. As expected, the prevalence of iron deficiency anemia mirrors that of anemia and iron deficiency; however, the difference in prevalence between urban and rural children is not statistically significant, nor are the differences between strata as marked as with anemia and iron deficiency. The prevalence of iron deficiency anemia declines with age, and shows little difference between boys and girls.

Overall, severe anemia is not common among children 12-59 months of age, nor is it common in any subgroup shown in Table 11 below. The distribution of degrees of anemia is statistically significantly different by age, with both the overall prevalence and the severity of anemia declining with age. There is little difference in the severity of anemia between boys and girls.

Table 10: Prevalence of anemia, iron deficiency, and iron deficiency anemia in children 12-59 months, by various demographic characteristics, Senegal 2018

	Anemia [b]				Iron deficiency [e]				Iron deficiency anemia [b, f]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	614	34.8%	(29.9, 40.2)		574	56.3%	(51.6, 61.0)		604	27.6%	(23.1, 32.6)	
Urban/rural				0.212				0.015				0.097
Urban	302	31.3%	(24.9, 38.5)		286	50.2%	(43.8, 56.7)		299	23.3%	(17.9, 29.8)	
Rural	312	37.8%	(30.4, 45.8)		288	61.5%	(55.1, 67.5)		305	31.1%	(24.4, 38.8)	
Stratum				0.080				0.057				0.341
Dakar	127	23.2%	(14.0, 35.9)		117	63.6%	(50.9, 74.6)		126	21.0%	(11.6, 34.9)	
Other urban	175	35.1%	(27.3, 43.7)		169	47.0%	(38.9, 55.2)		173	26.3%	(19.1, 34.9)	
Rural south	125	42.4%	(31.8, 53.7)		113	65.4%	(52.0, 76.7)		121	34.5%	(23.6, 47.4)	
Rural north	187	37.0%	(28.9, 45.9)		175	59.9%	(51.2, 68.1)		184	30.2%	(22.7, 38.9)	
Age group in months				<0.001				0.001				<0.001
12-23	108	55.3%	(43.2, 66.8)		103	70.3%	(58.3, 80.1)		107	47.2%	(34.9, 59.8)	
24-35	139	46.8%	(37.5, 56.3)		131	65.8%	(56.6, 74.0)		138	36.7%	(28.5, 45.7)	
36-47	184	29.1%	(22.6, 36.5)		170	52.5%	(43.7, 61.1)		181	22.7%	(16.7, 30.1)	
48-59	183	22.0%	(16.1, 29.1)		170	46.2%	(38.8, 53.7)		178	16.2%	(11.2, 22.9)	
Sex				0.422				0.022				0.632
Male	292	36.8%	(30.5, 43.5)		274	61.5%	(55.5, 67.2)		285	28.7%	(23.4, 34.6)	
Female	322	33.2%	(26.5, 40.5)		300	51.7%	(45.1, 58.3)		319	26.6%	(20.3, 34.1)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Anemia defined as hemoglobin < 110 g/L; adjustment for altitude is not required for Senegal.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.
[e] Iron deficiency defined as plasma ferritin < 12 µg/l, after BRINDA adjustment [31].
[f] Iron deficiency anemia defined as inflammation-adjusted plasma ferritin < 12.0 µg/L and hemoglobin < 110 g/L.

Table 11: Proportion of mild, moderate and severe anemia in children 12-59 months of age, Senegal 2018 survey

	Mild anemia [b]			Moderate anemia [b]			Severe anemia [b]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	614	19.4%	(16.1, 23.0)	614	14.8%	(11.7, 18.7)	614	0.6%	(0.3, 1.6)	
Urban/rural										0.099
Urban	302	17.9%	(13.6, 23.4)	302	12.1%	(8.3, 17.2)	302	1.3%	(0.5, 3.3)	
Rural	312	20.6%	(16.1, 25.9)	312	17.1%	(12.5, 23.0)	312	0.1%	(0.0, 0.8)	
Stratum										0.141
Dakar	127	11.4%	(7.6, 16.8)	127	11.4%	(4.7, 25.2)	127	0.4%	(0.1, 2.9)	
Other urban	175	19.9%	(14.3, 26.9)	175	13.3%	(8.5, 20.2)	175	1.9%	(0.6, 5.5)	
Rural south	125	20.9%	(14.8, 28.7)	125	20.7%	(14.2, 29.0)	125	0.9%	(0.1, 5.7)	
Rural north	187	21.4%	(16.3, 27.6)	187	15.6%	(10.4, 22.7)	187	0	(0.0, 0.0)	
Age group in months										<0.001
12-23	108	24.9%	(17.1, 34.7)	108	28.9%	(20.3, 39.5)	108	1.5%	(0.3, 6.2)	
24-35	139	22.9%	(16.8, 30.3)	139	22.7%	(16.3, 30.7)	139	1.2%	(0.3, 4.9)	
36-47	184	19.2%	(13.9, 25.9)	184	9.4%	(5.9, 14.7)	184	0.5%	(0.1, 3.6)	
48-59	183	14.5%	(10.1, 20.4)	183	7.4%	(4.2, 12.8)	183	0	(0.0, 0.0)	
Sex										0.846
Male	292	20.4%	(15.3, 26.7)	292	15.6%	(11.3, 21.1)	292	0.7%	(0.2, 2.3)	
Female	322	18.4%	(14.4, 23.2)	322	14.2%	(10.2, 19.2)	322	0.6%	(0.1, 2.3)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Mild, moderate, and severe anemia defined as hemoglobin 100-109 g/L, 70-99 g/L, and <70 g/L, respectively.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.2.7 Vitamin A deficiency

The prevalence of vitamin A deficiency would be classified as 'moderate' by the WHO [36], see **Table 12.** The prevalence is more than three times higher in rural children than in urban children, and this is reflected in the differences among strata. The prevalence of vitamin A deficiency is somewhat lower in younger children, but due to the wide confidence intervals this difference is not significant. There is only a small and not statistically significant difference in the prevalence of vitamin A deficiency between boys and girls.

Table 12: Prevalence of vitamin A deficiency in children 6-59 months, by various demographic characteristics, Senegal 2018 survey

Characteristic	N	% VAD [a, b]	95% CI [c]	p-value [d]
TOTAL	531	12.1%	(8.8, 16.4)	
Urban/rural				<0.001
Urban	261	4.7%	(2.5, 8.6)	
Rural	270	18.1%	(12.9, 24.9)	
Stratum				<0.001
Dakar	103	3.4%	(1.3, 8.2)	
Other urban	158	5.6%	(2.6, 11.8)	
Rural south	105	15.2%	(8.9, 24.6)	
Rural north	165	18.4%	(13.0, 25.5)	
Age group in months				0.554
12-23	90	6.6%	(2.7, 14.9)	
24-35	123	13.2%	(8.0, 21.0)	
36-47	155	13.2%	(7.4, 22.7)	
48-59	163	12.6%	(7.5, 20.4)	
Sex				0.623
Male	258	11.2%	(7.2, 17.1)	
Female	273	12.8%	(8.6, 18.7)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] VAD = Vitamin A deficiency, defined as retinol adjusted for inflammation <0.70 umol/L [37].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.2.9 Associations between micronutrient deficiencies and various factors

Anemia: As shown in **Table 13** below, anemia is much more common in iron deficient children than in children without iron deficiency. It is also somewhat more common in vitamin A deficient children, albeit without statistical significance. There is no statistically significant difference in the prevalence of anemia between children who are given commercial baby food and those who are not; however, among children who receive commercial baby food, those receiving fortified baby food have less than half the prevalence of anemia than children receiving unfortified baby food. There is little difference in the prevalence of anemia between children currently receiving iron supplements and those who do not; however, there is some suggestion, albeit without statistical significance, that children currently receiving vitamin A supplements have a lower prevalence of anemia. In addition, children who have received micronutrient powders also have a lower prevalence of anemia, but the number of children receiving this intervention is too small for this difference to achieve statistical significance.

Children 12-23 months of age who were breastfed within an hour of birth have a lower prevalence of anemia, but this difference is not statistically significant. There is little difference in the prevalence of anemia between children 12-23 months of age who are currently breastfed and those who are not, and between children in this age group who consumed five or more food groups in the prior 24 hours and children who did not. In contrast, children who have consumed iron or vitamin A rich foods are less likely to be anemic.

Among children 12-59 months of age, there is no statistically significant difference in the prevalence of anemia between those who are wasted versus not wasted, stunted versus not stunted, underweight versus not underweight, and overweight or obese vs those who are not. Anemia is more common in children 12-59 months of age who in the prior 15 days had fever, cough or respiratory difficulty; also, children with diarrhea had a higher prevalence of anemia, though this difference is not statistically significant. Similarly, there is some indication that children with inflammation have a higher prevalence of anemia, but this difference is not statistically significant.

Table 13: Associations between anemia and micronutrient biomarkers, fortified food and supplement consumption indicators, breastfeeding and diet diversity indicators, anthropometric indicators, and morbidity indicators in children 12-59 months of age, Senegal, 2018

Characteristic	N	% anemic [a]	p- value [b]
Micronutrient indicators			
Iron deficient			<0.001
Yes	325	51.5%	
No	248	15.0%	
Vitamin A deficient			0.094
Yes	60	44.9%	
No	470	34.1%	
Fortified foods and supplement consumption			
Currently consumes commercial baby food			0.222
Yes	68	41.5%	
No	541	34.3%	
If yes, commercial baby food is fortified *(includes only children receiving commercial baby food)*			0.008

Characteristic	N	% anemic [a]	p- value [b]
Yes	27	27.0%	
No	21	61.9%	
Currently taking iron supplements			0.830
Yes	16	32.2%	
No	596	35.0%	
Currently taking vitamin A supplements			0.093
Yes	50	23.3%	
No	561	36.0%	
Child ever consumed micronutrient powder			0.345
Yes	23	25.9%	
No	578	35.6%	
Breastfeeding and diet diversity indicators (age 12-23 months)			
Early breastfeeding			0.167
Yes	63	49.9%	
No	40	67.5%	
Child currently breastfed			0.978
Yes	74	55.4%	
No	34	55.1%	
Child consumed ≥5 food groups in past 24 hours[c]			0.879
Yes	36	56.7%	
No	72	54.5%	
The child has eaten iron-rich foods			0.019
Yes	127	31.6%	
No	83	42.3%	
The child has eaten vitamin A-rich foods			0.014
Yes	129	31.3%	
No	81	42.5%	
Anthropometric indicators			
Child is wasted [d]			0.595
Yes	69	31.9%	
No	532	35.5%	
Child is stunted [d]			0.155
Yes	70	44.2%	
No	533	33.9%	
Child is underweight [d]			0.881
Yes	58	33.9%	
No	549	35.0%	
Child is overweight or obese [e]			0.614
Yes	11	27.2%	
No	590	35.2%	
Morbidity indicators			
Child had fever			0.016
Yes	87	49.1%	

Characteristic	N	% anemic [a]	p- value [b]
No	520	32.4%	
Child had diarrhea			0.135
Yes	43	44.5%	
No	563	34.3%	
Child had cough and/or respiratory difficulty			0.003
Yes	48	57.4%	
No	560	33.1%	
Child has inflammation			0.151
None (CRP and AGP normal)	449	33.2	
Any inflammation (elevated CRP and/or AGP)	58	43.3	

Note: The N's are the denominators for a specific sub-group.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.
[c] Data do not allow calculation of standard WHO/UNICEF indicator for minimum dietary diversity in children 6-23 months of age. See text for definition of this modified indicator.
[d] Wasting, stunting, underweight includes children who are below-2 SD from the WHO Child Growth Standards population median
[e] Overweight or obese includes children who are equal or above +2 SD from the WHO Child Growth Standards population median

Iron deficiency: **Table 14** below shows that children with vitamin A deficiency are statistically significantly more likely to be iron deficient. There is no statistically significant difference in the prevalence of iron deficiency between children who consume commercial baby food and those who don't, and unlike anemia, iron deficiency is not statistically significantly less common in children consuming fortified baby food than children consuming unfortified baby food. There is no statistically significant difference in the prevalence of iron deficiency in children currently taking iron or vitamin A supplements compared to those not taking iron or vitamin A supplements, nor is there a difference in children who have taken micronutrient powders versus those who have not.

Among children 12-23 months of age, children with early initiation of breastfeeding are less likely to be iron deficient than children without. On the other hand, there is no statistically significant difference in the prevalence of iron deficiency between children 12-23 months of age who are currently breastfed and those who are not or between children who have consumed five or more food groups in the prior 24 hours and those who have not. However, children who ate iron-and-vitamin A-rich foods were less likely to be iron deficient.

Nor is there any significant difference between children 12-59 months of age who are stunted versus non-stunted, wasted versus non-wasted, underweight versus non-underweight, or overweight or obese versus non-overweight or obese. The prevalence of iron deficiency is similar among children with and without fever in the past 15 days, diarrhea in the past 15 days or current inflammation. On the other hand, children with cough or difficulty breathing in the past 15 days have a higher prevalence of iron deficiency than children who do not, but this difference is marginally statistically significant.

Table 14: Association between iron deficiency and vitamin A deficiency, fortified food and supplement consumption indicators, breastfeeding and diet diversity indicators, anthropometric indicators, and morbidity indicators in children 12-59 months of age, Senegal, 2018

Characteristic	N	% iron deficient [a]	p- value [b]
Micronutrient indicators			
Vitamin A deficient			0.036
Yes	60	69.8%	
No	471	55.0%	
Fortified foods and supplement consumption			
Current consumption of commercial baby food			0.123
Yes	65	66.1%	
No	506	55.1%	
If yes, commercial baby food is fortified (includes only children receiving commercial baby food)			0.313
Yes	24	55.4%	
No	21	67.5%	
Currently taking iron supplements			0.198
Yes	16	74.0%	
No	558	55.9%	
Currently taking vitamin A supplements			0.347
Yes	46	46.7%	
No	527	57.1%	
Child ever consumed micronutrient powder			0.308
Yes	22	44.2%	
No	541	56.9%	
Breastfeeding and diet diversity indicators (12-23 months)			
Early breastfeeding			0.045
Yes	60	61.9%	
No	38	86.4%	
Child currently breastfed			0.122
Yes	70	63.9%	
No	33	80.7%	
Child consumed ≥5 food groups in past 24 hours[c]			0.543
Yes	34	65.2%	
No	69	72.9%	
Child consumed iron-rich foods			0.002
Yes	201	51.8%	
No	125	66.3%	
Child consumed vitamin-A-rich foods			0.002
Yes	201	51.5%	
No	125	67.3%	
Anthropometric indicators			
Child is wasted [d]			0.316

Characteristic	N	% iron deficient [a]	p- value [b]
Yes	65	49.7%	
No	498	57.6%	
Child is stunted [d]			0.197
Yes	63	64.4%	
No	502	55.3%	
Child is underweight [d]			0.487
Yes	53	51.9%	
No	516	56.9%	
Child is overweight or obese [e]			0.758
Yes	11	51.5%	
No	552	56.7%	
Morbidity indicators			
Child had fever			0.751
Yes	82	58.1%	
No	487	56.2%	
Child had diarrhea			0.663
Yes	40	59.0%	
No	528	56.2%	
Child had cough and/or respiratory difficulty			0.053
Yes	47	69.9%	
No	523	55.2%	
Child has inflammation			0.863
None (CRP and AGP normal)	450	55.8%	
Any inflammation (elevated CRP and/or AGP)	58	54.6%	

Note: The N's are the denominators for a specific sub-group.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.
[c] Data do not allow calculation of standard WHO/UNICEF indicator for minimum dietary diversity in children 6-23 months of age. See text for definition of this modified indicator.
[d] Wasting, stunting, underweight includes children who are below-2 SD from the WHO Child Growth Standards population median
[e] Overweight or obese includes children who are equal or above +2 SD from the WHO Child Growth Standards population median

Vitamin A deficiency: There is little difference in the prevalence of vitamin A deficiency between children who consume commercial baby food and those who do not, and only a non-statistically significant difference between children who receive fortified commercial baby food compared to children who receive unfortified commercial baby food (**Table 15**). Although lacking statistical significance, there seems to be a lower prevalence of vitamin A deficiency among children currently taking an iron supplement compared to those who are not. On the other hand, there is little difference in vitamin A deficiency between children who were currently taking a vitamin A supplement or children who have consumed micronutrient powders compared to those not taking vitamin A supplements or micronutrient powders, respectively.

Children with early initiation of breastfeeding have a lower prevalence of vitamin A deficiency, albeit without statistical significance. Currently breastfeeding children have a substantial and statistically significant lower prevalence of vitamin A deficiency. There was little difference in the prevalence of deficiency between children who consumed five or more food groups in the past 24 hours prior to data collection compared to those who did not. Similarly, there was no statistically significant difference in the prevalence of vitamin A deficiency between children who consumed vitamin A-rich foods and those who did not.

There is no statistically significant difference in vitamin A deficiency prevalence between children who are wasted versus non-wasted, underweight versus not underweight, or overweight or obese versus non-overweight or obese. On the other hand, children with stunting have more than twice the prevalence of vitamin A deficiency than children without stunting, and this difference is highly statistically significant. Children with and without fever and with and without coffee or respiratory difficulty in the past 15 days have similar prevalences of vitamin A deficiency. On the other hand, children with reported diarrhea in the past 15 days have more than twice the prevalence of deficiency, albeit without statistical significance. On the other hand, children with inflammation have a substantially higher prevalence of vitamin A deficiency with high statistical significance.

Table 15: Association between vitamin A deficiency and fortified food and supplement consumption indicators, anthropometric indicators, breastfeeding and diet diversity indicators, and morbidity indicators in children 12-59 months of age, Senegal 2018

Characteristic	N	% vitamin A deficient [a]	p- value [b]
Fortified foods and supplement consumption			
Currently consumes commercial baby food			0.886
Yes	58	12.7%	
No	471	12.0%	
If yes, commercial baby food is fortified			0.453
Yes	21	18.8%	
No	19	9.9%	
Currently taking iron supplements			0.153
Yes	15	3.5%	
No	516	12.3%	
Currently taking vitamin A supplements			0.906
Yes	41	13.0%	
No	489	12.0%	
Child ever consumed micronutrient powder			0.845
Yes	18	13.7%	
No	503	12.2%	
Breastfeeding and diet diversity indicators			
Child had early initiation of breastfeeding			0.334
Yes	52	4.5%	
No	34	10.5%	

Characteristic	N	% vitamin A deficient [a]	p- value [b]
Child currently breastfed			0.041
Yes	61	2.5%	
No	29	13.0%	
Child consumed ≥5 food groups in past 24 hours[c]			0.881
Yes	26	5.9%	
No	64	6.8%	
Child consumed vitamin A-rich foods			0.236
Yes	31	10.7%	
No	29	14.7%	
Anthropometric indicators			
Child is wasted [d]			0.276
Yes	62	6.8%	
No	458	12.6%	
Child is stunted [d]			0.003
Yes	62	23.1%	
No	460	10.0%	
Child is underweight [d]			0.846
Yes	50	10.8%	
No	476	12.0%	
Child is overweight or obese [e]			0.333
Yes	11	23.5%	
No	509	11.6%	
Morbidity indicators			
Child had fever			0.987
Yes	73	12.2%	
No	453	12.2%	
Child had diarrhea			0.053
Yes	38	24.4%	
No	487	11.2%	
Child had cough and/or respiratory difficulty			0.540
Yes	45	15.2%	
No	482	11.9%	
Child has inflammation			0.001
None (CRP and AGP normal)	414	9.4%	
Any inflammation (elevated CRP and/or AGP)	53	27.2%	

Note: The N's are the denominators for a specific sub-group.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.
[c] Data do not allow calculation of standard WHO/UNICEF indicator for minimum dietary diversity in children 6-23 months of age. See text for definition of this modified indicator.
[d] Wasting, stunting, underweight includes children who are below-2 SD from the WHO Child Growth Standards population median
[e] Overweight or obese includes children who are equal or above +2 SD from the WHO Child Growth Standards population median.

3.3 Non-pregnant women 15-49 years of age

This chapter presents the results for all non-pregnant women, regardless of their lactation status. Chapters 8.1 and 8.2 in the appendix of this report provide results separately for non-pregnant non-lactating and for non-pregnant lactating women.

3.3.1 Non-pregnant woman characteristics

Table 16 below describes the demographic characteristics of non-pregnant women who participated in the Senegal micronutrient survey. As with children, about half of women lived in urban areas. Younger women are somewhat overrepresented.

Table 16: Description of sampled non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% [a]	% Women in Senegalese population [38]
TOTAL	1916	100%	
Urban/rural			
Urban	1025	49.9%	46.6%
Rural	891	50.1%	53.4%
Stratum			
Dakar	541	31.4%	22.3%
Other urban	484	25.1%	24.4%
Rural south	384	19.7%	12.7%
Rural north	506	23.7%	40.7%
Age (in years)			
15-19	361	19.5%	21.1%
20-24	326	17.4%	18.8%
25-29	354	18.4%	16.8%
30-34	297	14.7%	14.4%
35-39	263	13.5%	11.6%
40-44	175	9.2%	9.6%
45-49	140	7.3%	7.7%

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection.

3.3.2 Recent illness and health indicators

Overall, the 2-week cumulative prevalences of diarrhea and cough and/or difficulty breathing were not high in non-pregnant women 15-49 years of age, but fever and inflammation were much more common. There is no statistically significant difference in the cumulative 2-week prevalence of fever or diarrhea by urban/rural residence or stratum of residence (**Table 17**). On the other hand, there are statistically significant differences in fever and diarrhea by age; however, there is no consistent trend. The prevalence of cough and/or difficulty breathing is statistically significantly different among strata, with the highest prevalence occurring in urban areas. Unlike fever and diarrhea, there is no statistically significant difference in the prevalence of cough and/or difficulty breathing by age. Inflammation is more common in urban areas than in rural areas, and generally more common in older women, especially those 30 years of age and older.

Table 17: Proportion of non-pregnant women 15-49 years of age with various forms of morbidity in the past 2 weeks and inflammation status, by various demographic characteristics, Senegal 2018

Character-istic	Fever				Diarrhea				Cough and/or respiratory difficulty				Any inflammation			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*
TOTAL	1913	8.5%	(6.8, 10.7)		1909	2.1%	(1.4, 3.3)		1910	3.5%	(2.5, 4.7)		1799	17.1%	(15.3, 19.1)	
Urban/rural				0.292				0.345				0.013				0.001
Urban	1022	9.6%	(7.4, 12.4)		1019	2.6%	(1.5, 4.3)		1020	4.9%	(3.4, 7.0)		943	20.5%	(17.9, 23.4)	
Rural	891	7.4%	(4.9, 11.0)		890	1.7%	(0.8, 3.6)		890	2.0%	(1.1, 3.8)		856	13.9%	(11.6, 16.6)	
Stratum				0.327				0.242				0.019				0.006
Dakar	540	10.5%	(7.7, 14.3)		537	2.4%	(1.2, 4.6)		538	4.8%	(3.1, 7.2)		483	22.6%	(19.4, 26.2)	
Other urban	482	9.8%	(6.4, 14.5)		482	2.8%	(1.2, 6.2)		482	5.5%	(3.1, 9.7)		460	19.7%	(16.1, 23.9)	
Rural south	384	8.0%	(5.7, 11.2)		383	0.7%	(0.2, 1.9)		383	1.7%	(0.7, 4.2)		368	16.7%	(12.9, 21.3)	
Rural north	506	6.5%	(3.8, 10.8)		506	1.5%	(0.6, 3.6)		506	1.7%	(0.7, 3.7)		488	14.2%	(11.4, 17.5)	
Age group in years				0.006				0.011				0.473				<0.001
15-19	361	4.9%	(3.0, 07.9)		361	1.0%	(0.3, 3.1)		361	3.0%	(1.5, 5.7)		339	7.8%	(05.3, 11.2)	
20-24	326	7.5%	(4.6, 12.2)		323	1.7%	(0.6, 4.7)		324	3.6%	(1.5, 8.5)		303	15.0%	(11.1, 20.0)	
25-29	353	10.6%	(7.4, 14.9)		353	2.4%	(1.2, 4.8)		353	4.8%	(2.7, 8.3)		330	16.7%	(13.0, 21.3)	
30-34	296	7.4%	(4.9, 11.1)		296	1.5%	(0.6, 4.0)		296	2.2%	(1.1, 4.6)		282	22.0%	(17.1, 27.9)	
35-39	263	8.4%	(5.6, 12.4)		263	1.3%	(0.4, 3.6)		263	3.0%	(1.5, 6.0)		247	23.3%	(18.1, 29.3)	
40-44	174	16.1%	(10.0, 24.8)		173	7.1%	(3.0, 15.8)		173	05.5%	(2.7, 11.0)		163	20.5%	(13.9, 29.1)	
45-49	140	8.3%	(4.3, 15.6)		140	2.0%	(0.4, 9.9)		140	1.7%	(0.5, 5.8)		135	22.8%	(16.5, 30.6)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.3.1 Consumption of micronutrient supplements and fortified foods

The use of iron supplements was not common in non-pregnant women 15-49 years of age (**Table 18**). There were some differences among strata in the proportion of non-pregnant women who were currently taking iron supplements, albeit with marginal statistical significance. In general, iron supplementation was more common in women in urban areas, but this association was not statistically significant. Further, iron supplementation differed by age group, with the highest prevalence in women 20-34 years of age and the lowest in women 15-19 years of age.

About one-half of women lived in households in which oil was marked as fortified with vitamin A, but only one-quarter of women lived in households in which the flour was marked as fortified with iron and folate. The proportion of non-pregnant women living in households in which oil was marked as vitamin A fortified was higher in urban areas than rural areas, but did not differ with statistical significance by age. In contrast, there was relatively little difference in the proportion of women living in households in which flour was marked as fortified with iron and folic acid between urban and rural areas. Nonetheless, the prevalence of fortified flour was lowest in the rural north stratum. In addition, the proportion of women with fortified flour differ by age; adolescents 15-19 years of age have substantially less exposure to fortified flour than older women 20-49 years of age.

Table 18: Proportion of non-pregnant women 15-49 years of age with micronutrient supplementation and fortification, by various demographic characteristics, Senegal 2018

Characteristic	Currently taking iron supplements				Household oil marked as fortified with vitamin A				Household flour marked as fortified with iron and folate			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p- value [c]*	*N*	*% [a]*	*95% CI [b]*	*p- value [c]*
TOTAL	1909	13.8%	(11.6, 16.3)		1908	50.7%	(45.2, 56.3)		1910	25.4%	(20.6, 30.8)	
Urban/rural				0.088				0.002				0.275
Urban	1019	15.9%	(13.2, 19.0)		1020	59.3%	(52.4, 66.0)		1019	26.8%	(20.5, 34.3)	
Rural	890	11.7%	(8.6, 15.7)		888	42.2%	(33.6, 51.3)		891	24.0%	(17.3, 32.3)	
Stratum				0.046				<0.001				0.272
Dakar	536	17.8%	(14.1, 22.2)		537	65.8%	(56.1, 74.3)		536	29.2%	(20.9, 39.2)	
Other urban	483	13.7%	(10.2, 18.2)		483	55.8%	(45.0, 66.1)		483	26.1%	(17.0, 38.0)	
Rural south	384	16.8%	(12.3, 22.5)		383	36.8%	(26.1, 48.8)		384	27.3%	(16.6, 41.5)	
Rural north	505	9.9%	(6.7, 14.5)		504	44.3%	(33.2, 56.1)		506	21.7%	(14.2, 31.6)	
Age group in years				0.003				0.863				0.025
15-19	359	5.9%	(3.4, 9.9)		359	47.4%	(38.7, 56.2)		360	20.3%	(14.3, 28.2)	
20-24	324	16.2%	(11.8, 21.8)		325	52.4%	(44.9, 59.9)		324	27.9%	(21.3, 35.5)	
25-29	353	16.3%	(12.4, 21.0)		352	51.2%	(43.5, 58.8)		353	27.7%	(20.6, 36.2)	
30-34	297	17.8%	(12.5, 24.8)		297	52.5%	(44.6, 60.3)		297	24.8%	(18.7, 31.9)	
35-39	262	14.8%	(10.6, 20.2)		262	49.0%	(40.8, 57.2)		262	25.0%	(19.0, 32.1)	
40-44	175	13.9%	(9.4, 20.0)		175	53.2%	(43.7, 62.5)		175	28.6%	(20.7, 38.0)	
45-49	139	12.4%	(7.2, 20.6)		138	51.2%	(40.3, 62.0)		139	24.9%	(16.3, 36.1)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

Only about one third of non-pregnant women were familiar with vitamin A, and a much smaller proportion knew about foods fortified with vitamin A (**Figure 8**). The extent of knowledge of flour fortification was greater, with a majority of women knowing the importance of iron and folate to health. However, as with vitamin A, only a small proportion of women knew about foods fortified with iron and folate.

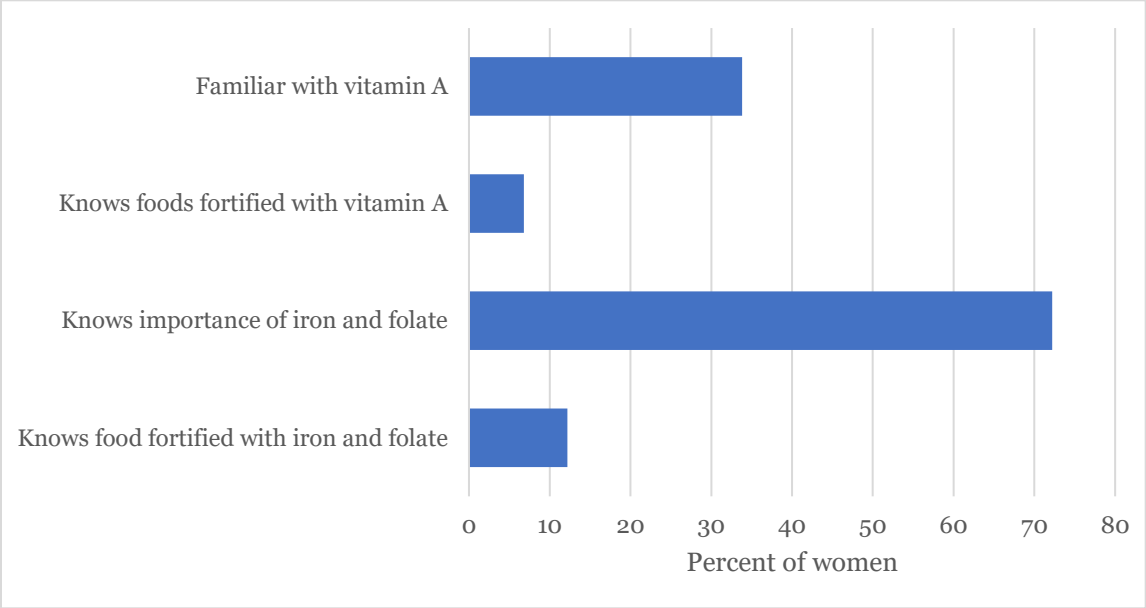


Figure 8: Proportion of non-pregnant women 15-49 years of age with knowledge of micronutrients and food fortification, Senegal 2018

The majority of non-pregnant women had had prior pregnancies and had living children at the time of survey data collection, and about one quarter were currently lactating (**Figure 9**). A substantial minority of non-pregnant women had had a past miscarriage or stillbirth.

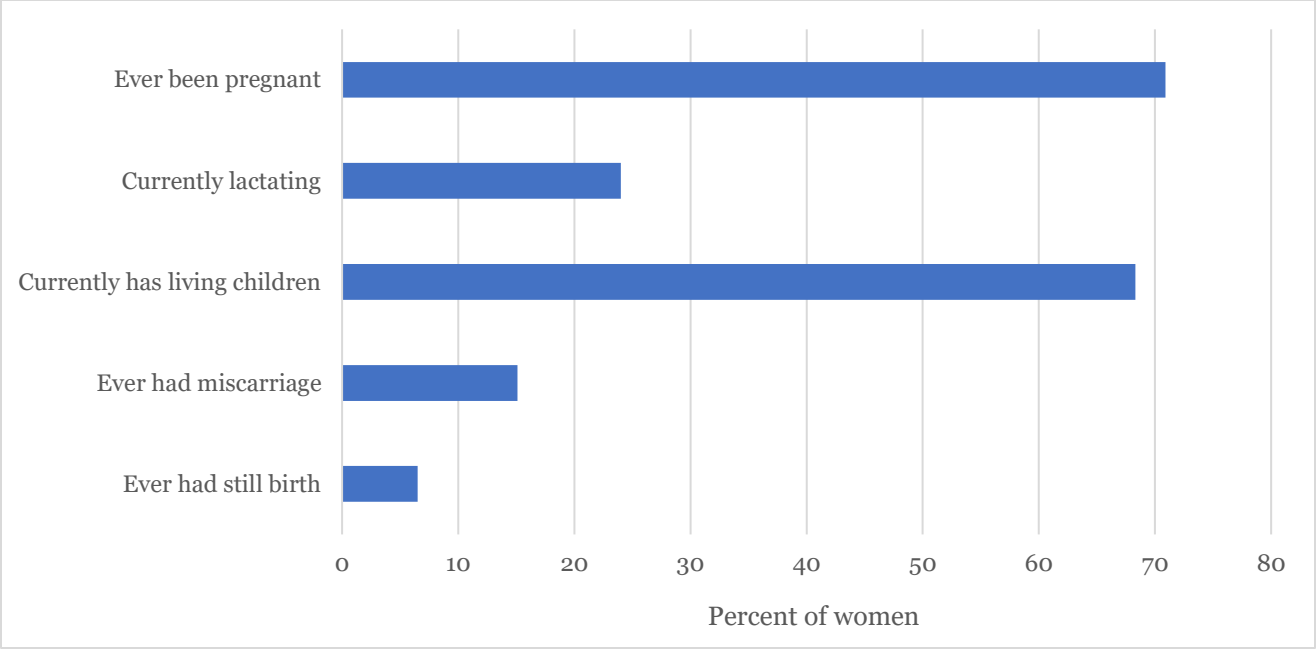
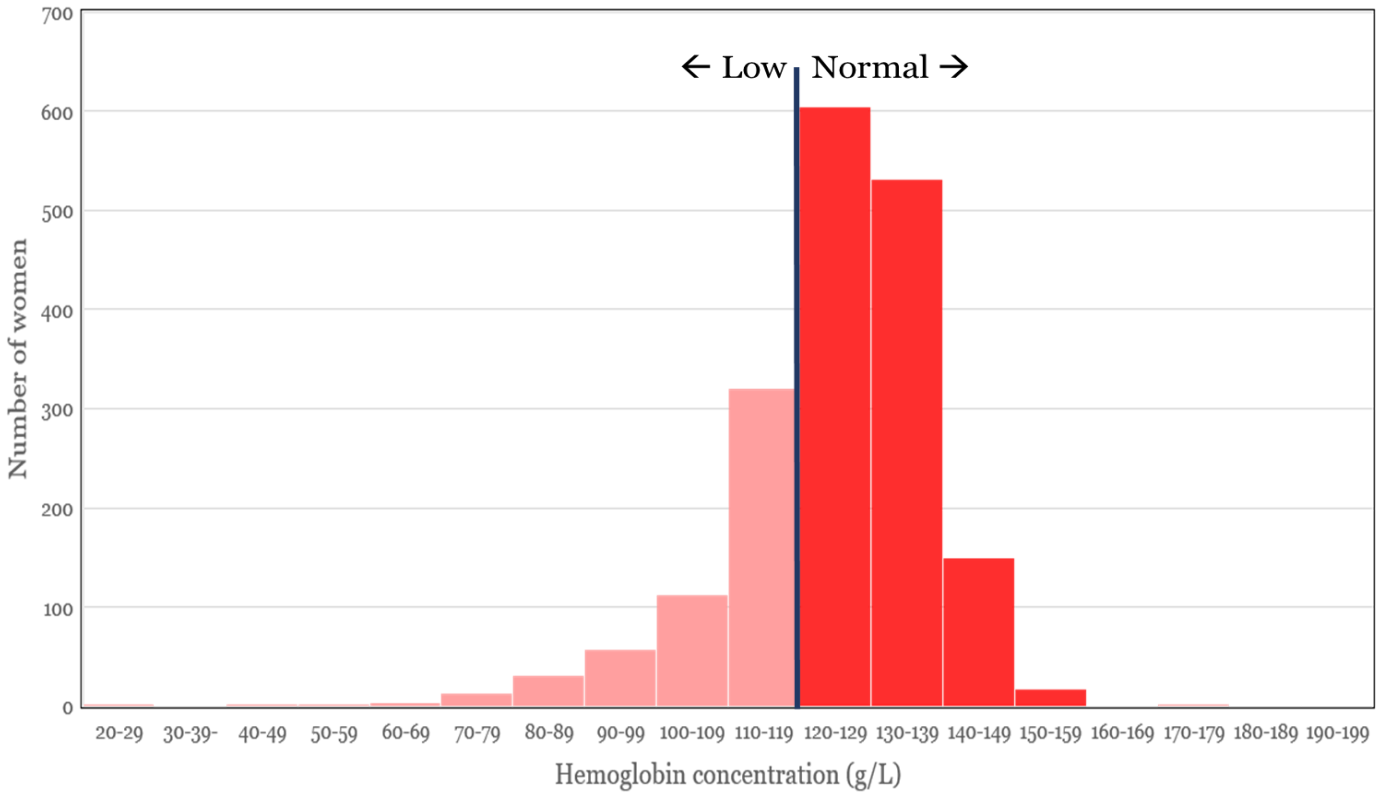


Figure 9: Proportion of non-pregnant women 15-49 years of age with various pregnancy indicators, Senegal 2018

3.3.2 Anemia, iron deficiency, and iron deficiency anemia

- **Hemoglobin concentration** (g/L)

Figure *10* below shows the distribution of hemoglobin values for non-pregnant women 15-49 years of age. Many women fall below the cut off defining anemia of 120 g/L. Few women have hemoglobin values of 150 g/L or higher. The weighted mean hemoglobin concentration is 124.2 g/L, and the standard deviation calculated without accounting for complex sampling is 15.0.



Hemoglobin concentration (g/L)

Figure 10: Unweighted distribution of hemoglobin concentrations in non-pregnant women 15-49 years of age, Senegal 2018

Figure 11 visualizes the proportion of non-pregnant women with concomitant iron deficiency and anemia, often referred to as iron deficiency anemia. It shows that for women, although to a lesser extent than among children, a sizeable proportion of anemia is accompanied by iron deficiency.

Figure 11: Venn diagram showing overlap between anemia and iron deficiency in non-pregnant women 15-49 years of age, Senegal 2018

The prevalence of anemia in non-pregnant women 15-49 years of age is somewhat lower than in young children (**Table 19**). The prevalence is statistically significantly higher in women living in rural areas, with women in the rural south stratum having the highest prevalence. There are no statistically significant differences among age groups.

Iron deficiency is much more common in women than is anemia. However, there is little difference in the prevalence of iron deficiency between women in urban and rural areas. Nonetheless, there are statistically significant differences among strata, with the highest prevalence in the rural south stratum. Iron deficiency is most common in women 15-24 years of age and least common in women 45-49 years of age with statistically significant differences among age groups.

Iron deficiency anemia is more common in women living in rural areas, especially in the rural south stratum. There are no statistically significant differences in the prevalence of iron deficiency anemia by age.

Severe anemia is relatively rare in nonpregnant women aged 15 to 49 years (Table 20)

The distribution of anemia severity shows a statistically significant difference between urban and rural women and women residing in the different strata. There was no statistically significant association between anemia severity and age

Table 19: Prevalence of anemia, iron deficiency, and iron deficiency anemia in non-pregnant women 15-49 years of age, Senegal 2018

	Anemia [b]				Iron deficiency [e]				Iron deficiency anemia [b, f]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	1854	28.9%	(26.6, 31.4)		1864	42.3%	(39.3, 45.3)		1869	18.5%	(16.5, 20.6)	
Urban/rural				0.001				0.351				0.001
Urban	978	24.7%	(21.6, 28.2)		982	40.8%	(37.1, 44.7)		990	15.0%	(12.6, 17.7)	
Rural	876	33.0%	(29.6, 36.6)		882	43.7%	(39.1, 48.5)		879	21.9%	(18.7, 25.4)	
Stratum				0.002				0.010				0.001
Dakar	511	24.2%	(19.8, 29.1)		507	43.2%	(37.9, 48.7)		516	16.7%	(12.9, 21.2)	
Other urban	467	24.4%	(19.6, 29.9)		475	37.4%	(31.9, 43.1)		474	13.7%	(10.6, 17.7)	
Rural south	378	37.3%	(30.2, 45.0)		379	52.2%	(45.1, 59.3)		379	26.5%	(20.8, 33.2)	
Rural north	498	31.3%	(27.6, 35.2)		503	40.1%	(34.1, 46.5)		500	20.5%	(16.6, 25.1)	
Age group in years				0.428				0.020				0.381
15-19	354	30.8%	(25.6, 36.5)		352	47.2%	(40.6, 54.0)		353	20.8%	(16.3, 26.2)	
20-24	318	27.6%	(22.6, 33.2)		318	47.4%	(41.5, 53.5)		319	19.4%	(15.2, 24.4)	
25-29	346	23.8%	(18.7, 29.9)		344	37.2%	(32.1, 42.6)		349	14.1%	(10.3, 19.2)	
30-34	288	30.6%	(24.8, 37.2)		289	43.5%	(37.1, 50.2)		292	20.7%	(15.8, 26.5)	
35-39	248	29.1%	(23.5, 35.3)		255	41.5%	(34.8, 48.6)		251	19.0%	(14.4, 24.6)	
40-44	163	33.2%	(25.4, 42.1)		168	40.2%	(32.7, 48.1)		166	18.7%	(13.2, 25.9)	
45-49	137	31.3%	(23.7, 40.0)		138	31.3%	(23.0, 41.1)		139	15.4%	(09.9, 23.0)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Anemia defined as hemoglobin < 120 g/L; adjustment for altitude not required.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.
[e] Iron deficiency defined as ferritin < 15 µg/l, after BRINDA adjustment [31].
[f] Iron deficiency anemia defined as inflammation-adjusted ferritin < 15 µg/L and hemoglobin < 120g/L.

Severe anemia is relatively rare in non-pregnant women 15-49 years of age (**Table 20**). The distribution of the severity of anemia shows a statistically significant difference between women in urban and rural areas and women residing in the different strata. There is no statistically significant association of anemia severity with age.

Table 20: Proportion of mild, moderate and severe anemia in non-pregnant women 15-49 years of age, Senegal 2018

	Mild anemia [b]			Moderate anemia [b]			Severe anemia [b]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	1854	17.6%	(15.8, 19.4)	1854	10.3%	(8.7, 12.0)	1854	1.1%	(0.7, 1.8)	
Urban/rural										0.005
Urban	978	14.9%	(12.5, 17.6)	978	9.0%	(7.4, 10.9)	978	0.9%	(0.4, 1.8)	
Rural	876	20.2%	(17.8, 22.7)	876	11.5%	(9.0, 14.5)	876	1.3%	(0.7, 2.5)	
Stratum										0.002
Dakar	511	12.6%	(9.7, 16.1)	511	10.2%	(7.5, 13.6)	511	1.4%	(0.6, 3.2)	
Other urban	467	16.0%	(12.7, 20.0)	467	7.7%	(5.5, 10.7)	467	0.6%	(0.2, 1.9)	
Rural south	378	19.8%	(15.4, 25.0)	378	15.2%	(11.5, 19.9)	378	2.3%	(1.1, 4.7)	
Rural north	498	19.6%	(16.9, 22.7)	498	10.6%	(7.9, 14.0)	498	1.1%	(0.5, 2.5)	
Age group in years										0.415
15-19	354	21.6%	(17.5, 26.3)	354	8.1%	(5.6, 11.6)	354	1.1%	(0.4, 2.9)	
20-24	318	16.3%	(12.2, 21.4)	318	10.8%	(7.3, 15.8)	318	0.5%	(0.1, 1.6)	
25-29	346	13.4%	(10.0, 17.6)	346	9.8%	(6.8, 13.9)	346	0.7%	(0.2, 1.9)	
30-34	288	18.3%	(13.7, 23.9)	288	11.3%	(7.6, 16.5)	288	1.1%	(0.4, 3.1)	
35-39	248	16.4%	(12.2, 21.6)	248	10.6%	(6.9, 15.9)	248	2.1%	(0.7, 6.0)	
40-44	163	19.6%	(14.0, 26.9)	163	11.0%	(6.7, 17.4)	163	2.6%	(0.6, 9.9)	
45-49	137	18.6%	(12.7, 26.4)	137	12.4%	(7.5, 19.8)	137	0.3%	(0.0, 1.9)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Mild, moderate, and severe anemia defined as hemoglobin 110-119 g/L, 80-109 g/L, and <80 g/L, respectively.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.3.3 Vitamin A deficiency

Vitamin A deficiency is not common in non-pregnant women 15-49 years of age (**Table 21**). Although there is no statistically significant difference in the prevalence of vitamin A deficiency between women in urban and rural areas, the prevalence is substantially higher in the rural south stratum then in the other three strata in which the prevalence is similar. The prevalence of vitamin A deficiency is also similar in all age groups.

Table 21: Prevalence of vitamin A deficiency by various demographic characteristics in non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% VAD [a, b]	95% CI [c]	p-value [d]
TOTAL	1821	2.8%	(2.0, 3.9)	
Urban/rural				0.092
Urban	958	2.0%	(1.1, 3.5)	
Rural	863	3.6%	(2.4, 5.4)	
Stratum				<0.001
Dakar	493	1.5%	(0.7, 3.0)	
Other urban	465	1.6%	(0.7, 3.2)	
Rural south	372	7.5%	(3.8, 14.3)	
Rural north	491	2.7%	(1.6, 4.6)	
Age group in years				0.938
15-19	345	3.3%	(1.7, 6.1)	
20-24	310	2.4%	(0.9, 6.2)	
25-29	338	2.9%	(1.5, 5.4)	
30-34	281	2.6%	(1.1, 5.8)	
35-39	248	3.2%	(1.4, 7.2)	
40-44	165	3.2%	(1.3, 7.6)	
45-49	134	1.3%	(0.4, 4.4)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] VAD = Vitamin A deficiency, defined as retinol <0.70 umol/L [24].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.3.4 Folate deficiency

In contrast to vitamin A deficiency, the prevalence of folate deficiency is very common in non-pregnant women 15-49 years of age, affecting one-half of women (**Table 22**). It is substantially more common in women in rural areas and is higher in women in the rural south stratum. There is little association between the prevalence of folate deficiency and age.

Table 22: Prevalence of folate deficiency by various demographic characteristics in non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% folate deficient [a, b]	95% CI [c]	p-value [d]
TOTAL	1865	50.2%	(46.0, 54.4)	
Urban/rural				0.022
Urban	983	45.3%	(39.4, 51.3)	
Rural	882	55.1%	(49.1, 60.8)	
Stratum				0.002
Dakar	508	42.4%	(36.9, 48.1)	
Other urban	475	49.5%	(40.5, 58.6)	
Rural south	379	63.9%	(55.1, 71.9)	
Rural north	503	52.4%	(45.2, 59.5)	
Age group in years				0.840
15-19	352	50.6%	(43.1, 58.1)	
20-24	319	47.1%	(40.0, 54.3)	
25-29	345	51.8%	(45.0, 58.6)	
30-34	289	50.2%	(43.4, 57.1)	
35-39	255	49.9%	(42.1, 57.7)	
40-44	168	48.3%	(38.9, 57.9)	
45-49	137	55.7%	(46.2, 64.7)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Folate deficiency, defined as serum folate < 10 nmol/L [25].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

3.3.6 Associations between micronutrient deficiencies and various factors

Anemia: As shown below in **Table 23**, anemia is much more common in women with iron deficiency and women with vitamin A deficiency. Folate deficiency is not statistically significantly associated with anemia. Women taking iron supplements do not have a statistically significantly different prevalence of anemia, yet women taking vitamin A supplements or women living in households with vitamin A fortified oil have a lower prevalence of anemia. In contrast, the prevalence of anemia is similar in women living in households with fortified flour and women living in households without fortified flour.

There is little difference in the prevalence of anemia between women who are currently lactating and those who are not, between women who have living children and those who do not. Although there is some suggestion that women who took iron supplements after their most recent delivery have a somewhat lower prevalence of anemia, this difference is not statistically significant. There are no statistically significant associations between the two week cumulative prevalence of fever, diarrhea, or cough and/or difficulty breathing. Nor is there a statistically significant association between current inflammation and anemia.

Table 23: Associations between anemia and micronutrient biomarkers, fortified food and supplement consumption, lactation and pregnancy history, and morbidity indicators in non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% anemic [a]	p- value [b]
Micronutrient indicators			
Iron deficient			<0.001
Yes	809	44.3%	
No	1029	17.9%	
Vitamin A deficient			<0.001
Yes	57	69.8%	
No	1739	27.7%	
Folate deficient			0.225
Yes	952	30.5%	
No	887	27.5%	
Supposedly fortified foods and supplement consumption			
Currently taking iron supplements			0.235
Yes	273	32.1%	
No	1574	26.4%	
Household oil marked as fortified with vitamin A			<0.001
Yes	935	24.2%	
No	290	30.1%	
Household flour marked as fortified with iron and folate			0.176
Yes	477	26.1%	
No	282	26.7%	
Lactation and pregnancy factors			
Currently lactating			0.776
Yes	443	28.3%	
No	1411	29.1%	

Characteristic	N	% anemic [a]	p- value [b]
Has living children			0.410
Yes	1256	29.6%	
No	598	27.5%	
Took iron supplement during prior pregnancy			0.800
Yes	1148	29.0%	
No	695	28.9%	
Took iron supplement after prior delivery			0.158
Yes	1015	28.3%	
No	124	37.7%	
Morbidity indicators			
Fever			0.727
Yes	162	30.3%	
No	1689	28.8%	
Diarrhea			0.482
Yes	35	35.0%	
No	1812	28.8%	
Cough and/or respiratory difficulty			0.841
Yes	63	30.1%	
No	1785	28.9%	
Inflammation			0.505
None (CRP and AGP normal)	1462	29.2%	
Any inflammation (elevated CRP and/or AGP)	312	27.1%	

Note: The N's are the denominators for a specific sub-group.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Iron deficiency: Women with vitamin A deficiency or folate deficiency are substantially more likely to have concurrent iron deficiency (**Table 24**). Currently taking iron supplementation is not associated with iron deficiency, but women living in households with vitamin A fortified oil or iron and folate fortified flour are both less likely to have iron deficiency.

Lactating women do not have a statistically significantly different prevalence of iron deficiency than nonlactating women. Women who have living children are less likely to be iron deficient. There is no statistically significant association between having taken iron supplements during the previous pregnancy or after the previous delivery and iron deficiency.

As with anemia, there is little association between the 2-week cumulative prevalence of fever, diarrhea, and cough and/or difficulty breathing and iron deficiency. There is also no statistically significant association between current inflammation and iron deficiency.

Table 24: Associations between iron deficiency and micronutrient biomarkers, fortified food and supplement consumption, lactation and pregnancy history, and morbidity indicators in non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% iron deficient [a]	p- value [b]
Micronutrient indicators			
Vitamin A deficient			0.020
Yes	58	60.8%	
No	1755	42.2%	
Folate deficient			0.016
Yes	961	45.4%	
No	902	39.1%	
Supposedly fortified foods and supplement consumption			
Currently taking iron supplements			0.290
Yes	274	39.2%	
No	1583	42.5%	
Household oil marked as fortified with vitamin A			0.001
Yes	941	37.0%	
No	294	48.5%	
Household flour marked as fortified with iron and folate			0.018
Yes	477	35.7%	
No	286	41.8%	
Lactation and pregnancy factors			
Currently lactating			0.293
Yes	451	39.7%	
No	1413	43.1%	
Have living children			0.009
Yes	1272	39.9%	
No	592	47.4%	
Took iron supplement during prior pregnancy			0.120
Yes	1162	40.3%	
No	691	45.7%	
Took iron supplement after prior delivery			0.347
Yes	1029	39.6%	
No	124	46.7%	
Morbidity indicators			
Fever			0.488
Yes	165	39.8%	
No	1696	42.6%	
Diarrhea			0.771
Yes	35	44.7%	
No	1822	42.3%	
Cough and/or respiratory difficulty			0.892
Yes	63	43.3%	

Characteristic	N	% iron deficient [a]	p- value [b]
No	1795	42.3%	
Inflammation			0.642
None (CRP and AGP normal)	1479	42.2%	
Any inflammation (elevated CRP and/or AGP)	319	43.9	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Vitamin A deficiency: There is little association between folate deficiency and vitamin A deficiency (**Table 25**). Nor is there a substantial difference in the prevalence of vitamin A deficiency between women who are currently taking iron supplements and those who are not, women living in households with vitamin A fortified oil and those not living in such households (albeit statistically different, the difference is not very big), and women living in households with iron and folate fortified flour and women not living in such households.

There is some suggestion that lactating women may have a somewhat higher prevalence of vitamin A deficiency than nonlactating women; however, this association is not statistically significant. There is little difference in the prevalence of vitamin A deficiency between women with and without children, women who took iron during their last pregnancy and those who did not, and between women who took iron after their previous delivery and those who did not. There is no statistically significant association between the 2-week cumulative prevalence of fever, diarrhea, or cough and/or difficulty breathing and vitamin A deficiency, nor between current inflammation and vitamin A deficiency.

Table 25: Association between vitamin A deficiency and micronutrient biomarkers, fortified food and supplement consumption indicators, breastfeeding and diet diversity indicators, and morbidity indicators in non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% vitamin A deficient [a]	p- value [b]
Micronutrient indicators			
Folate deficient			0.838
Yes	942	2.9%	
No	872	2.7%	
Supposedly fortified foods and supplement consumption			
Currently taking iron supplements			0.494
Yes	267	2.1%	
No	1547	2.9%	
Household oil marked as fortified with vitamin A			0.015
Yes	916	1.8%	
No	291	2.5%	
Household flour marked as fortified with iron and folate			0.821
Yes	465	3.2%	
No	280	2.5%	
Lactation and pregnancy factors			
Currently lactating			0.071
Yes	433	4.3%	
No	1388	2.3%	
Have living children			0.208
Yes	1240	3.2%	
No	581	2.0%	
Took iron supplement during prior pregnancy			0.169
Yes	1132	3.2%	
No	678	2.1%	

Characteristic	N	% vitamin A deficient [a]	p- value [b]
Took iron supplement after prior delivery			0.306
Yes	1004	3.4%	
No	119	2.0%	
Morbidity indicators			
Fever			0.429
Yes	161	1.7%	
No	1658	2.9%	
Diarrhea			0.346
Yes	35	1.1%	
No	1781	2.8%	
Cough and/or respiratory difficulty			0.677
Yes	59	2.1%	
No	1757	2.8%	
Inflammation			0.655
None (CRP and AGP normal)	1435	2.8%	
Any inflammation (elevated CRP and/or AGP)	313	3.3%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Folate deficiency: Folate deficiency is substantially more common in women who are not currently taking iron supplements, see **Table 26**. Although there is some suggestion that women living in households with vitamin A fortified oil or iron and folate fortified flour have a lower prevalence of folate deficiency, neither of these associations is statistically significant.

Lactating women are more likely to have folate deficiency. Women with children are also more likely to have folate deficiency, but this association is not statistically significant. Having taken iron during the previous pregnancy is statistically significantly associated with a higher prevalence of folate deficiency, but in contrast, women who took iron supplements after the most recent delivery have a lower prevalence of folate deficiency, albeit without statistical significance. Folate deficiency shows little association with the two week cumulative prevalence of fever, diarrhea, cough and/or difficulty breathing, or current inflammation.

Table 26: Association between folate deficiency and fortified food and supplement consumption indicators, breastfeeding and diet diversity indicators, and morbidity indicators in non-pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% folate deficient [a]	p- value [b]
Supposedly fortified foods and supplement consumption			
Currently taking iron supplements			0.002
Yes	274	37.6%	
No	1584	52.1%	
Household flour marked as fortified with iron and folate			0.083
Yes	478	44.3%	
No	286	49.0%	
Household oil marked as fortified with vitamin A			0.212
Yes	941	47.4%	
No	294	55.0%	
Lactation and pregnancy factors			
Currently lactating			0.041
Yes	451	55.2%	
No	1414	48.7%	
Have living children			0.062
Yes	1272	51.8%	
No	593	46.8%	
Took iron supplement during prior pregnancy			0.015
Yes	1161	52.6%	
No	693	45.8%	
Took iron supplement after prior delivery			0.252
Yes	1028	52.1%	
No	124	52.6%	
Morbidity indicators			
Fever			0.442
Yes	165	53.2%	
No	1697	50.0%	
Diarrhea			0.835
Yes	35	52.0%	
No	1823	50.2%	
Cough and/or respiratory difficulty			0.720
Yes	63	47.6%	
No	1796	50.3%	
Inflammation			0.410
None (CRP and AGP normal)	1480	50.0%	
Any inflammation (elevated CRP and/or AGP)	318	52.7%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

3.4 Pregnant women

3.4.1 Pregnant woman characteristics

Table 27 below describes the demographic characteristics of pregnant women who participated in the Senegal micronutrient survey. Compared to non-pregnant women, a smaller proportion of all pregnant women lived in urban areas. In addition, younger and older age groups contain fewer pregnant women.

Table 27: Description of sampled pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% [a]
TOTAL	105	100%
Urban/rural		
Urban	47	43.2%
Rural	58	56.8%
Stratum		
Dakar	15	11.8%
Other urban	32	31.4%
Rural south	30	14.9%
Rural north	28	41.9%
Age group in years		
15 - 19	11	10.8%
20 - 24	25	25.1%
25 - 29	27	28.0%
30 - 34	23	22.5%
35 - 39	15	11.3%
40 - 44	3	1.9%
45 - 49	1	0.4%

Note: The N's are the numbers for a specific sub-group.
[a] All percentages are weighted for unequal probability of selection among strata.

3.4.2 Consumption of micronutrient supplementation and fortified foods

Almost two-thirds of pregnant women were taking iron supplement at the time of data collection (**Table 28**). More than half of women lived in households with vitamin A fortified oil and more than one quarter of women lived in households with iron folate fortified flour. A large majority of women understood the importance of iron and folate to health, but a much smaller proportion knew about foods which were fortified with iron and folate. Fewer than half of pregnant women were familiar with vitamin A, and a small proportion knew about foods fortified with vitamin A.

Table 28: Proportion of pregnant women 15-49 years of age consuming supplements and fortified food and having knowledge of fortified food, Senegal 2018

Characteristic	N	% [a]	95% CI [b]
Currently taking iron supplement	105	63.1%	(51.2, 73.6)
Household oil fortified with vitamin A	105	57.9%	(45.0, 69.8)
Household flour fortified with iron and folate	105	29.3%	(18.8, 42.7)
Knows importance of iron and folate	104	89.1%	(80.2, 94.3)
Knows food fortified with iron and folate	105	8.2%	(3.4, 18.2)
Familiar with vitamin A	105	41.9%	(30.5, 54.2)
Knows foods fortified with vitamin A	101	6.0%	(2.3, 15.0)

Note: The N's are the denominators for a specific sub-group.
[a] All percentages are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.

3.4.3 Anemia and micronutrient deficiencies

Figure 12 below shows the distribution of hemoglobin values for pregnant women 15-49 years of age. Many women fall below the cut off defining anemia of 110 g/L. The weighted mean hemoglobin concentration is 115.8 g/L, and the standard deviation calculated without accounting for complex sampling is 14.9.

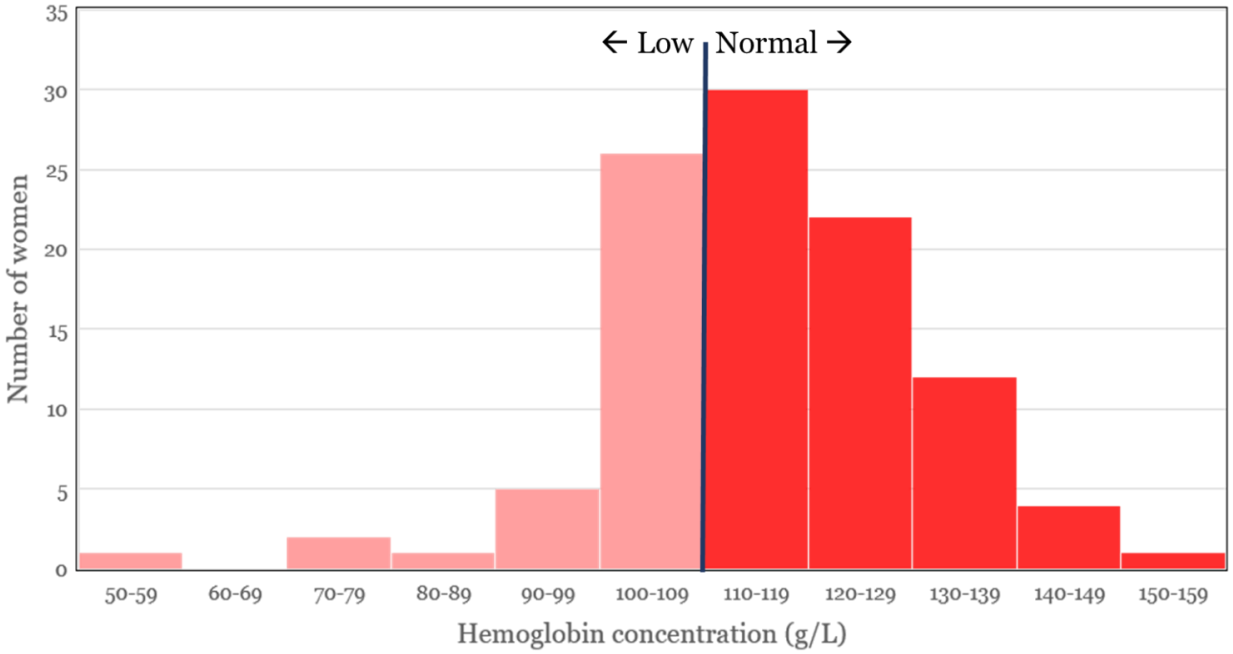


Figure 12: Unweighted distribution of hemoglobin concentrations in pregnant women 15-49 years of age, Senegal 2018

As shown in **Table 29**, almost one-third of pregnant women 15-49 years of age have anemia, and similar to children and non-pregnant women, few pregnant women have severe anemia. Iron deficiency is common in pregnant women. Vitamin A deficiency is more common in pregnant women than in non-pregnant women, but folate deficiency is less common in pregnant women than non-pregnant women.

Table 29: Prevalence of anemia and micronutrient deficienies in pregnant women 15-49 years of age, Senegal 2018

Characteristic	N	% [a]	95% CI [b]
Anemia[c]	104	31.0%	(21.5, 42.4)
Mild anemia	104	23.1%	(15.6, 32.9)
Moderate anemia	104	7.3%	(3.3, 15.3)
Severe anemia	104	0.5%	(0.1, 3.8)
Iron deficiency[c]	103	55.9%	(43.8, 67.4)
Iron deficiency anemia[c]	104	16.1%	(9.8, 25.4)
Vitamin A deficiency[c]	99	8.2%	(3.3, 18.9)
Folate deficiency[c]	103	37.0%	(26.8, 48.6)

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] Anemia defined as hemoglobin < 110 g/L; iron deficiency defined as inflammation-adjusted ferritin <12 µg/L; vitamin A deficiency defined as retinol <0.7 µmol/L; folate deficiency defined as folate <10 nmol/L.

4 Comparison of key indicators from the 2018 and 2010 surveys

4.1 Comparison of survey subjects

Table 30 below shows the comparison of the estimates for those demographic factors on which data were collected in a comparable fashion in both the 2010 and 2018 surveys. The weighted distribution of children and women by stratum could not be calculated for the 2010 survey because the authors lacked the necessary data to isolate the portion of the total sampling weight specific to the probability of selection of individual primary sampling units. Using the overall weights contained in the 2010 data sets to produce a weighted frequency distribution by stratum would result in a biased distribution which would be incomparable to the 2018 survey results. As a result, the distribution of survey subjects by stratum cannot be compared between the two surveys and is therefore not here. The results above give the distribution of the number of children, non-pregnant women, and pregnant women by stratum for the 2018 survey alone.

The children in the 2010 survey were less likely to be urban and were younger than children in the 2018 survey. Both surveys had approximately equal numbers of boys and girls. In contrast, non-pregnant women in the 2010 survey are more likely to be urban than non-pregnant women in the 2018 survey. The age distribution of women in the two surveys is roughly comparable. For pregnant women, both the urban/rural distribution and the age distribution of survey subjects are comparable between the two surveys.

Table 30: Comparison of survey subjects, 2010 and 2018, Senegal

Indicator	2010		2018		
	N	% [a]	N	% [a]	p-value [b]
Children 12-59 months of age					
Residence					
Urban	618	32.7%	347	46.5%	0.146
Rural	1244	67.3%	349	53.5%	
Age (in months)					
12-23	462	24.4%	124	15.3%	<0.001
24-35	485	25.9%	159	23.9%	
36-47	486	26.4%	209	28.0%	
48-59	429	23.4%	204	32.8%	
Female sex	937	50.2%	366	53.4%	0.193
Non-pregnant women 15-49 years of age					
Residence					
Urban	434	57.5%	1,025	49.9%	0.411
Rural	534	42.5%	891	50.1%	
Age (in years)					
15-19	207	20.4%	361	19.5%	<0.05
20-24	210	22.7%	326	17.4%	
25-29	141	15.7%	354	18.4%	
30-34	136	13.4%	297	14.7%	
35-39	104	10.2%	263	13.5%	
40-44	97	11.1%	175	9.2%	
45-49	73	6.5%	140	7.3%	
Pregnant women 15-49 years of age					
Residence					
Urban	36	45.8%	47	43.2%	0.826
Rural	64	54.2%	58	56.8%	
Age (in years)					
15-19	12	10.5%	11	10.8%	0.972
20-24	24	22.9%	25	25.1%	
25-29	24	25.6%	27	28.0%	
30-34	22	23.6%	23	22.5%	
35-39	15	14.2%	15	11.3%	
40-44	3	3.1%	3	1.9%	
45-49	0	-	1	0.4%	

Note: The N's are the numbers for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates difference between 2010 and 2018 results is statistically significant.

4.2 Children 12-59 months of age

As shown in **Table *31***, the overall prevalence of anemia in children 12-59 months of age declined substantially between the 2010 and 2018 surveys. Much of this decline is due to the decrease in the prevalence of moderate and severe anemia; the prevalence of mild anemia is similar between the two surveys. The prevalence of iron deficiency has also substantially declined. Naturally, there has been a concomitant decrease in the prevalence of iron deficiency anemia. On the other hand, the prevalence of vitamin A deficiency shows no statistically significant change between the 2010 and 2018 surveys. In addition, the prevalence of inflammation decreased fivefold between the two surveys.The mean average MUAC in children 12-59 months of age increased by almost 5 cm between the 2010 and 2018 surveys. Although the prevalence of low MUAC was low in both surveys, there was a statistically significant decline in its prevalence between 2010 and 2018.

Breastfeeding initiation generally improved between 2010 and 2018: the proportion of children who were given food or liquids before breastfeeding was initiated declined, and the proportion of children who had early initiation of breastfeeding increased. On the other hand, a higher proportion of children in the 2010 survey were still breastfeeding at the time of survey data collection than in the 2018 survey. The proportion of children who had ever been breast-fed was very high in both surveys. The proportion of children who had received commercial baby food almost doubled. Although the proportion of children currently receiving iron supplements was small in both surveys, there was a statistically significant increase in this proportion between 2010 and 2018. There was a larger increase in the proportion of children currently receiving vitamin A supplements.

Multiple variable modelling which included age, urban/rural residence, and survey as independent variables demonstrated that after accounting for the differences in age and urban/rural residence between the two survey samples, showed a statistically significant independent change of anemia and iron deficiency between the two surveys.

Table 31: Comparison of outcomes in children 12-59 months of age, 2010 and 2018, Senegal

Indicator	2010		2018		
	N	% or mean [a]	N	% or mean [a]	p-value[b]
Anemia and micronutrient deficiencies					
Anemia, any (%)	1479	66.0%	614	34.8%	<0.001
Mild anemia (%)	1479	22.4%	614	19.4%	<0.001
Moderate anemia (%)	1479	38.5%	614	14.8%	
Severe anemia (%)	1479	5.1%	614	0.6%	
Iron deficiency (%)	420	70.9%	248	56.3%	<0.001
Iron deficiency anemia (%)	1438	53.1%	604	27.6%	<0.001
Vitamin A deficiency (%)	1413	14.4%	531	12.1%	0.415
Inflammation (%)	1429	50.2%	508	9.8%	<0.001
Anthropometry					
MUAC (mean)	1550	145.5	688	150.2	<0.001
Low MUAC (%)	1550	3.4%	688	0.7%	0.001
Dietary and supplementation indicators					
Ate food before initiating breastfeeding (%)	1792	64.2%	692	43.1%	<0.001
Early initiation of breastfeeding (%)	1756	45.5%	119	60.2%	0.028
Currently breastfeeding (%)	1855	18.2%	695	12.1%	0.002
Ever breastfed (%)	1847	99.1%	124	97.6%	0.207
Received commercial baby food (%)	1846	5.6%	690	10.5%	0.016
Currently taking iron supplement (%)	1496	0.4%	693	2.6%	<0.001
Currently taking vitamin A supplement (%)	1524	1.7%	692	8.0%	<0.001

Note: The N's are the denominators for a specific sub-group.
[a] All percentages are weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates difference between 2010 and 2018 results is statistically significant.

4.3 Non-pregnant women 15-49 years of age

As seen in children, the prevalence of anemia in non-pregnant women 15-49 years of age declined substantially between the 2010 and 2018 surveys, and the prevalence of severe and moderate anemia declined more than the prevalence of mild anemia (**Table *32***). Although the change was less than that seen in children, the prevalence of iron deficiency also declined between the two surveys. On the other hand, there was little change in the prevalence of vitamin A deficiency in non-pregnant women, although in both surveys the prevalence was quite low. The prevalence of folate deficiency was very high in both surveys and showed little change. Inflammation was less common in women in the 2018 survey than in the 2010 survey.

A larger proportion of women were taking iron supplements at the time of data collection in the 2018 survey than in the 2010 survey; however, the proportion of women who had taken iron supplements

during their prior pregnancy declined. In contrast, the proportion of women who had taken iron supplements after their prior delivery increased substantially between the two surveys.

The proportion of women familiar with vitamin A and the proportion of women who knew the function of vitamin A both declined between the 2010 and 2018 surveys. The 2010 survey had a substantially larger proportion of non-pregnant women who were lactating that the 2018 survey.

As with children, multiple variable modelling which included age, urban/rural residence, and survey as independent variables demonstrated that after accounting for the differences in age and urban/rural residence between the two survey samples, both anemia and iron deficiency demonstrated an independent and statistically significant change between the two surveys.

Table 32: Comparison of outcomes in non-pregnant women 15-49 years of age, 2010 and 2018, Senegal

Indicator	2010		2018		
	N	% [a]	N	% [a]	p-value [b]
Anemia and micronutrient deficiencies					
Anemia, any (%)	955	47.2%	1854	28.9%	<0.001
Mild anemia (%)	955	21.8%	1854	17.6%	<0.001
Moderate anemia (%)	955	21.4%	1854	10.3%	
Severe anemia (%)	955	4.0%	1854	1.1%	
Iron deficiency (%)	959	56.6%	1864	42.3%	<0.001
Iron deficiency anemia (%)	956	32.7%	1869	18.5%	<0.001
Vitamin A deficiency (%)	959	2.1%	1821	2.8%	0.468
Folate deficiency (%)	895	49.6%	1865	50.2%	0.887
Inflammation (%)	959	28.8%	1799	17.1%	<0.001
Dietary and supplementation indicators					
Currently taking iron supplement (%)	956	8.6%	1909	13.8%	0.002
Took iron supplement last pregnancy (%)	677	81.8%	1905	63.6%	<0.001
Took iron supplement after last delivery (%)	655	60.0%	1176	90.6%	<0.001
Knowledge of vitamin A					
Knows about vitamin A (%)	962	54.4%	1913	33.8%	<0.001
If yes, knows what vitamin A does [c] (%)	463	77.7%	639	99.4%	<0.001
Pregnancy and lactation indicators					
Currently lactating (%)	681	40.2%	1916	24.0%	<0.001

Note: The N's are the denominators for a specific sub-group.
[a] All percentages are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] Includes only those pregnant women reporting familiarity with vitamin A.

4.4 Pregnant women 15-49 years of age

As seen in children and non-pregnant women, the prevalence of anemia declined substantially in pregnant women 15-49 years of age between the 2010 and 2018 surveys (**Table 33**). In contrast, the prevalence of iron deficiency showed a much smaller decline in pregnant women than in children or non-pregnant women, and this decline was not statistically significant. The prevalence of folate deficiency also

declined, but without statistical significance. The prevalence of vitamin A deficiency in pregnant women actually increased, albeit without statistical significance. Current inflammation was equally common in pregnant women in the two surveys.

The proportion of pregnant women 15-49 years of age currently taking iron supplementation increased substantially between the two surveys. There was little change in the proportion of pregnant women who were familiar with vitamin A; however, among those pregnant women familiar with vitamin A, a larger, though non-significant proportion could cite a health function for vitamin A in the 2018 survey than in the 2010 survey.

As with children and non-pregnant women, multiple variable modelling which included age, urban/rural residence, and survey as independent variables demonstrated that after accounting for the differences in age and urban/rural residence between the two survey samples, anemia demonstrated an independent and statistically significant change between the two surveys.

Table 33: Comparison of outcomes in pregnant women 15-49 years of age, 2010 and 2018, Senegal

Indicator	2010		2018		p-value[b]
	N	% [a]	N	% [a]	
Anemia and micronutrient deficiencies					
Anemia, any (%)	99	55.9%	104	31.0%	0.003
Severe anemia (%)	99	1.4%	104	0.5%	0.002
Moderate anemia (%)	99	25.1%	104	7.3%	
Mild anemia (%)	99	29.5%	104	23.1%	
Iron deficiency (%)	99	62.1%	103	55.9%	0.458
Iron deficiency anemia (%)	99	34.3%	104	16.1%	0.007
Vitamin A deficiency (%)	99	3.4%	99	8.2%	0.164
Folate deficiency (%)	92	52.2%	103	37.0%	0.112
Inflammation (%)	99	27.6%	102	27.9%	0.965
Dietary and supplementation indicators					
Currently taking iron supplement (%)	99	47.1%	105	63.1%	0.048
Knowledge of vitamin A					
Knows about vitamin A (%)	100	41.1%	105	41.9%	0.931
If yes, knows what vitamin A does[c] (%)	40	82.9%	38	97.0%	0.060

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates difference between 2010 and 2018 results is statistically significant.
[c] Includes only those pregnant women reporting familiarity with vitamin A.

5 Discussion

5.1 Anemia and iron deficiency

Both anemia and iron deficiency are common in women and children in Senegal. Anemia would be considered a "moderate" public health problem in both target groups according to the criteria published by the World Health Organization [21]. The prevalence of both anemia and iron deficiency is higher in rural areas, especially the rural South stratum. Such regional differences may be due to socioeconomic factors. The south of Senegal has the highest prevalence of poverty, as shown in **Figure 13** below [39]. Note that Ziguinchor, Sedhiou, Kolda, Kedougou, and Tambacounda Departments are all in the rural South stratum.

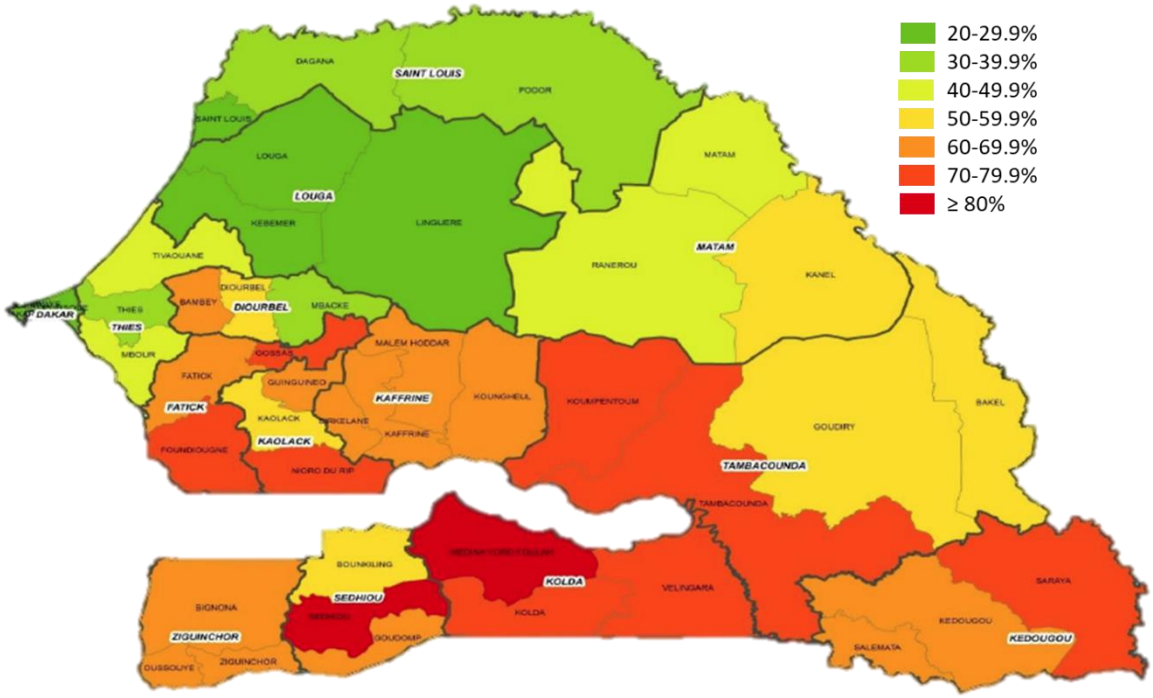


Figure 13: Poverty maps, developed by the ANSD and the World Bank for 2016 using 2013 census data, with minor modifications from [39]

Moreover, geographic differences in climate lead to differences in the risk of transmission and severity of infections which may lead to anemia. Malaria transmission is year-round in the south and southeast of Senegal while being largely confined to the rainy season in the North. In addition, the risk of hookworm infestation is lower in northern Senegal than in that portion of Senegal south of the Gambia [40].

Regardless, the 2018 survey results show that the prevalence of anemia is lower in Senegal than in many other African nations. This may – in part – be due a substantial decline in the incidence of malaria in recent years, thus potentially minimizing one of the major causes of anemia in malaria endemic areas.

On the other hand, the prevalence of anemia found in the 2018 survey is substantially lower than that found in prior DHS [14]. The reasons for this differences are difficult to fully explain. The 2018 survey included only children 12-59 months of age (compared to 6-59 months in DHS). Additionally the 2018

survey had a disproportionately older sample of children under five. In the 2018 survey and in all DHS, anemia was less common in older children. This has undoubtedly led to a lower apparent prevalence in anemia prevalence among children in the 2018 survey, but these effects cannot be expected to explain the drastic differences; furthermore, a secondary analysis of the DHS results excluding children aged 6-11 months indicates a prevalence of anemia of 70%, confirming the wide range of estimates of anemia prevalence. Also, it does not explain differences among women. As mentioned above, both malaria and helminth infestation, and presumably their contribution to anemia, may be seasonal. Data collection for the 2018 survey occurred in Apri/May 2018 – towards the end of the dry season when transmission of these diseases is lowest, while field work for the 2017 DHS took place from April to December, spanning from the end of the dry season throughout the rainy season, when malaria and helminth transmission increase, subsequently leading to higher anemia prevalence. Recent literature has assessed the potential bias introduced by using of different pre-analytical techniques (e.g. capillary vs. venous samples) but also equipment-induced differences, hinting towards systematic lower readings of the hemoglobin concentrations when the Hemocue 201 was used compared to the Hemocue 301 or complete blood count analyzers [41,42]. DHS collects capillary samples and typically uses the Hemocue 201, while in both the 2010 and 2018 surveys, venous blood sample was used on the Hemocue 201 in 2010 an the 301 in 2018.

There has been a substantial decline in the prevalence of both anemia and iron deficiency in both women and children since the 2010 survey. This improvement coincides with the implementation of iron and fortification of wheat flour in Senegal. The 2018 survey did not show an association between household flour fortification and anemia but with iron deficiency in women. Anemia can have multiple causes and thus, the absence of a direct association is not as suprising; as for iron deficiency, despite a statistical difference, the difference in prevalence is relatively small. Part of this weak association may be due to the inexact method of determining fortification; household flour containers were inspected for labels indicating fortification. This method cannot determine if a specific household flour sample met fortification specifications. Unless there is a regularly conducted and rigorous regulatory monitoring, it is unknown if flour samples were fortified to meet specifications. In addition, investigators cannot know if unfortified flour was repackaged into packages bearing the logo and vice versa. Moreover, poor fortification methods could lead to heterogeneously fortified flour, leading to some flour from a specific producer being well fortified and other flour being less well fortified. A coverage survey conducted in 2014 measuring iron content in wheat flour found that although almost all flour was fortified to some levels (96%), adequate iron levels were only identified in about half of flour samples [43].

Therefore, the results of the 2018 survey should be interpreted in the context of other indicators of performance of the flour fortification program, such as market surveys of fortification, industry data, etc. In addition, future surveys should consider measuring the iron content of household flour specimens as well as measuring flour consumption in households and in the target groups. This would allow correlation of individuals' iron status with the concentration of iron fortificant in their household flour.

Iron deficiency has been identified in this survey as a strong putative risk factor for anemia in different population groups. Despite this and although a large proportion of both children and women with anemia have concurrent iron deficiency, part of this concurrence is due to random combination of anemia and iron deficiency which may not be causative. In fact, the prevalence of iron deficiency anemia in children is only 8 percentage points higher than that expected if there were no causative association between these two conditions (19.6% prevalence of iron deficiency anemia expected by chance, 27.6% actual prevalence). In women, the prevalence of iron deficiency anemia is 6.3 percentage points higher than that

expected by chance (12.2% expected by chance, 18.5% actual prevalence). These findings indicate that iron deficiency does indeed contribute to anemia in both population groups; however, it does not explain the majority of cases of anemia in either children or women. An additional component of a more thorough future evaluation of oil and flour fortification would be the examination of a broad range of putative risk factors for iron deficiency and vitamin A deficiency in order to quantify the remaining role of iron deficiency in causing anemia and identify additional contributors which may be addressed in revised or new programming.

In this survey, vitamin A deficiency pas positively associated with both anemia and iron deficiency, while consuming vitamin A fortified oil or consumption of vitamin A supplements was negatively associated, suggesting a possible 'protective' effect of adequate vitamin A status or additional vitamin A intake. Such associations have been repeatedly described in the existing literature and plausible mechanisms are manifold, ranging from vitamin A deficiency increasing the frequency and severity of infectious diseases and poor mobilization of iron stores from tissues [41] or reduced erythropoiesis [45].

Underlying chronic inflammation has been described in the literature to be strongly associated with anemia, resulting in the so-called anemia of chronic disease [46]. The etiology is posited to be both iron-pathway dependent and independent [47]. Although in this survey, inflammation was hardly associated with anemia (or iron deficiency), it is noteworthy that the prevalence of any inflammation was drastically reduced between 2010 and 2018. As aforementioned, this could be partly explained by seasonality effects but also beneficial secular trends over time in improved hygiene practices or general improvements in socio-economic status.

5.2 Vitamin A deficiency

Vitamin A deficiency in non-pregnant women is not considered a substantial public health problem in Senegal, and this has not changed since 2010. The same is true for pregnant women despite a (statistically non-significant) increase of vitamin A deficiency. The results of the 2018 survey show a small but statistically significant association among non-pregnant women between vitamin A deficiency and living in a household which had oil bearing the fortification logo. Moreover, coverage with fortified oil (as defined by the package bearing the logo) is lower in rural.

Among children, vitamin A deficiency is categorized as being of 'moderate' public health concern according to the WHO [24], and it is more prevalent in children living in rural areas and is positively associated with underlying inflammation. The prevalence of vitamin A deficiency has remained relatively stable between 2010 and 2018, with only a slight and statistically non-significant decrease for 2018. At the same time, coverage with vitamin A supplements has increased from less than 2% to 8% of children; notwithstanding, this coverage remains low. But even a higher coverage would not necessarily be expected to decrease vitamin A deficiency due to the transient increase of serum retinol shortly after a supplement is consumed, as has been previously described [48]. The question in the 2018 survey was phrased 'Is your child currently taking vitamin A supplements?' and although Senegal has transited from twice-yearly campaigns to routine administration, the question does not capture children who were given supplements in the past six months. Thus, it is not surprising that the coverage found here is considerably lower than the 57% of children having been given vitamin A supplements in the past 6 months reported in the 2018 DHS [49].

The data available for this report did not allow the calculation of the proportion of children living in households with fortified oil (as defined by a package label) or their oil intake. However, it has been reported previously that while older children may benefit from fortified oil, smaller children likely consume insufficient amounts of oil for the added dietary vitamin A to have an important impact [50].

Population knowledge of vitamin A is relatively poor; only one third of women reported being familiar with vitamin A, and very few knew about foods which were fortified with vitamin A. Thus, population education on these subjects could result in higher dietary vitamin A intake among the population in general and children in particular.

5.3 Folate deficiency in Senegalese women

Folate deficiency is very common in adult women and has not changed substantially in non-pregnant women since the 2010 survey. On the other hand, folate deficiency has decreased among pregnant women albeit without statistical significance. In the regional context, the prevalence of folate deficiency found in Senegalese women is comparable to that reported for Ghana and Sierra Leone [51,52], higher than that of Cameroon [53], and lower than that of Côte d'Ivoire [54].

Data reported here among pregnant women indicate that almost two thirds of pregnant women consumed iron supplements during their pregnancy; since the majority of iron-containing pre-natal supplements used worldwide contain folic acid, the coverage estimate for iron supplementation and folic acid supplementation are likely similar. This estimate from the 2018 survey is lower than in 2010 and also lower than reported in the recent DHS, where the proportion of women having taken iron supplements at least once was almost universal [8]. Increased folic acid intake before pregnancy is very important to support foetal development and reduce the risk of neural tube defects. But because neural tube closing occurs very early in the pregnancy, before a woman oftentimes know that she is pregnant, adequate pre-conception folate status is fundamental. Folic acid fortification of cereal grains has been demonstrated to be an effective public health intervention to increase women's folic acid intake and substantially decreased the incidence of neural tube defects [55–59].

Wheat flour in Senegal is currently fortified with folate; however, the 2018 survey data show relatively poor coverage, when using the package logo as an indication about whether or not flour is fortified. As mentioned above, a more thorough evaluation of flour fortification could highlight avenues for improvement, thus resulting in higher dietary intake of folic acid among the target population. In order to do so, the evaluation should assess the actual iron content of the fortificant to extrapolate the folic acid content. In addition, such an evaluation should attempt to assess the flour intake of women to calculate the additional folic acid intake from fortified wheat flour.

5.4 Child anthropometry and feeding indicators

Several indicators of child nutrition are suboptimal in Senegal. Late initiation of breastfeeding is common, and a large proportion of children received other foods before their first breast milk meal after birth. In addition, many children lack dietary diversity, consuming fewer than five food groups in the previous 24 hours. A prenatal and antenatal program that explicitly addresses these issues among pregnant and postpartum women could improve the feeding behaviors of young children in Senegal. In addition, future assessments of infant and young child feeding should follow the standard methodology

recommended by WHO and UNICEF [60]. This standardization should allow for comparisons of these indicators in Senegal over time and for comparisons of Senegalese data with those of other countries.

The prevalence of child stunting found in the 2018 survey is considerably lower than that found in the 2017-2018 DHS (14% vs 16-19%, respectively), while wasting prevalence in this survey is approximately 4 percentage points higher (13% vs 8-9% in DHS). While the higher prevalence of wasting may be partly explained by the older age of the children enrolled in the 2018 survey compared to DHS, the differences in stunting prevalence are difficult to explain. Seasonality may have played a role but stunting being a chronic condition, this may be less plausible. Measurement bias in the 2018 survey or the DHS may play a role in producing these apparent difference, but data quality assessments for the 2018 survey show only some age heaping. There are no signs of serious bias in anthropometric measurements. Furthermore, the DHS likely faces similar challenges of age estimates, given the small proportion of birth certificates available and the inherent inaccuracy of reported child age given by many caregivers.

5.5 Strengths and limitations

5.5.1 Strengths

High comparability of the 2010 and 2018 surveys: The sampling approach used and the indicators collected were highly comparable between the two surveys. With the exception of assessment of folate deficiency (microbiological assay in 2010, clinical analyzer in 2018), the laboratory methods used to measure the concentration of biomarkers also comparable methods, and similar questionnaires were used.

Hemoglobin measurements:To measure hemoglobin, venous blood samples were collected in duplicate from each participant. Given the emerging literature on the likely variability in the use of capillary blood when assessing hemoglobin concentration, particularly in children, the use of a venous blood sample is an advantage [61,62]. In addition, the duplicate analysis of each blood sample further increases the robustness of the measurement

Quality of anthropometry measurements: Data quality checks for anthropometric measurements conducted on the 2018 dataset indicates good quality of anthropometry data collection. There is some age heaping at entire years of child age and some digit heaping in height measurements. However, other quality measures, such as the proportion of survey subjects with missing data for individual variables, the proportion of subjects with flagged anthropometric indices, and the standard deviations of the z-scores all indicate acceptable data quality.

High response rates: The true household, child, and woman response rates for the 2018 survey could not be calculated because the databases contained no information on the number of eligible households, children, and women who could not be found or who refused to be enrolled in the survey sample. Nonetheless, the proportion of enrolled women for whom laboratory results were available was quite high (**Table 58**). The proportion of enrolled children with anthropometric measurements was also quite high, but the proportion with laboratory results was much lower than seen for women; this may be related to higher rejection rates or insufficient blood volume obtained.

5.5.2 Limitations

Sub-par match between survey sample and recent census data: As shown at the beginning of each chapter for a specific population group of pre-school children and non-pregnant women, there is a relatively large difference between the proportion of survey subjects enrolled from urban and rural areas compared to the proportion from 2013 census data, whereas the sample in the rural North is underrepresented compared to census. Although there is no hard threshold, the variations seem relatively large, in particular if the most recent census was conducted not long before the survey. There are 5 years between the census and some of the discrepancies can be partly – but not entirely – explained by population movements towards urban centres. As such, caution has to be applied when interpreting the results presented in this report.

Absence of household data: No household-level information was collected in either the 2010 or 2018 surveys. Typically, such information includes household size and composition; sex of household head; educational level of the household head; primary income generating activities; data to calculate socio-economic status; and water, sanitation and hygiene indicators. As a result, analysis of the prevalence of micronutrient deficiency by certain household factors known to commonly influence nutritional status of children and women, such as household socioeconomic status, sex of the head of the household, household size, etc. could not be conducted.

No measurement of fortification adequacy of fortified wheat flour and vegetable oil and no consumption estimates: The 2018 survey collected only information about the proportion of women living in households that had wheat flour or vegetable oil bearing the fortification logo on the package. However, no food samples were actually taken to measure whether or not the foods were fortified or at what level they were fortified. Such information, together with estimates of quantities of the food vehicles consumed in the household, would have enabled the calculation of the additional nutrient intake coming from consumption of fortified food. This in turn, would have enabled a more in-depth analysis of a potential benefit of the fortification program; for example, demonstration of a dose-response relationship between fortified food consumption and biomarkers would provide some evidence of causality.

Dietary diversity and child feeding indicators: The databases available to the authors did not contain any data on women's dietary diversity and did not contain the data necessary to calculate standardized feeding indicators for preschool age children. In addition, because both surveys included only children 12 to 59 months of age, calculation of indicators for children younger than 6 months of age, children younger than 24 months of age, or children 6 to 23 months of age, which are the target ages for many of the standard IYCF indicators, was not possible [27]. Moreover, the dietary food groups for children did not match the dietary food groups used to define standard feeding indicators [63]. For these reasons, the indicators of breastfeeding and diet given in this report should not be directly compared to those from other populations in which the assessment used standard methodology.

Lack of thresholds defining iron, folate and vitamin A deficiency for pregnant women: For many of the biomarkers, there are no international consensus cut off values to define deficiency during pregnancy. For these biomarkers, the cutoffs widely recommended for non-pregnant women were used to define deficiency in pregnant women. Further, there are important physiological changes depending on gestational age influencing micronutrient status. Therefore, the estimates of micronutrient deficiency among pregnant women need to be interpreted with caution.

Different assays used for assessment of folate status: mentioned as a strength, the two surveys used comparable questionnaires and for several biomarkers, the same or similar analytical methods. However, the assessment of serum folate in the 2010 was done using a microbiologic assay, whereas the 2018 survey used a clinical analyzer (Abbott Architect). The biomedical literature describes differences between different analyzers [64], but the extent of the difference between these two methods is not easily quantifiable. As a result, the folate results of the two surveys should be compared with caution.

Sample weights in the 2010 survey: The sample weights of the 2010 survey were used as provided in the dataset; the person tasked with the sampling and calculation of sample weights could not be contacted to clarify the sample weights, but additional documentation seems to indicate that the sample weights were appropriately calculated. Though due diligence could not be conducted completely, there is some confidence in that sample weights were correctly derived, but a risk for potential bias exists, although the bias cannot be assessed. Therefore, the comparison of the results from the two surveys should be interpreted with some caution.

6 Recommendations

In this chapter, a set of recommendations is provided with a focus on anemia and micronutrient deficiencies (iron, folic acid, vitamin A), since this was the main purpose of the 2010 and 2018 micronutrient surveys. Other recommendations deemed relevant are also discussed.

6.1 Anemia and iron deficiency

Although the anemia prevalence found for the 2018 survey is considerably lower than that reported in recent DHS, anemia prevalence remains high in Senegalese young children and women. Iron deficiency is also very common and so is iron deficiency anemia. As such, additional interventions and programs are needed to further reduce these conditions. But also, there are some assessments that could be done to better understand the extent and the etiology of the anemia.

Clarify the current anemia situation: In order for Senegal to understand if the persistently high anemia prevalence in particular among children reported by the continuous DHS is reflective of the situation or an overestimate, it is recommended to consider adding the measurement of hemoglobin concentration in a population sub-sample using venous sampling and a complete blood counter with rigorous quality control in one of the next DHS. Alternatively, such an investigation could be done in a separate study to also better understand the etiology of anemia (see below). In the shor term, Senegalese stakeholders involved in the DHS and the 2018 survey (and other national surveys if existing) should discuss differences in data collection, pre-analytical procedures, analytical procedures (including quality control measures), and data analysis in an attempt to explain these rather drastic differences in anemia prevalence.

Increase the understanding of the etiology of anemia: Because the DHS and other similar surveys, including the 2018 survey reported here only assess a few possible risk factors for anemia, a more thorough and comprehensive assessment to identify those contributors which could be addressed by revised or additional interventions. Such an assessment may include measuring hemoglobin concentration from venous blood samples and using a complete blood counter with a well-established quality control scheme to demonstrate microcytosis and hypochromia, estimating quantities of wheat flour consumed along with measurement of the iron content of (fortified) wheat flour, and measuring malaria parasitemia, inflammation, hemoglobinopathies, hookworm and schistosoma infestation, micronutrient deficiencies (vitamin A, folate and vitamin B12 in particular), and other factors judged pertinent. Such a study would require careful design to take into consideration seasonality and regional differences.

Strengthen the wheat flour fortification program: As previously discussed, this survey did not measure iron content in wheat flour but collected information whether or not packages were bearing the fortification logo. Even with this approach it becomes evident that the coverage with fortified wheat flour should be increased. Additionally, it may be that the coverage with adequately fortified wheat flour, i.e. flour fortified at legally mandated levels is even lower, thus further reducing the potential impact of the fortification program. Several components can contribute to increase coverage and the systems in place should be revisited to identify potential weaknesses: fortification technology used at the level of the mills, access to premix, regulatory monitoring and enforcement, and inspection at points of importation and of

wholesalers. A market assessment may be needed to investigate flour brands and their market share along with fortification adequacy to identify common brands with sub-optimal fortification adherence.

An assessment of the iron fortificant used should be conducted and if needed, a focus should be put on increasing the use of more bioavailable forms of iron, such as sodium iron ethylenediamine tetra-acetate [65].

To increase demand for fortified foods, public awareness of fortification and the use of the logo should be enhanced through public education.

Other measures to improve iron status in young children: Improving the performance of the food fortification program, while improving dietary micronutrient intake of older children and women, will have little effect on the micronutrient intake of the youngest children because these children usually eat too little fortified staple food to benefit. Further, because the relatively low breastmilk iron content varies little with the mother's iron status, the mother's consumption of fortified food does not increase her breast-feeding infants iron intake. As a result, interventions other than fortification of staple foods are important in improving micronutrient status in young children. Such interventions, such as improving early initiation of breastfeeding, decreasing the proportion of children who consume other foods before the first breast-feed, and increasing dietary diversity among children 6 to 23 months of age, should be implemented to the extent possible in Senegal. In addition, use of micronutrient powders in children 6-23 months could reduce iron deficiency in children less than 24 months of age [66]. Exploration of other micronutrient-fortfied food vehicles targeting this age group could also be considered. This survey gathered no data on the subject nor are the authors aware of the prevalence of this practice, but delayed cord clamping after delivery, which is endorsed by the World Health Organization, has been shown to enhance newborns' body iron stores [67].

6.2 Vitamin A deficiency

While vitamin A deficiency among women is not reaching worrisome levels, its prevalence among children is higher albeit not alarming. Senegal has two specific measures to reduce vitamin A deficiency in place, namely supplements and vitamin A fortified oil. While this survey did not collect data on vitamin supplements use in the past 6 months (but only current consumption), the DHS does address this question and found for 2019 that just over 50% of children received vitamin A supplements in the previous 6 months. Thus, there is room for improvement, and a programmatic assessment may enable the identification of barriers to increased supplementation coverage. Vitamin A supplementation is of particular importance in young children, since their additional vitamin A intake from the fortified oil may be of limited effect due to the small quantities of food consumed compared to their nutrient needs. An option would be to explore fortified foods specifically for this age group. Regardless, future fortification coverage assessments should not be limited to observing the logo but should conduct analysis of the retinyl palmitate content of oil samples obtained from the households. If done in conjuncture with oil consumption estimates, this would allow a correlation analysis between vitamin A intake from oil and vitamin A status.

6.3 Folate deficiency

Given the relatively high prevalence of folate deficiency, measures to tackle this deficiency need to be strengthened. Both fortification with wheat flour and folic acid supplementation during pregnancy aim to tackle this issue, but both of these approaches can be optimized in the Senegalese context.

Understand folic acid intake from fortified wheat flour: Recommendations to strengthen the wheat flour fortification program have been discussed above and the same applies to folate. Considering that the premix used for fortification contains iron and folate at standard ratios, measurement of folic acid may not be required for routine analyses of fortification adequacy. However, to ensure that folic acid does not degrade to a large extent, stability tests should be conducted; a study conducted in Côte d'Ivoire found a discrepancy between iron and folic acid ratios compared to the expected ratio [68].

A correlation study between folic acid content of wheat flour (or proxied by iron levels) and folate status among non-pregnant women may be used to establish a link between the intake and folate status, which could be an important advocacy tool for policy makers but also during public awareness campaigns. Non-pregnant women rather than pregnant women are suggested due to the absence of established deficiency thresholds for pregnant women. As previously mentioned, although such cross-sectional studies bear inherent limitations to establish a causal chain, demonstration of a dose-response relationship between fortified food consumption and biomarkers would provide some evidence of causality. The serum folate assay represents a snapshot of vitamin status while the erythrocyte folate assay reflects the body's tissue stores. Erythrocyte folate assay could be considered in the next study, potentially in parallel with the simultaneous homocysteine assay, although the use of new biomarkers decreases comparability; these should be done in a partial sample in addition to the markers already used.

Increase supplementation coverage during pregnancy: The coverage of iron and folic acid supplementation in pregnant women should be further increased to bridge potential nutrient deficiencies at periods of increased requirements. Further, current recommendations propose the provision of multiple micronutrient supplements to pregnant women rather than iron and folic acid supplements as cost-effective alternative [69]. If not already in place, such a policy shift should be discussed for the Senegalese population. Any implementation should be accompanied by a communication campaign emphasizing the importance of micronutrients before and during pregnancy.

Potential additional measures to improve folate status pre-conceptionally: Since having adequate folate levels is very important around conception, with the neural tube closing within the first 4-5 weeks of gestation [70], interventions should be implemented to ensure that women planning to become pregnant receive folic acid supplementation before pregnancy. This is especially important during the implementation phase of folic acid fortification of wheat flour when the adequacy of fortification and coverage of fortified flour are suboptimal. It is generally difficult to target interventions to women planning to become pregnant and thus, specific recommendations are difficult to be made, but discussions about this should be held to try to find entry points to reach this vulnerable population.

6.4 Child anthropometry and feeding indicators

Future assessments of child feeding indicators should use the standardized infant and young child feeding indicators as recommended and recently updated by WHO and UNICEF [27]. This will allow comparison with other assessments, such as DHS, but also internationally to track progress. The methodology will require inclusion of all children less than 5 years of age.

A programmatic assessment of health education and other programs addressing child feeding behavior should be carried out to identify barriers to better practices related to early initiation of breastfeeding, exclusive breastfeeding, and dietary diversity in children.

Similar to the discrepancies identified on anemia prevalence between DHS and the 2018 survey, possible causes of differences in the prevalence estimates of child stunting and wasting should be discussed by personnel involved in implementing the surveys.

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8 Appendix

8.1 Analysis of non-pregnant, non-lactating women

8.1.1 Non-pregnant non-lactating woman characteristics

Table 34: Description of sampled non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% [a]
TOTAL	1,461	100
Urban/rural		
Urban	831	53.1%
Rural	630	46.9%
Stratum		
Dakar	455	25.4%
Other urban	376	27.8%
Rural south	265	9.3%
Rural north	365	37.6%
Age (in years)		
15-19	315	22.2%
20-24	233	16.3%
25-29	229	15.1%
30-34	205	13.5%
35-39	195	13.5%
40-44	152	10.5%
45-49	132	9.0%

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.

8.1.2 Recent illness and health indicators

Table 35: Proportion of non-pregnant non-lactating women 15-49 years of age with various forms of morbidity in the past 2 weeks and inflammation status, by various demographic characteristics, Senegal 2018

	Fever				Diarrhea				Cough and/or respiratory difficulty				Any inflammation			
Characteristic	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value[c]*
TOTAL	1460	9.2%	(7.2, 11.8)		1456	2.4%	(1.5, 3.9)		1457	3.5%	(2.5, 5.0)		1364	16.7%	(14.6, 18.9)	
Urban/rural				0.576				0.442				0.052				<0.05
Urban	830	9.9%	(7.5, 12.9)		827	2.9%	(1.6, 5.0)		828	4.9%	(3.3, 7.1)		761	19.8%	(16.9, 23.1)	
Rural	630	8.5%	(5.4, 13.2)		629	1.9%	(0.7, 4.7)		629	2.0%	(0.9, 4.6)		603	13.2%	(10.5, 16.5)	
Stratum				0.355				0.272				<0.05				<0.01
Dakar	455	10.3%	(7.3, 14.1)		452	2.1%	(1.0, 4.3)		453	5.3%	(3.5, 8.0)		406	21.5%	(18.1, 25.4)	
Other urban	375	10.5%	(6.9, 15.5)		375	3.3%	(1.4, 7.6)		375	5.1%	(2.7, 9.7)		355	19.1%	(14.8, 24.4)	
Rural south	265	6.0%	(3.5, 10.0)		264	0.7%	(0.2, 2.4)		264	0.7%	(0.2, 2.2)		253	16.2%	(12.0, 21.5)	
Rural north	365	7.8%	(4.5, 13.4)		365	1.7%	(0.6, 4.7)		365	1.9%	(0.8, 4.9)		350	13.5%	(10.5, 17.2)	
Age group in years				0.001				<0.05				0.356				<0.001
15-19	315	4.8%	(2.8, 8.0)		315	1.2%	(0.4, 3.6)		315	2.8%	(1.4, 5.4)		293	7.8%	(5.2, 11.5)	
20-24	233	6.5%	(3.1, 12.9)		230	1.5%	(0.4, 6.3)		231	4.6%	(1.7, 11.4)		216	12.8%	(8.8, 18.1)	
25-29	229	13.0%	(8.8, 18.7)		229	2.5%	(1.1, 5.5)		229	4.6%	(2.2, 9.3)		214	15.3%	(10.8, 21.1)	
30-34	205	7.4%	(4.5, 11.9)		205	2.0%	(0.7, 5.5)		205	1.9%	(0.8, 4.7)		192	22.3%	(16.5, 29.3)	
35-39	195	10.6%	(7.0, 15.6)		195	1.7%	(0.6, 4.7)		195	3.1%	(1.4, 6.5)		181	24.6%	(18.8, 31.5)	
40-44	151	18.5%	(11.7, 28.0)		150	8.2%	(3.5, 17.9)		150	6.3%	(3.1, 12.7)		141	20.6%	(13.6, 30.0)	
45-49	132	8.9%	(4.6, 16.7)		132	2.1%	(0.4, 10.6)		132	1.8%	(0.5, 6.1)		127	23.0%	(16.6, 31.1)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.1.3 Consumption of micronutrient supplements and fortified foods

Table 36: Proportion of non-pregnant non-lactating women 15-49 years of age with micronutrient supplementation and fortification, by various demographic characteristics, Senegal 2018

Characteristic	Currently taking iron supplements				Household oil marked as fortified with vitamin A				Household flour marked as fortified with iron and folate			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*
TOTAL	1454	12.0%	(9.8, 14.6)		1454	49.9%	(44.2, 55.7)		1455	24.0%	(19.3, 29.5)	
Urban/rural				<0.01				<0.01				0.276
Urban	825	15.2%	(12.2, 18.7)		826	58.0%	(50.9, 64.7)		825	25.4%	(19.1, 32.8)	
Rural	629	8.4%	(5.6, 12.4)		628	40.8%	(31.6, 50.8)		630	22.5%	(15.8, 31.0)	
Stratum				<0.05				0.001				0.211
Dakar	450	17.2%	(13.4, 21.8)		451	65.3%	(55.2, 74.1)		450	28.7%	(20.0, 39.2)	
Other urban	375	12.4%	(8.6, 17.6)		375	53.5%	(42.5, 64.1)		375	24.5%	(15.6, 36.4)	
Rural south	265	12.0%	(7.8, 17.8)		264	34.9%	(23.2, 48.7)		265	27.1%	(15.9, 42.2)	
Rural north	364	7.5%	(4.6, 11.8)		364	44.1%	(32.6, 56.3)		365	20.5%	(12.9, 31.1)	
Age group in years				<0.01				0.865				0.058
15-19	313	5.6%	(3.0, 10.2)		314	46.9%	(37.9, 56.1)		314	18.8%	(12.7, 26.9)	
20-24	231	10.5%	(6.9, 15.6)		232	52.9%	(44.2, 61.4)		231	26.2%	(19.0, 35.0)	
25-29	228	13.5%	(9.3, 19.3)		227	49.7%	(41.3, 58.1)		228	26.5%	(19.4, 35.1)	
30-34	205	20.0%	(13.4, 28.7)		205	53.0%	(43.7, 62.1)		205	25.5%	(18.7, 33.6)	
35-39	194	12.6%	(8.1, 18.9)		194	47.3%	(38.2, 56.6)		194	26.1%	(19.0, 34.7)	
40-44	152	14.9%	(9.9, 21.8)		152	51.1%	(40.3, 61.8)		152	25.1%	(17.5, 34.8)	
45-49	131	11.6%	(6.6, 19.7)		130	50.4%	(38.9, 61.9)		131	21.9%	(14.4, 31.8)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

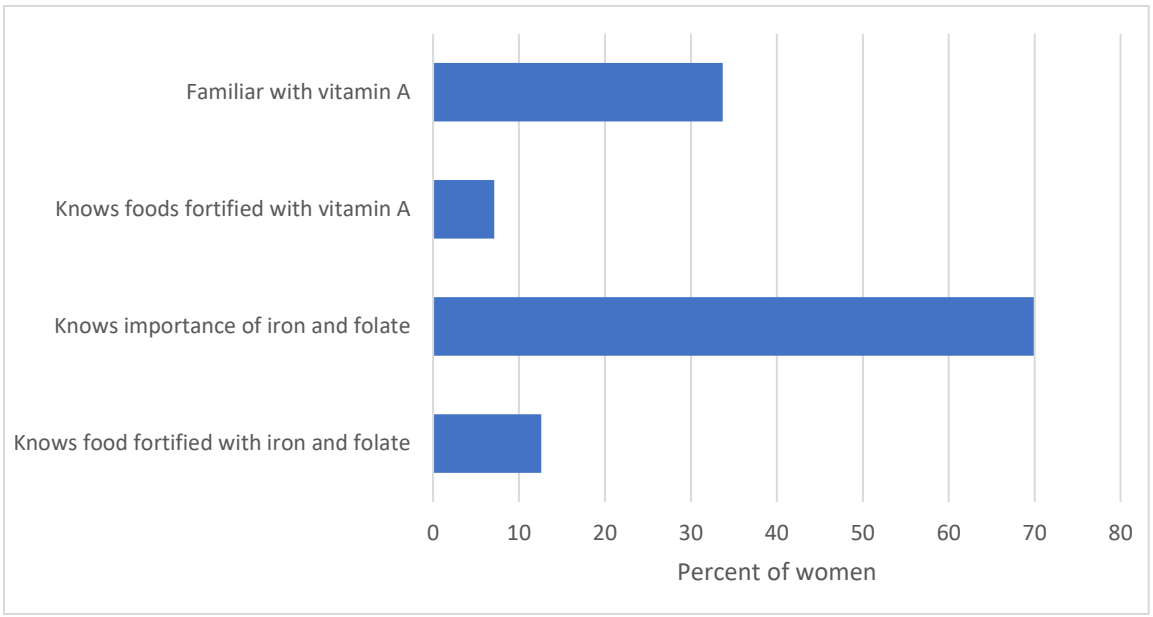

Figure 14: Proportion of non-pregnant non-lactating women 15-49 years of age with knowledge of micronutrients and food fortification, Senegal 2018

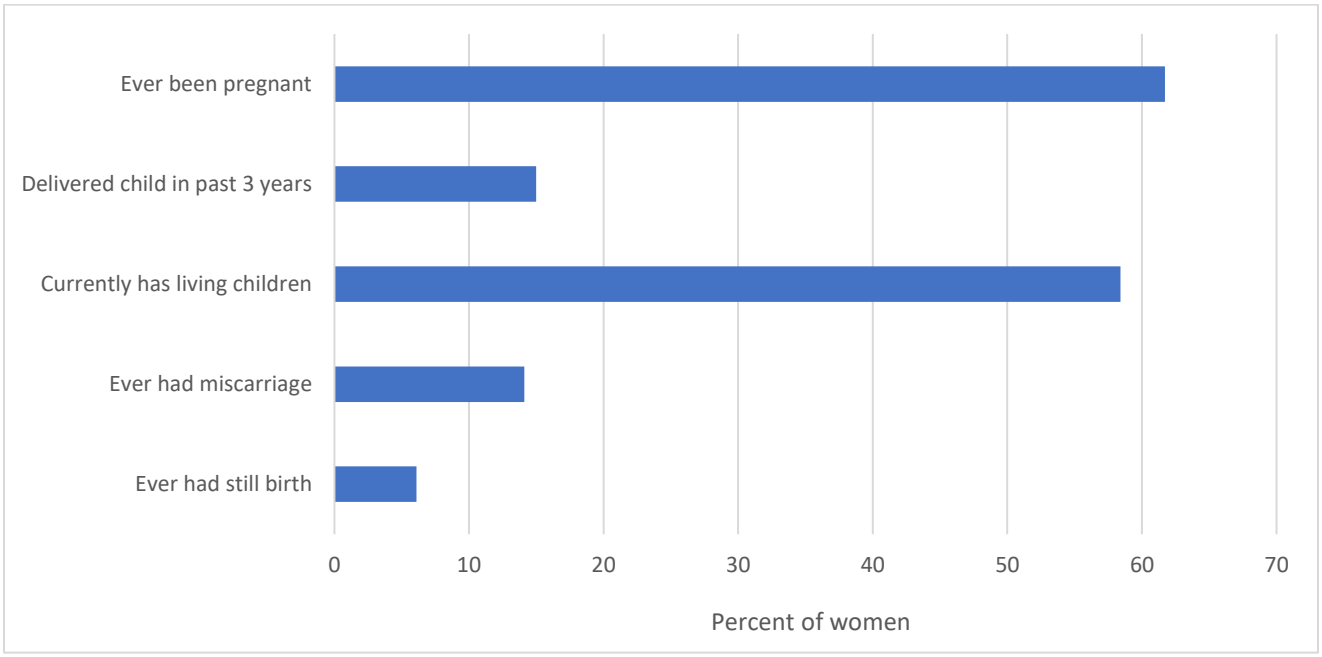

Figure 15: Proportion of non-pregnant non-lactating women 15-49 years of age with various pregnancy indicators, Senegal 2018

8.1.4 Anemia, iron deficiency, and iron deficiency anemia

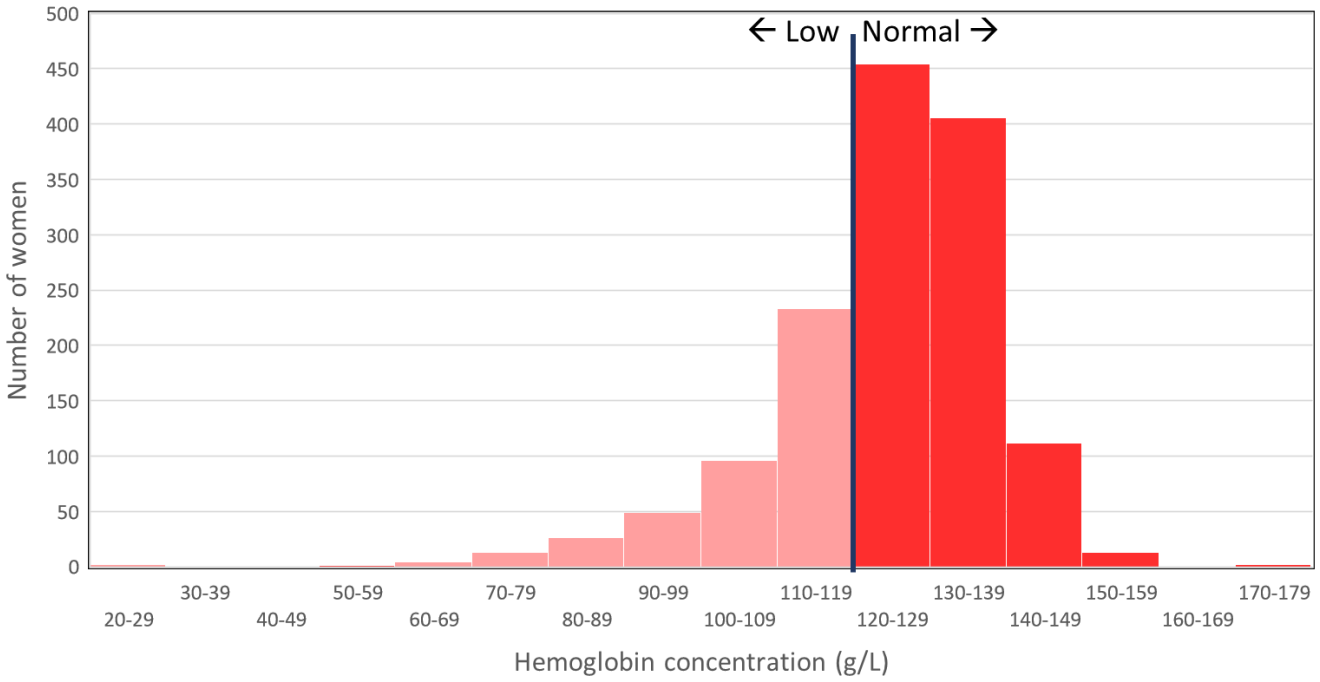

Figure 16: Distribution of hemoglobin concentrations in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Figure 17: Venn diagram showing overlap between anemia and iron deficiency in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Table 37: Prevalence of anemia, iron deficiency, and iron deficiency anemia in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

	Anemia [b]				Iron deficiency [e]				Iron deficiency anemia [b, f]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	1411	29.1%	(26.6, 31.8)		1413	43.1%	(39.7, 46.7)		1419	18.6%	(16.3, 21.1)	
Urban/rural				0.001				0.584				<0.05
Urban	792	24.9%	(21.8, 28.2)		791	42.2%	(38.1, 46.4)		799	15.8%	(13.1, 18.9)	
Rural	619	33.8%	(29.7, 38.3)		622	44.2%	(38.5, 50.0)		620	21.8%	(18.0, 26.0)	
Stratum				<0.01				0.06				<0.05
Dakar	427	25.4%	(21.1, 30.4)		423	45.4%	(39.7, 51.3)		431	18.9%	(14.5, 24.2)	
Other urban	365	24.7%	(19.7, 30.4)		368	38.8%	(33.1, 45.0)		368	14.3%	(10.7, 18.8)	
Rural south	260	39.1%	(30.9, 47.9)		260	50.7%	(43.7, 57.6)		260	27.1%	(21.3, 33.9)	
Rural north	359	31.7%	(27.2, 36.7)		362	39.6%	(32.9, 46.7)		360	19.6%	(15.2, 24.8)	
Age group in years												
15-19	308	31.0%	(25.5, 37.2)	0.589	306	47.4%	(40.3, 54.6)	0.119	307	20.8%	(16.1, 26.4)	0.804
20-24	226	25.1%	(19.5, 31.7)		225	47.7%	(40.4, 55.1)		226	19.2%	(14.4, 25.1)	
25-29	225	25.8%	(20.0, 32.7)		221	39.0%	(33.2, 45.2)		225	15.5%	(11.2, 21.1)	
30-34	199	29.3%	(22.6, 37.1)		198	43.8%	(36.2, 51.6)		202	18.8%	(13.6, 25.4)	
35-39	183	28.6%	(21.9, 36.4)		188	44.2%	(36.2, 52.4)		185	19.8%	(14.2, 27.0)	
40-44	141	33.4%	(25.5, 42.3)		145	39.5%	(31.2, 48.4)		143	18.4%	(12.6, 26.0)	
45-49	129	32.8%	(24.8, 42.1)		130	32.9%	(24.1, 43.0)		131	15.7%	(9.9, 24.0)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Anemia defined as hemoglobin < 120 g/L; adjustment for altitude not required.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.
[e] Iron deficiency defined as ferritin < 15 µg/l, after BRINDA adjustment [31].
[f] Iron deficiency anemia defined as inflammation-adjusted ferritin < 15 µg/L and hemoglobin < 120g/L.

Table 38: Proportion of mild, moderate and severe anemia in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

	Mild anemia [b]			Moderate anemia [e]			Severe anemia [b, f]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	1411	16.7%	(14.9, 18.6)	1411	11.3%	(9.5, 13.4)	1411	1.2%	(0.7, 2.0)	
Urban/rural										<0.01
Urban	792	13.7%	(11.4, 16.3)	792	10.3%	(8.5, 12.5)	792	0.8%	(0.4, 1.8)	
Rural	619	19.9%	(17.3, 22.8)	619	12.3%	(9.2, 16.3)	619	1.6%	(0.8, 3.2)	
Stratum										<0.01
Dakar	427	12.0%	(9.5, 15.0)	427	11.7%	(8.6, 15.9)	427	1.7%	(0.7, 3.8)	
Other urban	365	15.2%	(11.9, 19.4)	365	9.0%	(6.4, 12.4)	365	0.4%	(0.1, 1.8)	
Rural south	260	18.4%	(13.9, 24.0)	260	18.0%	(13.5, 23.5)	260	2.7%	(1.2, 6.3)	
Rural north	359	19.7%	(16.4, 23.5)	359	10.8%	(7.8, 14.8)	359	1.2%	(0.5, 3.0)	
Age group in years										
15-19	308	21.1%	(16.6, 26.4)	308	8.7%	(5.9, 12.5)	308	1.3%	(0.5, 3.3)	0.520
20-24	226	13.0%	(8.5, 19.3)	226	11.5%	(7.5, 17.1)	226	0.7%	(0.2, 2.2)	
25-29	225	12.1%	(8.2, 17.6)	225	12.9%	(8.6, 18.9)	225	0.9%	(0.3, 2.9)	
30-34	199	17.1%	(12.1, 23.5)	199	11.3%	(6.9, 17.9)	199	0.9%	(0.3, 3.0)	
35-39	183	14.9%	(10.4, 20.9)	183	11.9%	(7.4, 18.6)	183	1.8%	(0.5, 5.9)	
40-44	141	18.4%	(12.7, 25.9)	141	12.3%	(7.5, 19.7)	141	2.7%	(0.6, 11.6)	
45-49	129	20.0%	(13.5, 28.5)	129	12.6%	(7.6, 20.2)	129	0.3%	(0.0, 2.0)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Mild, moderate, and severe anemia defined as hemoglobin 110-119 g/L, 80-109 g/L, and <80 g/L, respectively.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.1.5 Vitamin A deficiency

Table 39: Prevalence of vitamin A deficiency by various demographic characteristics in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% VAD [a, b]	95% CI [c]	p-value [d]
TOTAL	1388	2.3%	(1.5, 3.4)	
Urban/rural				<0.01
Urban	779	1.1%	(0.5, 2.4)	
Rural	609	3.6%	(2.3, 5.9)	
Stratum				<0.001
Dakar	416	1.0%	(0.3, 2.7)	
Other urban	363	0.9%	(0.3, 2.6)	
Rural south	254	6.6%	(4.5, 9.5)	
Rural north	355	2.8%	(1.4, 5.4)	
Age group in years				0.791
15-19	301	2.4%	(1.2, 4.6)	
20-24	219	1.2%	(0.3, 4.0)	
25-29	218	2.3%	(0.9, 5.5)	
30-34	196	2.8%	(1.1, 6.5)	
35-39	185	2.9%	(1.0, 7.6)	
40-44	143	3.3%	(1.3, 8.5)	
45-49	126	1.4%	(0.4, 4.6)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] VAD = Vitamin A deficiency, defined as retinol <0.70 umol/L [24].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.1.6 Folate deficiency

Table 40: Prevalence of folate deficiency by various demographic characteristics in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% folate deficient [a, b]	95% CI [c]	p-value [d]
TOTAL	1414	48.7%	(44.4, 52.9)	
Urban/rural				0.082
Urban	792	45.0%	(39.2, 51.0)	
Rural	622	52.6%	(46.4, 58.8)	
Stratum				<0.05
Dakar	424	42.8%	(37.1, 48.8)	
Other urban	368	48.7%	(39.4, 58.1)	
Rural south	260	61.7%	(51.1, 71.3)	
Rural north	362	50.3%	(43.3, 57.2)	
Age group in years				0.628
15-19	306	46.8%	(39.0, 54.7)	
20-24	226	47.2%	(39.3, 55.3)	
25-29	222	51.6%	(43.7, 59.5)	
30-34	198	46.3%	(37.6, 55.2)	
35-39	188	45.6%	(37.3, 54.1)	
40-44	145	51.1%	(41.2, 61.0)	
45-49	129	56.2%	(46.2, 65.7)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Folate deficiency, defined as serum folate < 10 nmol/L [25].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.1.8 Associations between micronutrient deficiencies and various factors

Table 41: Associations between anemia and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% anemic [a]	p- value [b]
Micronutrient indicators			
Iron deficient			<0.001
Yes	624	43.8%	
No	1396	18.2%	
Vitamin A deficient			<0.001
Yes	39	67.0%	
No	1372	28.3%	
Folate deficient			0.410
Yes	703	30.5%	
No	1397	28.0%	
Fortified foods and supplement consumption			
Currently taking iron supplements	179	35.2%	0.059
Yes	1404	28.3%	
No			
Household oil marked as fortified with vitamin A			<0.001
Yes	705	24.5%	
No	492	29.4%	
Household flour marked as fortified with iron and folate			0.146
Yes	350	27.8%	
No	836	24.1%	
Pregnancy factors			
Have living children			0.271
Yes	813	30.3%	
No	1411	27.5%	
Took iron supplement during prior pregnancy			0.749
Yes	725	29.6%	
No	675	28.7%	
Took iron supplement after prior delivery			0.207
Yes	632	28.8%	
No	675	38.9%	
Morbidity indicators			
Fever			0.330
Yes	129	33.5%	
No	1410	28.7%	
Diarrhea			0.341
Yes	29	37.8%	
No	1406	28.9%	
Cough and/or respiratory difficulty			0.514

Characteristic	N	% anemic [a]	p- value [b]
Yes	48	34.2%	
No	1407	29.0%	
Inflammation			0.832
None (CRP and AGP normal)	233	28.5%	
Any inflammation (elevated CRP and/or AGP)	1348	29.3%	

Note: The N's are the denominators for a specific sub-group.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Table 42: Associations between iron deficiency and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% iron deficient [a]	p- value [b]
Micronutrient indicators			
Vitamin A deficient			0.041
Yes	39	61.2%	
No	1341	42.9%	
Folate deficient			0.068
Yes	708	46.0%	
No	704	40.3%	
Fortified foods and supplement consumption			
Currently taking iron supplements			0.881
Yes	179	42.3%	
No	1227	42.9%	
Household oil marked as fortified with vitamin A			<0.05
Yes	707	38.0%	
No	210	48.5%	
Household flour marked as fortified with iron and folate			0.152
Yes	349	38.7%	
No	221	40.3%	
Pregnancy factors			
Have living children			<0.05
Yes	821	40.1%	
No	592	47.4%	
Took iron supplement during prior pregnancy			0.207
Yes	731	40.8%	
No	671	45.6%	
Took iron supplement after prior delivery			0.177
Yes	638	39.6%	
No	84	51.0%	
Morbidity indicators			
Fever			0.092
Yes	131	36.4%	
No	1281	43.9%	
Diarrhea			0.938
Yes	29	42.5%	
No	1379	43.2%	
Cough and/or respiratory difficulty			0.728
Yes	48	40.4%	
No	1361	43.3%	
Inflammation			0.634
None (CRP and AGP normal)	236	45.3%	

Characteristic	N	% iron deficient [a]	p- value [b]
Any inflammation (elevated CRP and/or AGP)	1127	43.3%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Table 43: Associations between vitamin A deficiency and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% vitamin A deficient [a]	p- value [b]
Micronutrient indicators			
Folate deficient			0.981
Yes	697	2.3%	
No	684	2.3%	
Fortified foods and supplement consumption			
Currently taking iron supplements			0.548
Yes	173	1.7%	
No	1208	2.4%	
Household oil marked as fortified with vitamin A			<0.05
Yes	693	1.1%	
No	210	2.4%	
Household flour marked as fortified with iron and folate			0.643
Yes	341	2.9%	
No	218	1.7%	
Pregnancy factors			
Have living children			0.565
Yes	807	2.5%	
No	581	2.0%	
Took iron supplement during prior pregnancy			0.663
Yes	719	2.5%	
No	658	2.1%	
Took iron supplement after prior delivery			0.213
Yes	628	2.8%	
No	82	1.1%	
Morbidity indicators			
Fever			0.516
Yes	128	1.4%	
No	1259	2.4%	
Diarrhea			0.556
Yes	29	1.3%	
No	1355	2.3%	
Cough and/or respiratory difficulty			0.844
Yes	45	2.7%	
No	1339	2.3%	
Inflammation			0.956
None (CRP and AGP normal)	231	2.5%	
Any inflammation (elevated CRP and/or AGP)	1100	2.4%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal selection among strata.
[b] P value <0.05 indicates significance.

Table 44: Association between folate deficiency and fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant non-lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% folate deficient [a]	p- value [b]
Fortified foods and supplement consumption			
Currently taking iron supplements			<0.05
Yes		38.0%	
No		49.9%	
Household oil marked as fortified with vitamin A			0.554
Yes		46.8%	
No		49.9%	
Household flour marked as fortified with iron and folate			0.382
Yes		46.1%	
No		45.5%	
Pregnancy factors			
Have living children			0.257
Yes		50.0%	
No		46.8%	
Took iron supplement during prior pregnancy			0.133
Yes		50.5%	
No		46.1%	
Took iron supplement after prior delivery			0.187
Yes		49.7%	
No		57.1%	
Morbidity indicators			
Fever			0.656
Yes		50.5%	
No		48.4%	
Diarrhea			0.596
Yes		53.8%	
No		48.4%	
Cough and/or respiratory difficulty			0.787
Yes		46.3%	
No		48.7%	
Inflammation			0.392
None (CRP and AGP normal)		51.6%	
Any inflammation (elevated CRP and/or AGP)		48.2%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

8.2 Analysis of non-pregnant, lactating women

8.2.1 Non-pregnant lactating woman characteristics

Characteristics of non-pregnant lactating women randomly selected for the survey are presented in ***Table 45***.

Table 45: Description of sampled non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% [a]
TOTAL	455	100%
Urban/rural		
Urban	194	39.8%
Rural	261	60.2%
Stratum		
Dakar	86	14.5%
Other urban	108	25.2%
Rural south	119	13.6%
Rural north	142	46.6%
Age (in years)		
15-19	46	10.8%
20-24	93	20.9%
25-29	125	29.2%
30-34	92	18.5%
35-39	68	13.7%
40-44	23	4.9%
45-49	8	2.0%

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.

8.2.2 Recent illness and health indicators

Table 46: Proportion of non-pregnant lactating women 15-49 years of age with various forms of morbidity in the past 2 weeks and inflammation status, by various demographic characteristics, Senegal 2018

Characteristic	Fever				Diarrhea				Cough and/or respiratory difficulty				Any inflammation			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p- value [c]*	*N*	*% [a]*	*95% CI [b]*	*p- value [c]*
TOTAL	453	6.2%	(4.1, 9.3)		453	1.2%	(0.5, 3.0)		453	3.2%	(1.8, 5.6)		435	18.6%	(14.5, 23.5)	
Urban/rural				0.177				0.799				0.089				0.107
Urban	192	8.4%	(4.8, 14.3)		192	1.4%	(0.3, 5.5)		192	5.1%	(2.4, 10.6)		182	23.2%	(16.4, 31.8)	
Rural	261	4.8%	(2.6, 8.8)		261	1.1%	(0.3, 3.6)		261	1.9%	(0.8, 4.7)		253	15.7%	(11.0, 21.9)	
Stratum				0.066				0.268				0.103				0.233
Dakar	85	11.9%	(5.9, 22.7)		85	3.6%	(0.5, 20.4)		85	1.8%	(0.3, 10.9)		77	28.5%	(19.0, 40.5)	
Other urban	107	7.1%	(3.1, 15.6)		107	0.8%	(0.1, 5.0)		107	7.0%	(2.9, 15.7)		105	21.8%	(13.0, 34.3)	
Rural south	119	12.6%	(7.2, 21.0)		119	0.6%	(0.1, 4.2)		119	4.0%	(1.5, 10.2)		115	17.7%	(11.1, 26.9)	
Rural north	141	2.8%	(0.9, 8.2)		141	1.0%	(0.3, 4.0)		141	0.9%	(0.2, 3.8)		138	16.0%	(10.4, 23.7)	
Age group in years				0.406				0.752				0.791				0.671
15-19	46	5.2%	(1.0, 23.4)		46	-	-		46	4.3%	(0.6, 25.2)		46	7.7%	(2.4, 21.8)	
20-24	93	10.2%	(5.3, 18.8)		93	2.0%	(0.5, 7.7)		93	1.2%	(0.2, 8.4)		87	20.6%	(12.4, 32.2)	
25-29	124	6.6%	(3.1, 13.5)		124	2.3%	(0.6, 8.8)		124	5.1%	(2.1, 11.8)		116	19.1%	(12.8, 27.4)	
30-34	91	7.6%	(3.5, 15.7)		91	0.6%	(0.1, 4.1)		91	3.0%	(0.9, 9.5)		90	21.4%	(12.9, 33.5)	
35-39	68	1.7%	(0.4, 6.6)		68	-	-		68	3.0%	(0.6, 14.1)		66	19.2%	(11.2, 31.0)	
40-44	23	-	-		23	-	-		23	-	-		22	19.8%	(6.9, 45.1)	
45-49	8	-	-		8	-	-		8	-	-		8	20.0%	(4.0, 60.3)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.2.3 Consumption of micronutrient supplements and fortified foods

Table 47: Proportion of non-pregnant lactating women 15-49 years of age with micronutrient supplementation and fortification, by various demographic characteristics, Senegal 2018

Characteristic	Currently taking iron supplements				Household oil marked as fortified with vitamin A				Household flour marked as fortified with iron and folate			
	N	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*	*N*	*% [a]*	*95% CI [b]*	*p-value [c]*
TOTAL	455	19.3%	(14.9, 24.7)		454	53.3%	(45.3, 61.2)		129	29.7%	(22.6, 37.9)	
Urban/rural				0.851				<0.05				0.526
Urban	194	18.8%	(13.0, 26.3)		194	65.1%	(54.0, 74.8)		194	32.8%	(23.0, 44.4)	
Rural	261	19.7%	(13.7, 27.4)		260	45.5%	(34.7, 56.7)		261	27.6%	(18.4, 39.2)	
Stratum				0.266				<0.05				0.795
Dakar	86	20.7%	(13.6, 30.3)		86	68.4%	(54.7, 79.6)		86	32.1%	(19.6, 47.8)	
Other urban	108	18.5%	(11.1, 29.2)		108	64.3%	(49.1, 77.0)		108	32.0%	(18.4, 49.7)	
Rural south	119	27.5%	(20.6, 35.5)		119	40.9%	(28.0, 55.1)		119	27.8%	(15.7, 44.5)	
Rural north	141	16.4%	(9.7, 26.5)		140	44.8%	(30.3, 60.2)		141	24.7%	(14.4, 39.2)	
Age group in years				0.054				0.719				<0.05
15-19	46	7.8%	(2.8, 19.8)		45	50.3%	(31.3, 69.3)		46	30.4%	(14.8, 52.2)	
20-24	93	30.1%	(18.8, 44.4)		93	51.4%	(39.1, 63.5)		93	31.8%	(21.9, 43.8)	
25-29	125	20.7%	(13.5, 30.5)		125	53.5%	(40.6, 66.0)		125	29.7%	(18.7, 43.5)	
30-34	92	12.8%	(7.4, 21.2)		92	51.4%	(39.2, 63.4)		92	23.1%	(14.1, 35.4)	
35-39	68	21.6%	(12.0, 35.8)		68	54.1%	(37.6, 69.8)		68	21.6%	(12.4, 34.8)	
40-44	23	6.7%	(0.9, 36.0)		23	67.7%	(41.5, 86.0)		23	51.6%	(29.6, 73.0)	
45-49	8	23.5%	(6.1, 59.3)		8	61.8%	(24.5, 89.0)		8	66.3%	(29.2, 90.4)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] CI=confidence interval calculated taking into account the complex sampling design.
[c] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

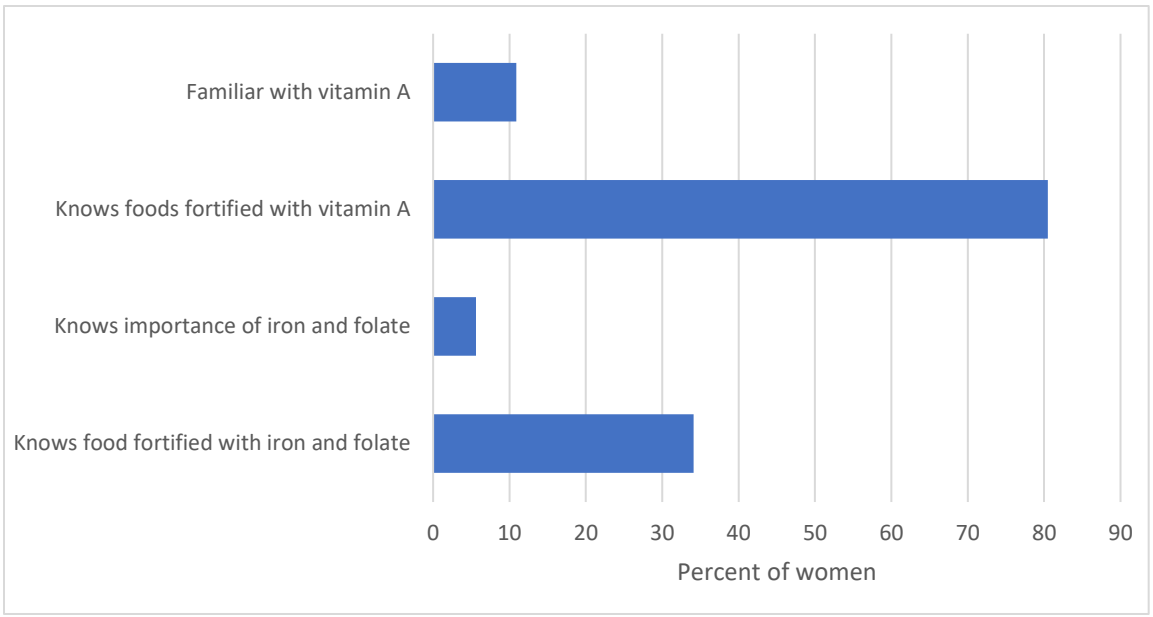

Figure 18: Proportion of non-pregnant lactating women 15-49 years of age with knowledge of micronutrients and food fortification, Senegal 2018

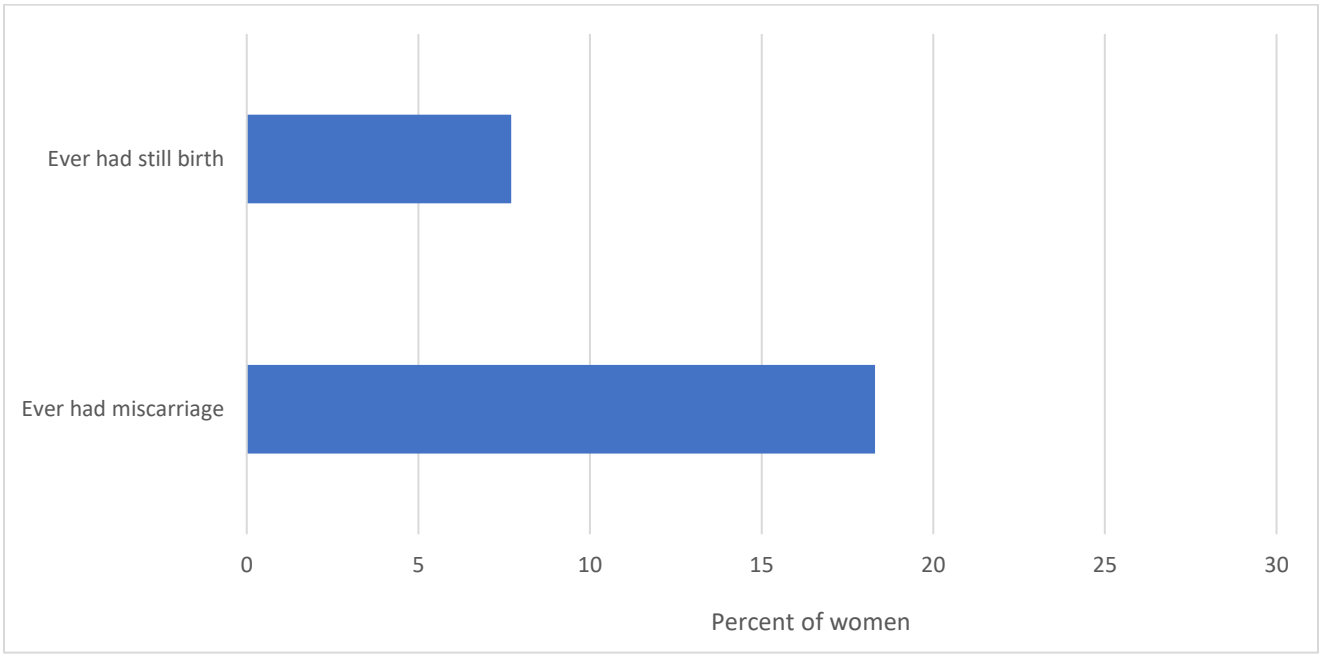

Figure 19: Proportion of non-pregnant lactating women 15-49 years of age with various pregnancy indicators, Senegal 2018

8.2.4 Anemia, iron deficiency, and iron deficiency anemia

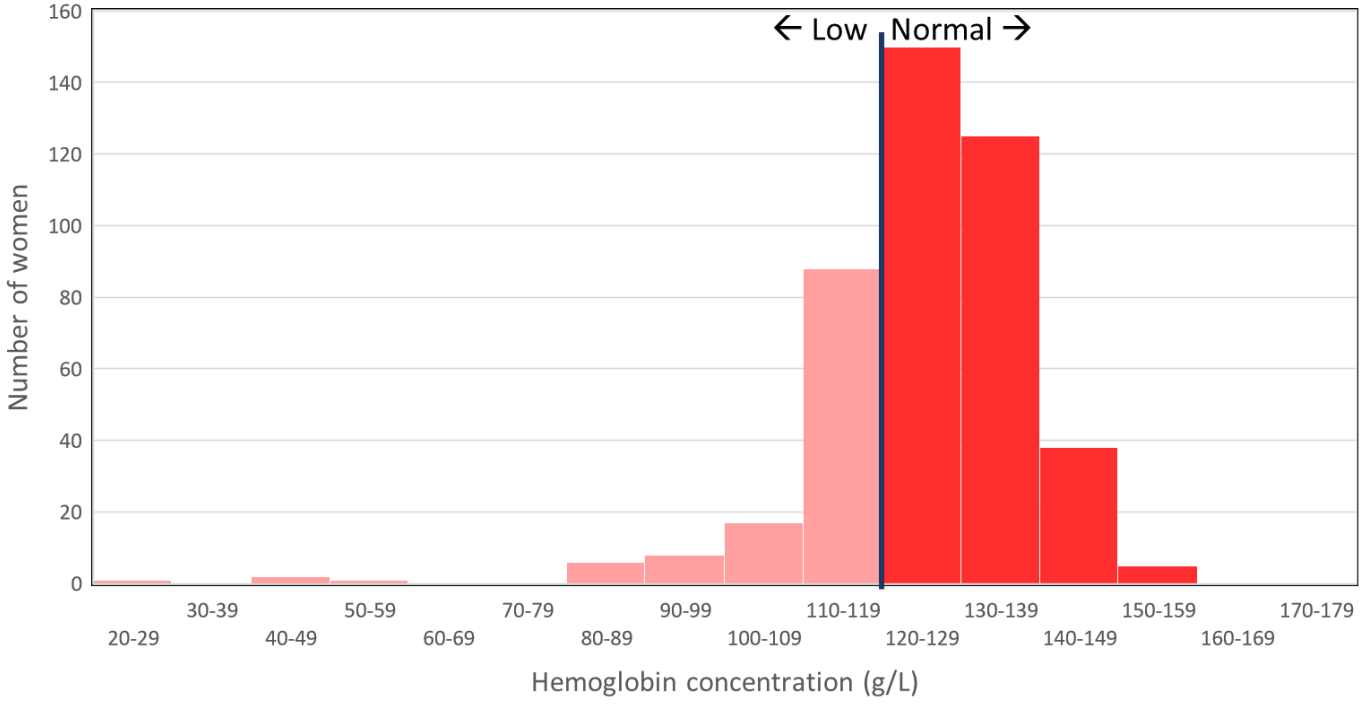

Figure 20: Distribution of hemoglobin concentrations in non-pregnant lactating women 15-49 years of age, Senegal 2018

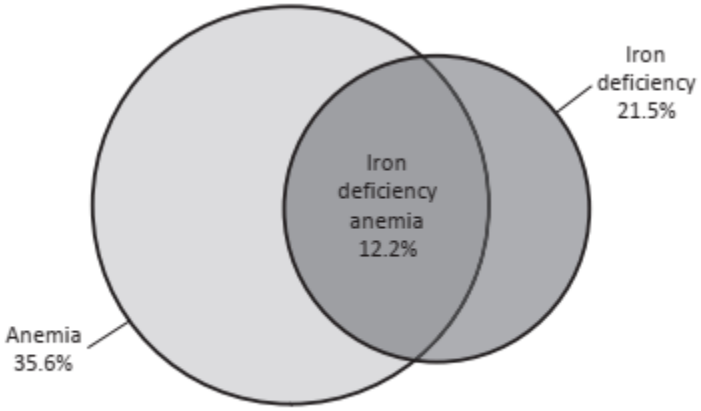

Figure 21: Venn diagram showing overlap between anemia and iron deficiency in non-pregnant lactating women 15-49 years of age, Senegal 2018

Table 48: Prevalence of anemia, iron deficiency, and iron deficiency anemia in non-pregnant lactating women 15-49 years of age, Senegal 2018

	Anemia [b]				Iron deficiency [e]				Iron deficiency anemia [b, f]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	443	28.3%	(23.6, 33.6)		451	39.7%	(34.3, 45.3)		450	18.0%	(14.1, 22.6)	
Urban/rural				0.203				0.187				<0.05
Urban	186	24.2%	(17.3, 32.8)		66	35.3%	(28.2, 43.2)		191	11.7%	(7.0, 18.8)	
Rural	257	31.0%	(24.8, 37.9)		121	42.6%	(35.1, 50.4)		259	22.1%	(16.7, 28.8)	
Stratum				0.109				0.01				0.001
Dakar	84	17.6%	(10.0, 29.1)		191	32.1%	(23.4, 42.3)		85	5.1%	(2.2, 11.7)	
Other urban	102	23.3%	(14.5, 35.4)		107	32.1%	(22.6, 43.3)		106	11.7%	(6.4, 20.4)	
Rural south	118	33.5%	(24.6, 43.7)		119	55.7%	(42.2, 68.4)		119	25.2%	(16.3, 36.9)	
Rural north	139	30.2%	(23.2, 38.2)		141	41.4%	(32.1, 51.4)		140	23.0%	(16.8, 30.6)	
Age group in years												
15-19	46	29.1%	(17.4, 44.4)	0.312	46	46.1%	(30.5, 62.5)	0.182	46	20.7%	(10.4, 36.9)	0.415
20-24	92	33.5%	(24.2, 44.3)		93	46.9%	(36.7, 57.3)		93	19.9%	(12.6, 29.8)	
25-29	121	20.5%	(12.8, 31.1)		123	34.2%	(25.3, 44.4)		124	12.0%	(6.0, 22.3)	
30-34	89	33.7%	(23.6, 45.5)		91	43.0%	(31.8, 55.0)		90	25.0%	(16.7, 35.7)	
35-39	65	30.5%	(19.8, 43.7)		67	33.5%	(22.0, 47.3)		66	16.3%	(8.7, 28.6)	
40-44	22	32.2%	(13.8, 58.4)		23	44.3%	(26.2, 64.0)		23	21.3%	(7.8, 46.3)	
45-49	8	10.3%	(2.2, 36.4)		8	10.3%	(2.2, 36.4)		8	10.3%	(2.2, 36.4)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Anemia defined as hemoglobin < 120 g/L; adjustment for altitude not required.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.
[e] Iron deficiency defined as ferritin < 15 µg/l, after BRINDA adjustment [31].
[f] Iron deficiency anemia defined as inflammation-adjusted ferritin < 15 µg/L and hemoglobin < 120g/L.

Table 49: Proportion of mild, moderate and severe anemia in non-pregnant lactating women 15-49 years of age, Senegal 2018

	Mild anemia [b]			Moderate anemia [e]			Severe anemia [b, f]			
Characteristic	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*N*	*% [a]*	*95% CI [c]*	*p-value [d]*
TOTAL	443	20.4%	(16.7, 24.6)	443	7.1%	(4.7, 10.5)	443	0.9%	(0.3, 2.7)	
Urban/rural										0.148
Urban	186	75.8%	(67.2, 82.7)	186	3.4%	(1.6, 7.1)	186	1.1%	(0.2, 7.1)	
Rural	257	69.0%	(62.1, 75.2)	257	9.5%	(5.9, 14.9)	257	0.7%	(0.2, 2.7)	
Stratum										0.183
Dakar	84	15.5%	(8.7, 25.8)	84	2.1%	(0.5, 7.9)	84	0%	-	
Other urban	102	19.0%	(12.0, 28.7)	102	3.1%	(1.2, 7.8)	102	1.3%	(0.2, 8.2)	
Rural south	118	22.9%	(15.5, 32.5)	118	9.3%	(5.4, 15.4)	118	1.3%	(0.3, 5.3)	
Rural north	139	19.4%	(14.4, 25.6)	139	10.0%	(5.6, 17.1)	139	0.8%	(0.1, 5.7)	
Age group in years										
15-19	46	24.9%	(14.1, 40.1)	46	4.2%	(0.9, 18.2)	46	0%	-	0.567
20-24	92	24.2%	(16.3, 34.3)	92	9.3%	(3.9, 20.5)	92	0%	-	
25-29	121	15.5%	(9.7, 23.7)	121	4.7%	(1.9, 11.6)	121	0.3%	(0.0, 2.2)	
30-34	89	21.0%	(13.4, 31.5)	89	11.2%	(5.7, 20.9)	89	1.4%	(0.2, 9.5)	
35-39	65	20.8%	(11.9, 33.8)	65	6.5%	(2.1, 18.7)	65	3.1%	(0.4, 19.5)	
40-44	22	28.0%	(10.9, 55.3)	22	2.3%	(0.3, 15.3)	22	1.9%	(0.3, 12.7)	
45-49	8	-	-	8	10.3%	(2.2, 36.4)	8	0%	-	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Mild, moderate, and severe anemia defined as hemoglobin 110-119 g/L, 80-109 g/L, and <80 g/L, respectively.
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.2.5 Vitamin A deficiency

Table 50: Prevalence of vitamin A deficiency by various demographic characteristics in non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% VAD [a, b]	95% CI [c]	p-value [d]
TOTAL	433	4.3%	(2.5, 7.6)	
Urban/rural				0.359
Urban	179	5.8%	(3.0, 11.0)	
Rural	254	3.4%	(1.4, 8.4)	
Stratum				0.303
Dakar	77	4.2%	(1.6, 10.7)	
Other urban	102	3.9%	(1.6, 9.3)	
Rural south	118	9.5%	(1.9, 36.0)	
Rural north	136	2.3%	(0.7, 7.3)	
Age group in years				0.623
15-19	44	9.6%	(2.7, 29.2)	
20-24	91	5.4%	(1.8, 14.6)	
25-29	120	3.7%	(1.5, 9.0)	
30-34	85	2.1%	(0.5, 8.0)	
35-39	63	4.1%	(0.8, 18.4)	
40-44	22	2.4%	(0.3, 16.2)	
45-49	8			

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] VAD = Vitamin A deficiency, defined as retinol <0.70 umol/L [24].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.2.6 Folate deficiency

Table 51: Prevalence of folate deficiency by various demographic characteristics in non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% folate deficient [a, b]	95% CI [c]	p-value [d]
TOTAL	451	55.2%	(48.5, 61.6)	
Urban/rural				<0.05
Urban	191	46.2%	(37.2, 55.4)	
Rural	260	61.0%	(51.7, 69.6)	
Stratum				0.010
Dakar	84	40.0%	(29.4, 51.6)	
Other urban	107	52.4%	(40.3, 64.2)	
Rural south	119	68.8%	(58.2, 77.7)	
Rural north	141	58.0%	(44.9, 70.1)	
Age group in years				<0.05
15-19	46	75.4%	(59.6, 86.5)	
20-24	93	46.7%	(34.4, 59.4)	
25-29	123	52.2%	(40.4, 63.7)	
30-34	91	59.1%	(46.6, 70.5)	
35-39	67	63.2%	(49.4, 75.1)	
40-44	23	30.2%	(13.7, 54.1)	
45-49	8	48.2%	(16.3, 81.7)	

Note: The N's are the denominators for a specific sub-group.
[a] All percentages except region-specific estimates are weighted for unequal probability of selection among strata.
[b] Folate deficiency, defined as serum folate < 10 nmol/L [25].
[c] CI=confidence interval calculated taking into account the complex sampling design.
[d] P value <0.05 indicates that at least one subgroup is statistically significantly different from the others.

8.2.8 Associations between micronutrient deficiencies and various factors

Table 52: Associations between anemia and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% anemic [a]	p- value [b]
Micronutrient indicators			
Iron deficient			<0.001
Yes	185	45.8%	
No	257	16.8%	
Vitamin A deficient			<0.001
Yes	18	75.0%	
No	406	25.8%	
Folate deficient			0.248
Yes	249	30.6%	
No	193	25.7%	
Fortified foods and supplement consumption			
Currently taking iron supplements	94	26.0%	0.582
Yes	349	28.9%	
No			
Household oil marked as fortified with vitamin A			0.053
Yes	230	23.4%	
No	83	31.7%	
Household flour marked as fortified with iron and folate			0.102
Yes	127	21.7%	
No	63	36.4%	
Pregnancy factors			
Took iron supplement during prior pregnancy			0.553
Yes	423	28.0%	
No	20	35.2%	
Took iron supplement after prior delivery			0.397
Yes	383	27.4%	
No	40	35.2%	
Morbidity indicators			
Fever			0.154
Yes	33	15.2%	
No	408	29.0%	
Diarrhea			0.562
Yes	6	17.1%	
No	435	28.3%	
Cough and/or respiratory difficulty			0.343
Yes	15	16.2%	
No	426	28.5%	
Inflammation			0.340

Characteristic	N	% anemic [a]	p- value [b]
None (CRP and AGP normal)	79	23.0%	
Any inflammation (elevated CRP and/or AGP)	347	29.2%	

Note: The N's are the denominators for a specific sub-group.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Table 53: Associations between iron deficiency and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% iron deficient [a]	p- value [b]
Micronutrient indicators			
Vitamin A deficient			0.179
Yes	19	60.0%	
No	414	39.9%	
Folate deficient			0.064
Yes	253	43.9%	
No	198	34.6%	
Fortified foods and supplement consumption			
Currently taking iron supplements			0.154
Yes	95	33.2%	
No	356	41.3%	
Household oil marked as fortified with vitamin A			0.067
Yes	234	33.9%	
No	84	48.6%	
Household flour marked as fortified with iron and folate			<0.05
Yes	128	28.0%	
No	65	46.9%	
Pregnancy factors			
Took iron supplement during prior pregnancy			0.486
Yes	431	39.3%	
No	20	49.3%	
Took iron supplement after prior delivery			0.857
Yes	391	39.5%	
No	40	37.7%	
Morbidity indicators			
Fever			0.106
Yes	34	55.4%	
No	415	38.8%	
Diarrhea			0.284
Yes	6	59.2%	
No	443	39.6%	
Cough and/or respiratory difficulty			0.311
Yes	15	53.2%	
No	434	39.4%	
Inflammation			0.881
None (CRP and AGP normal)	83	39.9%	
Any inflammation (elevated CRP and/or AGP)	352	39.0%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.

Characteristic	N	% iron deficient [a]	p- value [b]

[b] P value <0.05 indicates significance.

Table 54: Association between vitamin A deficiency and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% vitamin A deficient [a]	p- value [b]
Micronutrient indicators			
Folate deficient			0.867
Yes	245	4.5%	
No	188	4.1%	
Fortified foods and supplement consumption			
Currently taking iron supplements			0.495
Yes	94	2.9%	
No	339	4.7%	
Household oil marked as fortified with vitamin A			0.488
Yes	223	3.8%	
No	81	2.7%	
Household flour marked as fortified with iron and folate			0.906
Yes	124	3.9%	
No	62	5.5%	
Pregnancy factors			
Took iron supplement during prior pregnancy			0.458
Yes	413	4.5%	
No	20	0.0%	
Took iron supplement after prior delivery			0.897
Yes	376	4.6%	
No	37	4.1%	
Morbidity indicators			
Fever			0.743
Yes	33	3.1%	
No	399	4.4%	
Diarrhea			0.655
Yes	6	-	
No	426	4.4%	
Cough and/or respiratory difficulty			0.541
Yes	14	-	
No	418	4.3%	
Inflammation			0.608
None (CRP and AGP normal)	82	5.5%	
Any inflammation (elevated CRP and/or AGP)	335	4.0%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

Table 55: Association between folate deficiency and micronutrient biomarkers, fortified food and supplement consumption, pregnancy history, and morbidity indicators in non-pregnant lactating women 15-49 years of age, Senegal 2018

Characteristic	N	% folate deficient [a]	p- value [b]
Fortified foods and supplement consumption			
Currently taking iron supplements			<0.01
Yes	95	36.8%	
No	356	59.5%	
Household oil marked as fortified with vitamin A			
Yes		49.2%	
No		67.8%	
Household flour marked as fortified with iron and folate			
Yes	128	39.7%	
No	65	61.3%	
Pregnancy factors			
Took iron supplement during prior pregnancy			
Yes		56.1%	
No		32.4%	
Took iron supplement after prior delivery			
Yes	391	55.9%	
No	40	58.2%	
Morbidity indicators			
Fever			0.212
Yes	34	66.0%	
No	415	54.7%	
Diarrhea			0.425
Yes	6	40.8%	
No	443	55.5%	
Cough and/or respiratory difficulty			0.816
Yes	15	51.9%	
No	434	55.5%	
Inflammation			0.983
None (CRP and AGP normal)	83	55.8%	
Any inflammation (elevated CRP and/or AGP)	352	55.6%	

Note: The n's are un-weighted numerators for each subgroup; subgroups that do not sum to the total have missing data.
[a] Percentages weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates significance.

8.3 Comparison of indicators from the 2018 and 2010 surveys disaggreggated for non-pregnant non-lactating and non-pregnant lactating women

Table 56: Comparison of outcomes in non-pregnant non-lactating women 15-49 years of age, 2010 and 2018, Senegal

Indicator	2010		2018		
	N	%[a]	N	%[a]	p-value[b]
Anemia and micronutrient deficiencies					
Anemia, any (%)	414	43.5%	1411	29.1%	<0.001
Severe anemia (%)	414	4.0%	1411	1.2%	<0.001
Moderate anemia (%)	414	19.2%	1411	11.3%	
Mild anemia (%)	414	20.4%	1411	16.7%	
Iron deficiency (%)	414	53.1%	1413	43.1%	0.001
Iron deficiency anemia (%)	413	28.4%	1419	18.6%	0.002
Vitamin A deficiency (%)	414	1.7%	1388	2.3%	0.621
Folate deficiency (%)	387	47.2%	1414	48.7%	0.790
Inflammation (%)	414	26.3%	1364	16.7%	0.003
Dietary and supplementation indicators					
Currently taking iron supplement (%)	414	8.7%	1454	12.0%	0.114
Took iron supplement last pregnancy (%)	352	74.9%	1450	53.2%	<0.001
Took iron supplement after last delivery (%)	334	59.0%	741	89.9%	<0.001
Knowledge of vitamin A					
Knows about vitamin A (%)	413	52.8%	1458	33.7%	<0.001
If yes, knows what vitamin A does [c] (%)	195	79.6%	484	99.5%	<0.001

Note: The N's are the denominators for a specific sub-group.
[a] All percentages are weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates difference between 2010 and 2018 results is statistically significant.
[c] Includes only those women reporting familiarity with vitamin A.

Table 57: Comparison of outcomes in non-pregnant lactating women 15-49 years of age, 2010 and 2018, Senegal

Indicator	2010		2018		
	N	% [a]	N	% [a]	p-value[b]
Anemia and micronutrient deficiencies					
Anemia, any (%)	262	48.2%	443	28.3%	<0.001
Severe anemia (%)	262	3.9%	443	0.9%	<0.001
Moderate anemia (%)	262	21.8%	443	7.1%	
Mild anemia (%)	262	22.5%	443	20.4%	
Iron deficiency (%)	261	53.3%	451	39.7%	0.009
Iron deficiency anemia (%)	261	33.2%	450	18.0%	0.001
Vitamin A deficiency (%)	261	3.8%	433	4.3%	0.747
Folate deficiency (%)	248	59.9%	451	55.2%	0.438
Inflammation (%)	261	34.9%	435	18.6%	<0.001
Dietary and supplementation indicators					
Currently taking iron supplement (%)	262	11.4%	455	19.3%	<0.05
Took iron supplement last pregnancy (%)	261	94.9%	455	96.1%	0.485
Took iron supplement after last delivery (%)	262	64.4%	435	92.0%	<0.001
Knowledge of vitamin A					
Knows about vitamin A (%)	264	47.3%	455	34.1%	0.010
If yes, knows what vitamin A does [c] (%)	117	78.2%	155	99.1%	<0.001

Note: The N's are the denominators for a specific sub-group.
[a] All percentages are weighted for unequal probability of selection among strata.
[b] P value <0.05 indicates difference between 2010 and 2018 results is statistically significant.
[c] Includes only those women reporting familiarity with vitamin A.

8.4 Data quality checks

The tables and figures below show standard data quality checks. Basic demographic data were collected on all children and women (**Completeness**

Table *58*); however, the response rate was substantially lower for collection of biologic specimens, especially those requiring phlebotomy (ferritin, CRP, AGP, and retinol). Anthropometric measurements were missing on a very small proportion of children. Response rates for biologic specimen collection were substantially higher in women.

The sample of children in the 2018 survey was disproportionally made of girls; however, the sex ratio did not show an age trend (**Table 59**). **Figure 22** shows that child age was rounded to the nearest year in a large proportion of children. Similarly, women's ages were frequently rounded to the nearest five years (**Figure 23**). These are not unexpected findings in a population where calendar literacy is not widespread. **Figure 24, Figure 25**, and **Figure 26** show the distribution of decimals or final digits for child height/length, child weight, and child MUAC. There is some digit heaping in those measurements taken with analog methods (height/length and MUAC), but much less in weight measurements for which a digital scale was used. The Myers unblended indices indicate that this digit heaping is not extreme.

Figure 3, Figure 4, and **Figure 5** above show that the distributions of all z-scores are largely normal without substantial kurtosis or skewing. In addition, the standard deviation of z-scores is within acceptable limits and very similar to those shown in a large number of nutrition survey worldwide.[32] **Table 60** shows that very few anthropometric measurements were flagged for implausability. This demonstrates high quality measurement and minimal keypunching error.

8.4.1 Completeness

Table 58: Proportion of values which are blank or "Do not know" in children 12-59 months of age and women 15-49 years of age, Senegal 2018

Characteristic	N	% blank or DK
Children		
Age	696	0%
Sex	696	0%
Hemoglobin	614	13.4%
Ferritin	574	21.3%
CRP	574	32.1%
AGP	574	21.3%
Retinol	539	29.1%
Length/height	689	1.0%
Weight	689	1.0%
MUAC	688	1.0%
Women		
Age	2021	0%
Hemoglobin	1958	3.2%

Characteristic	N	% blank or DK
Ferritin	1968	2.7%
CRP	1968	2.7%
AGP	1969	2.6%
Retinol	1920	5.3%
Folate	1968	2.7%

8.4.2 Sex ratio and age distribution

Table 59: Sex ratio by age in children 12-59 months of age, Senegal 2018

Age group	Number boys	Number girls	Sex ratio (M:F)
12-23	65	59	1.10
24-35	80	79	1.01
36-47	84	125	0.67
48-59	101	103	0.98
Total	330	366	0.90

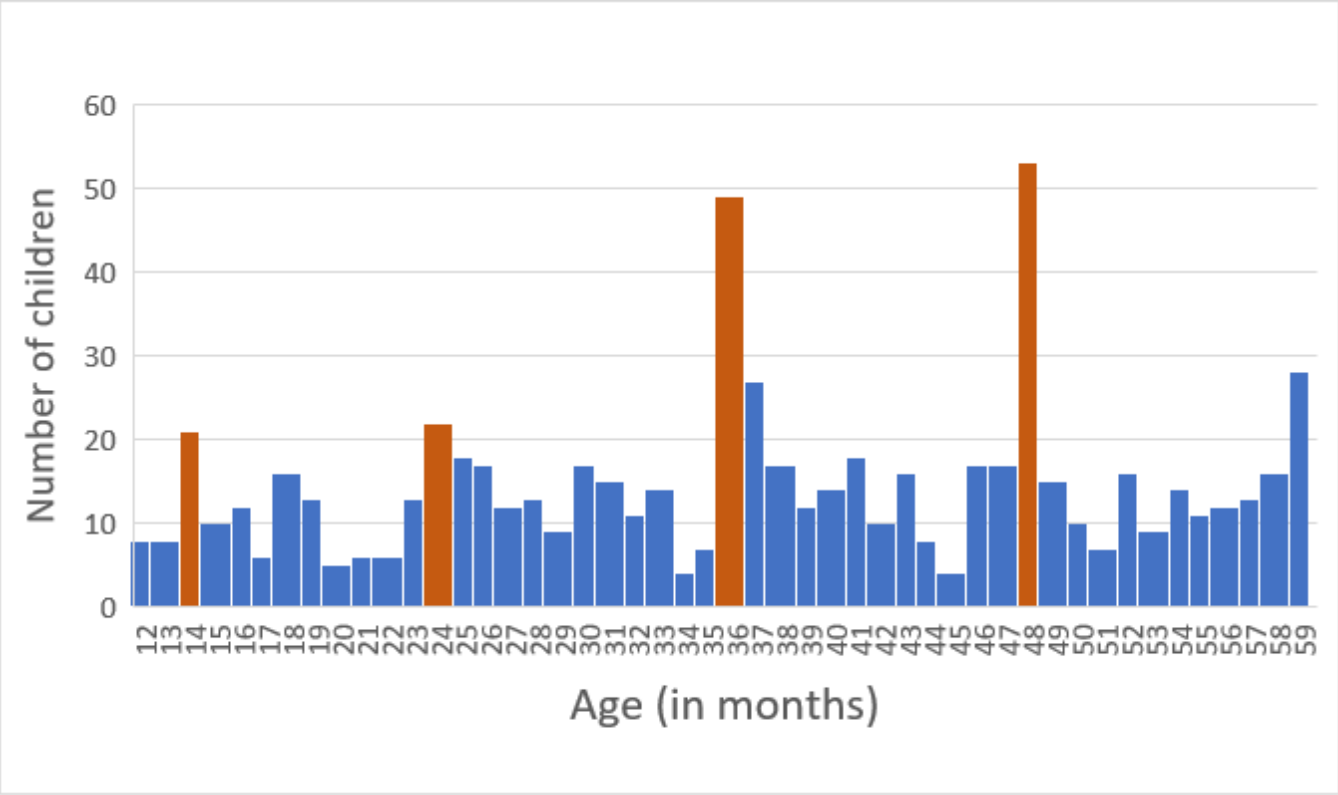

Figure 22: Distribution of ages in children 12-59 months of age, Senegal 2018

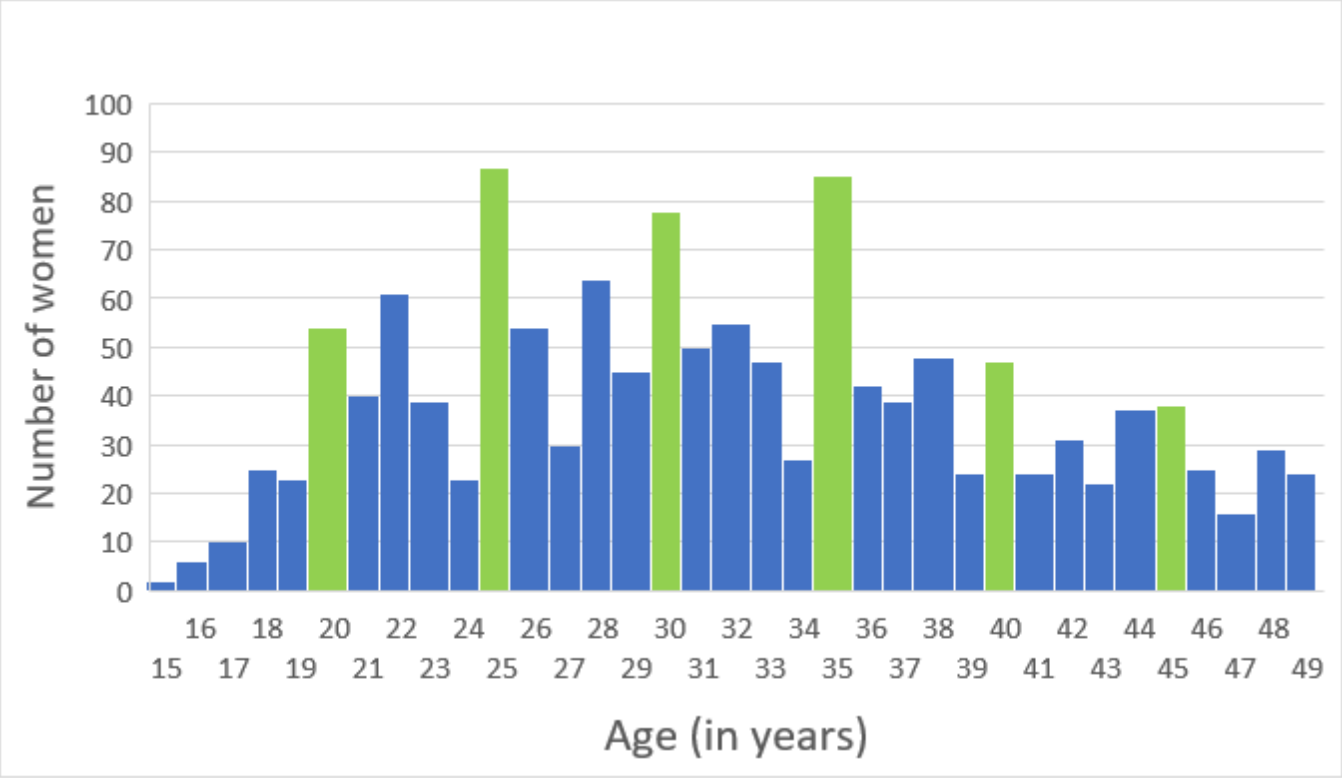

Figure 23: Distribution of ages in women 15-49 years of age, Senegal 2018

8.4.3 Digit preference for anthropometric measurements

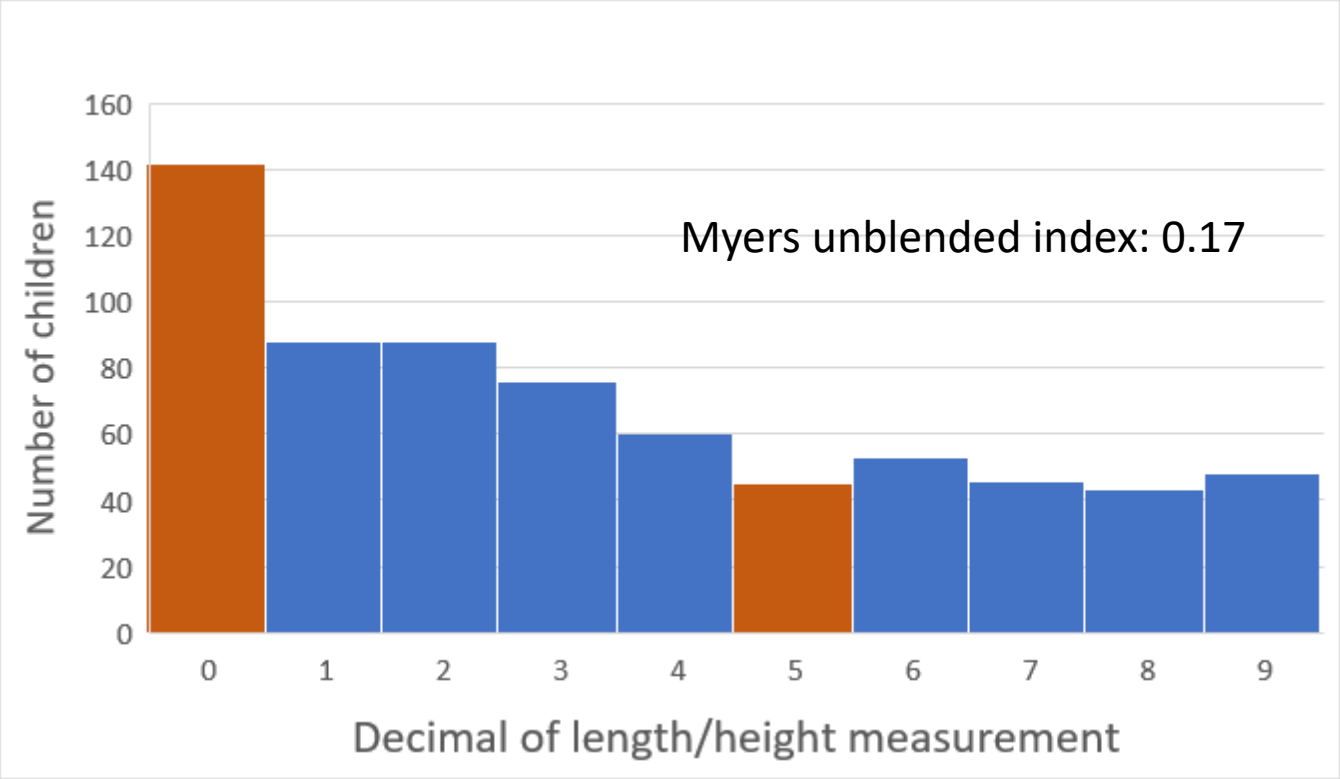

Figure 24: Distribution of decimals in height measurements of children 12-59 months of age, Senegal 2018

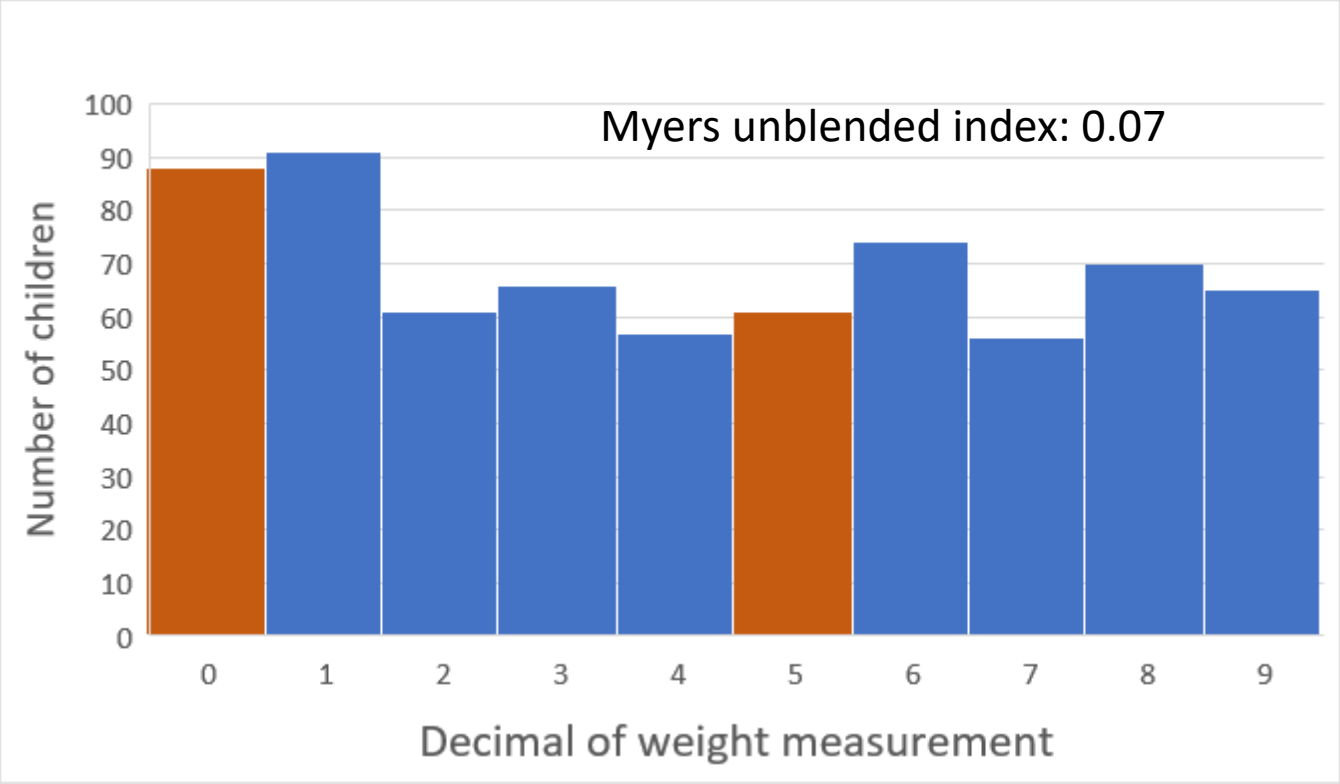

Figure 25: Distribution of decimals in weight measurements of children 12-59 months of age, Senegal 2018

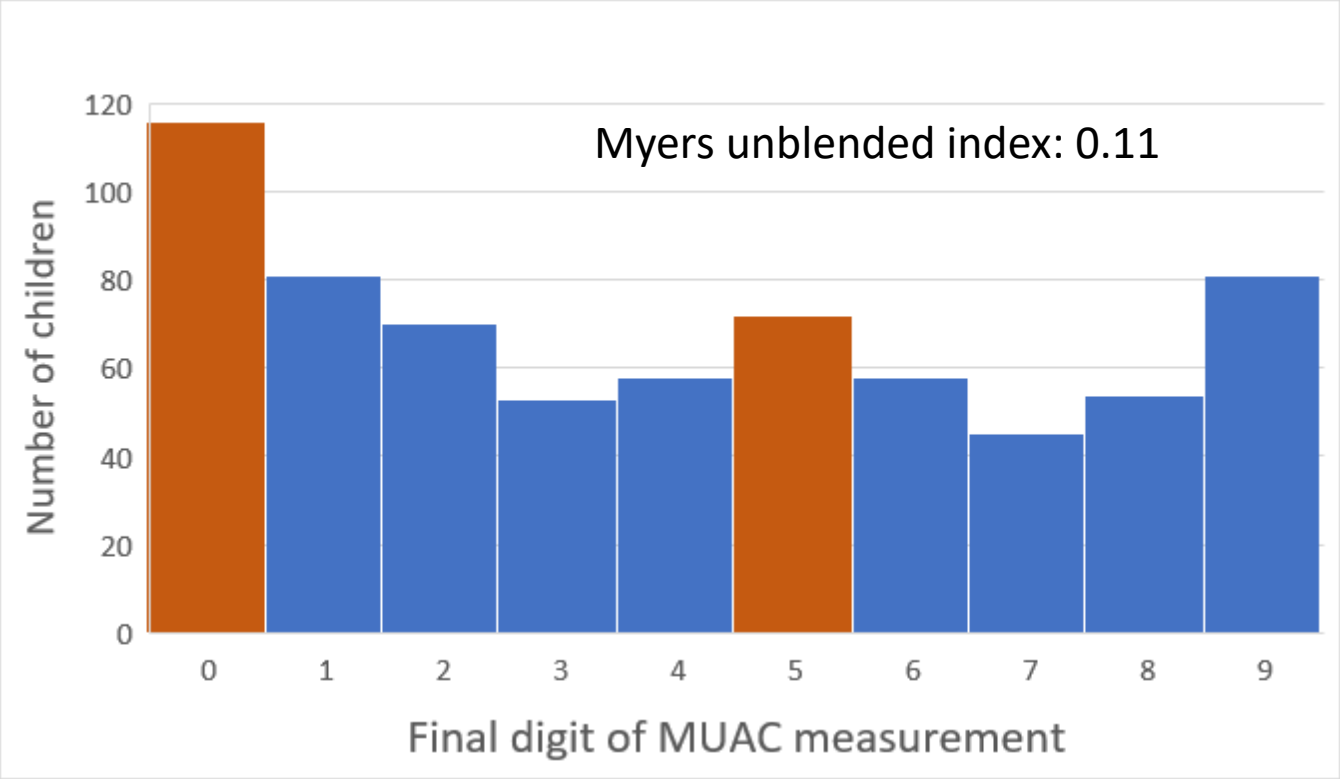

Figure 26: Distribution of decimals in MUAC measurements of children 12-59 months of age, Senegal 2018

8.4.4 Implausable z-score values

Table 60: Distribution of flags for anthropometric indices in in children 12-59 months of age, Senegal 2018

	Z-score out of range				
Flag	WHZ	HAZ	WAZ	# children	% of children
0				679	99.0%
1	✓			2	0.3%
2		✓		2	0.3%
3			✓	2	0.3%
4	✓	✓		0	0%
5	✓		✓	0	0%
6		✓	✓	1	0.1%
7	✓	✓	✓	0	0%