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Iron and folic acid supplementation during pregnancy: improving program content and strategies

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Abstract

Iron and folic acid supplementation during pregnancy: improving program content and strategies

By Amanda Wendt

Anemia is a severe public health issue in Bihar, India with 60% of pregnant women estimated to be anemic. Despite the Government of India's program for universal iron and folic acid (IFA) supplementation of pregnant women, low consumption and high maternal anemia prevalence persist. With the aim of improving IFA supplementation to pregnant women in Bihar, we examined the existing program assessing 1) determinants of IFA receipt and consumption, 2) the IFA supply chain, and 3) demand side facilitators and barriers.

We found IFA receipt and consumption to be significantly associated with antenatal care factors in addition to individual demographic variables. Adequate IFA consumption was also positively associated with presence of IFA supply. For both IFA receipt and consumption, unexplained facility level variation remained. This indicates additional contextual factors that have a significant impact on women's IFA receipt and consumption in Bihar. Understanding and incorporating these contextual factors into iron supplementation programming will be an important step in improving IFA receipt and consumption in Bihar.

Inadequate IFA supply is a major constraint to the Bihar IFA supplementation program, the extent of which varies widely across districts. Qualitative data revealed specific bottlenecks impacting IFA forecasting, procurement, handling of expired drugs, storage, lack of personnel, and few opportunities for training key players in the supply chain. Improvements at all levels in infrastructure, practices, and effective monitoring will be critical to strengthen the IFA supply chain in Bihar.

We found several key knowledge gaps regarding anemia and IFA. Low awareness of anemia as a widespread issue, low counseling on potential side effects by health workers, and health worker misconceptions regarding late pregnancy IFA consumption and dairy consumption need to be highlighted through training or community awareness strategies. High awareness of the health workers' role to distribute IFA and as a resource for health information demonstrated some program successes as well. Family members can also be important sources of encouragement or discouragement regarding IFA consumption. Including family members in IFA counseling should increase awareness of IFA benefits and potential side effects to help family members be facilitators of IFA consumption for beneficiaries.

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Abbreviations

ANC	Antenatal Care
ANM	Auxiliary Nurse Midwife
ASHA	Accredited Social Health Activist
AWW	Anganwadi Worker
CARE	Cooperative for Assistance and Relief Everywhere
CS	Civil Surgeon
DLHS	District Level Household Survey
FLW	Frontline Worker
HSC	Health Sub-Center
IFA	Iron and Folic Acid
IFHI	Integrated Family Health Initiative
MOIC	Medical Officer in Charge
MUAC	Mid-Upper Arm Circumference
NFHS	National Family Health Survey
PHC	Primary Health Center
PSU	Primary Sampling Unit
UNICEF	United Nations Children's Fund
VHD	Village Health Day
VHSC	Village Health and Sanitation Committee
WHO	World Health Organization

Chapter 1: Introduction

Anemia affects almost a quarter of the world's population (24.8%)[1], of whom nine out of ten live in developing countries[2]. Although anemia can impact men and women at any age, the most susceptible groups are young children and pregnant women[1]. The greatest anemia burden falls on the regions of Africa and South East Asia; India in particular, contributes the highest number of anemic pregnant women to the South East Asia region (over 70%)[1]. In India, an estimated 58% of pregnant women are anemic[3]. A recent study also found that from 1995-2011, anemia prevalence among pregnant women in South Asia remained largely unchanged[4]. Estimates also indicate that compared to other countries in South Asia, India made little improvement in reducing anemia prevalence among pregnant women over this time period[5].

Anemia, defined as a low hemoglobin count, is a condition with multiple etiologies. Iron deficiency is most often cited as the major cause of anemia, associated with an estimated 50% of cases[1]. For pregnant women, iron deficiency is also considered the most common nutritional deficiency[6]. During pregnancy, a woman is diagnosed with anemia if her hemoglobin concentration is lower than 110 g/L. This cut-off is lower than for non-pregnant women (120 g/L) because of hemodilution, which occurs as plasma volume increases during gestation. Hemoglobin also drops an additional 5 g/L in the second trimester[7]. Iron needs are much greater during pregnancy due to the growth of the fetus, placenta, and increasing red blood cell mass in addition to any blood loss during delivery. One pregnancy is estimated to require a net increase of 580mg of iron to account for this need[8]. Most of the increased iron demand occurs in the second and third

trimester. In fact requirements in late pregnancy are so high that daily iron needs cannot be reached with dietary iron alone, making existing iron stores critical to prevent maternal iron deficiency and anemia[8].

In many parts of India, achieving this iron sufficiency is particularly difficult primarily because of low iron intake, poor iron bioavailability (due to diets rich in phytates, phosphates, and fiber), and high prevalence of infections resulting in blood loss[5,9]. Non-pregnant women in India also suffer from high anemia prevalence (56% of ever-married women)[3]. Therefore, most women enter pregnancy with low iron stores or anemia, which may become more severe during gestation.

Consequences of iron deficiency anemia often include decreased work capacity[10] and fatigue[11]. Pregnant women have a greater risk to deliver preterm, have a low birth weight baby[12], and the child may have a higher risk of perinatal mortality[5]. Anemic women also may be more susceptible to infections or require a longer time to recover. Severe anemia can lead to cardiac failure and maternal death[5]. An estimated 20% of maternal deaths are due to anemia[13]. Children born of anemic mothers are more likely to have lower iron stores, which can lead to anemia, impaired mental development, motor skills[14], and social-emotional behavior[15].

Daily oral iron supplementation during pregnancy has proven to be effective in improving iron status among women and in reducing risk of delivering a low birth weight child[16]. In 1970, the Government of India instituted the strategy of iron supplement distribution by establishing the National Anemia Prophylaxis Program. They later expanded to universal supplementation of pregnant women. Evaluations of the program found inadequate implementation and impact, especially concerning supply and quality

of iron supplements[17]. Data indicate that in India and globally iron supplementation consumption is insufficient[18,19]. In India a 2007-08 national survey found that only 49.7% of women had attended three or more antenatal care (ANC) visits and just 24.6% had consumed iron and folic acid supplements (IFA) for 90 days or more[19].

Bihar, India, one of the most populous and impoverished states in the country, mirrors India's lack of success in iron supplementation. In Bihar, 60% of pregnant women are anemic, higher than the national prevalence. Over time, antenatal coverage has increased; however, even current numbers are well below the national average. Over the years 2002-4 (District Level Household Survey, Round 2 (DLHS-2)), 2007-08 (DLHS-3), and 2009 (United Nations Children's Fund (UNICEF) Coverage Survey) the percentage of women attending three or more antenatal care (ANC) visits was 16.0%, 26.4%, and 33.8%, respectively. Unfortunately, across the same years, the proportion of women consuming a full dose of IFA (consumption of 100 IFA over 90-100 days) was consistent and abysmally low at 6.4%, 5.6%, and 6.7%, respectively[20-22].

Both qualitative and quantitative studies have been conducted to examine why iron supplementation programs are failing to make an impact. Many barriers to IFA consumption by pregnant women have been identified including side effects[23-26], inadequate supply[27,28], forgetfulness[25,29], lack of ANC attendance[28,30], and ineffective frontline worker (FLW) counseling[27,28]. Three main avenues of improvement were identified by Victora et al. to improve large scale iron supplementation programs: (1) ensuring adequate supply and distribution through antenatal care, (2) improving adherence, and (3) increasing antenatal care coverage or utilizing alternative methods of supplement distribution[18].

Fortunately, in Bihar these changes appear more possible than they once did. In 2005, changes in government increased law and order, and large investments were made into health and other sectors[31]. This helped attract many public health organizations, including the Bill & Melinda Gates Foundation, to Bihar[32]. One such program is the Integrated Family Health Initiative (IFHI), led by CARE India. This five year initiative began in 2011 with the goal of improving maternal and child health outcomes by strengthening government capacity[33]. Emory has played a role of nutrition technical advisor in this program. Through their involvement, we were provided the opportunity to examine the issue of maternal anemia and IFA consumption in Bihar.

Objective & Aims

Within this context, our objective was to examine the current iron supplementation program as it exists in Bihar, assessing supply side and demand side facilitators and barriers.

The three aims were:

1) To examine individual and facility-level determinants of IFA receipt and consumption among pregnant women in rural Bihar.
2) To explore the current status of the government health system's IFA supply and distribution to identify bottlenecks that may contribute to insufficient or inconsistent supply.
3) To examine the perceptions of anemia and IFA supplementation among health workers, beneficiaries, and family members in order to identify key facilitators and barriers to IFA consumption.

For each aim, we then created practical recommendations to strengthen the iron supplementation program to be implemented by the government and collaborating organizations.

This research brings together key identified issues of iron supplementation programs to holistically address the supply, demand, and equity of IFA receipt and consumption in Bihar, India. Through this work we explore the main themes, facilitators, and barriers that emerge from this very distinct context. The specificity of this research can be beneficial to the Government of Bihar and local organizations. As we consider current policies, implementation issues, and key stakeholders that play major roles in IFA distribution and counseling in this region, we offer concrete and practical recommendations that are already adapted to the current context. Bihar, however, holds many parallels with other parts of India, and other parts of the world, especially rural, low-income settings. Therefore, taking into account this work along with results of studies conducted in other contexts, we can have a better understanding of what salient themes are common across iron supplementation programs in order to identify more universal facilitators and barriers to iron supplementation.

Chapter 2: Background

Anemia in Pregnancy – The Indian Context

Anemia, characterized by low hemoglobin, is a condition with many etiologies. In fact, pregnancy itself causes a "physiological anemia" which initiates in the 6th week and continues until the 32-34th week with the increase of plasma volume. In total, blood volume is estimated to increase approximately 45%[8]. Increasing red blood cell mass is a slower process and thus a lower hemoglobin count is seen in the second trimester of pregnancy[34] (approximately 5 g/L less[7]). The Centers for Disease Control and Prevention set the anemia cut-off during pregnancy as 110 g/L during the first and third trimester and 105 g/L in the second[34]. The World Health Organization's current standards set the anemia cutoff at 110 g/L throughout pregnancy, though they acknowledge the 5g/L decrease[7]. The body's need for iron actually drops in the first trimester as menstruation ceases but grows in the second and third trimester as maternal and fetal oxygen consumption increases[8]. These increased iron requirements result from growth of the fetus, placenta, red blood cell increase, and blood loss during delivery. In fact, the need is greater than can be absorbed from an iron-rich diet; therefore previous iron stores or an intervention such as oral iron supplementation is needed to prevent maternal anemia during this time[8].

Causes

There are several causes of anemia. During pregnancy, 75% of all anemias are attributed to iron deficiency anemia[34]. This is most likely due to the greatly increased iron requirements during gestation mentioned above. However, there are other nutrient

deficiencies known to cause anemia including vitamin A, folate, vitamin B12[35], copper, and protein[36]. Vitamin A plays a role in erythropoiesis, iron store mobilization, and can increase iron absorption[37]. Folic acid is also involved in erythropoiesis[37]. Folate deficiency can lead to megaloblastic anemia[34]. Pregnant women are also more at risk for developing folate deficiency due to extra folate requirements during gestation (folate being fundamental to DNA synthesis among other roles) and lactation, where mammary glands receive priority over maternal needs[38]. Vitamin B12 is involved in folate metabolism, and thus vitamin B12 deficiency leads to megaloblastic anemia following the same pathway as folate[37]. Copper is required for iron metabolism, and therefore copper deficiency can lead to anemia that does not respond to iron supplementation. In infants, this may also work in the reverse direction. High iron consumption led to lower copper absorption in one study[39]. Protein deficiency has also been associated with moderate anemia. However, this may be due to concurrent micronutrient deficiencies associated with a lack of dietary protein[40].

Non-nutritional factors can also play a significant role. Hookworms and other soil-transmitted helminthes are a major cause of anemia, especially in South East Asia. Poor infrastructure and sanitary conditions create ideal grounds for larvae development. Once hookworms enter the intestines, they feed off of the host's blood, causing blood loss that can ultimately lead to iron deficiency anemia once iron stores are depleted[38]. Malaria is another condition which causes anemia through increased breakdown and suppressed synthesis of erythrocytes[38]. Other non-nutritional causes of anemia include: blood loss, HIV status, sickle cell disease, thalassemias, schistosomiasis, and G6PD deficiency[35]. Additionally, chronic infection and/or inflammation has been shown to

cause an "anemia of chronic disease" which also reduces hemoglobin levels by increasing iron sequestration and decreasing the body's iron absorption[41].

As previously discussed, pregnancy also increases iron requirements. Therefore, some causes of anemia are attributed to pregnancy timing and frequency. Short inter-pregnancy intervals (< 6 months) have been associated with anemia[42] when compared to 18-23 month intervals in a cross-sectional study of women in Latin America and the Caribbean. However, systematic reviews on the subject have not found a consistent association[43,44]. The theory that is often presented to explain this phenomenon is called "Maternal Depletion Syndrome," which happens when closely spaced pregnancies do not allow the woman's body to replenish macro- and micro-nutrient stores from the previous pregnancy[43]. Another risk factor associated with anemia is early age at first pregnancy, often defined as ≤ 16 years of age. A recent meta-analysis found an increased odds of anemia in women ≤ 16 years vs. control groups of 1.36 (95% CI: 1.24, 1.49). This is possibly due to "feto-maternal competition" in which the mother's body, still growing, competes with the fetus for nutrients[45]. High parity can also be associated with anemia. One study found women with 7 or more pregnancies vs. those with 1-3 pregnancies had an increased odds of anemia of 4.17 (95% CI: 1.86, 9.38)[46].

In many cases, especially in contexts when malnutrition is common and poverty restricts food choices, nutrient deficiencies can occur simultaneously. For example, in south Malawi van den Broek et al. reported that anemic women with iron deficiency most often presented with other deficiencies as well (e.g. vitamin A, folate, vitamin B12) while 45% did not show signs of iron deficiency. Vitamin A was the second most prevalent nutrient deficiency in this population with 39% having low serum retinol[35]. A study done

in Ethiopia found iron and folic acid deficiencies and chronic illnesses as more significantly related to anemia status than parasitic infections. Half of the anemic women presented with iron deficiency, and a third were found to have folic acid deficiency[36].

One study in Tanzania by Antelman et al. found only 5% folate deficiency and 44% iron deficiency in anemic HIV positive pregnant women based on red blood cell morphology[47]. In another Tanzanian study of pregnant women iron deficiency and malarial parasitemia were independently associated with severe anemia. Seasonal variation was also reported as those presenting in late vs. early dry season were more likely to be severely anemic (OR=6.2, 95% CI=2.3, 16.4)[48]. A study of pregnant women in Malawi identified different major determinants depending on their parity. Iron deficiency and malaria parasitemia were the major factors associated with anemia in primigravida while iron deficiency and mid-upper arm circumference (MUAC) were significantly associated for sucundigravidae[49]. In Bangalore, researchers found that 95% of anemic women of low socio-economic status had iron deficiency. Dietary intake reports revealed reported intake was 9.5 mg per day, much lower than both the recommended 18 mg/day and previous reports of 25.1 mg/day. Iron bioavailability was also poor at 2.8%[50].

In India, plant-based diets are common, contributing to insufficient iron and other nutrient intakes such as folate, as well as low bioavailability[51]. Iron consumed in vegetarian diets is often non-heme iron, which has poor bioavailability, in addition to abundant amounts of inhibitory factors of fiber[52] and phytates[53]. Little or no meat consumption can also lead to low levels of vitamin B12, found in animal source foods[54]. In fact, two studies in Indian populations found 80% of preschool children and 70% of

adults to be Vitamin B12 deficient[55]. Another study conducted in Bangalore, India, found that in addition to low meat consumption, women reported low fruit intake and long cooking times of vegetables which may destroy other essential nutrients, such as vitamin C which enhances iron absorption[50]. Tea consumption, also common in India, can also lower iron absorption due to its high tannin content [56]. These diet patterns indicate poor and low quality iron intake in addition to other key nutrients which may lead to anemia before the start of pregnancy, requiring treatment of anemia during pregnancy and higher risk of developing moderate or severe anemia.

Consequences

Maternal

The most common and well documented consequence of iron deficiency anemia is decreased work capacity[57], specifically aerobic work capacity. This is due to iron's role as part of hemoglobin in oxygen transport in the body. Furthermore, iron supplementation trials have shown positive impacts on work capacity, which has important economic benefits for families that depend on labor for their livelihoods[38]. Vulnerability to infections and extended recovery times have also been seen in anemic women in India and other countries[5]. Recent studies have also found a relationship between anemia and post-partum depression[58], which was improved with iron supplementation among women with baseline iron deficiency anemia[59]. Severe anemia can lead to circulatory failure, leading to pulmonary edema, which can be fatal[5]. Globally, an estimated 20% of maternal deaths have been attributed to anemia[13]. In India, estimates show 20% of maternal deaths are attributed directly to anemia and another 20% indirectly[5].

Fetal

Anemia has been associated with many fetal outcomes. Anemic women are more likely to deliver preterm (< 37 weeks gestation) and their infant is more likely to be low birth weight (<2500g). A 2012 meta-analysis of 13 trials (10,148 women) did not find a significant impact of antenatal iron supplementation on premature delivery; however, the effects appeared to be greater when malaria was not present. However, investigators found a borderline low risk of preterm delivery defined as <34 weeks gestation[16]. Iron supplementation did show a significant impact on reducing risk of low birth weight infants (RR: 0.81, 95% CI: 0.68, 0.97) in a meta-analysis of 11 trials of 8,480 women. Mean birth weight was also significantly greater by 30.81g (95% CI: 5.94, 55.68) between mothers who consumed iron supplements and those who did not. No significant differences were seen in subgroup analyses by initial anemia status[16].

A 2004 meta-analysis found a significant decrease in perinatal mortality with a 10g/L increase in the population mean of hemoglobin[60]. However, a large randomized controlled trial in China did not find any reduction in perinatal mortality with iron supplementation; although authors did report a 54% reduction in early neonatal mortality[61].

Observational studies have also found iron deficiency to be associated with poorer cognitive development outcomes such as motor development[14] and emotional-social behavior[15]. In a follow-up to a randomized controlled trial in a Nepalese population with existing iron deficiency, authors found that prenatal iron and folic acid supplementation improved motor function, inhibitory control, and working memory in 7-9 year olds[62].

Additionally, a recent randomized controlled trial in China conducted a subgroup analysis comparing women with iron deficiency anemia (IDA) in their third trimester to those without IDA. They found that the children of the IDA women had a lower mental development index during 12, 18, and 24-month assessments. They also discovered that within this group, the children of women who consumed IFA had comparable mental development indexes. This indicated that even when anemia status is not corrected, prenatal IFA can protect child mental development[63].

Prevalence: India and Bihar

The greatest share of the global anemia burden falls upon the regions of Africa and South East Asia. Furthermore, South East Asia contributes the highest number of anemic preschool age children (115 million), non-pregnant women (182 million), and pregnant women (18 million) than any other world region (as defined by World Health Organization)[1]. Almost a third (32%) of all pregnant women with anemia worldwide are living in South East Asia and over 70% of those women live in India[1]. This situation is not only a severe public health issue, but also a stubborn one, as it has remained stagnant for over 40 years. Government of India estimates from 1970 reported anemia prevalence of 70%, 10%, and 50% in pre-school aged children, women of reproductive age, and pregnant women, respectively. These estimates and the adverse outcomes associated with anemia were the impetus for the initiation of the National Nutritional Prophylaxis Programme[64]. In 2005-06, National Family Health Survey, Round 3 (NFHS-3) data estimates of 79%, 56%, and 58% for the same groups unfortunately depict a worsening situation[3]. Comparing the last two National Family Health Surveys (NFHS), which took place in 1998-9 and 2005-06, we continue to see an increasing trend in anemia

prevalence. In a recent analysis, Balarajan et al. compared these two surveys and found a significant increase in anemia prevalence (RR: 1.08, 95% CI: 1.06, 1.10) even after adjustment for age, parity, education, wealth, and caste[65]. In fact, nationwide only 4 states made a significant improvement in anemia prevalence between the two time points[65]. In Bihar, NFHS-3 data shows anemia estimates are higher than the national prevalence with 87% of children 6-35 months old, 68% of ever-married women (15-49y), and 60% of pregnant women considered anemic[66]. In Balarajan et al.'s state by state analysis, authors also found a significant increase in anemia prevalence in Bihar from 1998-99 to 2005-06 (adjusted RR: 1.07, 95% CI: 1.03, 1.12)[65]. Hopefully, the upcoming NFHS round (2014-15) will show a more optimistic picture for Bihar and the country[67].

The National Anemia Control Program

History

In 1968, the Nutrition Society of India recommended a program to address the high anemia prevalence in the country, in light of anemia's consequences for low birth weight and perinatal mortality. The 'National Nutritional Anemia Prophylaxis Programme' was announced in the fourth five-year plan (1969-1974). Through this, each pregnant woman, during the last 100 days of pregnancy, was to receive iron and folic acid supplements (IFA) (60mg of elemental iron and 500µg folic acid)[17,64]. Projected coverage targets were 50%, reaching 60-75% by 1990[64].

In 1992, the national anemia policy became a part of the Child Survival and Safe Motherhood Program, which included changes to make iron supplementation mandatory for all women during pregnancy[68].

Currently, the policy is that all women should consume 100mg of elemental iron daily starting after their first semester of pregnancy as well as 100 days post-partum[69]. In the national guideline the specific iron compound is not specified. This was changed following a World Health Organization trial in India, which concluded that daily supplementation of 120mg or higher was needed to maximize hematological improvements among pregnant women[70]. Since then, the World Health Organization has lowered its recommended dose to 60mg per day as it was seen to be as effective as higher doses[71]. A recent update additionally lowered the recommended dose to 30mg per day in areas where anemia is not a 'severe public health problem' defined as 40% prevalence or higher[72].

Evaluating Impact

The Indian Council of Medical Research (ICMR) conducted an evaluation of the program in 1985-86. Several issues were discovered through this evaluation. These included lack of impact on anemia prevalence, poor IFA supply, low quality IFA tablets, and insufficient monitoring of IFA distribution. Authors also highlighted that the supplementation strategy was broadly seen as a "low priority" program. Based on this evaluation, ICMR recommended the following actions:

1) *Universal supplementation of pregnant women, due to lack of hemoglobin testing resources*
2) *Training of health workers involved in program implementation*
3) *Inspection of tablet quality content and coating*
4) *Pilot study to find optimal IFA delivery platform*

5) *Adequate and consistent supply at PHC*
6) *Target coverage based on population statistics*
7) *Explore additional strategies for anemia prevention and treatment*

In addition to this evaluation, Agarwal et al. investigated how states were determining their target numbers of pregnant women and children in Uttar Pradesh and Bihar. District officials in Uttar Pradesh could not give a "satisfactory reply," and no records could be found in Bihar. However, Uttar Pradesh's submitted reports showed 100-300% coverage in some districts. When authors calculated the actual coverage they found 16.2% and 1.6% for Uttar Pradesh and Bihar, respectively. For both districts, reported coverage was much higher than the ICMR survey estimates. Authors here also suggested that IFA administration be coupled with tetanus toxoid vaccinations[64].

An additional evaluation in four states (Maharashtra, Tamil Nadu, Orissa, and Uttar Pradesh) conducted in 1990-91 also found cases of over reporting of coverage when comparing reported coverage numbers to drugs purchased for the state. Budgets allocated by the state were also found to be insufficient due to rising costs of drugs and labor costs over time, while state funds remained static. During this evaluation, IFA was distributed at the time of tetanus toxoid vaccinations. However, it appeared that women who were receiving partial doses of IFA were being recorded as having received a full dose. IFA was also packaged in tins of 1,000 pills each. Thus, health workers would distribute 30 pills to the women either loose or wrapped in paper. The authors also reported that women who did receive blood tests at health sub-center were still being given 100 IFA tablets, regardless of anemia status. Proper drug storage facilities at state and district levels were poor or nonexistent, and inventory protocols were not being followed.

Records of beneficiary coverage by health workers were not monitored. The existence of guidelines and registers for health workers to document coverage varied by state[73].

A 1990 evaluation in Andhra Pradesh found that only 19% of 873 pregnant women had received IFA tablets with just 11% of these receiving more than 60 tablets. Discontinued IFA consumption due to side effects occurred only in 10% of those who received IFA. The primary reason women stopped consuming was not receiving more IFA from the health worker (79%). Health workers also reported inadequate supply. Poor coverage appeared to be due to inconsistent and inadequate IFA supply. Health workers were also unaware of some pregnant women in their coverage area. These findings are consistent with a multi-country evaluation by Galloway et al[28]. District officials interviewed stated that main implementation issues were poor supply, lack of personnel, and lack of monitoring. Furthermore, poor quality IFA tablets were reported with 30% of stock having lower iron content and all with lower folic acid levels than specified on the packaging[74].

In 2006, a small evaluation of the iron supplementation program (n=60), which had changed names to be called the "National Nutritional Anaemia Control Programme," focused on beneficiary receipt and consumption. Authors reported that 88% of the 60 women interviewed had registered their pregnancies and had interacted with an Auxiliary Nurse Midwife (ANM) or Anganwadi Worker (AWW). Receipt of IFA was very high at 90%, however only 38% received the full dose of 100 IFA tablets. Over half of the women (58%) consumed all of the tablets they received; however, this did not necessarily mean a full dose. Authors recorded the supply at this Primary Health Center (PHC) to be adequate and thus surmised that lack of follow-up by heath workers was responsible for

the low distribution. Women who did not consume their full dose explained their reasons as being side effects and beliefs that IFA would harm their child. Thus, the evaluation concluded that health workers should be trained further in counseling to emphasize the importance of preventing anemia to the women. No concluding comments were made concerning the lack of IFA receipt by women or lack of follow-up by health workers[75].

Overall, evaluations of the iron supplementation program have shown a lack of impact. Most studies described major issues in the supply chain leading to severe shortages and inconsistencies. Over time, implementation of some recommendations (e.g. universal supplementation, linking IFA distribution to tetanus toxoid vaccine administration, and additional training for health workers) appeared to improve the program. However, in the larger scale evaluations supply issues remained severe.

Evaluating Large-Scale Iron Supplementation Programs for Pregnant Women

Global Context

Throughout the world, many countries distribute iron supplements or IFA to pregnant women as part of their antenatal care. Potentially due to this coupling of interventions (IFA and antenatal care), iron supplementation programs are not as developed as other nutrition programs, and little global data has been disseminated about program successes or even which countries are implementing such a program[18]. To gain some understanding of iron supplementation coverage on a global scale, Gwatkin et al. reported the prevalence of any self-reported IFA used during the last pregnancy among 54 Demographic and Health Surveys. The median prevalence was 53%, and for South Asia this was only 44%[76]. Victora et al. also found that in India and other countries IFA

receipt varies significantly with wealth status. This is most likely due to the fact that receipt of antenatal care, the main delivery platform of IFA, is highly correlated to wealth[18]. The inequalities are even more drastic when looking at percentage of women receiving at least 90 IFA tablets across wealth quintiles. In the highest wealth quintile, 49% of women received ≥90 IFA tablets, compared to only 10% of those in the poorest quintile[18].

Victora et al. also highlighted three important steps needed in order for country-level iron supplementation programs to make an impact at the population level[18]:

Supply

Key supply points include a consistent IFA supply, adequate receipt of IFA at ANC, and monitoring of health workers to ensure adequate IFA stock and distribution. Lack of IFA supply has been reported as a major barrier to successful iron supplement distribution programs in many developing countries[28]. This issue not only affects iron tablet distribution but also tuberculosis programs and malaria prophylaxis programs as well[27]. Supply was also a key issue with the Government of India's iron supplementation program, as shown by the previously mentioned evaluations in the 80s and 90s[17,64,73,74]. In a workshop conducted in 1991 with the goal to increase the effectiveness of 5 country iron supplementation programs, iron tablet supply was also identified as an important constraint. Authors reported specific requirements of a successful supply chain system which included: sufficient fund allocation, appropriate needs assessment, restocking protocols including maintenance of buffer stocks, adequate storage location, incorporation of IFA into essential drug distribution, monitoring of stock levels,

identified source of supply, tablet packaging (e.g. coating, color, adequate packaging for recommended dose), and quality inspections[77]. A recent study of the Ghana Health Services identified similar needs in their logistics management system. Authors reported issues in budgeting, forecasting need, delays in procurement, and financial constraints. Adequate funding and appropriate supervision were reported as key facilitators of successful logistics management in that context[78]. Though not specific to IFA distribution, iron supplements are likely affected by supply issues.

Improving IFA supply in any context is a multi-factorial endeavor that requires appropriate policies, political will, coordination with the private sector, and trained health workers at all levels. Although evaluations of iron supplement programs exist that point to supply chain issues, few highlight specific recommendations and identify key stakeholders who would be required to make each recommendation a reality. While analyzing these issues on a global scale is helpful to understand common facilitators and barriers, understanding the local context of a specific program is critical to make contextually relevant improvements, taking into consideration local policies and practices.

Compliance

Lack of compliance may be related to issues surrounding health worker counseling and beneficiary knowledge and behaviors regarding IFA. In this manuscript, compliance and adherence refer to adequate IFA consumption during pregnancy. It is necessary to explore these factors to discover facilitators and barriers related to successful IFA consumption. Two multi-country reviews[28,79] and several studies have explored issues of

IFA adherence[25,29,30,80-83]. Anemia was not seen to be a major public health issue in India and other countries. This was described at the beneficiary level, with women considering anemia symptoms to be 'normal' pregnancy traits[28,82,83]. It was also described at the program level, as policy makers considered iron supplementation a "low priority" program[64,77].

IFA consumption can cause gastrointestinal side effects including nausea, stomach upset, diarrhea, and constipation. This was long considered the primary reason for poor compliance among women[11]. However, more recently, studies have shown that side effects may not have as much influence on discontinuation of IFA as previously thought. In 2002, Galloway et al. found that while 33% of women experienced side effects, only 10% stopped taking IFA because of this[28]. Other recent studies on iron supplement compliance also found that side effects were not a major barrier for consumption [29,30,84,85]. Effective health worker counseling on the benefits of IFA and explaining potential side effects beforehand have been cited as effective strategies to mitigate poor adherence due to side effects[27,28].

Several studies also presented enabling factors which were positively associated with IFA consumption. One of these was incorporation of reminding techniques, as forgetfulness was a barrier listed in several studies[23,25,28,29]. In Nepal, one study on antenatal micronutrient supplement adherence found forgetfulness as the major reason for non-compliance, despite counseling and visits twice per week. Authors highlighted the additional need for creating awareness about the benefits of taking the supplement in addition to reminding women, as both are critical factors[29]. In Cambodia, researchers found that use of reminding techniques, in addition to family support were significantly

associated with improved adherence (defined as consuming ≥65% of IFA tablets)[30]. Other factors associated with high compliance included a positive experience in taking IFA (e.g. feeling more energy, increased appetite) and understanding of IFA benefits for the child[28].

Equity

Among global and national level data[18,76], disparities among wealth status have been documented for antenatal care and IFA receipt. Access to ANC and ANC utilization have also been shown to influence IFA consumption[28,30,86]. Increasing equity may require changes to the existing antenatal care systems, such as reducing fees, and exploration of alternative outlets of IFA distribution such as community-based delivery channels[18].

One study of ANC quality in India found disparities between socio-economic status and quality of ANC care, as defined by indices of clinical, informational, and interpersonal quality of care. Not surprisingly, attendance of 4 or more ANC visits was associated with higher quality in all three indices. Authors additionally reported that quality predicted ANC utilization more so than access to a health facility. There was a disparity between wealth status of the woman and quality of care, however this was much more drastic in North India than in the South[87]. These issues of wealth, quality, and utilization disparities will be important to consider for IFA supplementation program improvements in Bihar.

Community-based IFA distribution may also be helpful to increase access to IFA and frequency of counseling by community health workers[88]. Two successful country-

level iron supplementation programs incorporated community health volunteers to distribute and counsel on IFA: Nicaragua and Nepal. These programs also had several other factors which led to their success, though community involvement through the health volunteers was an important component[18,88].

In order to improve iron programs, understanding the inequalities of the specific context can enable program planners to target the underserved populations for a more equitable program.

Chapter 3: Methods

Conceptual Framework

Our conceptual framework builds upon two well-known models: the Health Belief Model and the Social Ecological Model. A woman's decision to initiate and maintain IFA consumption is influenced by a variety of characteristics and beliefs. It can include modifying factors such as age, parity, wealth, educational attainment, religion, caste, personal beliefs, and attitudes. In addition, her perceived susceptibility to anemia and her understanding of what anemia is can play a role as well. Her perceived self-efficacy to be able to consume IFA daily as well as experiencing a "cue to action," which could include receiving counseling, mass media messages, or feeling anemia symptoms, can also influence her IFA consumption. However, these women do not live in a vacuum. Especially in India, a woman's choices and behaviors are interwoven with household traditions, power dynamics, cultural norms, and health services offered (Figure 3.1).

Therefore, we also incorporated the social ecological framework to allow for variation at different levels. At the interpersonal level, women interact with their family, peers, and frontline workers, who are also a part of the health system at the organizational level. All of these individuals are additionally affected by social and cultural norms which may influence their views regarding IFA consumption and anemia (Figure 3.1).

In our work, we also found that perceptions outlined in the Health Belief Model were emerging from other respondents at the organizational and interpersonal level. By incorporating these two models and showing the Health Belief Model components cutting

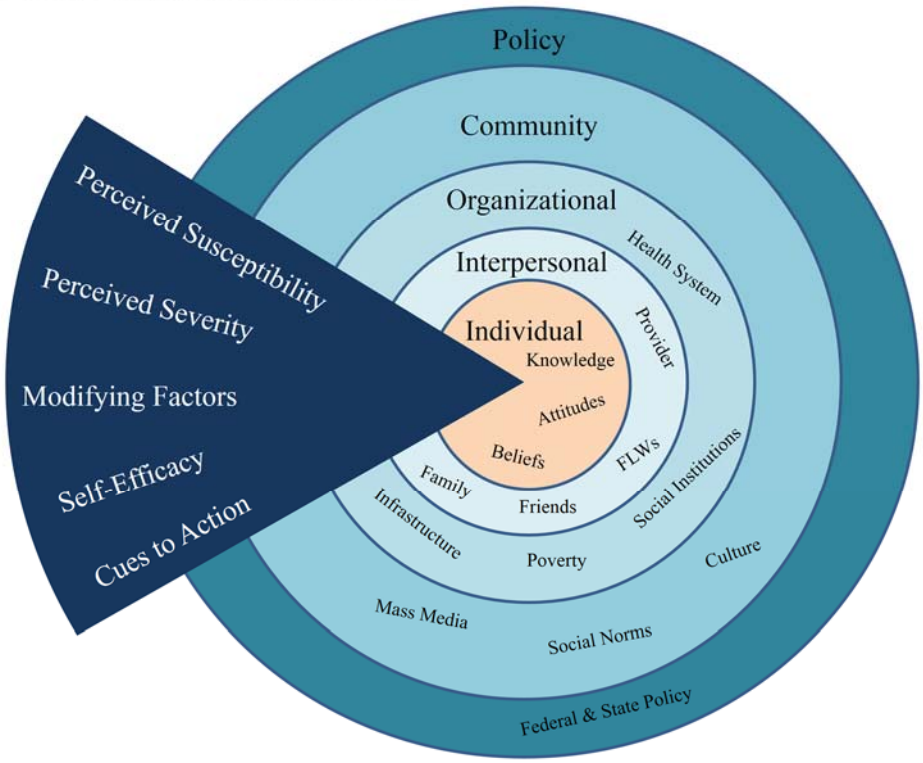
across levels, we illustrate that views of anemia and IFA may be influencing others who also play a role in IFA distribution or counseling.

The first study examines determinants of IFA receipt and consumption, which explores modifying factors at the individual level. In addition, this analysis incorporates aspects of antenatal care attendance and quality, which include interpersonal interaction with health workers, as well as the organizational capacity of the government health facilities.

Our research on the IFA supply chain explores the policy and organizational levels of this model by examining state policies on drug procurement and supply chain management as well as healthcare system protocols, which regulate how IFA reaches pregnant women from the supplier.

Finally, the third manuscript focuses on perceptions of community and health workers with regards to anemia and IFA. Through this analysis, we found that the views described in the Health Belief Model were being expressed by community members and frontline workers especially in terms of perceived susceptibility and severity of anemia. Beliefs held by community members and health workers no doubt influence the beliefs and actions of pregnant women and should be explored and addressed in order to change community demand as well as individual level behaviors (Figure 3.1).

Figure 3.1: Conceptual Framework

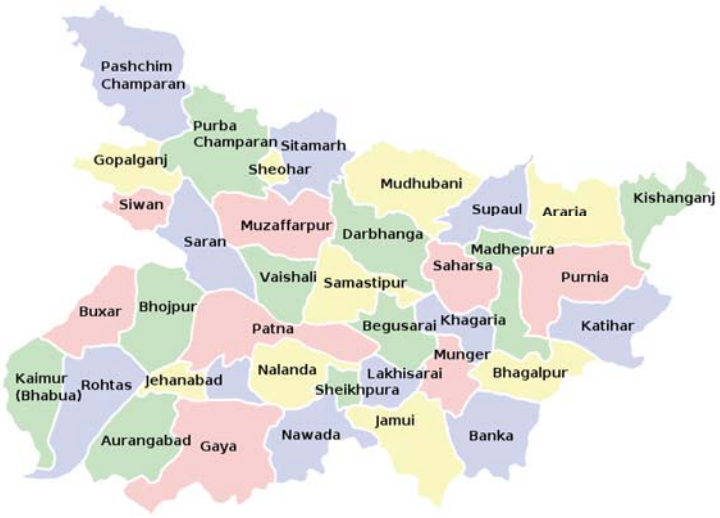


Study Setting: Bihar

Each of these studies was based on populations in the state of Bihar, India. The first study, examining IFA receipt and consumption determinants, included a statewide sample of pregnant women, consisting of women from all 37 districts. These data came from the District Level Household Survey, Round 3 (2007-08)[20]. For the second study examining IFA supply, data collection took place during 2011-12. The 8 districts selected for investigation were the focus districts of CARE India's Integrated Family Health Initiative. The districts were Begusarai, Gopalganj, Khagaria, Paschim Champaran, Patna, Purba Champaran, Saharsa, and Samastipur (Figure 3.2). This allowed for collaboration with CARE personnel to coordinate meetings with health workers at the district level. In addition, CARE block coordinators were available for assistance in

coordinating with block officials and recruiting health workers from the health sub-center and village levels. By selecting these 8 sites, adequate variation in terms of distance from the capital city of Patna was obtained.

Figure 3.2: Bihar State Map



From data obtained through qualitative research in these 8 districts, we chose 2 to conduct additional research on community and health worker perceptions of anemia and IFA (see Chapter 6). The districts of interest in this qualitative project were selected based on several factors: availability of IFA in the district, distance from the capital of Bihar (Patna), and consideration of antenatal care attendance and IFA receipt among pregnant women.

Table 3.1: Characteristics of Seven Districts Evaluated for IFA Supply

	District A	District B	District C	District D	District F	District G	District H
IFA Availability (preliminary qual. data)[a]	0.38	0	0.7	0.5	0.8	0.67	0.67

[a] Score was calculated based on observed availability during preliminary visits at district, block, sub-center, and village levels

During our visits to the district, block, sub-center, and village levels of healthcare service, we were able to ask about and observe whether IFA was available at these facilities. A scoring system was used to summarize what we observed at each location visited in these districts. We created 6 levels (district, block, sub-center, ASHA, AWW, and PW). A point was given if sources at this level had IFA. This was verified through observation or by record (e.g. a point was given if the stock register showed IFA in stock or if IFA was observed during the interview.) Half a point was awarded if the respondent claimed there was IFA though this was not confirmed by registers or observation. For pregnant women, half a point was awarded for women who had IFA but who had been introduced to us by a frontline healthcare worker, as this introduces significant bias that the worker might lead us to a woman who presents a "best case scenario." This was not a representative sample of the population; however, it did provide us with a summary of how much IFA was available at the different districts (Table 3.1).

The 2 districts that had top "scores" in IFA availability were selected after exclusions were made due to lack of cooperation from health officials and large urban populations. The selected districts offered benefits for this qualitative research as well. The districts were varying distances from the capital city of Patna. In addition, there were differences in resource availability and career prestige for healthcare officials in one district versus the other which allowed us to explore potential variation in their perceptions and work habits, which could also affect IFA distribution (conversations with CARE personnel).

Individual and Facility Level determinants of Adequate IFA Consumption among Pregnant Women in Rural Bihar, India

Research Objective

Our objective was to examine individual and facility-level determinants of IFA receipt and consumption among pregnant women in rural Bihar.

Rationale

In our first study we chose multilevel modeling to examine the determinants of IFA receipt and consumption among pregnant women in Bihar. Previous studies have assessed determinants of these outcomes but they have focused largely on individual level factors, often assessing which women were more or less likely to receive or consume IFA[25,30,89-91]. However, IFA is distributed through government health workers and government facilities. Therefore, differences in facilities or health worker capacity may be influencing women's IFA receipt or consumption independent of individual factors alone. We were able to explore this by using multilevel modeling, which allowed us to assess variation at the individual and facility level simultaneously.

In these models we also wanted to capture the variability in healthcare that women face. Therefore we sought to account for antenatal care quality and health sub-center capacity. There were many variables that represented antenatal care quality or HSC capacity to some degree. Therefore, we conducted factor analyses. In this way, we were able to reduce the number of variables added to the model and identify a structure to each set of variables based on their covariation.

Data Sources

We analyzed data from the third round of the District Level Household Survey (DLHS-3), completed in 2007-08, from the state of Bihar. DLHS-3 is a cross-sectional survey that provides representative data at national, state, and district levels by using a multi-stage stratified probability proportion to size sampling design[19]. The purposes of this survey included measuring maternal and child healthcare utilization as well as health facility capacity and effectiveness[19]. In Bihar, 46,840 ever-married women (15-48y) were surveyed. Household (n=47,137) and village (n=1,668) questionnaires were also conducted with household members and village representatives, respectively. Facilities surveyed included Health Sub-Centers (HSC, n=1,165), Primary Health Centers (PHC, n=524), and Community Health Centers (CHC, n=66). The response rates in Bihar for ever-married women and health sub-centers were 86.7% and 92.8%, respectively. HSC response rate was calculated using individual district reports[20].

Inclusion & Exclusion Criteria

For this analysis, we used data from ever-married women, village, and health sub-center surveys. For our 2 outcomes (IFA receipt and IFA consumption), we constructed 2 final samples.

We included women in our data analysis that had a live birth in the time period surveyed (from January 1, 2004 to 2007-08), lived in a primary sampling unit (PSU) covered by only one HSC, and had complete data for the outcome of interest and covariates. Due to these inclusion criteria, all women who did not attend ANC (and thus were not asked about IFA receipt or consumption) and those who lived in urban

residences (and were not covered by an HSC) were excluded. Women with incomplete or implausible data were also excluded. In our IFA consumption model, women who did not receive IFA were not asked about consumption and were therefore were excluded from that model.

We also excluded HSCs that did not cover a primary sampling unit (PSU) with an ever-married woman in our model, that covered more than one PSU, or that had missing data. In rural populations, PSUs were defined as census villages or communities[19]. For the IFA receipt outcome, we included 1,012 HSCs and for the IFA consumption outcome, 890 HSCs.

There were some differences between the total sample and our analytic samples. Women included in our models were older, more educated, of higher birth order, and less likely to be married before the age of 18 or be of a scheduled caste or tribe. Women included in our second model (IFA consumption), were more likely to have initiated ANC earlier, have had more frequent ANC visits, and have experienced more ANC practice and counseling. HSCs that were excluded were more likely to be in need of repair.

Dependent Variables

We constructed 2 primary outcomes for this analysis. Both outcomes were dichotomous variables regarding IFA supplements provided during ANC as routine standard of care through the government health system. Government guidelines require one dose of IFA to be 100mg elemental iron and 500 mcg folic acid from tablets or syrup[69].

The first outcome was defined as receipt of any iron and folic acid supplements during the last pregnancy. Interviewers asked women who reported having attended ANC how many IFA tablets or bottles they received during their last pregnancy. This included any quantity of IFA tables or IFA syrup. Those who answered any number greater than zero were classified as having received IFA [20].

Women who received IFA were asked how many days they consumed IFA tablets / syrup during their last pregnancy occurring after January 1, 2004[20]. The second outcome was whether the woman reported consuming IFA tables or syrup for 90 days or more and was generated only for women who reported that they received IFA during their last pregnancy.

Independent Variables

ANC: ANC variables included receipt and quality measures. ANC receipt was measured by a timing variable (Early enrollment (1st trimester) vs. late enrollment (2nd or 3rd trimester) of first ANC visit) and a frequency variable (<4 ANC visits vs. ≥4 ANC visits) according to WHO standards[92]. ANC quality variable comprised 18 practices and counseling topics measured by the survey instrument. These topics did not address IFA administration or counseling but were included as an overall quality measure of ANC services. There were 9 ANC practices (weight, height, blood pressure, blood test, urine test, breast exam, abdomen exam, sonogram/ultrasound, and delivery date given) and 9 ANC counseling topics (advice regarding delivery, nutrition, breastfeeding, keeping the baby warm, cleanliness at delivery, family planning for spacing and limiting, improved maternal and child nutrition, and importance of institutional delivery). We removed 5

variables (blood pressure, urine test, delivery advice, keeping the baby warm, and family planning for limiting) from the analysis because they were too highly correlated, causing a singular matrix. We used the remaining variables to conduct an exploratory factor analysis using polychoric correlation matrices. These have been shown to result in more accurate correlations between categorical variables, as compared to Pearson correlations[93]. We then extracted factors from a principal components analysis and rotated them orthogonally using the varimax method. The 13 variables separated into two distinct factors with eigenvalues >1: ANC practice and ANC counseling topics. We retained variables in factors which contained factor loadings of ≥ 0.5. These two factors explained 89% of the cumulative variance.

HSC: We conducted a factor analysis on 12 HSC characteristics. Of those, 3 characteristics were not included in the final factors because they had low loading values on all factors. Excluded variables consisted of the ratio of pregnant women registered in the previous month to HSC coverage population, sufficient printed ANC cards, and Auxiliary Nurse Midwife (ANM) residing in the HSC village. The other 9 variables formed three factors: 1) Village Health Day and Primary Health Center (PHC)/Village Monitoring, 2) Personnel Characteristics, and 3) Health Sub-Center Infrastructure. The first factor, Village Health Day and PHC/Village Monitoring, is comprised of the observation of Village Health Day, and PHC or Village monitoring activities. A large part of the PHC and Village Health and Sanitation Committee (VHSC) activities center around monitoring progress of the HSC's Village Health Day, at which IFA is distributed to pregnant women, among other ANC activities. The second factor, Personnel Characteristics, includes the number of HSC personnel, number of training topics

attended in the past 5 years, and receipt and utilization of untied funds. These characteristics may influence ANC coverage of the village, capacity of the workers to distribute and counsel on IFA benefits and consequences, and may indicate more active HSC workers. The third factor, Health Sub-Center Infrastructure, reflects structural capacity. This factor is represented by building condition (as observed by the interviewer), and access to water. We conducted polychoric factor analysis on these factors as described above. The 3 factors selected had eigenvalues of 1.10, 0.63, and 0.54. The 3 factors together explained 87% of the cumulative variance.

Covariates

Individual level covariates also included in the model have each been shown to be associated with anemia, maternal health service utilization, or IFA receipt. These were maternal age at index birth[94,95], age of marriage[95,96], maternal education[38,97], gender composition of living children[98], birth order of index pregnancy[38,94,99], caste[89], religion[89], and household wealth quintile[89].

Statistical Analyses

We conducted descriptive statistics, examining frequencies and percentages. We also reported the proportion of women who received any IFA and who consumed IFA for 90 or more days during their last pregnancy by each covariate along with chi-square tests of significance. All descriptive statistics and modeling took into account weighting and clustering at the primary sample unit level.

Data cleaning and factor analyses were completed in SAS 9.3 (SAS Inc., Cary, NC, USA). We assessed collinearity using the COLLIN macro and accounted for clustering using PROC SURVEYLOGISTIC (unpublished data) in SAS 9.3.

We accounted for the hierarchical nature of the data by conducting a multilevel logistic model. We included 2 levels: individual and community (primary sampling unit). To assess the need for an additional level (household), we put household identifiers in the model. This was not significant nor did it change our estimates so we present the 2-level model here, using the *xtlogit* command in Stata version 13 (StataCorp, College Station, TX, USA). We also made an *a priori* decision to assess possible interactions between all ANC variables. This was because women who received more ANC services may have been more likely to receive more counseling and attend ANC more frequently or earlier. For each outcome variable, 6 models were constructed, each including a set of factors: 1) Individual Factors, 2) Individual and ANC Timing and Frequency factors, 3) Individual and ANC Quality Factors, 4) Individual and HSC Factors, 5) All Factors, and 6) All Factors including Interactions. For each model, we used Akaike Information Criterion as a measure of goodness-of-fit in comparing final models[100]. We also report the facility level random effects. These measure the extent to which the outcome varies by PSU, while controlling for all other covariates. This can signal residual variation due to measures not included in the model or not measured by this survey, such as differences in beliefs or social norms surrounding iron consumption in communities, or facility variations that were not measured here.

Identifying Bottlenecks in the IFA Supply Chain in Bihar, India

Research Objective

Our objective was to examine the current status of the government health system's IFA supply and distribution system and to identify bottlenecks that may contribute to insufficient IFA supply.

Rationale

In this IFA supply chain evaluation, we chose qualitative in-depth interviews as a methodology to understand not just the government protocols, but also to learn how these were being implemented in reality and to understand why protocols were or were not being followed. Qualitative research is particularly useful in revealing processes such as decision making, as well as perceptions and behaviors[101]. In order to create practical and feasible recommendations, it is useful to understand not only what bottlenecks are occurring in the supply chain but also the reasoning behind these ineffective or incorrect behaviors, exploring why they begin and why they continue.

In this study we also conducted a survey with a representative sample of Auxiliary Nurse Midwives (ANMs) who worked at the health sub-center level over 8 districts in Bihar. Our questions stemmed from answers given during the qualitative portion of this study. By doing this, our goal was to support our qualitative findings with a representative sample of ANMs. We wanted to understand the magnitude of the IFA supply issue by examining actual stock levels in addition to IFA protocols followed. Because we had conducted qualitative research in these areas as well, we were able to better interpret our findings from this survey, which strengthened both our qualitative and quantitative conclusions.

Methods

We conducted a cross-sectional, mixed methods study to characterize IFA supply chain protocols and procedures across 8 districts in Bihar (Table 3.2). These districts were the initial focus districts of a 5 year project CARE Bihar is conducting called the Integrated Family Health Initiative (IFHI). This program supports the Government of Bihar to improve maternal and child health outcomes throughout the state by increasing delivery, uptake, and utilization of key family health services[33]. Our study consisted of qualitative in-depth interviews with key players in the IFA supply chain and a survey distributed to Auxiliary Nurse Midwives (ANMs).

Table 3.2: Antenatal care indicators for study site districts in Bihar - DLHS-3

	Any ANC	*ANC in 1st Trimester*	*≥3 ANC*	*Consumed ≥100 IFA tablets/syrup*
Begusarai	77.4	25.8	29.4	31.0
East Champaran	76.2	23.5	34.8	31.1
Khagaria	80.5	33.0	27.9	23.5
Patna	38.0	23.8	24.1	70.1
Samastipur	87.4	16.8	23.1	16.2
West Champaran	70.8	18.8	36.3	31.1
Gopalganj	74.5	32.2	32.2	32.2
Saharsa	40.0	21.5	13.7	65.2
Bihar	**59.3**	**24.2**	**26.4**	**46.7**

DLHS-3: District Level Household Survey, Round 3 (2007-08); **ANC**: antenatal care; **IFA**: iron and folic acid supplements

To assess the IFA supply chain, we collected both qualitative and quantitative data. From this we developed an overall description of the IFA supply chain in Bihar in addition to how ANMs receive and distribute IFA from the sub-centers using survey data.

From the qualitative data, we present bottlenecks in the IFA supply chain identified by interview participants.

Qualitative In-Depth Interviews

Participants

From November 2011 to July 2012, 59 in-depth interviews were conducted with health workers and medical supply managers at state, district, block, sub-center, and village levels. Officials in the Health Department, National Rural Health Mission (NRHM), and Integrated Child Development Scheme (ICDS) were included. ANMs, Accredited Social Health Activists (ASHAs), and Anganwadi Workers (AWWs) are all classified as frontline workers (FLWs) as they are responsible for IFA distribution to beneficiaries in the field.

In-depth interview meetings were requested by CARE staff with healthcare workers at the district, block, sub-center, and village level. Selection of frontline workers was based upon an *a priori* selection of health sub-centers in their respective coverage areas. Village level workers were interviewed based on assigned coverage area and availability. Initially, blocks close and far from the district capital, as defined by CARE staff, were chosen to add variation to the sample. Later, to avoid biased selection, blocks were selected randomly. However, some modifications were made as some blocks were too far to visit given time constraints.

Data Collection

In-depth interview guides, first drafted in English, focused on the respondent's perceived role in IFA receipt and distribution, IFA need estimation, and trainings received. Guides were constructed taking into account both relevant literature[27] and iterative discussions with co-authors and CARE Bihar personnel. One bilingual research assistant used English guides to conduct interviews. Quality and accuracy were verified through extensive training and review of recordings. Research assistants hired later required interview guides translated into Hindi. These guides were reviewed by external bilingual researchers to ensure validity. Interviews conducted in Hindi lasted between 30 and 60 minutes. The research assistants were trained in appropriate qualitative research techniques and debriefed daily with the primary author. Interviews were recorded. Notes and observations were also written at the time of the interview. The majority of recordings were transcribed directly into English by a bilingual researcher. In 2012, 10 additional interviews were conducted. These were transcribed into Hindi and then translated into English in a 2 step process. On a subset of transcripts, quality checks were completed by comparison of recordings to transcripts by an external bilingual researcher.

Data Management and Analysis

All transcripts were de-identified for analysis. Deductive and inductive codes were created based on research questions, field notes, and participant responses. A codebook was designed including code definitions, inclusion and exclusion criteria, and examples of code use. Thematic analysis was conducted to identify major themes and supply chain bottlenecks. These were then compared across districts, occupation groups, and supply chain levels (e.g. district, block, HSC, village). Practical recommendations were derived from respondent suggestions, published evaluations of Bihar's drug supply

chain, and analysis of the data. Analyses were conducted using MAXQDA (version 10, VERBI Software).

Auxiliary Nurse Midwife Surveys

Participants

ANMs were chosen as the target participants for this survey because of their dual role as part of the IFA supply chain and as key distributors of IFA to beneficiaries. ANMs are responsible for their own drug supply management and, being at the bottom of the supply chain, are most affected when both district and block shortages occur.

ANMs predominantly work at health sub-centers, which should serve a population of 3,000 - 5,000[102], and coordinate IFA distribution with ASHAs and AWWs, who work at the village level (AWC Population Norm: 300-800) [103].

Data Collection

We constructed a 27-item survey in collaboration with CARE Bihar staff to assess ANM IFA supply and protocols in the region. We randomly selected three ANMs from each of the 137 blocks across the 8 districts. A list of ANMs in each block was provided. Each ANM name was given a number and 3 numbers were randomly selected. If an ANM was no longer assigned to that block or refused, then another ANM was chosen randomly using the same system. CARE block coordinators who had been trained on survey contents and overall study objectives administered the surveys to the ANMs. We did not collect names on the survey forms to ensure confidentiality.

Data Management and Analysis

Block coordinators turned in completed surveys to CARE district offices which forwarded them to the state office. Trained research assistants input the data into an Excel spreadsheet (Microsoft Excel 2010, Redmond, WA) and quality checks were completed by the primary author.

All analyses were conducted using SAS v9.2 (SAS Inc., Cary, NC, USA). We calculated survey weights to account for non-responses, differing numbers of ANMs per block, and numbers of blocks per district. Following this, we calculated descriptive statistics including means and frequencies. Of the 137 blocks invited to participate, 11 blocks did not respond. Therefore, represented blocks (n=126) were compared with non-responsive blocks (n=11) on 7 antenatal care quality and coverage characteristics obtained from CARE program baseline data[104]. The 11 blocks not represented in our data were found to have fewer pregnant women receiving counseling during their last pregnancy by frontline workers (either ANMs, ASHAs, or AWWs) on the topics of pregnancy danger signs ($p<0.0001$), emergency preparedness ($p=0.04$), and family planning ($p<0.0001$). We found no significant differences when comparing the number of mothers who during their last pregnancy received at least 90 IFA tablets, were visited 2 or more times during the last trimester by any frontline worker (FLW), received advice from FLWs on immediate newborn care, or delivered their last child at a health facility (data not shown) (Unpublished data, CARE India).

Ethics

To maintain confidentiality, all districts were assigned letters (A, B, C, D, E, F, G, H) and health workers are referred to as state, district, and block officials. ANMs,

AWWs, and ASHAs are referred to by their titles and all storekeepers, including pharmacists and clerks with storekeeper responsibilities, are referred to as storekeepers.

The Institutional Review Board of Emory University reviewed and approved this study's protocol. All respondents provided informed oral consent.

Community and Health Worker Perceptions of Anemia and Iron and Folic Acid Consumption in Bihar, India

Research Objective

Our objective in this study was to examine the perceptions of anemia and IFA supplementation among health workers, beneficiaries, and family members in order to identify key facilitators and barriers to IFA consumption. We then make recommendations to strengthen the existing iron supplementation program, specific to the Bihar context.

Rationale

In our study examining the perceptions of anemia and iron consumption, our objective was to compare participant views on these subjects, which is a strength of qualitative research methodology. In this study, we valued the personal perspective. Each respondent had distinct knowledge and beliefs regarding anemia and IFA, which we sought to capture and understand. Furthermore, qualitative research methods can identify context and circumstances. For example, a woman may not have received IFA because she did not see a health worker, refused IFA tablets, asked the health worker but was not given IFA due to supply issues, or another reason entirely. However, through surveys,

this contextual information would not emerge and yet would be very important in understanding health worker-beneficiary interactions. Qualitative methodology also allows for unexpected responses and themes, which was important in both studies, as we did not know all of the possible program challenges *a priori*[101]. By using qualitative methods, we were able to detect unforeseen issues and challenges to successful IFA supply, consumption, and demand creation.

Participant Sampling

From June-July 2012, we conducted interviews and focus group discussions with 3 types of health workers, who are largely responsible for IFA distribution to pregnant women: Auxilary Nurse Midwives (ANMs), Accredited Social Health Activists (ASHAs), and Anganwadi Workers (AWWs). At the community level, we interviewed pregnant women and mothers-in-law and led focus groups with husbands. We chose to include mothers-in-law and husbands because of their influence in the household over financial and medical decisions. Collecting perspectives from community members as well as health workers in the same area also allowed us to compare knowledge and counseling of the health workers to awareness and experiences of the community members regarding anemia and IFA.

In each district, we talked to community members, ASHAs, and AWWs in two Anganwadi Center (AWC) coverage areas managed by one Health Sub-Center (HSC). We also interviewed the ANM from this HSC coverage area in addition to an ANM in a separate HSC area in order to increase the number of ANM responses. Pregnant women were randomly selected from a health worker's survey list of all pregnant women in her

area. In these districts, CARE Bihar had recently completed an initiative to increase coverage of these surveys, which had identified many "left out" pregnant women in the region[33]. Therefore, these were believed to be complete lists of pregnant women in the area. We interviewed pregnant women in their third trimester or with children less than 6 months of age. Once in these areas, we inquired about availability of mothers-in-law and husbands whose daughter-in-law or wife, respectively, was pregnant or had a child less than 2 years old.

For each interview we explained the study objectives and asked permission to record the interview. All participants gave oral consent. Our protocol was approved by the Emory University Institutional Review Board.

Data Collection

Interview and focus group guides were created in English and translated into Hindi. Research assistants, an external bilingual researcher, and the primary author reviewed the Hindi guides for accuracy. Pilot testing was also done to evaluate research assistants and make appropriate changes to interview and focus group guides.

All guides covered four main topics: 1) perceived causes and consequences of anemia, 2) awareness of IFA tablet benefits and consumption, 3) perceived facilitators and barriers to successful IFA consumption, and 4) trusted health information sources. Community members were asked about how they receive health information, while health workers were asked who community members go to for their health advice. The role of the family and power within the family unit concerning health decisions was also probed when asking about facilitators and barriers of IFA consumption.

Overall, 23 in-depth interviews and 11 focus group discussions were conducted in June and July of 2012. Interviews lasted 30-45 minutes and focus group discussions were approximately 1-1.5 hours in duration. These were done in Hindi or the local language and translated into English for analysis. Four research assistants conducted and transcribed the interviews. They were trained in the overall goals of the study, qualitative interviewing techniques, and research ethics. Most interviews and focus groups included an interviewer/moderator and a note-taker. In many, the primary author or another researcher were observers and took notes on body language and the setting. In a few cases where a note-taker was not available, the interviewer took notes during the discussion in addition to the audio recording. Of the four research assistants, two were male and two were female. During pregnant women interviews, only female researchers were present. Males also moderated each of the husband focus groups. Daily debriefings were held with the research assistants by the primary author. Initial transcripts were reviewed by the primary author and an external bilingual reviewer to ensure verbatim translations. Once completed, a subset of transcripts was compared against the recordings to ensure accuracy.

Hindi transcripts were translated into English by two groups of interpreters. Quality checks were done by external bilingual researchers at various time points to ensure accuracy. Additional rounds of translations were conducted to ensure accurate translations when inaccuracies were identified.

Data Analysis

English transcripts were analyzed in MAXQDA (version 10, VERBI Software). Inductive codes were created based on participant responses first from a subset of 6 transcripts, and then adding additional codes as they emerged. Memos were written throughout the analysis to highlight salient themes and topics of interest. Thematic analysis was conducted to identify major themes and patterns. Themes were then compared across participant type, participant category (health worker or community member), and district. Data, which were often reported in list form (e.g. anemia causes and consequences), were tabulated and sorted into categories (e.g. weakness, child health, delivery complications) in order to compare common answers despite distinct phrasing across participant types. Perspectives shared by most participant types were presented as 'common views,' while those shared by few participant types or one category (e.g. community members) were listed under 'divergent opinions.'

Chapter 4:

Individual and Facility Level Determinants of IFA Receipt and Adequate Consumption among Pregnant Women in Rural Bihar, India

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Abstract

Background: In Bihar, India, high maternal anemia prevalence and low IFA receipt and consumption have continued over time in spite of universal IFA distribution and counseling during pregnancy.

Purpose: To examine the individual and facility-level determinants of IFA receipt and consumption among pregnant women in rural Bihar, India.

Methods: Using District Level Household Survey (2007-08) data, multilevel modeling was conducted to examine the determinants of two outcomes: IFA receipt (any IFA receipt vs. none) and IFA consumption (≥90 days vs. <90 days). Individual-level and

facility-level factors were included. Factor analysis was utilized to construct ANC quality and HSC capacity variables.

Results: Women were more likely to receive any IFA when they received more ANC services counseling, and attended ANC earlier and more frequently. Significant interactions were found between ANC quality factors (OR: 0.37, 95% CI: 0.25, 0.56) and between ANC services and ANC timing and frequency (OR: 0.68, 95% CI: 0.56, 0.82). No HSC factors were significantly associated with IFA receipt. Women were more likely to consume IFA for ≥90 days if they attended at least 4 ANC check-ups and received more ANC services. IFA supply at the HSC (OR: 1.37, 95% CI: 1.04, 1.82) was also significantly associated with IFA consumption.

Conclusions: Our findings indicate that ANC factors (timing, frequency, and quality) play a key role in facilitating IFA receipt and consumption. Though HSC capacity factors were not found to influence our outcomes, significant variation at the facility level indicates unmeasured factors that could be important to address in future interventions.

Key Words: antenatal care, pregnant women, anemia, iron and folic acid

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Introduction

The World Health Organization (WHO) estimates that 56 million pregnant women (42%) globally are anemic[1], the majority of whom live in resource poor settings[2]. The largest

number of individuals affected (18.1 million) live in South-East Asia[1]. In Bihar, India, the anemia prevalence is even higher, affecting 60% of pregnant women in one of the largest and poorest states of the country[3].

During pregnancy, anemia can lead to several adverse outcomes including low birth weight, preterm delivery, stillbirth, and maternal and neonatal mortality[4-6]. Over half of anemia cases are estimated to be due to iron deficiency[2]. Fortunately, an efficacious and cost-effective strategy exists for iron deficiency anemia prevention and control. Daily oral iron supplementation success has been well documented in both hematological improvements[7] and clinical outcomes such as increased birth weight[8].

Since 1970, the Government of India has had an iron supplementation program, which expanded to provide universal iron supplementation for pregnant women in 1991[9,10]. However, evaluations, published from 1988-2007, have shown a lack of success both in implementation and outcomes[11-15]. Anemia prevalence among pregnant women in Bihar has increased from 46.4% in 1998-9 to 60.2% in 2005-06[16]. In addition, recent evaluations of iron and folic acid supplement (IFA) consumption have shown a dismal number of women receiving any IFA or consuming an adequate amount during pregnancy. In Bihar, National Family Health Survey, Round 3 (NFHS-3) (2005-06) data show 29.7% received IFA and only 9.7% of women consumed it for 90 or more days during their last pregnancy[3]. In 2009, UNICEF reported that only 6.7% of Bihari women consumed 100 or more IFA (tablets or syrup) and 67.3% had consumed none at all[17].

Government provided IFA is distributed through antenatal care (ANC), which in rural areas is provided at health sub-center (HSC) facilities. As the most peripheral health

facility, the HSC serves as the initial point of contact between the community and health system. Due to this role, "the success of any nation-wide program would depend largely on the well-functioning HSCs providing services of acceptable standard to the people"[18]. Therefore, a woman's receipt and consumption of IFA does not solely depend on individual and household level factors, but is also shaped by the capacity and service quality of her HSC facility.

Though several studies have examined individual factors associated with IFA receipt or adherence, few have addressed the role of ANC quality or facility capacity[19-23]. To our knowledge, none have accounted for facility characteristics as contextual factors by conducting multi-level modeling, which may show the impact that facilities make to women's IFA receipt and consumption beyond individual-level factors alone.

Thus our objective was to more robustly examine individual and facility-level determinants of IFA receipt and consumption among pregnant women in rural Bihar. We utilized data from the District Level Household Survey – Round 3 (2007-08), a nationally representative survey which recorded women's reported IFA receipt and consumption, ANC attendance and quality, and facility level characteristics[24] and employed a multi-level hierarchical logistic regression to account for variance at the facility level.

Methods

Data Sources

We analyzed data from the third round of the District Level Household Survey (DLHS-3), completed in 2007-08, from the state of Bihar. DLHS-3 is a cross-sectional survey that provides representative data at national, state, and district levels by using a multi-

stage stratified probability proportion to size sampling design[24]. Purposes of this survey included measuring maternal and child healthcare utilization as well as health facility capacity and effectiveness[24]. In Bihar, 46,840 ever-married women (15-48y) were surveyed. Household (n=47,137) and village (n=1,668) questionnaires were also conducted with household members and village representatives, respectively. Facilities surveyed included Health Sub-Centers (n=1,165), Primary Health Centers (n=524), and Community Health Centers (n=66). The response rates in Bihar for ever-married women and health sub-centers were 86.7% and 92.8%, respectively. HSC response rate was calculated using individual district reports[25].

Inclusion & Exclusion Criteria

For this analysis, we used data from ever-married women, village, and health sub-center surveys. For our two outcomes, (IFA receipt and IFA consumption), we constructed two final samples.

We included women in our data analysis that had a live birth in the time period surveyed (from January 1, 2004 to 2007-08), lived in a primary sampling unit (PSU) covered by only one HSC, and had complete data for the outcome of interest and covariates. Due to these inclusion criteria, all women who did not attend ANC (and thus were not asked about IFA receipt or consumption) and those who lived in urban residences (and were not covered by an HSC) were excluded. Women with incomplete or implausible data were also excluded. In our IFA consumption model, women who did not receive IFA were not asked about consumption and therefore excluded from that model (See Figure 4.1a).

We also excluded HSCs that did not cover a primary sampling unit (PSU) with an ever-married woman in our model, that covered more than one PSU, or that had missing data. In rural populations, PSUs were defined as census villages or communities[24]. For the IFA receipt outcome, we included 1,012 HSCs and for the IFA consumption second outcome, 890 HSCs (See Figure 4.1b).

There were some differences between the total sample and our analysis samples. Women included in our models were older, more educated, of higher birth order, and less likely to be married before the age of 18 or be of a scheduled caste or tribe. Women included in our second model (IFA consumption), were more likely to have initiated ANC earlier, have more frequent ANC visits, and experienced more ANC practice and counseling. HSCs that were excluded were more likely to be in need of repair.

Dependent Variables

We constructed two primary outcomes for this analysis. Both outcomes were dichotomous variables regarding IFA supplements provided during ANC as routine standard of care through the government health system. Government guidelines require one dose of IFA to be 100mg elemental iron (ferrous sulphate[18]) and 500 mcg folic acid from tablets or syrup[26].

The first outcome was defined as receipt of any iron and folic acid supplements during the last pregnancy. Interviewers asked women who reported having attended ANC how many IFA tablets or bottles they received during their last pregnancy. This included any quantity of IFA tables or IFA syrup. Those who answered any number greater than zero were classified as having received IFA [25].

Women who received IFA were asked how many days they consumed IFA tablets / syrup during their last pregnancy occurring after January 1, 2004[25]. The second outcome was whether the woman reported consuming IFA tables or syrup for 90 days or more and was generated only for women who reported that they received IFA during their last pregnancy.

Independent Variables

ANC: ANC variables included receipt and quality measures. ANC receipt was measured by a timing variable (Early enrollment (1st trimester) vs. late enrollment (2nd or 3rd trimester) of first ANC visit) and a frequency variable (<4 ANC visits vs. ≥4 ANC visits) defined by WHO standards[27]. ANC quality variable comprised 18 practices and counseling topics measured by the survey instrument. These topics did not address IFA administration or counseling but were included as an overall quality measure. Nine covered ANC practices (weight, height, blood pressure, blood test, urine test, breast exam, abdomen exam, sonogram/ultrasound, and delivery date given) and nine reviewed ANC counseling topics (advice regarding delivery, nutrition, breastfeeding, keeping the baby warm, cleanliness at delivery, family planning for spacing and limiting, improved maternal and child nutrition, and importance of institutional delivery). We removed 5 variables (blood pressure, urine test, delivery advice, keeping the baby warm, and family planning for limiting) from the analysis because they were too highly correlated, causing a singular matrix. We used the remaining variables to conduct an exploratory factor analysis using polychoric correlation matrices. These have been shown to result in more accurate correlations between categorical variables[28]. We then extracted factors from a principal components analysis and rotated them orthogonally using the varimax method.

The 13 variables separated into two distinct factors with eigenvalues >1: ANC practice and ANC counseling topics. We included variables in factors which contained factor loadings of ≥ 0.5. These two factors explained 89% of the cumulative variance (Table 4.1a).

HSC: We conducted a factor analysis on 12 HSC characteristics. Three of these were not included in the final factors because they had low loading values on all factors. Excluded factors consisted of the ratio of pregnant women registered in the previous month to HSC coverage population, sufficient printed ANC cards, and Auxiliary Nurse Midwife (ANM) residing in the HSC village. The other 9 variables formed three factors: Village Health Day and Primary Health Center (PHC)/Village Monitoring, Personnel Characteristics, and Health Sub-Center Infrastructure. The first factor, Village Health Day and PHC/Village Monitoring, is comprised of the observation of Village Health Day, and PHC or Village monitoring activities. A large part of the PHC and Village Health and Sanitation Committee (VHSC) activities center around monitoring progress of the HSC's Village Health Day, at which IFA is distributed to pregnant women among other ANC activities. The second factor, Personnel Characteristics, includes the number of HSC personnel, number of training topics attended in the past five years, and receipt and utilization of untied funds. These characteristics may influence ANC coverage of the village, capacity of the workers to distribute and counsel on IFA benefits and consequences, and may indicate more active HSC workers. The third factor, Health Sub-Center Infrastructure, reflects structural capacity. This factor is represented by building condition (as observed by the interviewer), and access to water. We conducted polychoric factor analysis on these factors as described above. The three factors selected had

eigenvalues of 1.10, 0.63, and 0.54. The 3 factors together explained 87% of the cumulative variance (Table 4.1b).

Covariates

Individual level covariates also included in the model have each been shown to be associated with anemia, maternal health service utilization, or IFA receipt. These were maternal age at index birth[29,30], age of marriage[30,31], maternal education[32,33], gender composition of living children[34], birth order of index pregnancy[29,32,35], caste[19], religion[19], and household wealth quintile[19] (See Table 2.2).

Statistical Analyses

We conducted descriptive statistics, examining frequencies and percentages. We also reported the proportion of women who received any IFA and who consumed IFA for 90 or more days during their last pregnancy by each covariate along with chi-square tests of significance. All descriptive statistics and modeling took into account weighting and clustering at the primary sample unit level.

Data cleaning and factor analyses were completed in SAS 9.3 (SAS Inc., Cary, NC, USA). We assessed collinearity using the COLLIN macro and accounted for clustering using PROC SURVEYLOGISTIC (unpublished data) in SAS 9.3.

We accounted for the hierarchical nature of the data by conducting a multilevel logistic model. We included 2 levels: individual and community (primary sampling unit). To assess the need for an additional level (household), we put household identifiers in the model. This was not significant nor did it change our estimates so we present the 2-level

model here, using the *xtlogit* command in Stata version 13 (StataCorp, College Station, TX, USA). For each outcome variable, six models were constructed, each including a set of factors: 1) Individual Factors, 2) Individual and ANC Timing and Frequency factors, 3) Individual and ANC Quality Factors, 4) Individual and HSC Factors, 5) All Factors, and 6) All Factors including Interactions. For each model, we used Akaike Information Criterion as a measure of goodness-of-fit in comparing final models[36]. We also report the facility level random effects. These measure the extent to which the outcome varies by PSU, while controlling for all other covariates. This can signal residual variation due to measures not included in the model or not measured by this survey, such as differences in beliefs or social norms surrounding iron consumption in communities, or facility variations that were not measured here.

Results

Sample Characteristics

In our IFA receipt model, our final sample was 7,765 women and 1,012 HSCs. For the outcome IFA consumption, our final sample included 2,905 women and 890 HSCs.

Women included in the IFA receipt model were predominantly 20 years or older (84.2%), married before the age of 18 (72.1%), uneducated (62.0%), had one or more sons (77.0%), had a birth order of three or greater (51.8%), Hindu (83.5%), and more likely to be in the two lowest wealth quintiles (67.1%). Although all women received at least one ANC check-up, 47.1% did not receive any ANC practices and 35.6% did not receive any counseling messages that were surveyed (Table 4.3a). Most villages that were included in our sample had an HSC in the village (40.0%) or were located within 5 km of an HSC

(46.0%) (Table 4.3b). Other public health facilities (e.g. Primary Health Centers, District Hospitals) were less likely to be available in or within 5 km of the communities (5.6% and 26.9%, respectively; *data not shown).*

A large proportion (79.9%) of HSCs that were serving these villages was out of IFA stock on the day of the survey. Just over half of HSCs observed Village Health Days, which serve as a monthly outreach to villages by health workers and provide an opportunity for community members to interact with health workers and receive basic services, advice, and preventative care[37]. Among these services are ANC check-ups, which should include IFA distribution[37,38]. Many HSCs also did not receive oversight from the Primary Health Centers (68.9% did not receive written feedback, 44.4% did not receive a visit from a medical officer in the previous month) or village committees (80.6% of HSCs reported no Village Health and Sanitation Committee present in the center's coverage area). Half of included HSCs had 2 or more health workers (45.8%) and most reported receiving training on 4-8 of the topics surveyed (training topics: integrated skill development (Reproductive and Child Health - I), Vector Borne Disease Control Programme, Directly Observed Treatment Short course, Immunization, Intra Uterine Device Insertion, Integrated Management of Neonatal and Childhood Illnesses, Skilled Birth Attendant, and any other trainings)[39]. Only 13.2% of included HSCs received and utilized untied funds (annual funds provided for local needs as determined by the ANM) during the previous year. The majority of HSC buildings needed repair (68.7%) and most did not have any source of water available at the site (60.2%) (Table 4.3b).

Individual Factors

When only individual demographic variables were considered, higher education, increased wealth, and lower birth order were positively associated with both IFA receipt and consumption (Tables 4.4a and 4.4b). Conversely, young age (<20 y), young age at marriage (<18 y), and non-Hindu religion were negatively associated with IFA receipt (Table 4.4a). Women of scheduled castes or tribes were less likely to consume IFA for 90 or more days (Table 4.4b). For both outcomes, including ANC variables attenuated most of the associations between the individual factors and outcomes. The addition of HSC factors did not meaningfully impact these relationships (Tables 4.4a and 4.4b).

In our final multilevel model for IFA receipt, controlling for covariates and interactions, women were less likely to receive any IFA during their last pregnancy if they were Muslim or another religion (vs. Hindu) (OR: 0.79, 95% CI: 0.66, 0.94) and more likely to receive IFA if they were educated (5-8 y vs. none: OR: 1.26, 95% CI: 1.06, 1.49; ≥9 y vs. none: OR: 1.67, 95% CI: 1.35, 2.06), married as an adult (≥18 y vs. <18 y: OR: 1.21, 95% CI: 1.05, 1.39), and in the richest quintile (Fourth vs. Poorest Quintile: OR: 1.30, 95% CI: 1.03, 1.64) (Table 4.4a).

Fewer demographic variables were significantly associated with consumption of IFA for 90 or more days. Women were less likely to consume IFA for the recommended time frame if they were of a scheduled caste or tribe vs. others (OR: 0.71, 95% CI: 0.53, 0.97) and more likely to consume if they were in the richest wealth quintile vs. the poorest (OR: 2.05, 95% CI: 1.17, 3.56) or more educated (≥9 y vs. none: OR: 1.75, 95% CI: 1.24, 2.48) (Table 4.4b).

Antenatal Care Factors

ANC trimester of initiation and frequency were significantly positively associated with receipt of any IFA (early enrollment and ≥4 visits vs. late enrollment and <4 visits: OR: 3.53, 95% CI: 2.44, 5.11; late enrollment and ≥4 visits vs. late enrollment and <4 visits: OR: 2.44, 95% CI: 1.69, 3.51; early enrollment and <4 visits vs. late enrollment and <4 visits: OR: 1.36, 95% CI: 1.19, 1.55) (Table 4.4a). Women had especially high odds of IFA receipt when they attended 4 or more ANC check-ups.

Women were much more likely to receive IFA if they received more services at their ANC appointments and when they received more counseling. ANC quality factors did show a significant interaction in this model (OR: 0.37, 95% CI: 0.25, 0.56). This indicates that as a woman receives increasing ANC services or counseling, her receipt of the other factor has less influence on whether or not she receives IFA. In addition, the ANC practice factor significantly interacted with the ANC timing and frequency variable as well (OR: 0.68, 95% CI: 0.56, 0.82) (Table 4.4a). Examining this interaction further, we found that for women who attended <4 ANC visits, the ANC practice factor had a stronger impact on IFA receipt than women who attended 4 or more. Women who attended more ANC visits also were more likely to receive more ANC services, so there was less variation in this group.

Women who received any IFA were more likely to consume for 90 or more days if they attended 4 or more ANC appointments, regardless of the timing of their enrollment. Women were also more likely to consume IFA for 90 days if they received more antenatal care services (ANC services factor score 1-unit change: OR: 2.62, 95% CI: 1.86, 3.71) (Table 4.4b). Receipt of counseling was not significantly associated with

adequate IFA consumption. No significant interactions were found between ANC variables in this model.

Health Sub-Center Factors

No HSC factors showed a significant relationship to women's IFA receipt, including IFA supply and HSC proximity (Table 4a).

Only the Village Health Day & PHC/Village Monitoring factor (OR: 1.46, 95% CI: 1.03, 2.07) and IFA supply (OR: 1.33, 95% CI: 1.03, 1.71) were significantly associated with IFA consumption when controlling for demographic variables. In the final model, women living in villages where the HSC had IFA in stock on the day of the survey were more likely to have consumed IFA for 90 or more days during their last pregnancy (OR: 1.37, 95% CI: 1.04, 1.82) (Table 4.4b).

Random Effects and AIC

For each model presented, facility level random effects are presented along with standard errors. In addition, Akaike Information Criteria are reported to reflect overall fit of the model. For both outcomes of interest, the facility level variation is significant, indicating that both IFA receipt and IFA consumption of 90 days or more varied by both facility level factors in addition to individual characteristics of the women.

For IFA receipt, the addition of ANC variables (Timing and Frequency: 0.6641, SE: 0.0457; Quality: 0.6250, SE: 0.0469), HSC variables (0.6585, SE: 0.0443), and the cumulative models did appear to reduce the facility level random effects slightly, meaning that these variables helped to explain some of the variation between

communities. However, there are still significant differences between communities with regard to IFA receipt, as the random effects were still significant in our final model (0.6259, SE: 0.0473) (Table 4.4a).

In addition, our final model shows the best fit using AIC values. In particular, ANC Quality factors seem to improve fit more so than ANC Timing and Frequency or HSC factors.

For IFA consumption for 90 days or more, facility level variations did not decrease with addition of all factors to the model but rather increased slightly (Individual Model: 0.702; All Factors Model: 0.7805). Therefore in our analysis, our included ANC and HSC factors did not affect the variation between facility coverage areas. Unexplained variation still exists between these groups. However, AIC values do show that our final model fit the best out of those presented (AIC: 2747) (Table 4.4b).

Discussion

The results of this analysis demonstrate that individual and ANC factors are significantly associated with IFA receipt and consumption in this context. Surprisingly no HSC characteristics were associated with IFA receipt, though women covered by HSCs with IFA on the survey day did have higher odds of consuming IFA for 90 or more days.

Individual Factors

Both IFA receipt and consumption improved with higher educational attainment and household wealth. This relationship has been found in many studies and shown to play a role in a variety of maternal health service utilization patterns as well as pregnancy

outcomes[19,32,40]. Odds of IFA receipt were also significantly lower for those who married before 18 years of age and also for non-Hindus. Early marriage has been associated with inadequate maternal healthcare utilization[41,42] and pregnancy complications[31], which may be due to lack of decision-making power within the household in health related matters[43]. In our sample, the majority of non-Hindu women were Muslim (99.5%). Several studies in India have shown that Muslim women utilize maternal healthcare less than Hindu women[42], going to ASHAs for antenatal and postnatal activities[44], institutional delivery (in Bihar)[45], skilled attendants at delivery[46,47], and maternal and child IFA receipt[19]. One study suggested delivery care disparities in the Muslim community may be due to the practice of *purdah* (gender segregation)[46]. Women of scheduled castes or tribes were less likely to consume IFA for 90 or more days during their last pregnancy, though this was not a significant factor in IFA receipt. Pasricha et al.'s analysis of NFHS-3 national data also found a non-significant relationship between scheduled caste/tribe and maternal IFA receipt. However, they did find children in scheduled caste households were less likely to receive IFA supplementation[19]. In a smaller study in Karnataka, mothers in scheduled castes were less likely to receive IFA[19]. Scheduled castes or tribe populations are also often of lower socio-economic status and socially excluded, leading to a lack of healthcare access, although this relationship persisted when controlling for education and household wealth. All of these factors may impact both IFA receipt and adequate consumption[48]. It is interesting to note that these individual factors remained significant even when controlling for ANC services provided and counseling messages given. This may reflect a higher level of awareness to understand messages or different levels of treatment given by health providers even when similar services were given[49].

Antenatal Care Factors

Especially in low-resource settings, early and frequent ANC attendance may not translate into quality care or counseling[50]. Therefore, we constructed two factors to account for ANC quality: ANC service provision and counseling topics covered. The ANC service factor proved to be significant in both successful receipt and consumption of IFA, even after controlling for timing of initiation and frequency of ANC. This corroborates the findings of Pasricha et al. who also found ANC quality measures were significantly associated with IFA receipt in addition to ANC timing and frequency. Authors reported that women were more likely to have received antenatal IFA if they also received postnatal care or an antenatal blood test[19]. Our ANC measures included only components of antenatal care, which may be more useful when evaluating antenatal and postnatal care separately. In addition, the ANC service and ANC counseling factors may be applied to other outcomes during pregnancy as they provide a comprehensive assessment of high vs. low quality ANC instead of two specific practices.

For IFA receipt, we also found two significant interactions with ANC variables. The ANC practice and counseling interaction shows that as ANC services or counseling increase, the variation in the other factor has less influence on whether or not IFA is received. This may indicate that at a certain point the overall quality of the ANC check-up is high enough that IFA is being received and slight fluctuations in services or counseling received do not influence receipt of IFA as much. In comparison, among women receiving very few services or minimal counseling, a slight improvement in quality in either domain, services or counseling, has a greater impact on IFA receipt.

A significant interaction was also found between ANC practice and ANC timing & frequency. Examining this further, we found that for women attending fewer visits, receiving more services had a greater impact on IFA receipt than for those attending four or more visits. This seems to show that with fewer visits, the quality of those visits becomes increasingly important with regard to IFA receipt. This may occur because of inconsistent IFA supply, where increased healthcare interaction increases the odds of IFA availability. This finding may also add to the current debate of the WHO antenatal care model, which encourages a reduced visit schedule[51]. Our data suggest that increasing the number of required ANC visits may increase opportunities for IFA access and counseling surrounding consumption, especially when service delivery is poor. More ANC visits would also increase opportunities for ANC service provision and repetition of counseling messages. However, under optimal conditions, fewer ANC visits would be needed. It is also possible that women who attended ANC four or more times may also have easier access to the HSC e.g. live near a major roadway. Individual and household beliefs surrounding healthcare utilization may also play a role. For example, women may have greater decision-making power within the household, increased autonomy, or have a greater say in her healthcare needs. Another explanation may be that these were women suffering from pregnancy complications, attended more appointments, and therefore more likely to receive IFA.

Among those women who did receive IFA, consumption for 90 days or more was significantly associated with both receipt of more ANC practices and greater number of ANC visits. Increased ANC frequency may positively impact IFA consumption through repeated health worker contact and follow up, reminding women to consume IFA and

reinforcing counseling messages. Independently of repeated contacts, women who received more ANC services were also more likely to consume IFA for 90 or more days. This added correlation is often missed when including only ANC timing and frequency in models. The ANC counseling factor and early ANC enrollment with <4 appointments were not significantly associated with adequate IFA consumption. Though it was surprising that counseling did not impact IFA consumption, it should be noted that counseling specific to IFA was not asked about in the survey, which may have a more meaningful effect. In addition, the counseling variable was based on number of topics covered and did not take into account topic repetition or counseling quality. If <4 ANC visits were attended, initiating ANC in the first trimester did not increase the likelihood of consuming IFA for 90+ days. Effective IFA counseling and health worker engagement have been shown in other studies to be important determinants of adequate IFA consumption. Women not understanding the correct dosage and forgetfulness were cited by Seck et al. as significant barriers to IFA adherence[20]. A qualitative study in Tamil Nadu also noted the motivation of health workers and perceived need by the community as important determinants of antenatal iron supplementation compliance[52]. These aspects of counseling effectiveness and community awareness were not assessed in our analysis.

Health Sub-Center Factors

Studies show mixed results as to whether healthcare facility capacity is associated with earlier or more frequent ANC attendance. Some report that facility characteristics are associated with improved ANC utilization[47,53,54] though others cite non-significant relationships[55-57]. There is more consistency in the literature surrounding health facility access. Many studies do report travel time, distance, or health facility population

coverage as significant factors in adequate ANC attendance[47,53-55]. Haverkate et al.'s analysis of women's hemoglobin status found that hemoglobin differences due to wealth quintiles were attenuated by increased number of health facilities[58]. In our analyses, HSC capacity, access, and supply factors were not associated with any IFA receipt, regardless of whether ANC variables were included in the model or not. HSC supply of IFA is dependent upon the supply available at the block, which depends on IFA from the district level. As such, HSC IFA supply may serve as a proxy for availability in the district. This lack of association may have been influenced by the fact that many women who received IFA did so through a private source (62.8%), as opposed to a public source (38.4%). Also, the study excluded women who did not attend ANC. It is possible that the existence of HSC facilities is associated with population-level access to IFA even if there is no association among women attending ANC.

HSC capacity did play a slightly larger role in adequate IFA consumption. When ANC factors were not included in the model, the HSC factor *Village Health Day and PHC/Village Monitoring* was significantly and positively associated with IFA consumption for 90 or more days. One goal of Village Health Days is to provide ANC to pregnant women at the village level, which includes IFA distribution[38,59]. Therefore, it is encouraging that observation of Village Health Days and monitoring by the PHC and village was associated with increased IFA consumption. This relationship did become non-significant when ANC quality and frequency factors were included in the model. This may indicate that the Village Health Days' role in increasing IFA consumption is through increased service provision and contact between the healthcare worker and beneficiary during ANC.

IFA consumption for 90 or more days was also significantly associated with HSC IFA supply on the day of the survey. This shows the importance of supply in providing adequate IFA to women, as this is clearly a requirement for consuming IFA for the recommended time period. IFA availability at the point of contact is required to receive additional IFA, which is often spread out over three visits, and to receive follow up IFA counseling. This agrees with other studies which show lack of IFA supply as a barrier to IFA adherence[23,60,61]. Seck et al. also suggested that the presence of IFA can affect not only receipt of IFA by beneficiaries but also quality of IFA counseling. They suggested that healthcare workers who did have IFA may have more effectively counseled on the rationale for taking IFA than those who did not[20].

Strengths and Limitations

This study had several strengths. We utilized a state representative dataset of ever-married women in Bihar, India. This survey additionally linked healthcare facilities with the populations they serve, which made it possible to model health facility characteristics with relevant populations. In addition, we examined ANC quality as well as attendance and thus were able to measure the association of quality and timing/frequency to IFA receipt and consumption. We were also able to explore facility level factors and their relationship to provision of IFA and consumption among beneficiaries.

Our analysis also has some limitations. All variables included in the model were based upon self-report by the women or facility workers except for HSC building condition (reported by the interviewer). Women in our dataset were significantly different from the survey populations on several factors; most notably all had attended at least one ANC.

Therefore, our results are not generalizable to the women who did not access ANC. Additionally, the women included in our analysis did not exclusively attend ANC from a government source. In fact, the majority received at least some ANC through the private sector (40.8% vs. 33.0% from the public sector) or obtained IFA through a private source. Our ANC counseling variable contained several important topics of ANC, though we did not have a variable specific to IFA counseling, which would have been more pertinent to our analysis. Finally, our IFA supply variable was only a measure of IFA supply availability on the survey day. However, this was the most complete variable for IFA supply and directly measured the supplement of interest. IFA supply availability was not measured at the block or district level.

Implications

Overall, IFA receipt and consumption among pregnant women in rural Bihar are low and changes are needed to improve IFA delivery and compliance. Throughout Bihar, a consistent IFA supply is needed to provide women the opportunity to take IFA throughout pregnancy. Only 20% of HSCs in our sample had IFA on the day of the DLHS-3 survey. The Government of Bihar has taken steps to improve the supply of IFA and other essential drugs with the recent formation of the Bihar Medical Services & Infrastructure Corporation Limited[62] which has the goal of streamlining drug procurement and logistics[63]. Hopefully these efforts will greatly improve IFA supply in the region. It should also be noted that most women who did receive IFA received it from the private sector. Ensuring private providers and pharmacists have access to accurate information on IFA prophylaxis use during pregnancy may also aid in women's understanding and appropriate use of iron supplements.

Our multilevel models also showed a significant amount of variation at the facility level, which was not accounted for in our analyses. In this data, each facility covered a distinct village; therefore additional variation may have occurred at the facility or community level. Potential unmeasured community level factors include social norms surrounding healthcare utilization, social support, unmeasured access issues (e.g. flood prone communities), or women's empowerment to make health decisions [47,64]. Two multilevel analyses of maternal health utilization in India also found unexplained variance at the community and district levels for most outcomes, including ANC attendance. These studies focused on PHC characteristics at the district level and demographic variation at the community level[47,56]. Jat et al. also found no influence of PHC factors on maternal health service outcomes and hypothesized that this may be due to private healthcare utilization[56]. Interventions which go beyond the individual and household level to target facility and community level factors will be critical in addressing issues of both IFA receipt and adequate consumption. IFA distribution and counseling through other means in addition to ANC such as the private sector or community groups has also been suggested in areas with poor ANC coverage or quality[65]. Further research could examine this unexplained variance which may give insight on additional strategies to increase IFA receipt and consumption in Bihar.

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Table 4.1a: Characteristics and Rotated Factor Loadings for Antenatal Care Factors[a]

	ANC[b] Practices	ANC[b] Counseling
Eigenvalue	7.16	1.60
Proportion Variance Explained	0.73	0.16
Rotated Factor Loadings		
Blood Tested	0.87	-
Weight Measured	0.81	-
Abdomen Examined	0.81	-
Sonogram/Ultrasound Taken	0.80	-
Breast Examined	0.76	-
Height Measured	0.76	-
Delivery Date Given	0.72	-
Importance of Cleanliness at Delivery	-	0.83
Better Nutrition for Mother and Child	-	0.80
Family Planning for Spacing	-	0.75
Breastfeeding	-	0.75
Importance of Institutional Delivery	-	0.73
Nutrition Advice	-	0.59

[a] Factor loadings $\leq|0.5|$ are not shown.

[b] **ANC**: Antenatal Care

Table 4.1b: Characteristics and Rotated Factor Loadings for Health Sub-Center Factors[a]

	Village Health Day: Support & Monitoring	Personnel Characteristics	Sub Center Infrastructure
Eigenvalue	1.10	0.63	0.54
Proportion Variance Explained	0.42	0.24	0.21
Rotated Factor Loadings			
Observation of any Village Health Day	0.56	-	-
Written feedback from PHC[c]	0.50	-	-
VHSC[d] present in some villages in HSC[b] area	0.42	-	-
Medical Officer visited HSC[b] in previous month	0.36	-	-
Received and utilized untied funds from previous financial year	-	0.37	-
HSC[b] Personnel	-	0.46	-
HSC[b] Training	-	0.44	-
Present Condition of Existing Building	-	-	0.44
Water Available at Sub Center	-	-	0.43

[a] Factor loadings ≤|0.35| are not shown.
[b] **HSC**: Health Sub-Center
[c] **PHC**: Primary Health Center
[d] **VHSC**: Village Health and Sanitation Committee

Table 4.2: Variable Definitions Included in Multilevel Modeling of IFA Receipt and Consumption

Variables	*Description*
Facility Level Variables	
HSC Factors	Estimated factor scores calculated to describe overall HSC capacity
HSC Factor: Village Health Day and PHC/Village Monitoring	Estimated factor score describing Village Health Day observation and PHC/Village support and monitoring
Observation of Any Village Health Day	If the HSC worker conducts Village Health Day, a grouping of activities which includes IFA distribution to pregnant women – No(Ref.); Yes
Any written feedback from the PHC	If any written feedback from the PHC has been received in the previous month – No(Ref.); Yes
Village Health and Sanitation Committee	If Village Health and Sanitation Committee is present in some or all of the villages in the HSC coverage area – No(Ref.); Yes
Medical Officer visit	If a Medical Officer has visited the HSC in the previous month – No(Ref.); Yes
HSC Factor: Personnel	Estimated factor score describing personnel characteristics
Untied Funds	If HSC untied funds were received and at least partially utilized in the previous year – No(Ref.); Yes
Number of Personnel	Number of health workers at the HSC at the time of survey – 0-1 workers (Ref.); 2+ workers
Personnel Training	Number of training topics received by HSC workers in the last five years – 0-3 topics (Ref.); 4-8 topics
HSC Factor: Sub Center Infrastructure	Estimated factor score describing HSC infrastructure quality
Present Condition of Building	Present condition of HSC building as observed by interviewer – Needs repair (Ref.); Satisfactory
Water Available at Sub Center	If there is a source of water at the HSC – No(Ref.); Yes
IFA Stock Out on Day of Survey	If IFA is available on the day of the survey – No(Ref.); Yes
Distance to nearest HSC	Distance in km from the village to the nearest HSC – In village (Ref.); <5 km away; ≥5 km away
Individual Level Variables	
Age	Maternal age at index birth - <20y; 20-24y; >24y (Ref.)

Age Living with Husband	Maternal age when cohabitation with husband began - <18y; ≥18y (Ref.)
Maternal Education	Highest level of education attained in years – None or Don't know (Ref.); 1-4y; 5-8y; 9-12y; >12y
Gender Composition of Living Children	Presence of living sons – No(Ref.); Yes
Birth Order of Index Pregnancy	Birth order of the index pregnancy – 1st birth; 2nd birth; 3rd or greater birth (Ref.)
Caste	Caste of woman: scheduled caste, scheduled tribe, or other (Ref.)
Religion	Religion of woman: Hindu or Muslim/Other (Ref.)
Household Wealth Index Quintiles	Index of household assets calculated at the national level and divided into quintiles[25] – Poorest (Ref.); Second; Middle; Fourth; Richest
ANC Timing and Frequency	Recommended frequency and Initiation of ANC according to WHO standards[27] – 1st trimester and ≥4 visits (Ref.); 2nd-3rd trimester and ≥4 visits; 1st trimester and <4 visits; 2nd-3rd trimester and <4 visits
ANC Factors	Estimated factor scores calculated to describe overall ANC quality
ANC Factor: Practices	Estimated factor score describing specific practices occurring during ANC visits.
Abdomen Examined Blood Tested Breast Exam Delivery Date Given Height Measured Sonogram/Ultrasound Taken Weight Measured	Components of ANC visits were identified by women's self-report[25]. – No(Ref.); Yes
ANC Factor: Counseling Topics Covered	Estimated factor score describing specific counseling topics covered during ANC visits.
Better Nutrition for Mother and Child Breastfeeding Cleanliness at Delivery Family Planning – Spacing Importance of Institutional Delivery Nutrition Advice	Counseling topics addressed during ANC visits were identified by women's self-report[25]. – No(Ref.); Yes

IFA: Iron and Folic Acid; **PSU**: Primary Sampling Unit; **HSC**: Health Sub-Center; Ref.: Reference Value; **PHC**: Primary Health Center; **ANC**: Antenatal Care; **WHO**: World Health Organization

Table 4.3a: Individual Level Factors of Study Population by Prevalence of Iron and Folic Acid Receipt and Consumption

	Received Any IFA		*Chi-Square*	*Consumed IFA for 90+ Days*		*Chi-Square*
	N	%	p-value	N	%	p-value
Overall	7765	37.4		2905	23.8	
Age						
<20 y	1237	37.8	<0.0001	1148	22.4	0.2352
20-24 y	3071	42.0		468	23.1	
>24 y	3457	33.2		1289	25.2	
Age of Marriage						
<18 y	5602	33.2	<0.0001	1859	20.3	<0.0001
18 y	2163	48.3		1046	29.8	
Mother's Education						
None / Don't Know	4812	28.7	<0.0001	1382	14.6	<0.0001
1-4 y	610	36.7		224	18.3	
5-8 y	1202	46.5		559	25.9	
≥9 y	1141	64.9		740	40.8	
Gender Composition of Living Children						
No Sons	1782	41.2	0.0002	2171	22.9	0.0591
1+ Sons	5983	36.3		734	26.3	
Birth Order of Index Pregnancy						
1	1981	45.5	<0.0001	1251	19.0	<0.0001
2	1758	42.8		901	29.3	
≥3	4026	31.1		753	25.0	
Caste						
Scheduled Castes or Tribes	1671	33.8	0.0017	565	14.5	<0.0001
Others	6094	38.4		2340	26.0	
Religion						
Hindu	6486	38.9	<0.0001	2527	24.3	0.1135
Muslim & Others	1279	29.6		378	20.4	
Wealth Index Quintiles						
Poorest	2154	26.5	<0.0001	571	13.0	<0.0001
Second	3061	33.4		1023	19.3	
Middle	1510	44.4		671	23.3	
Fourth	835	59.0		493	37.8	
Richest	205	71.7		147	52.3	
Husband's Education						
None / Don't Know	2714	25.9	<0.0001	702	12.8	<0.0001
1-4 y	700	33.1		232	14.2	
5-8 y	1553	35.8		556	18.4	

9-12 y	2315	47.9		1109	30.4	
>12 y	483	63.3		306	41.8	
ANC[a] Timing & Frequency[b]			<0.0001			<0.0001
Early Enrollment & ≥4 ANC[a] Visits	837	71.7		600	49.5	
Late Enrollment & ≥4 ANC[a] Visits	215	63.7		137	40.9	
Early Enrollment & <4 ANC[a] Visits	2232	40.3		900	17.6	
Late Enrollment & <4 ANC[a] Visits	4481	28.3		1268	14.1	
ANC[a] Practices[b]			<0.0001			<0.0001
None	3903	19.2		749	9.2	
1-3	2630	48.9		1287	19.6	
4-7	1232	70.5		869	42.4	
ANC[a] Counseling[b]			<0.0001			<0.0001
None	2841	21.3		605	15.4	
1-3	3376	41.0		1385	20.4	
4-7	1548	59.1		915	34.3	

[a] **ANC**: Antenatal Care
[b] It should be noted that all women in the study population received at least one ANC visit. Those who did not attend ANC were not asked about IFA receipt or consumption.

Table 4.3b. Facility Level Factors of Study Population by Prevalence of Iron and Folic Acid Receipt and Consumption

		Received Any IFA	*Chi-Square*		*Consumed IFA for 90+ Days*	*Chi-Square*
	N	%	p-value	N	%	p-value
Overall	7765	37.4		2905	23.8	
HSC[a] Distance from Village						
In Village	3106	37.9	0.8364	1178	25.5	0.0986
<5km	3568	37.1		1325	23.6	
≥5km	1091	36.8		402	19.4	
IFA Out of Stock on Day of Survey			0.0611			0.0304
Yes	1560	39.9		623	27.6	
No	6205	36.8		2282	22.7	
Factor 1: VHD & PHC/Village Monitoring						
Observation of any Village Health Day			0.0609			0.005
No	3388	35.9		1216	20.8	
Yes	4377	38.6		1689	25.9	
Written feedback from PHC[b]			0.0576			0.0423
No	5352	36.4		1951	22.5	
Yes	2413	39.5		954	26.4	
VHSC[c] present in some villages in HSC[a] area			0.3213			0.1992
No	6259	37.0		2319	23.2	
Yes	1506	38.9		586	26.1	
Medical Officer visited HSC[a] in previous month			0.5713			0.5456
No	3445	37.9		1305	24.4	
Yes	4320	37.0		1600	23.3	

Factor 2: Personnel Characteristics						
Untied Funds[d]			0.8213			0.9473
No	6737	37.3		2516	23.8	
Yes	1028	37.8		389	23.6	
HSC[a] Personnel			0.4364			0.1464
0-1 worker	4210	36.9		1553	25.0	
2+ workers	3555	38.0		1352	22.3	
HSC[a] Training			0.0966			0.7253
0-3 topics	3327	36.0		1198	23.4	
4-8 topics	4438	38.5		1707	24.0	
Factor 3: Sub Center Infrastructure						
Present Condition of Existing Building			0.0082			0.0495
Needs Repair	5337	36.1		1926	25.0	
Good / Satisfactory	2428	40.3		979	21.2	
Water Available at Sub Center			0.2328			0.0616
No	3093	36.3		1123	21.7	
Yes	4672	38.1		1782	25.1	

[a] **HSC:** Health Sub-Center; b **PHC:** Primary Health Center; c **VHSC**: Village Health and Sanitation Committee; [d] Received and utilized untied funds from previous financial year

Table 4.4a. Multilevel Modeling of Any IFA Receipt During Last Pregnancy

Parameter	Individual Factors	ANC Factors		HSC Factors	All Factors	All Factors + Interactions
		Time	Quality			
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*	*OR (95% CI)*
Age						
<20 y	0.81 (0.66, 0.99)	0.89 (0.73, 1.10)	0.93 (0.76, 1.16)	0.81 (0.66, 0.99)	0.96 (0.77, 1.18)	0.95 (0.76, 1.17)
20-24 y	1.03 (0.91, 1.18)	1.05 (0.92, 1.20)	1.08 (0.94, 1.25)	1.03 (0.91, 1.18)	1.09 (0.95, 1.25)	1.08 (0.94, 1.24)
>24 y	1.00	1.00	1.00	1.00	1.00	1.00
Age of Marriage						
<18 y	1.00	1.00	1.00	1.00	1.00	1.00
18 y	1.18 (1.04, 1.35)	1.20 (1.05, 1.37)	1.19 (1.04, 1.37)	1.18 (1.04, 1.35)	1.20 (1.04, 1.37)	1.21 (1.05, 1.39)
Mother's Education						
None / Don't Know	1.00	1.00	1.00	1.00	1.00	1.00
1-4 y	1.18 (0.97, 1.44)	1.13 (0.93, 1.39)	1.00 (0.81, 1.23)	1.18 (0.97, 1.44)	1.00 (0.81, 1.23)	0.98 (0.79, 1.21)
5-8 y	1.46 (1.25, 1.71)	1.44 (1.22, 1.63)	1.26 (1.07, 1.49)	1.46 (1.24, 1.71)	1.27 (1.07, 1.50)	1.26 (1.06, 1.49)
≥9 y	2.42 (1.99, 2.95)	2.14 (1.75, 2.62)	1.69 (1.37, 2.08)	2.42 (1.99. 2.94)	1.67 (1.35, 2.05)	1.67 (1.35, 2.06)
Gender Composition of Living Children						

No Sons	1.00	0.97	0.99	1.00	0.98	0.97
	(0.88, 1.14)	(0.85, 1.11)	(0.86, 1.14)	(0.88, 1.14)	(0.85, 1.13)	(0.84, 1.12)
1+ Sons	1.00	1.00	1.00	1.00	1.00	1.00
Birth Order of Index Pregnancy						
1	1.66	1.41	1.22	1.66	1.18	1.18
	(1.39, 1.98)	(1.17, 1.68)	(1.01, 1.47)	(1.40, 1.99)	(0.98, 1.42)	(0.98, 1.42)
2	1.36	1.29	1.16	1.36	1.15	1.15
	(1.17, 1.58)	(1.10, 1.50)	(0.99, 1.36)	(1.17, 1.58)	(0.98, 1.35)	(0.98, 1.34)
≥3	1.00	1.00	1.00	1.00	1.00	1.00
Caste						
Scheduled Castes	1.01	1.06	1.10	1.01	1.12	1.13
& Tribes	(0.88, 1.16)	(0.92, 1.21)	(0.96, 1.27)	(0.88, 1.16)	(0.97, 1.29)	(0.98, 1.30)
Others	1.00	1.00	1.00	1.00	1.00	1.00
Religion						
Hindu	1.00	1.00	1.00	1.00	1.00	1.00
Muslim & Others	0.74	0.76	0.77	0.75	0.79	0.79
	(0.63, 0.88)	(0.64, 0.90)	(0.65, 0.92)	(0.64, 0.89)	(0.66, 0.94)	(0.66, 0.94)
Wealth Index Quintiles						
Poorest	1.00	1.00	1.00	1.00	1.00	1.00
Second	1.23	1.20	1.12	1.22	1.11	1.12
	(1.07, 1.41)	(1.05, 1.38)	(0.97, 1.29)	(1.07, 1.40)	(0.97, 1.28)	(0.97, 1.29)
Middle	1.48	1.34	1.20	1.48	1.17	1.16
	(1.25, 1.76)	(1.13, 1.59)	(1.43, 1.48)	(1.25, 1.75)	(0.98, 1.40)	(0.97, 1.39)
Fourth	1.89	1.68	1.31	1.87	1.29	1.30
	(1.51, 2.35)	(1.34, 2.10)	(1.04, 1.66)	(1.50, 2.33)	(1.02, 1.63)	(1.03, 1.64)
Richest	2.48	1.95	1.30	2.46	1.23	1.31
	(1.69, 3.63)	(1.31, 2.89)	(0.86, 1.95)	(1.68, 3.61)	(0.82, 1.86)	(0.87, 1.97)
Husband's Education						
None / Don't Know	1.00	1.00	1.00	1.00	1.00	1.00

1-4 y	1.29 (1.06, 1.57)	1.25 (1.03, 1.53)	1.20 (0.98, 1.47)	1.29 (1.06, 1.57)	1.19 (0.97, 1.45)	1.16 (0.95, 1.43)
5-8 y	1.24 (1.06, 1.44)	1.21 (1.04, 1.42)	1.10 (0.94, 1.29)	1.24 (1.06, 1.44)	1.11 (0.94, 1.30)	1.09 (0.93, 1.28)
9-12 y	1.38 (1.17, 1.61)	1.26 (1.07, 1.48)	1.10 (0.93, 1.30)	1.37 (1.17, 1.60)	1.08 (0.91, 1.27)	1.06 (0.90, 1.26)
>12 y	1.62 (1.24, 2.12)	1.44 (1.09, 1.89)	1.19 (0.90, 1.59)	1.62 (1.23, 2.11)	1.17 (0.88, 1.56)	1.15 (0.86, 1.53)
Antenatal Care Timing and Frequency						
Early enrollment and ≥4 visits		4.30 (3.56, 5.19)			1.85 (1.50, 2.28)	3.53 (2.44, 5.11)
Late enrollment and ≥4 visits		2.59 (2.61, 4.93)			1.75 (1.25, 2.45)	2.44 (1.69, 3.51)
Early enrollment and <4 visits		1.52 (1.35, 1.72)			1.27 (1.12, 1.43)	1.36 (1.19, 1.55)
Late enrollment and <4 visits		1.00			1.00	1.00
ANC Factors						
Practice			7.17 (5.89, 8.73)		5.56 (4.50, 6.87)	13.12 (9.51, 18.09)
Counseling			1.90 (1.62, 2.21)		1.86 (1.59, 2.18)	2.61 (2.12, 3.21)
*Practice*Counseling Interaction*						0.37 (0.25, 0.56)
*Timing & Frequency * Practice*						0.68 (0.56, 0.82)
HSC Factors						
VHD & PHC/Village Monitoring				1.13 (0.90, 1.40)	1.10 (0.88, 1.37)	1.11 (0.89, 1.38)
Personnel Characteristics				1.13 (0.87, 1.48)	1.03 (0.79, 1.35)	1.01 (0.77, 1.32)

Sub Center				1.25	1.21	1.22
Infrastructure				(0.93, 1.67)	(0.90, 1.62)	(0.91, 1.64)
IFA Stock Out on Day of Survey						
Yes				1.09	1.08	1.09
				(0.92, 1.29)	(0.91, 1.28)	(0.92, 1.29)
No				1.00	1.00	1.00
Distance to Nearest HSC						
In Village						
<5 km				0.96	0.94	0.93
				(0.83, 1.11)	(0.81, 1.09)	(0.80, 1.08)
≥5 km				0.95	0.90	0.90
				(0.78, 1.17)	(0.73, 1.11)	(0.73, 1.10)
Community Level Random Effect (SE)	0.6636 (0.0442)	0.6441 (0.0457)	0.6250 (0.0469)	0.6585 (0.0443)	0.6180 (0.0473)	0.6259 (0.0473)
AIC	9421.26	9140.56	8712.50	9427.16	8683.59	8636.77

ANC: Antenatal Care; **HSC**: Health Sub-Center; **PHC**: Primary Health Center; **SE**: Standard Error; **AIC**: Akaike Information Criterion

Table 4.4b. Multilevel Modeling of IFA Consumption for 90+ Days During Last Pregnancy

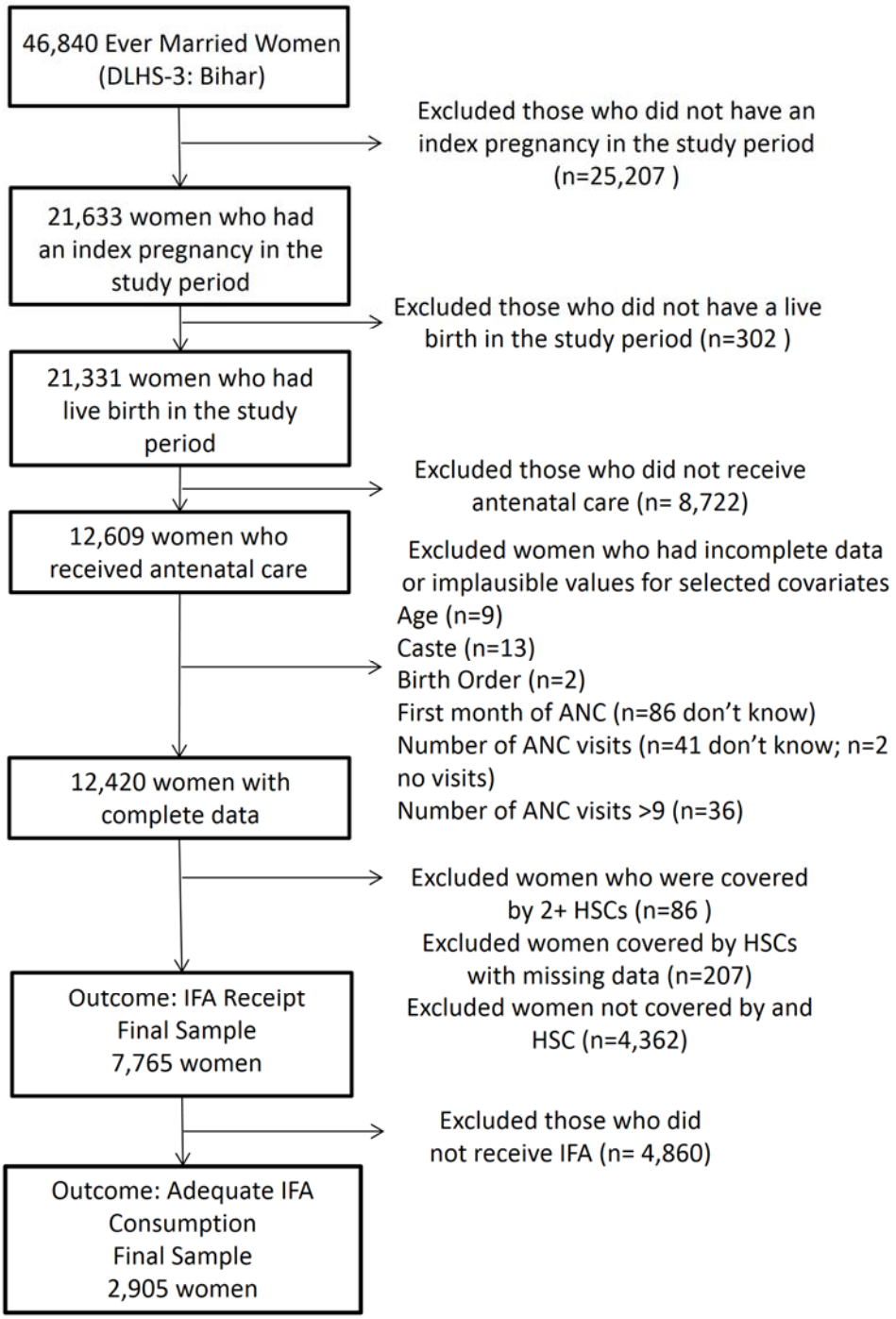
Parameter	Individual Factors	ANC Factors		HSC Factors	All Factors
		Time	Quality		
	OR (95% CI)	*OR*	*OR*	*OR*	*OR*
Age					
<20 y	0.68 (0.47, 1.00)	0.81 (0.55, 1.21)	0.78 (0.53, 1.14)	0.67 (0.46, 0.98)	0.84 (0.57, 1.25)
20-24 y	0.82 (0.64, 1.05)	0.84 (0.65, 1.09)	0.85 (0.66, 1.09)	0.81 (0.64, 1.04)	0.84 (0.65, 1.10)
>24 y	1.00	1.00	1.00	1.00	1.00
Age of Marriage					
<18 y	1.00	1.00	1.00	1.00	1.00
18 y	0.82 (0.65, 1.04)	0.82 (0.64, 1.06)	0.82 (0.64, 1.05)	0.81 (0.64, 1.02)	0.81 (0.63, 1.04)
Mother's Education					
None / Don't Know	1.00	1.00	1.00	1.00	1.00
1-4 y	1.13 (0.75, 1.69)	1.07 (0.7, 1.65)	1.05 (0.69, 1.60)	1.14 (0.76, 1.71)	1.05 (0.68, 1.62)
5-8 y	1.39 (1.03, 1.88)	1.37 (1.00, 1.88)	1.26 (0.92, 1.71)	1.4 (1.04, 1.9)	1.31 (0.95, 1.80)
≥9 y	2.16 (1.56, 2.98)	1.88 (1.34, 2.65)	1.84 (1.31, 2.57)	2.14 (1.55, 2.96)	1.75 (1.24, 2.48)
Gender Composition of Living Children					
No Sons	1.06 (0.84, 1.34)	1.06 (0.82, 1.35)	1.08 (0.85, 1.37)	1.05 (0.83, 1.33)	1.05 (0.82, 1.35)
1+ Sons	1.00	1.00	1.00	1.00	1.00
Birth Order of Index Pregnancy					
1	1.73 (1.27, 2.36)	1.31 (0.94, 1.82)	1.36 (0.99, 1.88)	1.76 (1.29, 2.41)	1.22 (0.88, 1.71)
2	1.2 (0.91, 1.59)	1.08 (0.81, 1.44)	1.06 (0.8, 1.41)	1.23 (0.93, 1.62)	1.04 (0.77, 1.39)

≥3	1.00	1.00	1.00	1.00	1.00
Caste					
Scheduled Castes & Tribes	0.62 (0.46, 0.83)	0.68 (0.50, 0.92)	0.69 (0.51, 0.93)	0.62 (0.47, 0.83)	0.71 (0.53, 0.97)
Others	1.00	1.00	1.00	1.00	1.00
Religion					
Hindu	1.00	1.00	1.00	1.00	1.00
Muslim & Others	1.02 (0.74, 1.41)	1.01 (0.72, 1.42)	1.07 (0.76, 1.49)	1.02 (0.74, 1.41)	1.03 (0.73, 1.46)
Wealth Index Quintiles					
Poorest	1.00	1.00	1.00	1.00	1.00
Second	1.3 (0.94, 1.79)	1.31 (0.94, 1.84)	1.16 (0.84, 1.61)	1.27 (0.92, 1.74)	1.18 (0.84, 1.66)
Middle	1.23 (0.86, 1.77)	1.07 (0.74, 1.56)	1.01 (0.7, 1.46)	1.22 (0.85, 1.74)	0.96 (0.65, 1.4)
Fourth	1.79 (1.2, 2.65)	1.59 (1.05, 2.41)	1.31 (0.87, 1.98)	1.75 (1.18, 2.60)	1.31 (0.86, 2.00)
Richest	2.99 (1.78, 5.01)	2.62 (1.52, 4.54)	1.96 (1.15, 3.35)	2.95 (1.76, 4.95)	2.05 (1.17, 3.56)
Husband's Education					
None / Don't Know	1.00	1.00	1.00	1.00	1.00
1-4 y	1.06 (0.67, 1.68)	1.06 (0.66, 1.71)	0.97 (0.61, 1.56)	1.04 (0.66, 1.66)	0.98 (0.61, 1.60)
5-8 y	1.26 (0.89, 1.78)	1.2 (0.84, 1.71)	1.11 (0.78, 1.59)	1.29 (0.91, 1.81)	1.13 (0.79, 1.63)
9-12 y	1.64 (1.17, 2.29)	1.47 (1.03, 2.08)	1.36 (0.96, 1.92)	1.65 (1.18, 2.31)	1.32 (0.93, 1.89)
>12 y	1.97 (1.27, 3.05)	1.65 (1.04, 2.61)	1.58 (1, 2.48)	1.98 (1.28, 3.07)	1.48 (0.93, 2.36)
Antenatal Care Timing and Frequency					
Early enrollment and ≥4 visits		4.85 (3.66, 6.43)			3.4 (2.52, 4.59)

Late enrollment and ≥4 visits		4.27 (2.75, 6.62)			3.19 (2.03, 5.01)
Early enrollment and <4 visits		1.15 (0.89, 1.5)			1.05 (0.81, 1.37)
Late enrollment and <4 visits					
ANC Factors					
Practice			4.6 (3.35, 6.32)		2.62 (1.86, 3.71)
Counseling			1.11 (0.86, 1.43)		1.08 (0.83, 1.4)
HSC Factors					
VHD & PHC/Village Monitoring				1.46 (1.03, 2.07)	1.43 (0.98, 2.09)
Personnel Characteristics				0.81 (0.53, 1.24)	0.87 (0.55, 1.38)
Sub Center Infrastructure				0.73 (0.46, 1.17)	0.69 (0.42, 1.14)
IFA Stock Out on Day of Survey					
Yes				1.33 (1.03, 1.71)	1.37 (1.04, 1.82)
No				1.00	1.00
Distance to Nearest HSC					
In Village				1.00	1.00
<5 km				0.94 (0.74, 1.18)	0.95 (0.74, 1.22)
≥5 km				0.72 (0.51, 1.02)	0.73 (0.51, 1.06)
Community Level Random Effect	0.702 (0.106)	0.794 (0.108)	0.733 (0.107)	0.682 (0.106)	0.781 (0.108)
AIC	2950	2780.37	2838	2946	2746.6

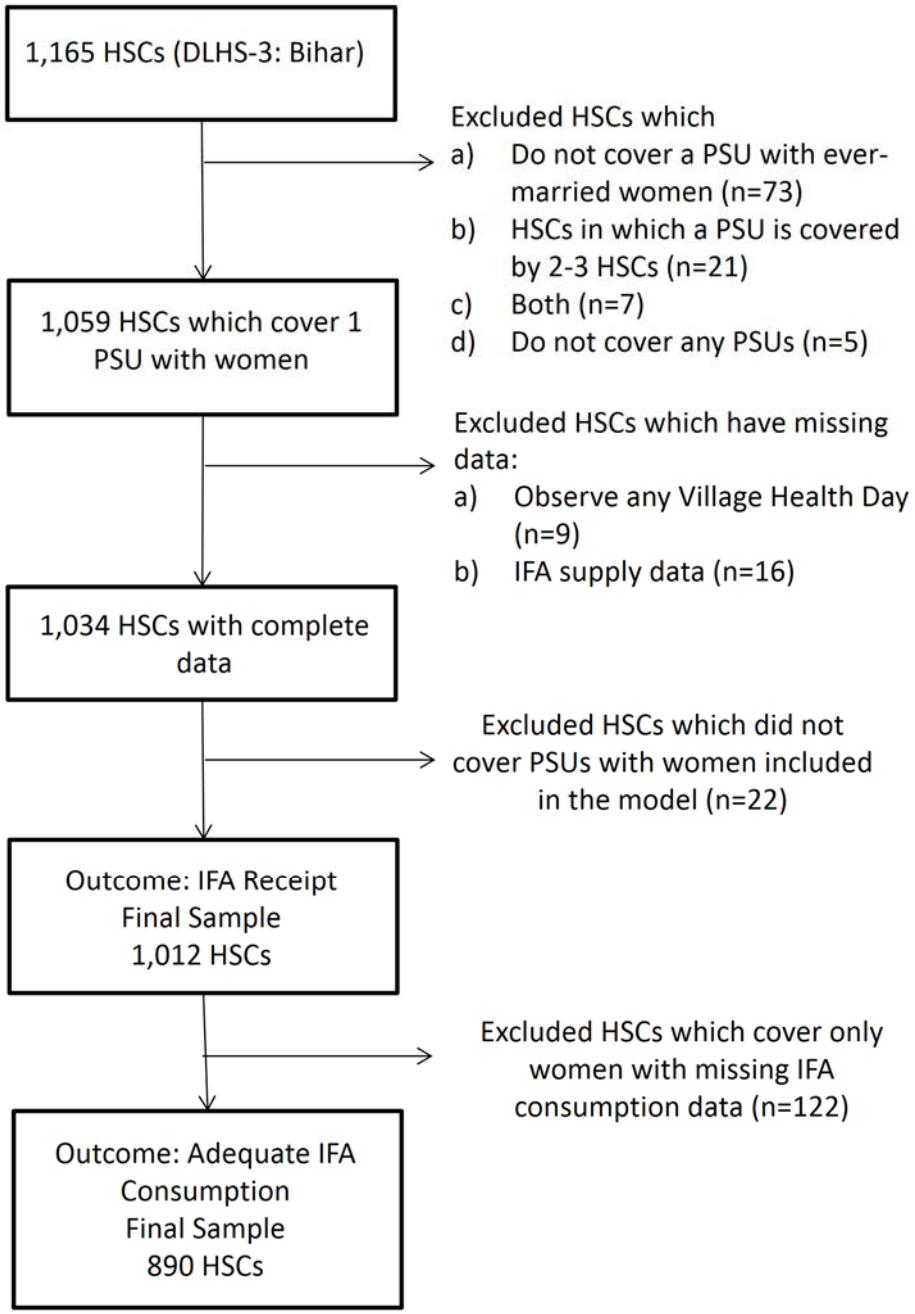
ANC: Antenatal Care; **HSC**: Health Sub-Center; **PHC**: Primary Health Center; **AIC**: Akaike Information Criterion

Figure 4.1a. Flowchart of Ever-Married Women Exclusions and Final Sample



Flowchart of exclusions and final sample of ever-married women surveyed in Bihar through DLHS-3.
DLHS: District Household Survey; **ANC**: antenatal care; **HSC**: health sub-center; **IFA**: iron and folic acid tablets or syrup

Figure 4.1b. Flowchart of Health Sub-Center Exclusions and Final Sample



Flowchart of exclusions and final sample of health sub-centers surveyed in Bihar through DLHS-3.
HSC: Health Sub-Center; **DLHS**: District Level Household Survey; **PSU**: Primary Sampling Unity; **IFA**: iron and folic acid tablets or syrup

Chapter 5:

Identifying Bottlenecks in the IFA Supply Chain in Bihar, India

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Abstract

Objective: To examine the current status of the government health system's iron and folic acid (IFA) supply and distribution system and to identify bottlenecks that may contribute to insufficient IFA supply.

Data Sources / Study Setting: Primary data collection was conducted in November 2011 and July 2012. Interviews and surveys were done across 8 districts in Bihar, India.

Study Design: A cross-sectional, observational, mixed methods approach was utilized. Surveys were conducted to examine IFA supply and practices of receipt and distribution. In-depth interviews were conducted with health workers at the state, district, block, sub-

center, and village levels. These explored the respondent's perceived role in the supply chain, forecasting, purchasing or requests, distribution, and trainings received.

Data Collection: Survey response rate was 83% (n=340). Descriptive statistical analyses and bivariate logistic regression was utilized. In-depth interviews totaled 59. Thematic analysis and cross-comparison across health worker type, level, and district were utilized to identify key bottlenecks in the supply chain.

Principal Findings: Overall, 44.1% of ANMs were out of IFA stock. Stock levels and supply chain practices varied greatly across districts. Qualitative data revealed specific bottlenecks impacting IFA forecasting, procurement, handling of expired drugs, storage, lack of personnel, and few opportunities for training for key players in the supply chain.

Conclusions: Inadequate IFA supply is a major constraint to the IFA supplementation program, the extent of which varies widely across districts. Improvements at all levels in infrastructure, practices, and effective monitoring will be critical to strengthen the IFA supply chain in Bihar.

Key Words: iron and folic acid, supply chain, pregnant women, anemia

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Introduction

Worldwide 1.62 billion people are estimated to have anemia [1]. A recent analysis estimates that anemia affects 38% or 32 million pregnant women globally[2]. In Bihar,

India, these numbers are even higher with 68% of ever-married women (15-49y) and 60% of pregnant women estimated to be anemic, even higher than national prevalence estimates (56% and 58%, respectively)[3]. Women with maternal anemia are more likely to deliver preterm, and have offspring with low birth weight[4] and low fetal iron stores leading to impaired cognitive development[5]. Severe anemia can lead to complications during delivery including increased blood loss, cardiac failure, and maternal mortality[4]. Oral iron supplementation is well documented as effective treatment and prevention for iron deficiency anemia[6,7].

In 1970, the Government of India established the National Nutritional Anemia Prophylaxis Program to address widespread anemia, targeting high risk groups for iron supplementation. They expanded the program in 1991 to include universal supplementation of pregnant and lactating women as part of standard antenatal care. Current iron recommendations include a daily dose of 100mg elemental iron for 100 or more days starting at 14-16 weeks during pregnancy continuing through the 3rd month post-partum[8]. The preferred compound of iron is not specified. Unfortunately, high anemia prevalence in the nineties persisted[4]. In Bihar although 84.5% of women report attending an antenatal care (ANC) check-up, only 10% report consuming iron and folic acid (IFA) supplements for at least 100 days during their last pregnancy[9]. Investigators who have assessed low IFA intake among pregnant women in India and other low and middle income countries cite many barriers to use including gastrointestinal side effects[6,10-13], lack of comprehensive counseling by health providers[14-17], IFA negatively seen as a medicine[14], and distrust of government IFA or freely available IFA[14,17]. IFA supply issues have also been recognized as an important barrier to IFA adherence in

several contexts[14,16,17]. Supply chain issues may be a major problem in Bihar. According to facility data from a nationally representative sample of health facilities, 78% of health sub-centers surveyed in Bihar reported being out of IFA stock for 10 or more days during the previous month[18]. To our knowledge, no studies to date have set out to specifically and comprehensibly describe the IFA supply chain in India, characterize the potential bottlenecks that produce barriers to access and availability, and identify feasible and contextually relevant solutions.

Our objective was to explore the current status of the Government of Bihar's IFA supply and distribution system to identify bottlenecks that may contribute to insufficient or inconsistent supply. Based on knowledge gained from participant responses, we then offer practical recommendations that can be implemented by the government and collaborating organizations.

Methods

From November 2011 – July 2012 we conducted a cross-sectional, mixed methods study to characterize IFA supply chain protocols and procedures across 8 districts in Bihar. These districts were the initial focus districts of a five year project CARE Bihar is conducting called the Integrated Family Health Initiative (IFHI) with financial support from the Bill and Melinda Gates Foundation. This program supports the Government of Bihar to improve maternal and child health outcomes throughout the state by increasing delivery, uptake, and utilization of key family health services[19]. Our study consisted of qualitative in-depth interviews with key players in the IFA supply chain and a survey

distributed to Auxiliary Nurse Midwives (ANMs) who are lowest level of the supply chain.

To assess the IFA supply chain, we collected both qualitative and quantitative data. From this we developed an overall description of the IFA supply chain in Bihar in addition to how ANMs receive and distribute IFA from the sub-centers using survey data. From the qualitative data, we present bottlenecks in the IFA supply chain identified by interview participants.

Qualitative In-Depth Interviews

Participants

In total, 59 in-depth interviews were conducted with health workers and medical supply managers at state, district, block, sub-center, and village levels. Officials in the Health Department, National Rural Health Mission (NRHM), and Integrated Child Development Scheme (ICDS), were included (Table 5.1). ANMs, Accredited Social Health Activists (ASHAs), and Anganwadi Workers (AWWs) are all classified as frontline workers (FLWs) as they are responsible for IFA distribution to beneficiaries in the field.

In-depth interview meetings were requested by CARE staff to healthcare workers at the district, block, and village level. Selection of frontline workers was based upon *a priori* selection of health sub-centers their respective coverage areas. Village level workers were interviewed based on assigned coverage area and availability. Initially, blocks close and far from the district capital, as defined by CARE staff, were chosen to add variation to the sample. Later, to avoid biased selection, blocks were selected randomly. However, some modifications were made as some blocks were too far to visit given time constraints.

Data Collection

In-depth interview guides, first drafted in English, focused on the respondent's perceived role in IFA receipt and distribution, IFA need estimation, and trainings received. Guides were constructed taking into account both relevant literature[16] and iterative discussions with co-authors and CARE Bihar personnel. One bilingual research assistant used English guides to conduct interviews. Quality and accuracy were verified through extensive training and review of recordings. Other interviewers required interview guides translated into Hindi. These guides were reviewed by external bilingual researchers to ensure validity. Interviews conducted in Hindi lasted between 30 and 60 minutes. The research assistants were trained in appropriate qualitative research techniques and debriefed daily with the primary author. Interviews were recorded. Notes and observations were also written at the time of the interview. The majority of recordings were transcribed directly into English by a bilingual researcher. In 2012, 10 additional interviews were conducted. These were transcribed into Hindi and then translated into English in a two-step process. On a subset of transcripts, quality checks were completed by comparison of recordings to transcripts by an external bilingual researcher.

Data Management and Analysis

All transcripts were de-identified for analysis. Deductive and inductive codes were created based on research questions, field notes, and participant responses. A codebook was designed including code definitions, inclusion and exclusion criteria, and examples of code use. Thematic analysis was conducted to identify major themes and supply chain bottlenecks. These were then compared across districts, occupation groups, and supply

chain levels (e.g. district, block, HSC, village). Supply chain bottlenecks were identified throughout the transcripts and compared across groups of respondents to highlight key similarities and differences. Practical recommendations were derived from respondent suggestions, published evaluations of Bihar's drug supply chain, and analysis of the data. Analyses were conducted using MAXQDA (version 10, VERBI Software).

Auxiliary Nurse Midwife Surveys

Participants

ANMs were chosen as the target participants for this survey because of their dual role as part of the IFA supply chain and as key distributors of IFA to beneficiaries. ANMs are responsible for their own drug supply management and being at the bottom of the supply chain, are most affected when both district and block shortages occur.

ANMs predominantly work at health sub-centers, which should serve a population of 3,000 - 5,000[20], and coordinate IFA distribution with ASHAs and AWWs, who work at the village level (AWC Population Norm: 300-800) [21].

Data Collection

We constructed a 27-item survey in collaboration with CARE Bihar staff to assess ANM IFA supply and protocols in the region. We randomly selected three ANMs from each of the 137 blocks across the 8 districts. A list of ANMs in each block was provided. Each ANM name was given a number and three numbers were randomly selected. If an ANM was no longer assigned to that block or refused, then another ANM was chosen randomly using the same system. CARE block coordinators who had been trained on survey

contents and overall study objectives administered the surveys to the ANMs. We did not collect names on the survey forms to ensure confidentiality.

Data Management and Analysis

Block coordinators turned in completed surveys to CARE district offices which forwarded them to the state office. Trained research assistants input the data into an Excel spreadsheet (Microsoft Excel 2010, Redmond, WA) and quality checks were completed by the primary author.

All analyses were conducted using SAS v9.2 (SAS Inc., Cary, NC, USA). We calculated survey weights to account for non-responses, differing numbers of ANMs per block, and numbers of blocks per district. Following this, we calculated descriptive statistics including means and frequencies. Of the 137 blocks invited to participate, 11 blocks did not respond. Therefore, represented blocks (n=126) were compared with non-responsive blocks (n=11) on 7 antenatal care quality and coverage characteristics obtained from CARE program baseline data [22]. The 11 blocks not represented in our data were found to have fewer pregnant women receiving counseling during their last pregnancy by frontline workers (either ANMs, ASHAs, or AWWs) on the topics of pregnancy danger signs ($p<0.0001$), emergency preparedness ($p=0.04$), and family planning ($p<0.0001$). We found no significant differences when comparing the number of mothers who during their last pregnancy: received at least 90 IFA tablets, were visited two or more times during the last trimester by any FLW, received advice from FLWs on immediate newborn care, or delivered their last child at a health facility(data not shown) (Unpublished data, CARE India).

Ethics

To maintain confidentiality, all districts were assigned letters (A, B, C, D, E, F, G, H) and health workers are referred to as state, district, and block officials. ANMs, AWWs, and ASHAs are referred to by their titles and all storekeepers, including pharmacists and clerks with storekeeper responsibilities, are referred to as storekeepers.

The Institutional Review Board of Emory University reviewed and approved this study's protocol. All respondents provided informed oral consent.

Results

IFA Procurement and Distribution

The State Health Society (SHS) selects companies and fixes rates for drugs through a competitive bidding process. According to our interviews, districts receive funding for medicines based on population. However, other literature states that this is based on previous consumption[23,24]. Actual purchasing is decentralized to the district level. The Civil Surgeon (CS) is responsible for submitting the purchase order based on State Health Society and District Store information, which is then approved by the District Magistrate. IFA is usually purchased on an annual or biannual basis. Once drugs are received, drug quantity is verified by the District Magistrate's office and drug quality by a drug inspector. After this, district storekeepers distribute stock to each PHC. Block officials are responsible for hiring a vehicle to transport stock to and from the district store. Written requests for stock from the block level are approved by the medical officer in charge (MOIC), then the Civil Surgeon, and finally sent to the District Store for fulfilment. Often when district storekeepers receive IFA, they distribute it to blocks

through a push system (e.g. without requiring requests for additional drugs). ANMs are the primary recipients of IFA from the primary health care centers. ASHAs initially received IFA in their ASHA kits but now are replenishing their stock using the block supply. The Anganwadi Worker's IFA supply for distribution is at the discretion of the ANM or ASHA as she does not receive IFA through ICDS. Though all three frontline workers have the capacity to distribute IFA, they play varying roles. All distribute at the Anganwadi Center (AWC) during monthly Village Health, Sanitation, and Nutrition Days (VHSND). The ANM additionally distributes IFA at her health sub-center (HSC). The ASHAs and AWWs promote the VHSNDs and bring pregnant women to the Anganwadi Center. Pregnant women who are registered but miss a VHSND are placed on a "due list." These women are then visited by either an ASHA or Anganwadi Worker and given IFA (Figure 5.1). While there are national and state government policies in place for essential medicine procurement in Bihar, lack of clarity and documentation have been cited as barriers to the successful implementation of this process[23]. This has also led to variability in supply chain performance across districts (Figure 5.2). In addition, there is little guidance concerning IFA supply at the more peripheral levels. For example, frontline workers (ANM, ASHA, and AWW) have specific guidelines for IFA distribution during antenatal care[25], however proper stock management is not addressed.

ANM Survey Results

In total, 340 ANM surveys were completed for an 83% response rate. ANMs reported that their health sub-center's coverage population was on average 9,471, almost twice as large as the government norm (Table 5.2). Only 55.9% of ANMs reported having IFA in stock (Table 5.3). Those that did have IFA reported an average stock of 4,306 tablets

(Table 5.2). By district, the percentage of ANMs who reported a current IFA stock out varied greatly ranging from 0-90.5% (Table 5.3). Of the 340 ANMs surveyed, only 71 reported distributing IFA to AWWs in the last month (mean tablets distributed: 1,547 tablets) whereas 131 reported distributing IFA to ASHAs (mean: 619 tablets) (Table 5.2).

Approximately 10% of ANMs reported they could not request IFA from the PHC and that they only receive it through fixed deliveries (push system). However this percentage varied widely by district from 3.5% in district G to 19.8% in District H. Over one fifth (21.8%) of ANMs said that they only request IFA after they are completely out and therefore do not maintain a buffer stock. This also varied greatly between districts (Table 5.3). Those that kept buffer stocks, reported a wide range of stock levels with a mean buffer stock estimate of 751 tablets (Table 5.2). Only 2.9% of ANMs reported that they could use health sub-center funds to purchase IFA locally (data not shown) while 67.8% said they could only receive IFA at the PHC. These percentages differed greatly by district (Table 5.3). ANMs who did report using a buffer stock system were more likely to have IFA in stock at the time of the survey (OR: 3.0 [1. 5, 6.0] (p=0.0022)).

Qualitative Data Results

Our analysis of the in-depth interviews revealed several key bottlenecks at various levels in the IFA supply chain.

IFA Need

IFA need was most often reported to be calculated based on the district size with 3-3.3% of the total population estimated to be pregnant women. Lactating women, despite being entitled to IFA by policy mandate[8], were not included in this estimate. Some officials

emphasized that data from the blocks were not even needed to arrive at this estimate. *"No! We don't need a requirement [from the PHCs] for placing the order. The number of pregnant women... is calculated. So we place [the order] as per the population"* (District F Official).

IFA Requests

IFA Purchasing - District

According to the state official, suppliers should have medicines ready in 45 days for the first order and within 21 days for subsequent orders. To increase supplier accountability to this timeline, the State Health Society established a penalty for late deliveries. *"If they don't deliver on time then from 0.5% per day up to 37% I'll deduct their money from the payment"* (State Official). However, in almost all districts, drugs were received an estimated one to three months after the purchase order was submitted. *"And by the way, there is no supplier who will supply you the order at a time. This problem is always there in the supply chain. If we place an order, we get it after 3 months"* (District C Official). *"It takes about one and a half to two months to get the [IFA] delivery"* (District A Official). Reporting delayed shipments to the State Health Society was only described to us by two of the eight districts. In contrast, most districts did not articulate a strategy to encourage timely drug delivery. *"We just wait for the further supply of the tablets from the company"* was the response from one District B Official during times of IFA shortage.

Block Requests

Though a clear system for requesting IFA exists, the use and perceived effectiveness of written requests varied between districts. What the blocks receive is largely dependent on district store supply, getting more when abundant and less if there are fewer IFA supplements in stock. In District C, a block official explained that they do not request out of stock drugs because they call the district beforehand and therefore know what is available. If there is no stock available, *"I just wait"* (District F Block Official) was a common response. In District D, they further emphasized that they receive IFA only from the district store (vs. an alternative source). In District A, they also mentioned feeling helpless when they had no medicines and could not get more through local purchasing. *"What will we do? We are helpless. We send the indents [written requests] regularly to send us folic acid. All the basic medicines which are needed to run the hospital, like Paracetamol, Methergine, etc…. even that is not being supplied from the past one and a half years"* (District A Block Official).

In some cases, the entire process of filing a written request for IFA was not seen as a useful exercise. *"Well! There is no result of sending the indent. Whenever they get the IFA they inform us and we get it from them. For our safe side we send the indent so that no one points us out that 'you were not having the IFA, so what did you do about that?'"* (District C Storekeeper). However, in District A, where IFA had been in shortage for several months, an MOIC reported that there was no result despite sending requests for IFA each month.

ANM Requests

There were also some inconsistencies and challenges reported by the ANMs and the primary health care center store regarding IFA requests. Block officials often reported that ANMs submitted written requests while many ANMs stated that they received IFA from the store without submitting an estimate of their need. Some ANMs however mentioned that they submitted a written or verbal request if the needed additional stock between fixed distributions. ANMs were also responsible for drug transport. None reported using HSC funds for this, but rather taking drugs to the health sub-center at their own expense. When primary health care centers did not have IFA in stock, ANMs reported there was no other way to purchase IFA locally for distribution, *"If there will be no stock at the PHC then what can we do?"* (ANM, District G). At one block, a storekeeper also told us of a different issue, namely ANMs not wanting to take IFA and other medicines because of difficulties in transportation or what he perceived as apathy.

> *They [ANMs] don't want to take it… we have to make them. At times, they even make excuses like I have not brought my bag this week when I'll come next week then will take it. Then they take the medicines afterwards.* (District F Storekeeper)

Buffer Stock

Although several officials and storekeepers spoke of keeping buffer stocks, extra stock set aside to avoid stock outs between purchases, we did not observe buffer stocks in these stores (n= 3). All district and block storekeepers who had recently ordered IFA, had done so only when they were completely out of stock. In multiple stores there was little or no IFA, and the storekeeper spoke of the futility of writing a written request except in the case of an audit. In other stores, we were told buffer stocks were unnecessary. *"We never*

felt the need of keeping buffer stock and never faced shortage" (District F Official). Some described their stocking practices which clearly did not involve buffer stock use, *"I distribute only to those whose stock gets over"* (District F Storekeeper).

Expiring & Expired Medicines

The most common strategy reported to handle expiring drugs (IFA shelf life was 17-23 months) was to distribute them as quickly as possible. One storekeeper explained *"We have the pressure of consuming the IFA before it gets expired"* (District C Block Storekeeper). Another block described what happened when they tried to return expiring drugs back to the district, *"Then they instruct us to consume the maximum at your level, as there is no need of return, and even it is not done, and 'til date has not been returned. I cannot even tell you how these medicines are disposed. We just inform the MOIC and doctor about the status and ask them to prescribe the medicine"* (District A Storekeeper). He further explained that the most recent incident of excess expiring stock was distributed in the *Mahadalit Tolas* (the poorest areas). ANMs also reported that often this excess IFA goes to waste. *"But now we usually get about to expire medicine in bulk from the CS. It is not possible for us to distribute 10,000s of tablets in a month"* (ANM, District A).

Blocks that are left with expired medicines form a committee which decides how to dispose of the stock. In District A, the district storekeeper explained that when a drug was about to expire in 6 months, it would be sent out to the PHCs. The block storekeeper in District C explained that though they inform the district of their expiring drugs, they may still need to dispose of their medicines locally. *"I only know that if the medicine is near*

expiry I have to inform before 3 months of expiry date. If they refuse to take then in that case I can't fight for that. Then I have to dump it at my place only. So according to the procedure it will be discarded or will we keep it like that only" (District C Block Storekeeper).

Stock organization and managing of expiration dates, etc. was also almost exclusively done either by memory or through the stock register. *"We first keep this in mind that which medicine is of what type, it's all mind talk. The medicines which seem to expire first we supply them first, it stays in my mind"* (District F Storekeeper). Only one storekeeper showed us a separate sheet with only expirations dates to help him know which medicines had a nearby expiration date at a glance.

Storeroom

Several district and block officials expressed concern or concessions made on the basis that there was not enough space, or not a fixed location to store medicines. In District A, medicines were being stored in the district hospital hallway and some vacant rooms. Due to this transient space, the storekeeper made a point to distribute medicines quickly as he did not have room to store them.

At the block level this trend continued. At one district, the block official and storekeeper mentioned the lack of racks and disorder of the store. The storekeeper explained, *"We want the inventory arranged so it looks nice, but we manage in a given space only."* A district official however, told us that the district suffered from lack of a storeroom but that the blocks had space and storekeepers at their disposal.

Regarding ANMs, many told us that they stored their medicines with ASHAs, at Anganwadi Centers, or at home because their sub-centers were not functional. *"We store IFA in our bags with our self. Sub-center is there but it is not functional so we don't store there"* (ANM, District A). Other ANMS stored their drugs at their health sub-center in a locked cupboard or on a rack.

Two storekeepers spoke of rat protection (traps or blocking cracks in the wall) but only one storekeeper acknowledged the fact that damaged stocks happen. *"How much we can avoid the stock from getting spoiled? Rats enter the store and that is the fact. Sometime the medicines even get damaged in transporting or moving it from one store to another store. However much we try, we won't be able to save it"* (District G Storekeeper).

Personnel & Training

District/Block

Overall, most health officials did not see trainings on supply management and logistics as helpful or necessary. *"No! [Trainings are] not given. See, what happens madam is that I don't feel that these kind of trainings are brain teasing"* (District C Block Official). This block official then explained how easy the storekeeping job was. *"Once they are in the store they continue with their work. It's not a tough job. The chart is there, you have to fill the serial no. and name of the medicine… So filling up these columns is very simple."* However, at many stores we went to, pharmacists were not even available. *"No [I] never got any training, I am clerk over here, as there is no trained storekeeper or pharmacist. This post is for a pharmacist… but since the government has not arranged for this, still work had to be done so I am doing this."* (District A Storekeeper).

Almost all storekeepers said they did not receive training in supply or store management. Only one official, in charge of a district hospital store said he received training from the Indian Institute of Health Management Research through SHS for hospital management. It is possible that this training may have been specific to hospital issues. Both block and district storekeepers explained that their training had come from asking others what to do, not from any formal training on supply management.

> *"No nothing like that, I have not got any kind of training I just ask from the old people over here that what is the requirement on this basis."* (District A Block Storekeeper)

> *"No. I am doing this myself and following the same culture of the person who was working here before me."* (District H Storekeeper)

HSC/Village

According to published training materials, frontline workers (ANMs, ASHAs, and AWWs) should be conducting a coordinated effort to identify and register pregnant women, bring them to VHSND, distribute IFA, and counsel pregnant women on IFA consumption and benefits[26]. However interviews revealed varying roles across districts for each FLW. This may be due to inconsistent training across districts with regards to IFA distribution. ANMs usually stated that all FLWs distributed IFA. However, it appeared that distribution was most often conducted by the ANM and one other frontline worker with the third not taking a dominant role. In District H, AWWs were responsible for IFA distribution to beneficiaries and any IFA distribution to the ASHAs, *"ANM gives IFA tablets to me… I give [the ASHA] the tablets."* (AWW, District H). ASHAs here did

not take a major role in giving IFA, *"I don't distribute much. I write the names of the pregnant women who come to the Anganwadi Center to take the tablets"* (ASHA, District H). In contrast, an ASHA in District D explained that AWWs did not distribute IFA, *"No! Apart from the ANM, only ASHA gives [IFA]."* However, in other districts, lack of training was a barrier to ASHA IFA distribution. *"ASHA do not give IFA to pregnant women as they are not confident. So they give the IFA to the ANMs to distribute. ASHA only brings women to the center. She does the counseling"* (ANM, District A). In another district, the ASHAs only distributed under ANM supervision, *"She brings [her IFA] to the center. They have not been trained properly….When they come to us with their kit, we explain them which medicine to give and to whom"* (ANM District D).

Lack of Personnel

The state official mentioned lack of manpower for the bidding process used to select suppliers in addition to shortages of doctors, pharmacists, and nurses. The lack of nursing colleges in Bihar and lack of teachers for ANM training programs were also mentioned as important factors for this deficiency of personnel. "*There is an acute shortage of doctors and nurses… Here at our ANM schools, there is a shortage for teachers. There are 109 vacancies. For that, only 54 people turned up out of which 34 were placed"* (State Official).

Discussion

IFA supply is a public health issue in Bihar, the extent of which varies greatly across districts. Supply issues are further exacerbated by ineffective practices, which occur at several levels of the supply chain. We discovered specific bottlenecks which impacted

IFA forecasting, procurement, handling of expired drugs, storage, and an overall lack of personnel. In addition, few opportunities for training in these areas existed for important players in the supply chain. We then recommend steps to address these key barriers (Table 5.4).

Forecasting future IFA need was typically done using a top down approach (e.g. calculations conducted with population estimates) rather than one based on actual needs. In fact, this was not possible at the block level because if IFA was not available, requests from the ANMs were not documented. Reacting to fluctuating demand was further inhibited by annual purchasing, instead of a more flexible timeline. Lack of appropriate forecasting mechanisms in Bihar's drug supply chain have been identified in earlier work by Roy, et al[27] and government reports[28,29]. However, in order to improve IFA forecasting, timely and accurate information of availability and need are integral. Computerization of available inventory would enable real time tracking of stock and allow efficient monitoring of stock receipt and distribution (Table 5.4). The Government of Bihar does have plans to computerize store inventories in the near future[24] and appears to be making progress[30]. Ensuring that regular updates are conducted as well as standardized documentation of block, sub-center, and village needs and consumption will be a key to the success of these new changes (Table 5.4). In a comparative analysis, Bossert et al. found that facilities which used a centralized information system with enforcement of on time reporting, accuracy, and standardized forms were more successful than those with more decentralized systems[31]. Furthermore, updating IFA estimates to incorporate lactating women in addition to pregnant women will be an important change. This then must be accompanied by health worker training to distribute

and counsel lactating women on continued IFA consumption to reflect current policy (Table 5.4).

IFA purchasing at the district level is done through a regulated system with fixed prices and suppliers. However, we saw that supplier delays were common and many districts responded by simply waiting for the supply to become ready. Existing policies to deduct payment from suppliers for late shipments should be enforced[32]. Accurate and timely reporting of stock and purchase orders should enable this process to be monitored. Ensuring use and execution of polices such as this should increase the accountability of drug suppliers in Bihar (Table 5.4).

Another key factor in IFA need assessment is receiving and documenting requests from the block, sub-center, and village levels. This appeared to be lacking in two important aspects. First, written requests were not seen as effective by many workers at the block and health sub-center levels. This sometimes led to ineffective practices such as waiting for drugs to be delivered by a push system instead of submitting requests. In addition, some blocks selectively ordered their supplies, not requesting drugs they knew to be out of stock, a practice also reported in Zambia[33]. Another issue that was present in all districts was that when requests were made, there was a lack of documentation in cases where out of stock drugs were ordered. From the health sub-center and village level, requests were often verbal and if no IFA was available at the block level, these were not documented, which made it difficult to assess need when there was no available stock. A report from Darbhanga district also noted the lack of written drug requests from health centers and the pushing of drugs to centers[27]. Documenting these requests will help in identifying needs at these lower levels and should be reported even if a stock out occurs.

In order to improve this process, training and effective monitoring should be instituted to ensure written requests for IFA are made, documented, and importantly, are met with a rapid response. During prolonged stock outs, health facilities should implement the use of untied or *Rogi Kalyan Samiti* funds for local IFA purchases (Table 5.4).

In district and block stores, use of buffer stocks was also often lacking. Though many storekeepers knew what buffer stock levels were and how they worked, several appeared not to re-order IFA until they were completely out of stock. Incorporating standardized re-order levels into the store ledgers and computerized reporting will help not only in ordering practices but also in monitoring to ensure a more consistent supply[31](Table 5.4). Government documents state that districts should purchase a six month supply and keep 2-3 months of buffer stock[24] though this was not seen in the districts.

Sometimes even in the same districts suffering stock outs, expired IFA was an issue as well. This seemed to occur due to lack of requests from lower levels and other inventory management issues. Plans for disposal of expired medications were also not transparent or standardized and often resulted in passing the about to expire IFA to frontline workers and encouraging more prescriptions to patients from providers. Inventory practices such as FEFO (first to expire, first out) should be utilized and monitored to prevent these situations[34]. When they do occur, transparent and standardized plans should be made to properly dispose of medicines (Table 5.4). Excess expired medicines have also been reported in other parts of India[35,36] and other countries such as Uganda[37,38] and Nigeria[39].

In order to carry out many of these practices, improvements are needed at district and block storerooms. Many storerooms were at temporary locations, which in some cases

restricted the amount of stock that could be stored and investments in shelving or security. Stock cards were not found at any storeroom visited, which have been cited as an important part of inventory control[27,31](Table 5.4).

In most cases, there was a clear lack of training for the role of the storekeeper and in general for trainings surrounding supply protocols. While many officials viewed the storekeeper role as simple and unworthy of training – or that storekeepers were already trained in the necessary skills – storekeepers themselves often felt that training would be useful, were overwhelmed with their duties, and were not performing the necessary tasks to allow for a properly functioning storeroom. Training also appeared to be lacking for frontline workers who are all responsible at some level for keeping IFA stock, distributing IFA, and counseling beneficiaries. Holding trainings using the health sub-center platform would also allow for coordination and communication between the frontline workers, as this would bring together the ANMs, ASHAs, and AWWs within a single sub-center coverage area[19]. This training must also include IFA distribution to lactating women, as the majority of frontline workers we interviewed did not distribute IFA to this population (Table 5.4).

This study has several strengths. First, we were able to interview a wide range of people who played varying roles in Bihar's IFA supply chain. Also, in all eight districts we were able to interview at least one representative from each level of the supply chain. Through the ANM surveys we were also able to support our qualitative work by quantitatively demonstrating the variable IFA supply and associated inventory control practices. During interviews with storekeepers, we also examined stock ledgers and storerooms when possible to verify statements by the respondents.

There were also some limitations to this research. This study is largely qualitative and therefore is not generalizable. However, we did find that many of our identified themes did agree with existing supply chain literature from other parts of India as well as other countries. Therefore the bottlenecks identified here may be useful to assess in other contexts when examining supply chain issues. Though we did talk to several different groups involved in IFA receipt and distribution, we were not able to interview suppliers, drug inspectors, or district magistrates, who play a large role in monitoring of the Bihar IFA supply chain. These individuals may provide additional informative insight into strengths and weaknesses of the current system. Additionally, we did not include interviews with pregnant women, who could provide insight on health worker distribution practices, coverage, and IFA counseling.

Overall, many of these identified bottlenecks have also been acknowledged in previous assessments of delivery of essential medicines by the Government of Bihar[28,29], the Public Health Foundation of India[23], and an assessment of Bihar's Darbhanga district[40]. Fortunately, the state government has taken an active role in improving the overall supply chain focusing on state level drug procurement in particular through the establishment of the Bihar Medical Services and Infrastructure Corporation Limited[24]. This has followed the pattern of several Indian states in replicating the drug procurement model of Tamil Nadu[41], recognized by the World Health Organization[42] and Government of India[43] to be a highly successful system of essential drug procurement. The Tamil Nadu model is largely associated with centralized drug tendering and purchasing, which allows lower bidding prices and increases accessibility. District warehouses and computerized systems for inventory management and forecasting are also hallmarks of the Tamil Nadu system

which the Bihar Government also plans to incorporate[24,41]. In addition, the Government of Bihar has also increased IFA purchasing to incorporate distribution to lactating women[24]. This increase in political will and effort to improve the supply of essential medicines, of which IFA is a part, is an important step forward in increasing IFA supply accessibility to pregnant women in Bihar.

However, many of the issues raised in our study may not be resolved by the changes underway. As Bihar moves to improve drug supply, their strategy focuses primarily on the drug tendering process, district warehouse construction, and improved demand assessment. However, the poor practices that we discovered at the district, block, sub-center, and village need to be addressed to attain a fully functioning drug supply system. This will become increasingly important in light of the "Iron+ Initiative," which will expand universal IFA supplementation to children from 0-19 years and women of reproductive age in addition to pregnant and lactating women. This program also introduces four additional types of IFA tablets of different iron content and color[44]. Especially with the roll out of this program and the existing demands, improving the IFA supply chain will be critical to the success of this initiative.

In many iron supplementation programs, low utilization of IFA has been assumed to be due to poor adherence, and often attributed to individual factors of the pregnant women. However, when the supply chain itself is dysfunctional, this too reduces the value of the intervention in the eyes of the beneficiaries. Inconsistent supply can foster distrust among patients for the healthcare system as a whole[45]. Strengthening the Bihar supply chain will be critical to improving the iron supplementation programs in Bihar. More research will be useful to examine how more effective monitoring and evaluation can be achieved in

addition to the feasibility and maintenance of a more dynamic, flexible supply chain system.

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Table 5.1: Qualitative In-Depth Interviews Conducted

Supply Chain Level	*State*	*District*	*Block*	*Sub Center*	*Village*
Participants Interviewed	State Health Society Official	Civil Surgeon District Program Manager District Storekeeper District Hospital Manager	Medical Officer in Charge Block Health Manager Block Community Mobilizer Block Storekeeper Pharmacist Clerk	Auxiliary Nurse Midwife	Accredited Social Health Activist Anganwadi Worker
Total Interviews (n)	1	20	14	13	11

Table 5.2: Coverage, iron and folic acid stock, and distribution as reported by ANM, per Health Sub-Center

Characteristic	N	Mean (95% CI)
Population served by health sub-center	288	9471 (8848, 10094)
Pregnant women registered in previous month	313	20 (19, 22)
Percent of population registered per year (%)[a]	267	2.8 (2.5, 3.0)
Current IFA stock (number of tablets)	331	2325 (1744, 2906)
Current IFA stock, if present (number of tablets)	182	4306 (3283, 5329)
Number of IFA tablets given to AWW in previous month	71	1547 (899, 2195)
Number of IFA tablets given to ASHA in previous month	131	619 (357, 881)

ANM: Auxiliary Nurse Midwife; **IFA**: iron and folic acid; **AWW**: Anganwadi Worker; **ASHA**: Accredited Social Health Activist; Extreme values were excluded from each category; [a] According to our qualitative data, IFA purchasing estimates are made based on the assumption that 3-3.3% of the total population are pregnant women.

Table 5.3: ANM reported iron and folic acid supplement supply status and procurement protocols by district

	IFA Out of Stock (%)	*Cannot Request IFA from PHC (%)[a]*	*Uses Buffer Stock (%)[b]*	*Average Buffer Stock (mean (95% CI))[c]*	*Only obtains IFA from the PHC (%)[d]*
District A	90.5	17.3	59.1	447 (265, 628)	81.9
District B	28.1	7.0	87.4	911 (355, 1467)	63.2
District C	63.3	5.3	81.4	544 (219, 867)	64.1
District D	0.0	7.3	92.6	1112 (520, 1704)	81.7
District E	26.0	17.5	69.6	1196 (425, 1967)	82.8
District F	47.8	14.3	60.2	1182 (246, 2118)	78.1
District G	16.2	3.5	82.1	303 (121, 485)	41.0
District H	13.8	19.8	42.6	1177 (613, 1743)	82.7
Total	44.1	9.5	74.4	751 (554, 949)	67.8

ANM: Auxiliary Nurse Midwife; **IFA**: iron and folic acid supplements (100mg elemental iron and 500 mcg folic acid); **PHC**: Primary Health Center; **CI**: Confidence Interval; On average 6.9% of survey data was missing from the above table; [a] ANMs responded to a multiple choice question asking how they receive IFA from the PHC with possible responses: through fixed deliveries (cannot request), through fixed deliveries (can request), or can only receive IFA through request; [b] Alternate responses were: request IFA when completely out of stock or cannot request IFA; [c] Average buffer stock was calculated only among those ANMs reporting buffer stock use; [d] Alternate responses were: can take IFA from ASHA kits, can borrow IFA from other sub-centers, or can purchase IFA using sub-center funds;

Table 5.4: Identified bottlenecks of Bihar's IFA supply chain, proposed actions, and key stakeholders

Identified Bottleneck	*Proposed Action*	*Key Stakeholders*
Lack of appropriate IFA need forecasting	Standardized demand forecasting based on accurate estimates of district needs and previous consumption	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM
	Computerization and clear documentation of inventory, stock requests, and expiry dates	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM
	Estimates to include lactating women population; IFA distribution and counseling standard	SHS, BMSICL, District Storekeeper, Block Storekeeper, ANM, ASHA, AWW
Late supplier deliveries resulting in inconsistent supply	Utilization of updated BMSICL policy to deduct payment upon late delivery, damaged stock, etc.[32]	SHS, BMSICL, District Officials[a], District Storekeeper

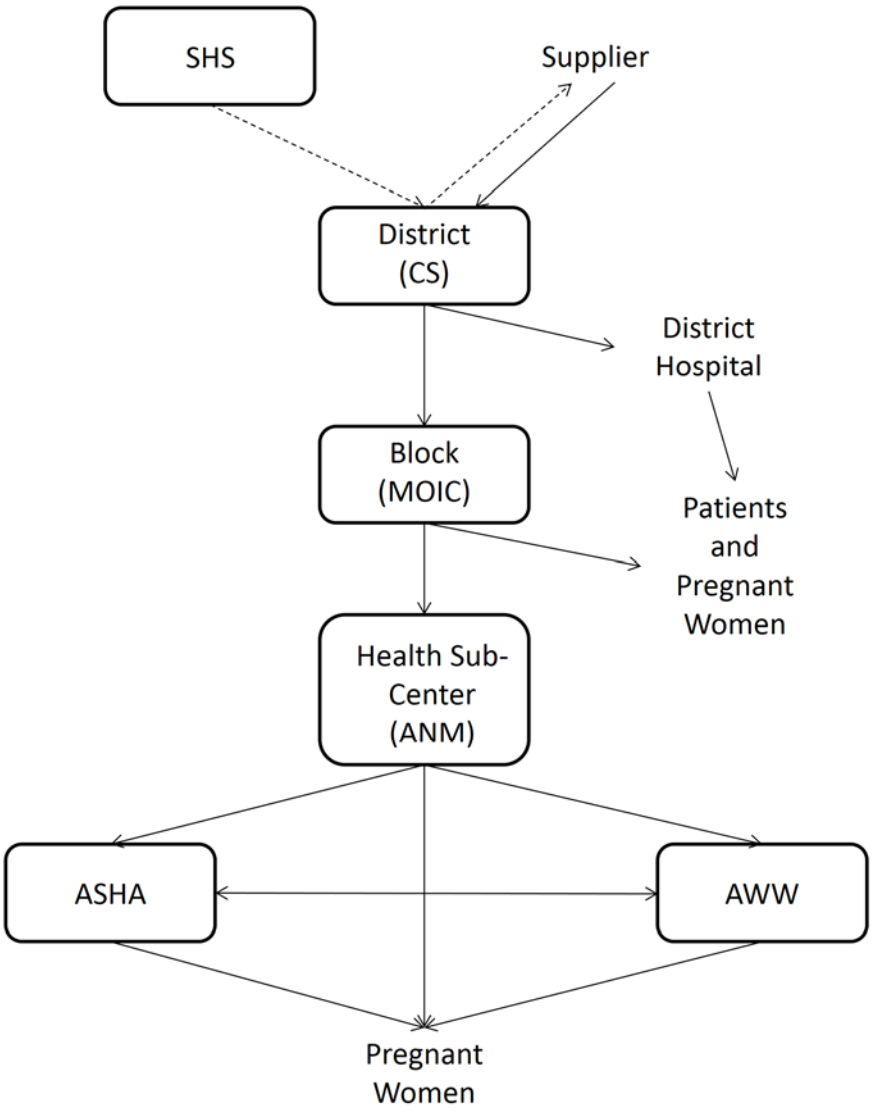
Indents not being utilized nor perceived as effective	Training and monitoring to assure indent use and effectiveness	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM, ASHA
Perceived or actual inability to procure IFA when needed through local purchasing	Explore use of untied, *Rogi Kalyan Samiti*, or other funds to purchase IFA locally in times of shortage	SHS, BMSICL, District Officials[a], District Storekeeper, RKS, Block Officials[b], Block Storekeeper, ANM, ASHA
Lack of buffer stock use at all levels	Implementation, monitoring, and evaluation of existing buffer stock requirements[24]	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM, ASHA
	Ensure adequate storage facilities so stock can be stored safely	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM

No safe disposal plan for expired medicines and pushing of expiring drugs to patients and frontline workers	Transparent plan to prevent expired medicines through appropriate purchasing practices and safe disposal of expired medicines	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM, ASHA
Storeroom transiency and disorder	Construct, purchase, or long-term rental of adequate storerooms. Funding for racks, labels, and shelves.	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper, ANM
	Training for storekeepers including storeroom order and inventory protocols.	SHS, BMSICL, District Officials[a], District Storekeeper, Block Officials[b], Block Storekeeper
Inconsistent training on IFA counseling/distribution across FLW types	IFA counseling/distribution training for all frontline workers who work with pregnant women	Block Officials[b], ANM, ASHA, AWW
	Training for all frontline workers together at health sub-center level to improve	Block Officials[b], ANM, ASHA, AWW

coordination and communication

SHS: State Health Society; **BMSICL**: Bihar Medical Services and Infrastructure Corporation Ltd.; **ANM**: Auxiliary Nurse Midwife; **ASHA**: Accredited Social Health Activist; **AWW**: *Anganwadi* Worker; **RKS**: *Rogi Kalyan Samiti* (Patient Welfare Committee); [a] District Officials: Civil Surgeon, District Program Manager; [b] Block Officials: Medical Officer In Charge, Block Health Manager

Figure 5.1: Major Components of IFA Supply Chain in Bihar, India



Flow chart showing the distribution of iron and folic acid supplements and funds from the state level (SHS) to the beneficiaries (pregnant women).

Dotted lines: funds for purchase of IFA supplements; **Solid lines**: iron and folic acid supplements; **Boxes**: Surveyed populations; **SHS**: State Health Society; **CS**: Civil Surgeon; **MOIC**: Medical Officer in Charge; ANM: Auxiliary Nurse Midwife; **ASHA**: Accredited Social Health Activist; **AWW**: Anganwadi Worker

Figure 5.2: A District Comparison

To demonstrate the range of IFA stock and supply chain practices, a brief comparison was made of two districts based on those with a higher and lower functioning IFA supply chain.

A Working Model

At the district level, IFA was purchased twice per year. A "shortage" was defined as 15-20,000 IFA at which point they order more. Drug purchases were based upon documented block need. However, at the block, this was calculated based on total population, not necessarily consumption and estimated need. Several officials reported no shortages since they have been in office, although others stated some circumstances (e.g. campaigns, seasonal flooding) in which temporary unavailability can happen. ANMs report receiving IFA on a "pull" system, where they receive IFA based only on their written requests. Even in these districts with available supply at the district/block levels, some ANMs still reported no IFA in stock, with plans to retrieve some through the PHC at their next weekly meeting.

Chronic Shortage

The last time primary healthcare centers and ANMs received IFA was over 6 months ago. This IFA was due to expire the following month; therefore most of it was thrown away. Beyond that, no IFA had been received in the past year and a half for ANC distribution. One PHC was barely receiving any drugs, despite monthly written requests, "we are only giving B-complex and cough syrup. On that only the whole hospital is running." (Block official). Some ANMs, frustrated by the lack of response, have stopped writing drug requests to lighten their workload. Block officials are worried about the distrust this fostered in patients, who assume that the health workers were stealing their medicines.

Chapter 6:

Facilitators and Barriers to Iron Supplementation in Bihar, India: Perspectives of Women, Family, and Health Workers

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Abstract

Anemia is a severe public health issue in Bihar, India, with 60% of pregnant women estimated to be anemic. Despite the Government of India's program for universal supplementation of pregnant women, low consumption and high maternal anemia prevalence persist. Previous iron and folic acid (IFA) supplementation program evaluations have focused on perspectives of the women only; however, including multiple views of health workers and family members may create a more comprehensive

picture of program strengths and limitations. The research objective was to examine the perceptions of anemia and IFA supplementation among health workers, beneficiaries, and family members in order to identify key facilitators and barriers to IFA consumption. Overall, 23 in-depth interviews and 11 focus group discussions were conducted in two districts of Bihar, India. Three types of health workers, pregnant women, husbands, and mothers-in-law were included in the sample. All respondents ascribed anemia to poor nutrition as a result of poverty. Most described anemia consequences as severe in degree and this may have led to the general perception that anemia was rare in each participant's community. Some IFA knowledge was widespread though other concepts, such as proper dose, and techniques to address side effects were less known. Some incorrect counseling messages were discovered as well (e.g. restriction of IFA in the last month of pregnancy, consumption of IFA with milk). A few women also described being charged for antenatal care services and registration. The role of the family was shown to have great potential to encourage or discourage supplementation. From these results, recommendations include increasing awareness of anemia in the community and for health workers, and health worker training to improve counseling messages and to include family members in IFA counseling sessions, enlisting their help to encourage consistent IFA consumption in pregnant women.

Key Words

Anemia, pregnant women, iron and folic acid, health workers, qualitative

Introduction

Anemia is a 'severe public health problem' in India, according to the World Health Organization[1]. In Bihar, three out of every five pregnant women are estimated to be anemic (60%), even more than the national prevalence (58%)[2]. Iron deficiency anemia consequences can range from decreased work capacity[3], reduced immune function, fatigue[4], and even symptoms of depression[5]. During pregnancy, increased risk of low birth weight, preterm delivery, and low fetal iron stores have been found[6], which can lead to reduced motor skills and mental development of the child[7]. In cases of severe anemia, cardiac failure and maternal death can result[8]. In one Bihar hospital study, anemia was found to be one of the four major causes of maternal mortality over a two year period[9]. Fortunately, to prevent and treat anemia, oral iron supplementation has long been established as an effective intervention to improve iron status[10]. Other studies have also found iron supplementation to reduce risk of low birth weight[11-13], improve iron status[13,14], and restore mother-child interactions[15].

In 1970, the Government of India established the National Anemia Prophylaxis Program to address this widespread issue. After further evaluations, the program expanded to mandate universal supplementation to pregnant women[16]. However, national surveys and program evaluations have shown continued high anemia prevalence and low iron and folic acid supplement (IFA) consumption among pregnant women[2,17]. In 2010, although 84.5% of mothers attended at least one antenatal care (ANC) visit during their last pregnancy, only 10% reported consuming IFA for 100 days or more[18].

Several barriers of IFA consumption have been cited in the literature including side effects[19-22], inadequate supply[23,24], forgetfulness[21,25], lack of ANC attendance[24,26], and ineffective frontline worker (FLW) counseling[23,24]. Many of these studies focus on the

woman's perspective; however, husbands and mothers-in-law play significant roles in the household in terms of health service utilization in India and other developing country contexts [27-30]. Therefore, considering the perspectives of women with husbands and mothers-in-law may help gain a more complete understanding of how IFA messages are reaching and being interpreted within the family unit. Furthermore, although many studies focus on the presence of health workers to encourage IFA consumption (e.g. frequency of interactions), few examine what health worker perceptions are regarding anemia and IFA and how this may impact the counseling provided. By examining health workers' views along with community members, we were able to examine IFA supplementation from the perspectives of both IFA supply and demand within the community.

Our objective in this study was to examine the perceptions of anemia and IFA supplementation among health workers, beneficiaries, and family members in order to identify key facilitators and barriers to IFA consumption. We then make recommendations to strengthen the existing iron supplementation program, specific to the Bihar context.

Methods

Study Setting

We conducted interviews and focus groups in two districts, which will be referred to as District A and District B, located in the state of Bihar. These districts were purposively selected due to varied (near and far) distance from the capital, Patna, and based on the author’s previous work, which indicated that IFA was available and being distributed at

each site. Additionally, these were focus districts in a program CARE Bihar is conducting called the Integrated Family Health Initiative. This project aims to support the Government of Bihar in strengthening public sector capacity to improve maternal and child health outcomes. We were able to utilize CARE's contacts with the health sector to initiate contact with health care workers and gain appropriate permissions from health officials.

Within each district, the block and HSC were chosen based on the primary author's previous research in the area to identify existing IFA supply. Previous contact with CARE staff and health officials in the region also enabled the research team to quickly and effectively make arrangements in the field, sensitize communities, and recruit participants.

Sampling

We conducted interviews and focus group discussions with three types of health workers, who are largely responsible for IFA distribution to pregnant women: Auxilary Nurse Midwives (ANMs), Accredited Social Health Activists (ASHAs), and Anganwadi Workers (AWWs). At the community level, we interviewed pregnant women and mothers-in-law and facilitated focus groups with husbands. We chose to include mothers-in-law and husbands because of their influence in the household over financial and medical decisions. Collecting perspectives from community members as well as health workers in the same area also allowed us to compare knowledge and counseling of the health workers with the awareness and experiences of the community members regarding anemia and IFA.

In each district, we talked to community members, ASHAs, and AWWs in two Anganwadi Center (AWC) coverage areas managed by one Health Sub-Center (HSC). We also interviewed the ANM from this HSC coverage area in addition to an ANM in a separate HSC area in order to increase the number of ANM responses. Pregnant women were randomly selected from a health worker's survey list of all pregnant women in her area. In these districts, CARE Bihar had recently completed an initiative to increase coverage of these surveys, which had identified many "left out" pregnant women in the region[31]. Therefore, these were believed to be complete lists of pregnant women in the area. We interviewed pregnant women in their third trimester or with children less than six months of age. Once in these areas, we inquired about availability of mothers-in-law and husbands whose daughter-in-law or wife, respectively, was pregnant or had a child less than two years old.

For each interview we explained the study objectives and asked permission to record the interview. All participants gave oral consent. Our protocol was approved by the Emory University Institutional Review Board.

Data Collection

Interview and focus group guides were created in English and translated into Hindi. Research assistants, an external bilingual researcher, and the primary author reviewed the Hindi guides for accuracy. Pilot testing was also done to evaluate research assistants and make appropriate changes to interview and focus group guides.

All guides covered four main topics: 1) perceived causes and consequences of anemia, 2) awareness of IFA tablet benefits and consumption, 3) perceived facilitators and barriers

to successful IFA consumption, and 4) trusted health information sources. Community members were asked about how they receive health information, while health workers were asked who community members go to for their health advice. The role of the family and power within the family unit concerning health decisions was also probed when asking about facilitators and barriers of IFA consumption.

Overall, 23 in-depth interviews and 11 focus group discussions were conducted in June and July of 2012. Interviews lasted 30-45 minutes and focus group discussions were approximately 1-1.5 hours in duration. These were done in Hindi or the local language and translated into English for analysis. Four research assistants conducted and transcribed the interviews. They were trained in the overall goals of the study, qualitative interviewing techniques, and research ethics. Most interviews and focus groups included an interviewer/moderator and a note-taker. In many, the primary author or another researcher were observers and took notes on body language and the setting. In a few cases where a note-taker was not available, the interviewer took notes during the discussion in addition to the audio recording. Of the four research assistants, two were male and two were female. During pregnant women interviews, only female researchers were present. Males also moderated each of the husband focus groups. Daily debriefings were held with the research assistants by the primary author. Initial transcripts were reviewed by the primary author and an external bilingual reviewer to ensure verbatim translations. Once completed, a subset of transcripts was compared against the recordings to ensure accuracy.

Hindi transcripts were translated into English by two groups of interpreters. Quality checks were done by external bilingual researchers at various time points to ensure

accuracy. Additional rounds of translations were conducted to ensure accurate translations when inaccuracies were identified.

Data Analysis

English transcripts were analyzed in MAXQDA (version 10, VERBI Software). Inductive codes were created based on participant responses first from a subset of 6 transcripts, and then adding additional codes as they emerged. Memos were written throughout the analysis to highlight salient themes and topics of interest. Cross comparisons were done across participant type, participant category (health worker or community member), and district. Data which was often reported in list form (e.g. anemia causes and consequences) was tabulated and sorted into categories (e.g. weakness, child health, delivery complications) in order to compare common answers despite distinct phrasing across participant types. Perspectives shared by most participant types were presented as 'common views' and while those shared by few participant types or one category (e.g. community members) were listed under 'divergent opinions.'

Results

Commonly held views on anemia causes

All participant types reported that lack of food or nutritious food was an important cause of anemia. Proper quantity, frequency, and quality (e.g. green leafy vegetables, milk, fruits, and fish) were mentioned as key components of a proper diet. *"[Doctors] recommend us to eat green leafy vegetables, eggs, and milk to prevent weakness and raise blood levels*" (Husband FGD, District B).

Poverty was the main deterrent listed by all participant groups as a key barrier to a healthy diet. Poor families could not afford milk and fruit in particular, so frontline workers would emphasize inclusion of green vegetables and beans; however, these were also seen as too expensive by some. "*They don't take proper food like milk, fruits, and green vegetables. These are not available where there is poverty*" (ANM, District A). Especially in these poorer families, women were also the last to eat, further restricting dietary choices. *"Whatever remains after serving to others is then taken by the pregnant woman. Nothing special is provided or made for them."* (AWW, District A). Family tension, or conflicts with other family members, was also mentioned as a barrier to proper nutrition. Frontline workers in particular reported this as a significant reason for women not eating as much or as frequently as men, which could then lead to anemia. "*They are not able to have food 2-3 times per day when they should have it 4-5 times a day… She does not eat 4-5 times in anger because of fights at home*" (AWW, District A).

Divergent opinions on anemia causes

Community members largely focused on diet and issues affecting good nutrition as causes of anemia, and only FLWs identified IFA tablets as an important factor. Healthcare workers also highlighted close birth spacing and high parity as behaviors that elevated anemia risk (Table 6.1). These were not mentioned by pregnant women, mothers-in-law, or husbands.

Common views of anemia consequences

The most commonly reported consequence of anemia was weakness. This was described various ways but was often characterized as difficulty in walking, working, and sometimes as "laziness." Swelling, often of hands and feet, were also described by all types of

participants. Complicated deliveries and increased risk of maternal or child death were seen as the longer term consequences of anemia during pregnancy. "*Child can die during or after birth. Mother can also die due to excess bleeding*" (Pregnant Woman, District B). Most of the symptoms and consequences of anemia agreed upon by all groups were accurate, except in the case of jaundice, which does not occur in iron deficiency anemia.

Divergent opinions of anemia consequences

Compared to anemia causes, there was more variation in the reported consequences of anemia. Many consequences were only mentioned by some of the participant types. For example, increased risk of preterm birth as well as poor child growth and development were exclusively reported by FLWs. Diagnostic symptoms of severe anemia were mentioned only by ANMs who cited paleness and dark circles around the eyes. All FLW types also mentioned vision loss or blurred vision as symptoms of anemia during pregnancy (Table 6.1). In a few interviews, community participants incorrectly attributed some diseases to anemia, such as polio or tuberculosis. *"[The child] can suffer from typhoid, tuberculosis, polio, jaundice, that's what we have heard*" (Mother-in-Law, District A). Of all the groups, mothers-in-law and husbands were the most unsure of anemia consequences.

Common views of IFA tablet benefits

In all groups there were three benefits of iron and folic acid tablets that were most commonly mentioned: increased blood formation, improved health for the child, and greater strength or energy. Though several pregnant women were unsure of their answers, all did state at least one of these three benefits of IFA. Only one mother-in-law interview and husband FGD were not able to state any IFA benefits. Few respondents mentioned

specifically that IFA helped to prevent anemia. However, knowing this did not necessarily indicate increased understanding.

> *PW: She said that by consuming it until six months there won't be blood deficiency in the body…*
>
> *Interviewer: So what are the benefits if there is not blood deficiency?*
>
> *PW: [Quiet]… I didn't ask but she said there won't be blood deficiency in the body.*
>
> (Pregnant Woman, District A)

Common views of anemia prevalence

The majority of participants reported that anemia was not common in their village. Almost all FLWs stated that this was not an issue for the majority of pregnant women in their coverage areas. "*In rural areas we don't find such problems… Poor people normally eat green vegetables in their diet so they don't suffer from such problems*" (ANM, District B). This may have been influenced by a lack of severe symptoms, as at times more subtle anemia symptoms may still have been present. "*We have not met anyone who is not eating and is unwell. There are some problems like dizziness, weight loss but nothing serious*" (AWW, District A). Most mothers-in-law and husbands agreed that anemia was not a prevalent issue. Of those who responded, only three participants reported that anemia was common among pregnant women in their community.

Process

Common views on IFA intake

Almost all participants were aware that IFA is taken on a daily basis. Knowledge of where to receive IFA was also known among all respondent groups. Most commonly mentioned were the ASHAs along with other government workers (e.g. ANMs, AWWs, or doctors) in addition to places where these people could be found (e.g. PHC, VHND). Husband and Mother-in-law groups additionally mentioned private sources where IFA could be purchased. Knowledge of access did not seem to be a barrier for any group. However, two pregnant women had asked their local ASHA for IFA but did not receive it. "*I know that this tablet is being given at the center, but ASHA never gave me any iron tablets to consume*" (Pregnant Woman, District B). Therefore, knowledge of how to receive IFA did not necessarily translate into IFA receipt.

Divergent views on IFA intake

As expected, the FLWs knew the proper dosage (100 IFA tablets) and suggested taking IFA at night before sleeping. When asked about side effects, they explained that these usually subside within 2-3 days. Pregnant women were also almost universally aware that IFA was to be taken each night. Frontline workers recommended this to help women avoid the nausea that could follow IFA consumption. "*It will cause nausea for some time and then she will sleep. That is the reason it is not given during the day*" (AWW, District A). However, those who had not already received 100 tablets did not mention this as the full required dose, though often knew they were to ask for more. Most husbands and mothers-in-law did not know the full required dose of IFA (Table 6.1).

In District A, a different piece of advice was given. Half of the women were told to stop consuming IFA during the eighth or ninth month of their pregnancy. The AWW focus

group in this district also explained that women should stop taking IFA in this last month of pregnancy (Table 6.1). No other frontline worker that we interviewed specified this cut-off, however all frontline workers in District A were adamant that no more than 100 tablets were to be taken during pregnancy. One pregnant woman specified that if she took IFA during her last month, "*there will be pressure on the baby*" (Pregnant Woman, District A). This was not discussed in District B, however, of the seven women we interviewed here, only one had received the full dose of IFA.

One counseling message distinct to District B was to consume IFA with milk. ASHA groups suggested this practice, especially if experiencing side effects from IFA. One mother-in-law and husband group also mentioned this behavior (Table 6.1). "*We all know that when using iron tablets our body temperature increases… to keep control of our temperature we should take milk to keep balanced*" (Husband FGD, District B). No pregnant women specified this strategy. However, no women interviewed in District B consumed the full dose of IFA. Three attributed their discontinued use to IFA side effects.

Barriers

Commonly reported barriers to IFA consumption

Most groups reported that pregnant women stopped taking IFA due to side effects including nausea, vomiting, or gas. Especially when side effects happened, participants stated that other family members may be more likely to discourage the women from taking IFA (e.g. mother-in-law or husband). FLWs and pregnant women also cited not trusting IFA because it was given free by the government. The concern that IFA could increase body temperature

was also cited by members of three separate participant groups. *"[IFA] will form heat in the stomach… This will harm the child*" (Pregnant Woman, District B).

Divergent opinions on barriers to IFA consumption

Some groups experienced or described barriers to IFA consumption that were not mentioned by others. FLWs reported clinical symptoms such as diarrhea, black stool, or dizziness as reasons women would give for not consuming IFA. However, no community member recounted these symptoms. Pregnant women alone articulated some reasons for not taking IFA, which deviated from other groups. These were not believing that IFA was helpful, not feeling any difference after taking, forgetting or losing pills, or not believing in consuming medicines (Table 6.1). "*I knew about the benefits. ASHA had also informed me about it but still I didn't consume the tablets because I didn't believe. I thought what would I do if anything bad happened*" (Pregnant Woman, District B). Interestingly, mothers-in-law did not describe or did not know any reasons why women might not take IFA. Perhaps the most striking barrier expressed by only pregnant women and mothers-in-law was that in order to get registered between 5-20 rupees were charged by frontline workers to get their ANC card (Table 6.1). This was described in both districts. These fees were not mentioned by frontline workers. Antenatal care services including registration and IFA distribution are supposed to be free of charge. "*We call [the ANM], she gets the vaccination. Five rupees for an old card and ten rupees for new. She doesn't give if we don't pay*" (Mother-in-Law, District A).

Facilitators

Common views on FLW counseling

Across groups, ANMs were the most knowledgeable about anemia and IFA. They counseled women at "the time of vaccination" (Village Health and Nutrition Day) and if accompanied by family members, she would also talk to them. ANMs did not live in the villages and did not visit pregnant women at their homes. Therefore, they did not check up on the women and saw ASHAs as the most trusted resource of the rural women. When asked whose advice women believe the most one ANM replied*, "ASHA didi. We go there once or twice a month. ASHA didi always roams around and looks for deliveries"* (ANM, District A). ANMs were also a resource for the ASHAs and AWWs if a pregnant woman had a problem or was not following advice, *"when they don't listen to us then we take them to the ANM"* (ASHA focus group, District A).

Pregnant women and community members most often mentioned ASHAs as distributing IFA and conducting home visits. The most commonly identified role of the ASHA was to take pregnant women to the Anganwadi Center for the monthly Village Health and Nutrition Day and to accompany them for the delivery. *"ASHA came in the second month of my pregnancy… ASHA gave me medicines for energy and took me to the center. Then I was given an injection by a doctor who came from the block"* (Pregnant Woman, District B). ASHAs reported talking to in-laws more often and gave their cell phone numbers to families in case they had questions or needed medical care.

Pregnant women who we talked to had all experienced some interaction with a frontline worker. All knew and could list at least one benefit of IFA. All women except one mentioned that a frontline worker had come to her home or talked to her outside of the Village Health and Nutrition Day. Mothers-in-Law and husbands also knew of the different frontline workers and that they were sources of health information for pregnant women.

However, mothers-in-law and husbands both had less knowledge about anemia and IFA, reflecting less counseling received by frontline workers on these subjects.

Divergent experiences in FLW counseling

In most cases, we found that major themes held across districts. However we did find a key difference in FLW counseling. In District A, AWWs reported that they conducted home visits. Pregnant women in this district also reported seeing AWWs at their homes and receiving advice about IFA (Table 6.1). However, in District B, AWWs did not visit homes on a regular basis, *"we don't meet every day, but at the time of polio we meet them"* (AWW focus group, District B). In addition, some frontline workers in District A suggested that women leave IFA on their bed to remember to take it at night. This strategy was not mentioned by District B health workers.

Husband's knowledge from FLW counseling also varied depending on how much time they spent at home, conversations with their wife and mother, and attendance of doctor visits (Table 6.1). While several husbands mentioned information gleaned from these sources, others did not see the relevance in asking about these topics. *"We bring her what she needs, she uses it, cooks, we eat, and then sleep. If there is an elder woman, our wives will go and ask her about it"* (Husband focus group, District A).

Common Views on Family Support

During most interviews, family members were described as a potential source of support for the women. In the traditional family structure, the in-laws and husband were the decision makers in household nutrition, medical decisions, and mobility. "*Here women don't go to the market. So we only have to go and we will get the important things that they*

need or what the doctor has advised and also some particular things that she wants to eat" (Husband focus group, District B). Women who attended antenatal care were usually accompanied by a family member or health worker and families were asked to buy several things to prepare for the delivery. Frontline workers did counsel family members about IFA though this often seemed to occur if they happened to be there at the time of counseling and were not individually sought out. For two pregnant women in District B, family members outside of their villages were a key knowledge source. *"This tablet is being distributed at my sister-in-law's place. From there only I came to know that these tablets are given to pregnant women and that it is distributed from the Anganwadi Center"* (Pregnant Woman, District B). This woman had not received IFA during this or previous pregnancies. In all cases, the family members were the first to know about each woman's pregnancy, with frontline workers being informed often months later.

Discussion

In Bihar, India, high maternal anemia prevalence and low IFA consumption have persisted despite the government's program of IFA distribution and counseling. Through collecting multiple perspectives on anemia and IFA, we have identified key improvements which could be made in anemia awareness, frontline worker counseling, and the role of the family in IFA receipt and consumption.

Knowledge of Anemia

All participant types agreed that anemia, identified by 'lack of blood' or *khoon ki kami*, was caused and worsened by a lack of proper nutrition, largely the result of low household incomes. This was not surprising and has also been described by community

members and healthcare workers across multiple countries[24,32]. A recent study in Mumbai, India, identified further barriers to women's dietary changes including husband's food choices and restriction of non-vegetarian foods during pregnancy[33]. Household stress, or 'family tension,' was also commonly identified as a reason why women restricted their own diet. Stress or high workload has also been cited by other studies as a perceived cause of anemia[24,32,34], though to our knowledge none cited family stress as a specific barrier for poor nutrition choices. The link between iron and anemia, however, was almost exclusively described by frontline workers. This has been found elsewhere[32,33] and could play a role in women and family members not associating IFA consumption to anemia prevention and treatment.

Overall, all participants described anemia as a serious condition with weakness as the most commonly reported symptom. This agrees with previous studies [24,33,34], two of which also found that women in India also perceived weakness as a typical characteristic of pregnancy, not requiring medical attention [24,33]. In our data, weakness was often described in more severe contexts (e.g. not being able to walk, falling down). Consequences such as maternal and child death and delivery complications were also highlighted. In all cases, anemia symptoms were more in line with those present in severe anemia.

Perhaps due to this recognition of only severe anemia symptoms, frontline workers and many community members reported that anemia was either rare or nonexistent in their communities. While severe anemia in Bihar is relatively uncommon among pregnant women (2%), including mild/moderate anemia raises the prevalence to 60%, according to National Family Health Survey (NFHS) data[2]. ASHA training manuals also reflect this

disconnect; severe anemia symptoms are clearly outlined, but the subtler traits of mild/moderate anemia are not clearly defined[35]. This has clear implications on how frontline workers are counseling women and their family members and the importance they place on consistent IFA consumption. FLW training updates should emphasize how widespread anemia is and that lack of severe symptoms does not mean women do not have anemia. Increasing community awareness about anemia, its prevalence, and linking anemia to iron deficiency and IFA consumption may also increase understanding and compliance.

Frontline Worker Counseling

Comparing frontline worker responses to community member knowledge, we found successes and opportunities for improvements to counseling messages regarding dose, timing, and potential side effects.

Almost all community members identified at least one of three commonly stated benefits of iron tablets: blood formation, improved child health, and increased strength or energy. Several studies also show these IFA benefits as frequently reported by beneficiaries[21,24,33,34,36]. In this case, we found similar information reaching women, mothers-in-law, and husbands. It was very encouraging to see that messages were reaching family members as well.

Government of India guidelines state that IFA (100mg elemental iron and 500mcg folic acid) should be taken daily for at least 100 days starting at 14-16 weeks as well as 100 days postpartum[37]. All community members were aware that IFA was taken on a daily basis during pregnancy. However, one area of improvement was knowledge of the proper

IFA dose, which may have been influenced by IFA supply. In our interviews, it appeared that women who had not received all 100 IFA tablets were not sure how many supplements comprised a full dose. Mothers-in-law and husbands were also unsure of the complete IFA dose for pregnant women. This was a very real issue in our data as less than half of the women interviewed received a full IFA dose. This distinction also comes into play in circumstances of inconsistent supply, which may have occurred to two women in the sample who were not able to obtain IFA from their ASHA. Inadequate IFA supply is an issue at the health sub-center level in Bihar[38] and has been cited as a key barrier of iron supplement consumption in developed and developing country populations [23,24,34,39-41]. Therefore if there was no supply or women missed their antenatal care check-ups, families may not have even been aware that more IFA tablets were needed. Not knowing the proper dose was also major factor for low compliance among pregnant women in Senegal [21]. Clarifying the appropriate dose for women and their family members can enable them to ask for additional IFA when needed or procure it on their own if IFA supplies are out of stock.

In one instance, we found that FLW's counseling messages on IFA timing ran contrary to existing guidelines. In District A, half of the pregnant women reported being told to stop taking IFA in the 8th or 9th month of pregnancy. Only AWWs described this message however all frontline workers in District A believed women should take no more than their dose (100 tablets) of IFA, which does not follow government policy that at least 100 IFA tablets are to be consumed during pregnancy [42]. Decreasing these women's window of opportunity by one or two months gives women who arrive late to ANC less time to consume IFA before the delivery and could curtail some women's consumption even if

they had been planning to consume the full dose before delivery. Studies from low and middle income countries have reported women's irregular IFA consumption nearing delivery [24,25]; however, the authors did not find another instance of frontline workers advising women to restrict IFA consumption during this time.

Side effects due to IFA consumption were commonly mentioned by all participant types as a reason why women stop taking supplements. Exploring this issue further, we found that IFA counseling on this topic could be strengthened by addressing potential side effects with women and family members; counseling to not consume IFA with milk, tea, or coffee; and utilizing beliefs of IFA as heat causing to encourage consumption of iron absorption enhancers, keeping in mind cost constraints. Most frontline workers knew how to counsel about IFA side effects. However, it appeared that women who had not suffered side effects or had but did not talk about this with frontline workers were not counseled on possible issues. Warning women and their families ahead of time could lessen negative reactions if they do occur[23]. Many studies that have found side effects to have little influence over continued IFA consumption have also included repeated health worker interactions or improved counseling regarding potential side effects[21,25,41,43]. In Bihar, preemptive counseling surrounding possible side effects may improve IFA consumption as women will not be surprised if these do occur. Including in-laws and husbands in this counseling may also increase family support and mitigate negative responses.

In District B, some frontline workers recommended consuming IFA with milk if experiencing side effects or as general practice. Additionally, no participant described guidelines concerning IFA consumption with coffee or tea, despite training

recommendations that these should be avoided as they inhibit iron absorption[35,44]. Studies in Nigeria and South India have found that women often consumed IFA along with milk, tea, or coffee[34,45]. In Tunisia, drinking tea after eating was significantly associated with iron deficiency anemia in a population of reproductive age women[32]. In Bihar and much of India, these beverages are commonly consumed and frontline worker counseling must include advice to restrict consumption of these beverages when taking IFA. Steps should also be taken to correct misinformation that milk is recommended to consume with IFA.

One commonly mentioned reason for not consuming IFA was the concern that IFA caused 'heat' in the body. Other studies in India found pregnant women avoiding 'hot' foods[33] and concern that IFA, described as 'hot', would harm the child [36]. One remedy implemented in Hong Kong was to recommend appropriate 'cold' foods to consume with IFA, such as oranges, which also promote iron absorption [24]. This recommendation could potentially be beneficial for the Indian context though 'hot' and 'cold' delineations change by region and would have to be adjusted [46]. For example, in our data we heard conflicting views as to whether milk was a 'hot' or 'cold' food. In addition, financial constraints of the population should be considered.

Role of the Family

Through our interviews, we found that the husband and mothers-in-law can be powerful positive or negative influences on the behaviors of the pregnant woman; however, they are often not involved in some key areas of IFA counseling. Overall, both mothers-in-law and husbands showed the most uncertainty and lack of knowledge regarding anemia causes and consequences, IFA consumption and dosing, and barriers to IFA consumption.

Taking into consideration the husband's role of purchasing food and medicines and the in-laws who most often accompany women to health appointments, including them in the conversation of health and nutrition during pregnancy has obvious benefits. In terms of IFA, mothers-in-law and husbands were often first to know about any symptoms associated with IFA consumption. Therefore, if they did not know about the potential side effects of IFA, then logically they might discourage consumption, especially if they were not aware of the benefits for mother and child. Including family members in counseling surrounding anemia consequences, IFA benefits, and potential side effects may transform the family unit into a positive influence on the pregnant woman's consumption. In quantitative and qualitative analyses, family support was found to be a key factor for IFA adherence among pregnant women [26,36]. FLWs can increase family member exposure to counseling messages by repeated home visits and making sure to engage those who accompany women to the health center. With these changes, the family is poised to play a key role in reminding the women to take IFA daily and to procure IFA when more is needed.

Strengths & Limitations

This study had several strengths. We interviewed health workers, beneficiaries, and family members, which led to a more complete picture of the existing iron supplementation program. The community members we interviewed were additionally from coverage areas of the included health workers, therefore we were able to triangulate some counseling messages from multiple sources.

Our study also had some limitations. All information was based on self-report and subjective interpretations of personal experiences. However, in most cases we were able to confirm these insights with other participant views. Interviews were also conducted with four research assistants, two female and two male. Participants may have responded differently based on the interviewer's gender. We did ensure that all pregnant women were interviewed by women and husband's focus groups were moderated by men. Though our research assistants were not healthcare personnel, being affiliated with CARE may have influenced our participants and they may have tried to 'please' the interviewer at some points. This may have led to such situations as health workers presenting more ideal counseling scenarios or pregnant women overstating FLW interaction or IFA consumption. Though our selection of pregnant women was random, mothers-in-law and husbands were selected by convenience sampling on availability and this may have impacted results as well. As in all qualitative data, our results are not generalizable. However, our identified themes may be helpful in strengthening iron supplementation programs in similar settings.

Implications

Overall, we found key knowledge gaps which could be addressed through health worker training or community awareness strategies. Recognition of anemia as a widespread issue will be central to motivating FLWs and families to understand the importance of IFA tablets during pregnancy as well as highlighting the link between anemia and iron deficiency. Additional monitoring should also ensure that ANC services are being provided free of charge as some of the most impoverished families may not receive services due to fees being charged for registration. Enhanced FLW training should

correct inappropriate messages as well as focus on how to counsel and negotiate treatment regimens with women and their families[23]. Finally, ensuring home visits from ASHAs and AWWs as well as counseling strategies such as reminding techniques may help prevent forgetfulness as well as increase family member interactions which may ultimately lead to a more supportive environment for women's IFA consumption.

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Table 6.1: Unique Domains of Participants' Knowledge and Behavior Surrounding IFA and Anemia

Community Members	*All* • Nutrition and poverty as only anemia causes • Uncertainty in anemia consequences • Mixed beliefs of anemia prevalence	*Pregnant Woman* • Unique barriers to IFA consumption o Does not like medicines o Forgot/lost tablets o Does not believe or feel positive effects • Fees for ANC service • Counseled to stop consuming in 9th month • Heard anemia/IFA messaging outside of village through family sources	*Mother in Law* • Unsure of full IFA dose • Did not mention any reason to stop IFA consumption • Fees for ANC service	*Husband* • Unsure of full IFA dose • Knowledge of IFA messages varied with time at home
Frontline Workers	*All* • Nutritional and non-nutritional causes of anemia • Role of iron • Anemia perceived as rare • Unique barriers to IFA consumption o Diarrhea o Black stool o Dizziness	*ANM* • Diagnostic symptoms of severe anemia • Interaction with pregnant women at VHND • Resource for ASHA/AWW	*ASHA* • Incorrect counseling o Take IFA with milk • Most accessible resource to village women	*AWW* • Incorrect counseling o Do not consume IFA during 9th month • AWW home visits varied by district

IFA: iron and folic acid; **ANC:** antenatal care; **ANM:** Auxiliary Nurse Midwife; **ASHA:** Accredited Social Health Activist; **AWW:** Anganwadi Worker

Chapter 7: Conclusions

In Bihar, India, high maternal anemia and low iron and folic acid (IFA) receipt and consumption persisted despite the Government of India's program mandating universal IFA distribution and counseling. Overall, our research goal was to examine the existing iron supplementation program in Bihar, India. We did this by assessing the determinants of IFA receipt and consumption, the IFA supply chain, and the knowledge and demand of anemia and IFA among the community and health workers.

In the DLHS-3 analysis, we discovered significant variables at the individual, interpersonal, and organizational level which influenced IFA receipt or consumption among pregnant women. In the context of our conceptual framework, we found modifying factors which included wealth, education, religion, caste, and age of marriage. Antenatal care variables spanned the levels of interpersonal (health worker interaction) and organization (facility infrastructure and supply) (Figure 3.1).

The IFA supply analysis also identified bottlenecks at the organizational level, which could influence the women's perceived self-efficacy. For example, if a woman attempted to obtain IFA from a health worker and she was told repeatedly there was none in stock, this may discourage the woman from asking in the future and lower her perceived self-efficacy. In one case, we found that poor supply was also fostering distrust in the community. A block official stated that community members felt health workers were stealing their medicines. Inconsistent supplies may therefore increase barriers at the community level by decreasing trust of health workers (Figure 3.1).

Through our qualitative analyses we found that both family members and health workers believed that anemia was rare in their communities. This low perceived susceptibility may be due to a high perceived severity of anemia, which we also observed. For example, if anemia leads to severe and noticeable consequences, then the lack of those consequences indicates low anemia prevalence. If this perception of low anemia prevalence is common at the community level and with those who implement policy at the organizational level, little change may be expected despite federal policy strategies (Figure 3.1).

Our Program Logic Model of the iron supplementation program in Bihar also shows key activities which influence both supply and demand. By assessing the existing activities, we were able to recommend improvements to these actions such as better counseling messages and strategies as well as improved supply chain practices. The next step in this process is to implement these changes and measure outputs and short-term outcomes to evaluate which strategies are most successful and ready to be scaled up. Additionally, examining existing strategies of mass media promotion in order to assess the impact of these strategies is needed to evaluate the worth of these additional IFA promotion activities (Figure 7.1).

Key Findings

Determinants of IFA Receipt

We found that among women in rural Bihar who attended at least one antenatal care check-up, individual factors still play a significant role in determining IFA receipt and consumption. Odds of both receipt and consumption were associated with

educational attainment and with wealth. Odds of IFA receipt was lower for women who married before 18 years of age and for non-Hindus. Also, the odds of adequate IFA consumption was lower for women of scheduled castes. These relationships persisted after adjusting for antenatal care, health sub-center factors, and other individual factors.

As expected, antenatal care factors were associated with IFA receipt and consumption as this is the main route of IFA delivery for most women utilizing government healthcare. Services provided at ANC were significantly related to both IFA receipt and consumption. For IFA receipt, ANC practice and ANC timing and frequency variables had a significant interaction. This appeared to indicate that for women attending four or more appointments, the number of practices provided were less influential to IFA receipt. Overall, women who attended more ANC did receive more ANC practices. Also, for women who received IFA, both ANC practices and ANC frequency were related with adequate IFA consumption though ANC counseling and 'early enrollment with <4 ANC visits' were not significantly associated.

Health Sub-Center factors were not associated with IFA receipt. However in the IFA consumption model, IFA supply was correlated with adequate IFA consumption. This may have influenced consumption via supply (women who received enough tablets consumed them) or through added counseling.

IFA Supply

In our mixed methods analysis of IFA supply in Bihar, we found critical bottlenecks which impacted IFA supply including forecasting, procurement, handling of expired drugs, storage, a lack of personnel, and training opportunities for key players in

the supply chain. Existing forecasting strategies involved a top down approach, and often documentation was not available to implement a needs based approach. Timely drug receipt was another identified bottleneck. Though policies existed to motivate suppliers to deliver on time, few districts were utilizing this strategy. Writing requests and documenting them was an additional issue that prohibited effective procurement and forecasting. Many IFA requests were shared with storekeepers verbally and were not recorded. Only completed requests were noted for stock keeping purposes. Keeping buffer stocks was another behavior that could be improved. Though several respondents knew what buffer stocks were, we did not see any storekeepers who appeared to be practicing this behavior. In many cases, expiring drugs were pushed out to lower levels (e.g. district to block, block to sub-center) in order to get rid of them. Stockroom infrastructure was also lacking, and in many cases storerooms were transient locations, prohibiting permanent upgrades to be implemented. Many of these issues could be addressed by increasing training of storekeepers as well as other health workers on the practices of efficient stock management.

IFA Demand and Counseling

By collecting multiple perspectives on anemia and IFA, we were able to obtain a more complete picture of Bihar's iron supplement program. Through this we were able to identify some key areas for improvement. Most of the health workers and community members perceived anemia to be rare or nonexistent in their communities. This was most likely due to the perception that anemia symptoms are always severe and noticeable. Understanding of mild and moderate anemia was not mentioned in our interviews. We also identified several potential areas for improvement in the current health worker

counseling messages and strategies. Women and community members were often able to describe at least one benefit of IFA; however, few knew the correct dosage. In addition, some health workers were restricting women from taking IFA in the 8th or 9th month of pregnancy, and others were suggesting consumption of IFA with milk. Both of these practices are incorrect. Side effects and strategies to mitigate them were known by the health workers; however, they did not appear to be mentioned unless the woman had an issue. Finally, the role of the family in IFA consumption was explored. Family members, especially husbands and mothers-in-law, held great power in the family unit and were often missing key information which may prevent them from discouraging IFA consumption or motivate them to encourage IFA intake. These findings could be addressed by health worker training and building community awareness around anemia and IFA.

Strengths and Limitations

In the DLHS-3 analysis, study strengths included a large representative sample of ever-married women in rural Bihar. We were also able to use several ANC characteristics to create two ANC factors which reflected ANC quality by practice and counseling measures. However, due to the survey's questioning pattern, we had to exclude women who had not received ANC, which limited interpretations to this subset of women. All answers given were also based on self-report and therefore subject to recall bias. We were also limited in that there was no survey question addressing IFA counseling, which would have been most appropriate. The counseling questions also covered several topics but did not ask about message repetition or time spent on each topic.

The research evaluating supply and demand of IFA in Bihar had several strengths. We were able to interview a wide range of respondents from various levels of government and in the community. This allowed a broad perspective on issues of supply (from state level to health sub-center) and demand (health workers, beneficiaries, and family members). In both studies, we were able to compare experiences across respondents, which enabled us to confirm key points mentioned within and across districts. In the supply manuscript, we were additionally able to gather quantitative data from Auxiliary Nurse Midwives (ANMs), which further supported the qualitative results with a representative sample from the 8 districts surveyed.

One study limitation is that only a selected number of sites in Bihar were visited. Of the 38 districts, we only went to 8 (IFA Supply) and 2 (Perceptions of Anemia and IFA) for data collection. However, with these we were able to identify common themes and compare districts to find traits specific to each region. Conclusions reached by qualitative analysis are also not generalizable. However, we did find that many of our themes agreed with existing literature from other developing countries as well as other parts of India. Therefore, insights gained here may be useful for iron supplementation programs in similar settings. Both studies were also cross-sectional in nature. We did not re-visit sites to review supply protocols or IFA counseling over time.

Proposed Actions

Through this coordinated approach to the overall research question, we have identified several proposed actions to improve this program which should create a more consistent IFA supply, encourage more effective counseling, address misinformation, and

suggest potential campaigns or interventions which could be avenues for further research (Table 7.1).

Improving IFA Supply

Actions proposed for improving the IFA supply apply broadly to all essential medicines in Bihar. Therefore, improving the IFA supply chain will have a positive effect on the rest of essential drugs. Improvements identified focus on the district, block, sub-center, and village levels.

At the district level, civil surgeons and storekeepers work with suppliers to purchase drugs and pick up shipments. In several instances, they mentioned delayed shipments. Ensuring utilization of the State Health Society policy should help in minimizing these late drugs, though few district officials mentioned this strategy. We propose that ensuring awareness and use of this policy will increase on time drug deliveries to districts from suppliers (Table 7.1).

Storekeeper training was rarely done and was underappreciated by many district and block officials. However, storekeepers almost universally seemed interested in receiving training, and many felt overwhelmed in their position. In addition, though pharmacists had received training in pharmacy school, in some instances storekeepers or clerks, who had received minimal training from their predecessors, were running the store. Training which would include sessions on forecasting, maintaining a buffer stock, purchasing, documentation, and storeroom order may help to increase efficiency in the supply chain. After these trainings, monitoring activities and refresher trainings will be needed to ensure sustained improvement in the supply chain. Health workers – ANMs,

Accredited Social Health Activists (ASHAs), Anganwadi Workers (AWWs) - can also benefit from this training in order to manage their stocks more efficiently (Table 7.1).

Expiring and expired drugs were also an issue found in the supply chain. Some districts distributed expiring drugs down to the block, where they often distributed it to the ANMs. Therefore, the IFA was disposed of by the ANMs as they could not distribute such large numbers of IFA at one time. This also leads to dysregulation in drug disposal. Blocks and districts have committees which decide on disposal tactics; however, ANMs do not necessarily follow these protocols. Developing a transparent and standardized method of dealing with expired medicines as well as inventory practices should be enforced to prevent expired medicines and to deal with them appropriately when it does happen (Table 7.1).

In times of drug shortage, there are funds in place to purchase drugs locally. Exploring the use of these funds and promoting this practice among ANMs and blocks will enable them to take appropriate measures to care for their patients in times of shortage (Table 7.1).

IFA Demand

Increasing IFA demand among the community members involves more effective counseling by health workers to help foster this demand, as well as building community awareness. The Integrated Family Health Initiative (IFHI) project has implemented a new way of health worker training called the Health Sub-Center platform. This involves working with all health workers in a health sub-center (HSC) coverage area (ANM, AWWs, and ASHAs) to train together, which fosters coordination within this team of

health workers. Currently CARE is creating a 'maternal nutrition' training session, and we propose additions be made to IFA counseling messaging (Table 7.1). In addition, general training sessions on IFA counseling for ANMs, ASHAs, and AWWs should include these updates as well.

Making the true prevalence of anemia known in each district and discussing mild and moderate anemia symptoms and consequences will be necessary. As of now, health workers feel that very few women are suffering from anemia in their communities. Therefore, convincing them of the problem will be critical. If possible, testing the health workers' own blood to diagnose anemia among themselves may shed light on the issue as well, as many of them are probably anemic (as are an estimated 68% of non-pregnant ever-married women in Bihar[3]) (Table 7.1).

In one district we interviewed, health workers appeared to be counseling women that IFA consumption must be avoided in the last one or two months of pregnancy. It's unclear where this recommendation came from, but it should be emphasized that women can take IFA through delivery and should also be taking 100 IFA tablets post-partum, as per national policy[108]. Taking IFA during this time is especially important for restoring the woman's iron stores, which may be exhausted from the current pregnancy. In Bihar, short inter-pregnancy intervals are common, thus making sure that the woman's iron stores are replenished should also help with her next pregnancy as well. The misinformation should be examined further to find out why women think IFA consumption should be restricted or why health workers are recommending this strategy. Information should be disseminated that this is false and that women should be

encouraged to consume at least 100 IFA tablets, even in their 8th and 9th month of gestation (Table 7.1).

In our data, some women had been counseled on how to mitigate side effect symptoms. However, women who did not suffer from side effects did not know about the existence or strategies of how to handle side effects. Addressing side effects preemptively makes this situation more manageable. Warning about side effects is important so that when women do feel gastrointestinal discomfort, nausea, etc. they can take precautionary measures and will be less likely to discontinue consumption. Engaging family members in this discussion is also paramount, as we found that many family members did not appear to be counseled on side effect strategies. If women are experiencing side effects and tell their family members who are not aware of potential side effects and strategies, it is logical that family would discourage IFA consumption. Health workers should be trained to discuss side effects upon IFA distribution and engage family members in this discussion. This way the family may be better prepared to address side effects when they happen and may be more likely to ask the health worker for additional techniques (Table 7.1).

Unfortunately one technique we heard to ameliorate IFA side effects was to consume IFA with milk. Calcium is known to inhibit absorption of non-heme iron[134], and the training modules do specify that milk is not to be consumed with IFA[135]. In addition, coffee and tea also inhibit iron absorption due to polyphenols[134]. Though this is mentioned in the ASHA training manuals[135], no health worker mentioned this in our interviews. Emphasizing this in training and encouraging women to consume IFA with water and fruits or fruit juice will help those women who are compliant to actually absorb

the iron in these tablets. Potentially, this message could be further encouraged through local beliefs regarding 'hot' and 'cold' foods. IFA tablets are typically thought of as 'hot.' In one case, a husband explained that milk should be taken with IFA to maintain body temperature. Finding foods that are thought to balance IFA's 'heat,' which improve absorption or at least do not inhibit it, could be a novel way to incorporate local food beliefs to increase adoption of correct IFA behaviors (Table 7.1).

Campaigns

In addition to health worker advice, families can receive information from mass media outlets, health campaigns, family, and friends. Therefore, increasing awareness of anemia at a community level could be an important way to promote IFA consumption and reinforce health worker messages. Community campaigns could involve hemoglobin testing, to increase awareness that anemia is a widespread issue, cooking demonstrations - using local, economical, iron-rich foods - and disseminating IFA counseling messages such as the benefits of IFA. In India, young children, adolescent girls and boys, women of reproductive age, pregnant women, and lactating women are all targets for iron supplementation according to national policy[108]. Therefore, these groups could be targeted together to combine resources and maximize outreach (Table 7.1).

In the DLHS-3 analysis, it was evident that many women received some antenatal care and purchased IFA from private sources. Therefore, creating awareness among private providers of appropriate IFA counseling and dosages should be encouraged. Establishing baseline knowledge and gaps will be important to ensure proper messages

are being used in the private sector, as their knowledge base is distinct from government health workers (Table 7.1).

Interventions

In addition to enhanced trainings, the following interventions aim to increase health worker accountability, improve awareness of key IFA messages, encourage preconception and post-partum IFA consumption, and expand iron consumption through fortification.

As others have found, we confirmed that women forget to take IFA. While increased number of ANC visits and home visits help women to remember the importance of IFA, a daily reminder could be even more useful to help women remember to take their pills. Cell phone use is common in many developing countries, and using cell phone timers to remind women to consume their IFA may be helpful in increasing consumption. Health workers could promote usage of timers and check to see if they are being used for that purpose. In some cases, the woman may not have a phone but could use a family member's phone. In this way, other family members would also be involved in encouraging IFA consumption within the household (Table 7.1).

Another intervention could be to send texts or graphics to beneficiaries each day to remind them to take their IFA. This could be set up automatically so the health worker is not texting individual beneficiaries each day. Along with a reminder, IFA counseling messages could be added to inform about IFA benefits and anemia consequences, warn of side effects, and encourage appropriate IFA consumption strategies. In Iran, a randomized controlled trial was conducted using this approach. Researchers found that

consumption in the intervention group significantly increased, though they found no difference in serum ferritin or hemoglobin values between intervention and control groups [136]. However, women with iron deficiency anemia were excluded, and the mean ferritin values were well above iron deficiency levels. An effect might have been seen if this study had included anemic women, as they would absorb more iron from the iron supplements. Therefore, it is possible that in the Bihar population, this intervention would show improvement in compliance and iron status indicators (Table 7.1).

In Bihar, an ongoing intervention uses cell phones among health workers. A possible addition to this intervention could be to use health workers' phones to increase accountability during home visits. An existing intervention in the Saharsa District in Bihar is using automated due lists to encourage home visits to these women[33]. One addition may be using GPS tracking to "check-in" to the women's houses to confirm that they were at that location and encourage additional home visits. Additionally, mapping health workers' visits may help identify gaps or areas that are not being covered. Incentives may be used to encourage better coverage or increased number of house visits during the antenatal and post-partum periods (Table 7.1).

Though all women in our data could list at least one IFA benefit, many did not know all benefits or other key messages such as full dosage or side effect strategies. Providing posters or flyers can easily be misplaced or lost. Additionally, asking health workers to carry extra items may cause undue stress or lead to these items being left at home and not distributed. However, the IFA blisterpacks themselves are already being distributed. Putting graphics on the back of IFA packages may increase knowledge

without increasing items to keep track of. In addition, the woman will see these messages on a daily basis as she consumes IFA (Table 7.1).

Two additional interventions may encourage several healthy behaviors including IFA consumption: the newlywed package and the delivery package. This intervention would give a package of goods, which would include IFA, to newlyweds or to women who have just delivered. For example, for newlyweds the woman may become pregnant soon, thus giving IFA and other items tailored to this stage of life may be beneficial. For women who have just delivered, giving them information and items such as IFA could be helpful during this post-partum time.

In our data, many health workers and community members described poor families as those who ate only chapatti and salt. This demonstrates the dearth of food variety that impoverished families consume but also presents an opportunity. Flour fortification with iron may be an important step to improving the Bihar population's iron status. Wheat products in the form of chapatti, roti, and others are a key staple food. Fortifying this wheat with iron would be a way to increase iron consumption for those who are not consuming a diverse diet or IFA supplements (Table 7.1).

Finally, some women in our data and in the literature [28,82] discontinue IFA or do not consume IFA because of a dislike for consuming "medicines." Though iron and folic acid is a supplement, it is perceived as a medicine by most of the participants we interviewed. It's possible that if an equally effective remedy existed and could be distributed nationally, this may alleviate those concerns. One possibility is an iron containing Ayurvedic tablet called *Punarnavadi Mandur* which is already being

distributed through ASHA kits in India for anemia and dropsy[137]. Very few studies have been done to research the effectiveness, side effects, dosing, and acceptability of these tablets[138,139]. If it is found to be effective and with fewer side effects, as some claim[138], this may be an interesting alternative for the Indian population, where Ayruvedic remedies are often perceived favorably (Table 7.1).

Overall, through this research, we have identified many actions that may strengthen the iron supplementation program in Bihar, India. Future work should aim to test these programmatic changes and evaluate the impacts on outcomes such as supply availability, health worker counseling, increased knowledge of the beneficiaries and of the community, and ultimately increased IFA receipt and consumption leading to reduced prevalence of maternal anemia. These changes may also have a broader impact such as improving supply chain and logistic practices and increasing anemia awareness among all high risk groups.

Implications and Future Research

Though our research results have been generated from Bihari populations, there are relevant implications for other parts of the world as well. First, many of the bottlenecks we identified have been reported in other parts of India as well as other low and middle income countries. Thus, our results may be useful to other programs in similar settings and may identify relevant indicators to measure as well. For example, many states in India are currently implementing changes to their supply chain in an attempt to emulate the model in place in Tamil Nadu, recognized by the World Health Organization as an effective drug procurement model[140,141]. Therefore, evaluations to

ascertain effectiveness of changes to the drug tendering and distribution process are being conducted in several states [141-143]. These evaluations tend to focus on how drugs are purchased and on governance surrounding tendering and drug quality. Our evaluation results and strategies offer insight to the lower levels of the supply chain, from the village level up to the district. Both upstream and downstream perspectives are critical to understand and improve the supply chain, and ensure successful delivery of quality drugs to beneficiaries. Our methodologies additionally could be employed to investigate supply chain practices in other states at all levels in order to further improve IFA and other essential medicine distribution in other parts of India. Additionally, the findings of our work are similar to those found in other low and middle income countries that have also reported supply chain issues such as poor forecasting mechanisms[144], frequent stock outs[145], supplier delays[145], and expired drug stock[145-147]. Therefore, our recommendations and methodology may be useful to consider in countries with similar contexts.

Furthermore, we also offer a set of tools to assess existing programs' activities and impact. By utilizing state level survey data, we were able to observe overall IFA receipt and consumption at the state level, as well as identify the determinants of these outcomes. Multilevel modeling techniques were useful to assess variation at the individual and facility levels. We discovered significant variation among facility sites / coverage areas that remained unexplained. However, this variation highlights the importance of contextual factors even in an iron supplementation intervention. Assessing antenatal care quality also revealed the importance of services and counseling given, independent of antenatal care attendance. The current debate regarding the usefulness of antenatal care has posited that these visits may not be associated with improved maternal

outcomes [122,148]. However, we show that when high quality appointments take place, these can be directly beneficial in terms of IFA receipt and adequate IFA consumption, an intervention shown to improve both maternal and child outcomes.

In the supply chain, multiple people from multiple organizations have to coordinate actions to bring IFA to beneficiaries at the village level through health worker distribution. Utilizing a mixed methods approach, we were able to further understand the magnitude and variability of the IFA supply situation in Bihar. Using qualitative methods, we not only were able to ask about protocol use and supply but also capture the context and motivation behind different decisions about supply chain procedures. In addition, we were able to learn about the constraints faced at each level of the supply chain and highlight differences between the policies and realities in the field. In many low and middle income countries, drug supply logistics are an issue and incorporating this methodology may be a useful strategy to capture the scope of the supply issue at all levels and the surrounding context on a broader scale.

We also conducted interviews or focus groups with multiple participant types in order to learn about community and health worker perceptions of anemia and IFA. Many studies focus solely on the women's perspective in iron supplementation programs, which is important. However, by capturing the views of the three types of health workers, husbands, and mothers-in-law, we were able to gain a more complete picture of how iron supplementation is viewed in the community. This strategy may be very useful for other programs as well. In India and many low and middle income country settings, the family unit and in-laws play a significant role in women's diets and healthcare utilization. Therefore understanding their perspective and knowledge, or lack of, can highlight

important gaps or opportunities to engage the family members and to further understand their views. By examining their constraints as well as the beneficiary's, programs can tailor health worker training to address issues raised at the family level or take advantage of positive actions that are taking place.

Finally, our work adds to the program evaluation literature as we present methodologies which can be applied to multiple types of programs in different contexts. Incorporating quantitative and qualitative methods to understand the magnitude of the issues of interest in addition to the context surrounding health outcomes, decisions made, and views of health workers and community members can provide a strong base from which to make decisions regarding program improvements and overall understanding of an issue.

Summary

In summary, this dissertation provides further information to aid in programming and implementation of iron supplementation programs among pregnant women in Bihar, India. By examining this issue looking at determinants of IFA receipt and consumption, IFA supply, and IFA demand, we were able to gain a comprehensive view of the program and design practical recommendations which address the identified gaps. We found that even within women who attend antenatal care, IFA receipt and consumption is not occurring equitably over all education levels and income brackets. Antenatal care quality and attendance plays a major role in successful IFA receipt and consumption; however community variability still exists and was not accounted for with individual or facility level factors. We also discovered key bottlenecks which impact the stock availability of

IFA to health centers at the district, block, and health sub-center levels. This included forecasting, procurement, handling of expired drugs, storage, and an overall lack of personnel and training opportunities for key players in the supply chain. Overall, anemia was not perceived to be a widespread issue in the communities we visited. Health worker IFA counseling was being given, but several improvements could be made including family engagement, counseling on potential side effects, restricting consumption of iron absorption inhibitors, and encouraging IFA consumption through late pregnancy. Proposed actions were then recommended to strengthen the iron supplementation program and improve the health and welfare of pregnant women in Bihar.

Figure 7.1: Program Logic Model of Iron Supplementation Program in Bihar, India

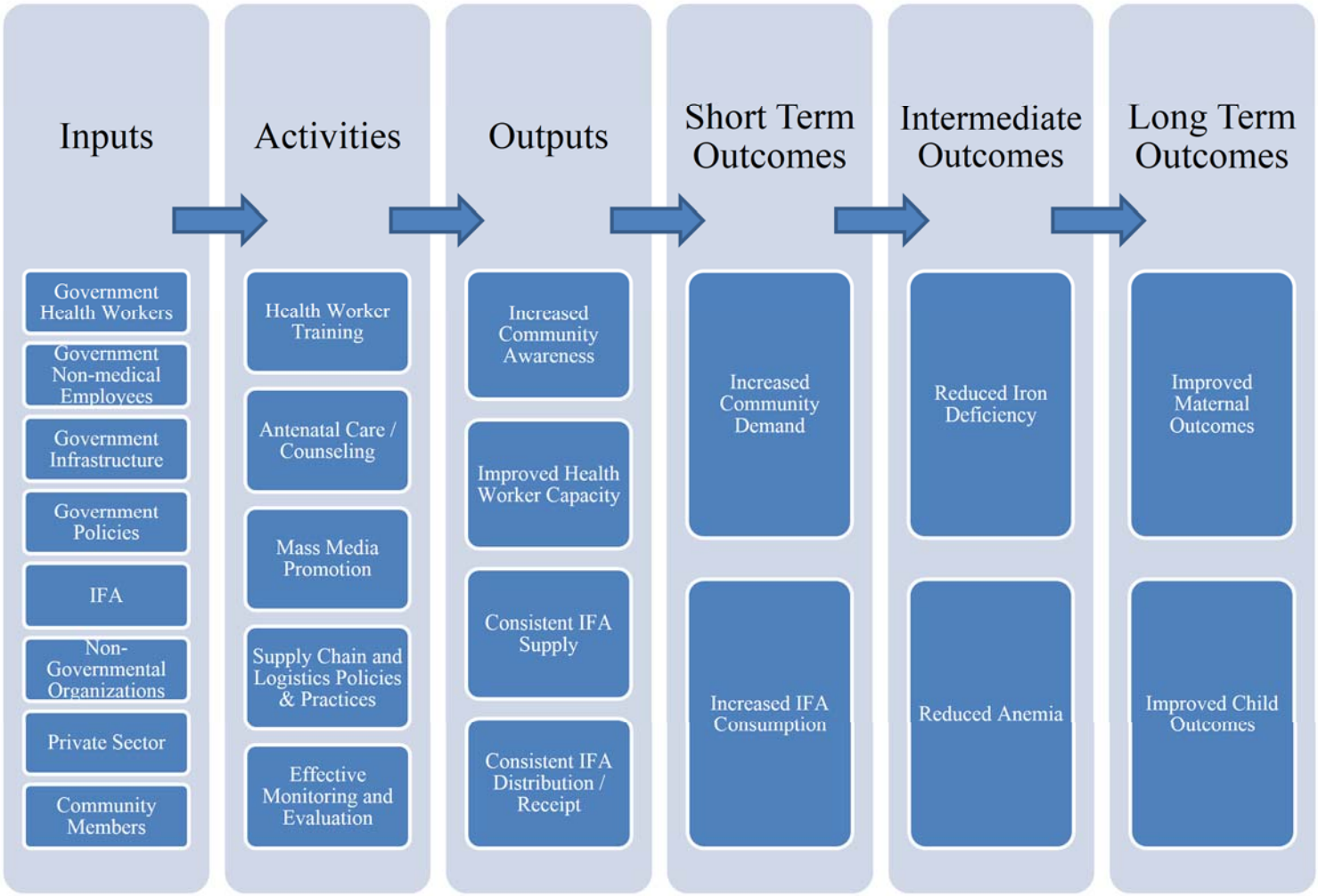

Table 7.1: Proposed Improvements to Iron and Folic Acid Supplementation among Pregnant Women

Topic (Platform)	*Proposed Action*	*Responsible Party*	*Metric*	*Monitoring & Evaluation Responsible Party*
IFA Supply (District / Block Training)	Utilize SHS penalty for late drug supplier deliveries	District level (DHS, CS, Storekeeper)	Document review • Expected arrival date estimated by supplier – if late, was SHS contacted? Did they impose penalties on the supplier?	Initially • CARE team Later • SHS or District self-assessment
	Storekeeper / Pharmacist training on Supply Logistics • Forecasting according to established standards • Buffer stock protocol • When to request stock / responding to requests • Document submitted drug requests • Storeroom order o *Funding requests for storeroom improvement (e.g.*	Storekeeper / Pharmacist; Logistics trainer	Document review • How were supply orders calculated? • At what stock level were additional supplies ordered? • When requests were made for low / out of stock items, when were additional supplies ordered? Observation • Storeroom order – racks, organization, separate sheet with expiration dates, up to date register, tracking of submitted drug requests Interview Storekeepers/Pharmacists	Initially (3-6 month follow-up) • CARE team – Block coordinators Ongoing • Incorporate into CARE's "Self-driven Quality Improvement (QI)" • Existing government oversight

	racks, labels)		• Lessons learned from training • Adoption of new practices from training	
	Transparent plan to prevent expired medicines through appropriate purchasing and safe disposal of expired medicines	All levels engaged in drug storage responsibilities (Storekeepers, ANM, ASHA) and leadership (CS, MOIC, LHV)	Document review • Was plan made? Is it feasible? • How often are medicines expiring? Evaluate drug purchasing procedures if necessary. Observation • Most recent disposal of expired medicines – does it comply with the agreed upon plan? Why (not)?	Initially • CARE team Later • District/Block self-assessment
	Explore use of untied, RKS, other funds to purchase IFA locally when in shortage.	District, block leadership, Village committees	Document review • Was a plan made? • Has it been utilized? How often? How much $$ was spent? • Have ANMs / block been out of stock of IFA? (survey or document review)	Initially • CARE team Later • District/block self-assessment • Existing government oversight
IFA Supply (HSC Platform)	Incorporate drug supply / logistics training • Forecasting • Buffer stock protocol	ANM, ASHA Logistics trainer	Document Review • Stock register (use of buffer stock) o Dates o Supply balance	Initially • CARE team • Incorporate into HSC platform assessment

	• How to use untied funds (or other) to purchase drugs locally		• Expected vs. Actual IFA use (based on population numbers) Interview FLWs • Lessons learned from training • Adoption of new practices from training	Later • Existing government oversight
IFA Demand (HSC Platform)	Incorporate IFA counseling into maternal nutrition training session • True anemia prevalence • IFA consumption through delivery • Warn about side effects • Restrict milk, coffee, tea consumption with IFA • Utilize regional 'hot' and 'cold' foods to encourage iron enhancer consumption • Utilize home visits and AWC interactions to engage family members on all counseling topics	CARE, ANM, ASHA, AWW	LQAS • Questions regarding knowledge and behaviors with IFA Survey • For FLWs, beneficiaries, and family members • Knowledge and behaviors	Initially • CARE Block Coordinators Later • LQAS

IFA Demand (Community Awareness Campaign)	Community campaigns to highlight • True anemia prevalence • IFA counseling messages	CARE, ANM, ASHA, AWW, Private / Public sector organizations	Survey • For beneficiaries, community members • Knowledge and source of information	Initially • Pre/Post surveys – CARE team Later • LQAS; CARE • National surveys; Government
Private Sector (Campaign)	According to DLHS data, many women receive IFA from private sources (62.8%: DLHS-3). A campaign could be done to encourage IFA counseling / provide information to pharmacists, private providers.	• CARE, Private sector providers / pharmacists • Existing relationships developed through private sector innovation	Survey • Knowledge • IFA given to PW • Counseling given to PW • Advice solicited by PW	Initially • CARE team Later • LQAS (beneficiaries)
IFA Counseling (Intervention)	• Counsel to set a daily reminder on cell phone	• CARE, ANM, ASHA, AWW • Incorporate into HSC platform or ICT innovation	LQAS • IFA consumption Survey • Feedback – Did women set reminders? Did it help? • How many tablets did women consume?	Initially • CARE team Later • LQAS

			• Information on characteristics and compliance	
	• Automatic daily text reminders from FLWs (or program) • Text can include reminder and counseling fact, e.g. "Did you take your IFA today? IFA helps make your baby smarter!"	• CARE, ANM, ASHA, AWW • Incorporate into HSC platform or ICT innovation	LQAS • Increases in knowledge / consumption Survey • Feedback about texts • Consumption – observing blister packs if possible • Knowledge about IFA / anemia	Initially • CARE team Later • LQAS
Home Visits (Intervention)	To encourage home visits – understand coverage area • In home visit app – embed a "check-in" which shows where the woman is. Could help in finding gaps / areas that the FLW is not covering	CARE, ANM, AWW, ASHA	Data analysis • GPS data Survey • Feedback • Technical issue troubleshooting	Initially • CARE team Later • Simple format would have to be established for government oversight
IFA Packaging (Intervention)	• Advocate for graphics on blister packs with key messages (*e.g. strong baby)*	BMISCL, Suppliers	Survey • Pilot testing of acceptability • Pre/Post during pilot testing and roll out on IFA messaging and use	Initially • CARE team Later • Government oversight

Newlywed Package (Intervention)	To promote preconception health – include IFA tablets	CARE, ANM, AWW, ASHA	Survey • Number made / received • Feedback form newlyweds on receipt / counseling / utility • Number of IFA consumed before pregnancy	Initially • CARE team Later • Government oversight
Delivery Package (Intervention)	To promote IFA / healthy behaviors postpartum – include IFA tablets	CARE, ANM, AWW, ASHA	Survey • Number made / received • Feedback form mothers on receipt / counseling / utility • Number of IFA consumed postpartum	Initially • CARE team Later • Government oversight
Flour Fortification (Intervention)	To increase iron in poorer populations with few food choices	Government, Fortification program	Survey • Dietary choices • Hematological indices	• Government – incorporate into national surveys
Explore Ayruvedic Remedies (Intervention)	Examine effectiveness of *Punarnavadi Mandur* – currently distributed in India	Government, Researcher	RCT • Effectiveness • Side effects • Acceptability	Initially • Researchers Later • Government

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