Midwifery 61 (2018) 15–21

Contents lists available at ScienceDirect

Midwifery

journal homepage: www.elsevier.com/locate/midw

Financial decision making power is associated with moderate to severe anemia: A prospective cohort study among pregnant women in rural South India

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ARTICLE INFO

Keywords:
Anemia
Decision making
India
Pregnant
Women

ABSTRACT

Objective: According to the World Health Organization, about half of all pregnant women in India suffer from some form of anemia. While poor nutrition is the most common cause, social factors, such as gender and religion, also impact anemia status. This study investigates the relationship between anemia and socioeconomic and health-related factors among pregnant women in Mysore, India.
Design: Prospective cohort study conducted between January 2009 and 2012
Setting: 144 rural villages ten or more kilometers outside of Mysore City received integrated antenatal care and HIV testing services provided by mobile medical clinic in their communities.
Participants: 1675 pregnant women from the villages were screened. All women and their infants were then followed up for up to a year after childbirth.
Methods: women who provided informed consent underwent an interviewer-administered questionnaire, physical examination by a doctor, and antenatal laboratory investigations including blood test for anemia. Women were followed through pregnancy and 12 months after childbirth to assess mother-infant health outcomes. Anemia was categorised as *normal*, *mild*, *moderate*, and *severe,* with moderate/severe anemia defined as a hemoglobin concentration of less than 100 g/l.
Measurements and findings: two out of three pregnant women were anemic at baseline (1107/1654; 66.9%). Of those women, 32.7% (362) had mild anemia, 64.0% (708) had moderate anemia, and 3.3% (37) had severe anemia. Anemia was associated with lower education among spouses (p = 0.021) and lower household income (p = 0.022). Women living in a household where others had control over household decision-making had lower odds of moderate/severe anemia (Adjusted Odds Ratio: 0.602; 95% Confidence Interval: 0.37–0.97) as compared to women who shared decision-making power with others in the household.
Conclusion: Interventions to reduce anemia should focus on education among men and other household decision makers on the importance of nutrition during pregnancy in India.
Implications for practice: To our knowledge, this research is one of the first to examine how control of household resources is related to risk for anemia among pregnant women in India. Our data suggests that interventions aimed at reducing anemia may need to address economic factors beyond nutrition and iron status to reduce the burden of anemia among women in developing countries.

Introduction

According to the World Health Organization, about half of all pregnant women in India suffer from some form of anemia (World Health Organization, 2008). While poor nutrition is the most common cause, malaria; parasitic diseases; HIV infection; and genetic disorders

Abbreviations: AIDS, Acquired Immune Deficiency Syndrome; ANC, Antenatal Care; AOR, Adjusted Odds Ratio; CI, Confidence Intervals; HIV, Human Immunodeficiency Virus; INR, Indian Rupees; OR, Odds Ratio; USD, United States Dollars; VIF, Variance Inflation Factor; WHO, World Health Organization

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https://doi.org/10.1016/j.midw.2018.02.014
Received 2 October 2017; Received in revised form 28 January 2018; Accepted 13 February 2018

also add to the burden of disease (Candio and Hofmeyr, 2007). A study conducted with 186 pregnant women in South India found that on average, women consumed as little as 61% of the recommended daily caloric allowance, and only about four in every hundred had adequate levels of iron in their diet (Hutter, 1996). A study in the state of Haryana also showed that 67.7% of pregnant women suffered from iron deficiency anemia, and among these cases, women also had high rates of insufficient folate and vitamin B12 stores, thus highlighting the additional nutritional health challenges faced by Indian pregnant women (Pathak et al., 2007).

Anemia in pregnancy has been associated with poor maternal and infant outcomes (Scholl, 2005). In India, it is thought to contribute to about 40% of the country's maternal deaths (Registrar General of India, 2004). A tertiary hospital in northern India found that severely anemic pregnant women had a higher risk of premature rupture of membranes, hypertensive diseases of pregnancy, abruption, congestive cardiac failure, and postpartum hemorrhage (Rohilla et al., 2010). Although evidence from other parts of the world is mixed (Haider et al., 2013), studies from India have also shown that anemia in pregnancy is associated with a higher risk for neonatal and perinatal death, low birth-weight infants, and preterm deliveries (Hirve and Ganatra, 1994; Kalaivani, 2009; Rohilla et al., 2010; Kumar et al., 2013; Bora et al., 2014).

Moreover, anemia in pregnancy is a socially patterned phenomenon that disproportionally affects rural, low-income, and socially marginalised women (Bharati et al., 2008; Bharati et al., 2015). Ahmad et al. found that Indian women attending a rural maternity clinic in Maharashtra were more likely to be anemic if they were Hindu, younger in age, had fewer years of education, and lower in socioeconomic status. Other studies have confirmed this association (Bisoi et al., 2011; Sharma et al., 2013).

The etiology of anemia among pregnant women in India is multifactorial (Nagaraj, 2003). Pregnant women in South India commonly adhere to cultural dietary norms that aim to promote her health and the health of the developing fetus (Placek and Hagen, 2015), however there is some evidence that religious strictures against animal products may contribute to low hemoglobin levels among women (Sarri et al., 2006). Indu Capoor has also observed that in a predominantly patriarchal society like India, women are socialised to serve the largest portion of food to their husbands and male children first, and only then feed the remaining food to their female children and themselves (Capoor, 2000). In addition, there is evidence from India and other parts of South Asia that females face significant social discrimination resulting in little power over intra-household decisions and subsequent nutritional deficits and anemia among women (Gillespie and Mason, 1991).

This study is part of a large prospective cohort study examining the influence of integrated antenatal care and HIV testing using mobile medical clinics on uptake of services for prevention of mother-to-child transmission of HIV among pregnant women in rural South India. Specifically, this study investigates the relationship between anemia in pregnancy with socioeconomic and health-related factors. To our knowledge, this research is one of the first to examine how control of household resources is related to risk for anemia among pregnant women in India.

Methods

The study was conducted from January 2009 to January 2012 in Mysore District, Karnataka. The District has a population of 2,994,744 persons, of which 1,483,538 are female. About 58.6% of residents live in 1332 rural villages (Government of India, 2011). Estimated annual per capita income for rural residents at Indian Rupees (INR) 16,086 [United States dollars (USD) $322], and literacy at 63.3% are low compared with all-India annual per capita income of INR 38,005 [USD $760] and literacy rate of 74.0% (Wilcox et al., 2016; Shiddalingaswami and Raghavendra, 2017). Rural district residents are mainly Hindu (86%), 7% are Muslim, and 7% belong to other religions (Mysore District, 2002). A nutrition status report on Mysore District which included the rural and urban communities showed that 61% of pregnant women had mild, 34% moderate, and 2.4% severe anemia (Singh et al., 2006).

A total 1675 pregnant women living in 144 rural villages ten or more kilometers from Mysore City received integrated antenatal care and HIV testing provided by mobile medical clinic. This longitudinal study examined acceptability of mobile integrated antenatal care and HIV testing in rural villages of Mysore *Taluk*. On the day of the mobile medical clinic, pregnant women who came for services were screened for eligibility. Interested participants were informed about the study, and if eligible, underwent an informed consent process in a private location. Participants completed an interviewer-administered questionnaire and physical examination by a doctor and complete laboratory investigations. Of 1675 women who completed an antenatal visit, 1654 (98.7%) were successfully followed-up after childbirth. These participants comprised the study sample for this analysis. See Kojima et al. for complete details of study methods and protocol (Kojima et al., 2017).

The protocol for the study was approved by the Institutional Review Boards of Vikram Hospital and Public Health Research Institute of India in Mysore, India. All participants underwent an informed consent process and gave written consent for participation. Taking part in the study was strictly voluntary and participants were assured that anonymity would be observed at all times. Confidentiality of participants was maintained by using a study identification number on all study records. Permissions were obtained from the District AIDS Prevention and Control Officer, the District Health Officer, and the *Taluk* Medical Officer for Mysore District, prior carrying out the study. The study team also met with the National Rural Health Mission workers in the village to discuss the program before commencement.

After completion of an examination by the doctor, a trained nurse collected blood samples from consenting participants to screen for HIV and other routine antenatal investigations. Anemia testing was conducted on blood samples using Hemoglobin (Cyanomethemoglobin) Beacon Test (Beacon Diagnostics Pvt. Ltd. Kabilpore, Gujarat, India).

Outcome and explanatory variables selection

A pre-tested structured questionnaire in the local language of *Kannada* was used to collect information about sociodemographics, medical, reproductive history, maternal health and labor complications, birth outcomes, and utilization of health services before and after childbirth. On the basis of a literature review, 25 variables were selected that may potentially be associated with anemia (e.g. sociodemographics, reproductive history, such as number of previous pregnancies and history of poor birth outcomes).

The outcome of the study, anemia status, was assessed at baseline. Anemia was categorised as *normal*, *mild*, *moderate*, and *severe* for pregnant women having hemoglobin (Hb) levels of 110 g per liter (g/l) or higher, 100–109 g/l, 70–99 g/l, and less than 70 g/l, respectively based on WHO recommendations. Since only 2.2% of women were classified as having severe anemia, severe and moderate anemia groups were combined to create a moderate/severe anemia variable with Hb concentration less than 100 g/l to avoid issues with small cell counts during statistical analysis.

The main explanatory variable, control of household resources, was assessed by the following question: 'Who primarily decides how the money earned in the house will be used?' Response categories included 'myself', 'husband', 'jointly me and husband', 'others in the household', and 'jointly with others in the household'. The other independent variables of interest were: Education defined as *primary* for those with 1–7 years of schooling and *secondary* for those with 8 or more years of schooling. Since the cost of subsistence and salaries are lower in rural

areas, monthly household income was defined as *low* at ≤ 4000 Indian rupees (approximately USD $72; 1 USD = INR 55.60 at time of data collection), *middle* at 4001–10,000 rupees (USD $180), and *high* for incomes greater than 10,000 rupees. History of poor birth outcomes included past history of induced or spontaneous abortions, stillbirths, death of a child, or low birth-weight baby. Low birth weight (LBW) was defined as < 2500 g. Place of childbirth was defined as *home, public institution,* and *private institution*; *home* and *public institution* were combined due to the low prevalence of home deliveries among this sample of women. Delivery/birth complications information was collected from the discharge summary from the women and included factors such as prolonged labor, maternal health complications, and adverse infant health outcomes. Symptoms and signs of anemia based on doctor examination included pallor of nail beds, conjunctiva, face, oral mucosa, and tip of tongue; cold extremities; brittle nails; fast heartbeat and dyspnea. All demographic and socioeconomic variables were self-reported by the participants at baseline. Gestational age and physical signs of anemia were assessed during the medical exam by a doctor. Pregnancy outcomes were assessed at the follow-up visit and were verified by comparing to the hospital discharge notes.

Statistical analyses

Data are presented as frequency and per cent of total for categorical variables and as mean and standard deviation (SD) and median and range for continuous variables. Differences in anemia by sociodemographics, maternal health, and birth outcomes were identified by χ^2 test and one-way ANOVA for categorical and continuous variables, respectively. Multinomial logistic regression analyses were conducted to identify variables associated with anemia. Crude and adjusted odds ratios (OR) and corresponding 95% confidence intervals (CI) were calculated to test the association between anemia and pre-selected variables. Variables found to be significantly associated with anemia using χ^2 or ANOVA tests or those of clinical importance were selected as independent variables *a priori* to be included in the model. Variables with low response variability (≥90% fell in one response category) and with a large percentage of missing values (> 10%) were excluded from the model. Variance inflation factors (VIFs) and Pearson product-moment correlation coefficient (r) were generated for all independent variables to check for the presence of multicollinearity. A two-tailed statistical significance of $p \leq 0.05$ was used for all analyses. Statistical analyses were performed using SPSS v.20 (SPSS Inc., Chicago, IL).

Findings

Table 1 describes the sociodemographic characteristics of the participants. Of 1675 women who were initially recruited, 1654 (98.7%) completed the entire study protocol. The median age of the women was 20 years (range: 14–40 years) and almost all reported their religion as Hindu (98.9%). The majority of these women (86.9%) and their husbands (71.8%) had at least some education. Half of the women lived in a household with a low monthly income (51.8%), and most had no health or life insurance (89.9%) and no decision-making power over household expenditures (91.4%).

Anemia

Two of out of three pregnant women were anemic at baseline (1107/1654; 66.9%). Of those women, 32.7% (362) had mild anemia, 64.0% (708) had moderate anemia, and 3.3% (37) had severe anemia (Fig. 1). Nearly half of the women with anemia did not show any physical signs of anemia during the medical exam (mild, 55.8% [202]; moderate/severe, 48.6% [362]).

The association between anemia and decision-making power over household expenditures was borderline significant (p = 0.063); the proportion of women who had at least some control of household

Table 1
Baseline characteristics of the cohort of pregnant women seen at the mobile medical clinic in rural Mysore, India between 2009 and 2011 (N = 1654).

Characteristics	N	(%)
Age of mother (in years)		
Mean (SD)	20.87	(2.817)
Median (Range)	20	(14–40)
Mother's education		
None	217	(13.1)
Primary	672	(40.6)
Middle school	555	(33.6)
Secondary or above	210	(12.7)
Father's education		
None	467	(28.2)
Primary	488	(29.5)
Middle school	473	(28.6)
Secondary or above	226	(13.7)
Monthly household income		
Low	856	(51.8)
Middle	680	(41.1)
High	118	(7.1)
Decides how household money is spent		
Mother	22	(1.3)
Husband	601	(36.3)
Others in household	911	(55.1)
Jointly with others in the households	120	(7.3)
Health or life insurance		
Uninsured	1487	(89.9)
Insured	167	(10.1)
Gestational period (weeks)		
Mean (SD)	24.08	(8.42)
Median (range)	24	(5–41)

Education: *Primary* = 1–8 years; *middle school* = 9–10 years; *secondary or above* = 11+ years.
Monthly household income: *low* ≤ 4000 Indian Rupees (INRs), *middle* 4001–10,000 INRs, *high* > 10,000 INRs.
1 United States dollar (USD) = 55.6 INR.

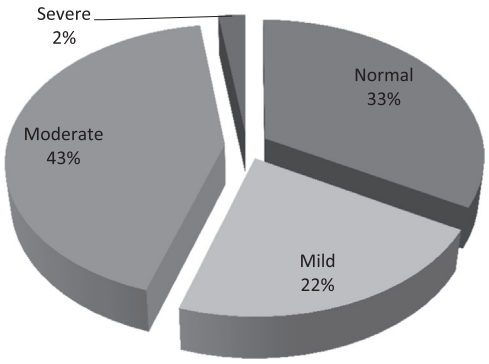

Fig. 1. Diagnosis of anemia among a cohort of pregnant women in rural Mysore, India between January 2009 and 2011 (N = 1654). Anemia during pregnancy: *normal*, hemoglobin (Hb) ≥110 g/liter (g/l); *mild*, 100 ≤ Hb < 110 g/l, *moderate*, 70 ≤ Hb < 100 g/l; *severe*, Hb < 70 g/l.

resources increased with the severity of anemia (Table 2). In general, the proportion of women whose husbands had less than a middle school education (p = 0.006); those with lower household income (p = 0.022); those with a history of pregnancy (p = 0.004) and living children (p = 0.001); those that completed less than four ANC visits during pregnancy (p = 0.056); and those that delivered at home or in public institutions (compared to private institutions) (p = 0.007) was higher among women with anemia. The proportion of women that delivered by caesarean section (compared to vaginally) (p = 0.001) and

Table 2
Sociodemographic factors, maternal health, and birth outcomes by anemia status among pregnant women seen at the mobile medical clinic in rural Mysore, India between 2009 and 2011 (N = 1654).

		Anemia			
		None *N* = 547 *n* (%)	Mild *N* = 362 *n* (%)	Mod/ Severe *N* = 745 *n* (%)	*p*-value
Sociodemographic factors	Mother's age*	20.75 (2.730)	20.74 (2.734)	21.02 (2.914)	0.145
	Mother's education				
	None	59 (10.8)	45 (12.4)	113 (15.2)	0.289
	Primary	225 (41.1)	155 (42.8)	292 (39.2)	
	Middle school	185 (33.8)	121 (33.4)	249 (33.4)	
	Secondary or above	78 (14.3)	41 (11.3)	91 (12.2)	
	Husband's education				
	None	139 (25.4)	109 (30.1)	219 (29.4)	*0.021*
	Primary	141 (25.8)	112 (30.9)	235 (31.5)	
	Middle school	181 (33.1)	98 (27.1)	194 (26.0)	
	Secondary or above	86 (15.7)	43 (11.9)	97 (13.0)	
	Household monthly income				
	Low	280 (51.2)	166 (45.9)	410 (55.0)	*0.022*
	Middle	221 (40.4)	165 (45.6)	294 (39.5)	
	High	46 (8.4)	31 (8.6)	41 (5.5)	
	Decides how household money is spent				
	Mother	5 (0.9)	5 (1.4)	12 (1.6)	0.063
	Husband	179 (32.7)	135 (37.3)	287 (38.5)	
	Others in household	332 (60.7)	194 (53.6)	385 (51.7)	
	Jointly with others in household	31 (5.7)	28 (7.7)	61 (8.2)	
	Health or life insurance: Uninsured	485 (88.7)	320 (88.4)	682 (91.5)	0.133
Reproductive history	Previous pregnancies: Yes	273 (49.9)	208 (57.5)	438 (59.0)	*0.004*
	Existing living children: Yes	226 (41.3)	184 (50.8)	378 (50.9)	*0.001*
	History of poor birth outcomes: Yes	126 (23.0)	103 (28.5)	200 (26.9)	0.138
	Abuse by husband/family: Yes	11 (2.0)	10 (2.8)	31 (4.2)	0.077
	Gestational period (weeks)*	23.61 (8.89)	24.10 (8.48)	24.41 (8.01)	0.241
Pregnancy outcomes	Birth order*	1.64 (0.76)	1.73 (0.74)	1.82 (0.87)	*0.001*
	Vital status of baby				
	Living	498 (91.0)	337 (93.1)	699 (93.8)	0.351
	Aborted/ Died before birth	23 (4.2)	13 (3.6)	19 (2.6)	
	Died during or after birth	26 (4.8)	12 (3.3)	27 (3.6)	
	Less than 4 Antenatal Checkups	24 (4.4)	19 (5.3)	56 (7.6)	0.056
	Delivery place				
	Home	12 (2.3)	12 (3.4)	36 (5.0)	*0.007*
	Public institution	287 (54.9)	187 (53.6)	434 (59.9)	
	Private institution	224 (42.8)	150 (43.0)	255 (35.2)	
	Delivery type: Cesarean	108 (20.7)	49 (14.0)	95 (13.1)	*0.001*
	Preterm delivery				
	No	282 (53.9)	186 (53.3)	428 (59.0)	0.207
	Yes, ≤ 2 weeks early	218 (41.7)	142 (40.7)	262 (36.1)	
	Yes, > 2 weeks early	23 (4.4)	21 (6.0)	36 (5.0)	
	Delivery/birth complications: Yes	249 (47.5)	146 (42.2)	294 (40.7)	*0.049*

Anemia during pregnancy: *normal*, Hemoglobin (Hb) ≥110 g/liter (g/l); *mild*, 100 ≤ Hb < 110, *moderate/severe*, Hb < 100 g/l.
Education: *Primary* = 1–8 years; *middle school* = 9–10 years; *secondary or above* = 11+ years.
Monthly household income: *low* ≤ 4000 Indian Rupees (INRs), *middle* 4,001–10,000 INRs, *high* > 10,000 INRs.
1 United States dollar (USD) = 55.6 INR.
History of poor birth outcomes includes history of induced or spontaneous abortions, stillbirths, death of a child, or low birth weight (defined as < 2500 g).
Abuse was self-reported and includes physical, sexual, or emotional abuse by husband or husband's family within 12 months after baseline.
Place of delivery: *public institution* includes sub-centers, primary health centers, district health hospitals; *private institution* includes maternity homes, private nursing homes, and other facilities.
Delivery/birth complications were defined as at least one of the following: prolonged labor; excessive bleeding, convulsions, or fever among the mothers; cord around baby's neck; jaundice, difficulty breathing, convulsions, fever, crying excessively, skin lesions, bleeding easily, high fever, low body temperature, poor feeding, or diarrhea among the babies; low birth-weight baby; admission of the infant to ICU after childbirth; hospitalization of mother for more than 72 hours after childbirth; or mother received blood transfusion while hospitalised after childbirth.
* Results presented as mean and standard deviation. Differences tested by one-way ANOVA.

those who experienced childbirth or birth complications (p = 0.049) was lower among women with anemia.

Previous pregnancies were highly correlated with birth order (r = 0.82) and with living children (r = 0.85); the latter two variables were excluded from the model. While fitting the model, multicollinearity was present between previous pregnancies and history of poor birth out-

Table 3
Multinomial logistic regression analyses of the odds of anemia among pregnant women seen at the mobile medical clinic in rural Mysore, India between 2009 and 2011 (N = 1654).

	Unadjusted odds ratio (95% confidence interval)				Adjusted odds ratios (95% confidence interval)[†]			
	Mild versus Normal[*]	P-value	Moderate/severe versus Normal[*]	P-value	Mild versus Normal[*]	P-value	Moderate/severe versus Normal[*]	P-value
Mother's age	0.999 (0.952–1.049)	0.976	1.035 (0.995–1.077)	0.090	0.968 (0.914–1.026)	0.273	0.998 (0.953–1.046)	0.935
Mother's education								
None	1.451 (0.844–2.494)	0.178	*1.642 (1.061–2.540)*	*0.026*	1.117 (0.608–2.053)	0.722	1.172 (0.713–1.925)	0.531
Primary	1.311 (0.853–2.014)	0.218	1.112 (0.785–1.577)	0.550	1.034 (0.644–1.662)	0.890	0.892 (0.605–1.314)	0.564
Middle school	1.244 (0.800–1.936)	0.333	1.154 (0.807–1.649)	0.433	1.046 (0.654–1.672)	0.852	1.035 (0.708–1.515)	0.858
Secondary or above	Ref.		Ref.		Ref.		Ref.	
Father's education								
None	*1.568 (1.006–2.444)*	*0.047*	1.397 (0.975–2.002)	0.069	1.592 (0.962–2.637)	0.071	1.114 (0.741–1.677)	0.603
Primary	*1.589 (1.021–2.472)*	*0.040*	*1.478 (1.033–2.113)*	*0.032*	1.612 (0.990–2.626)	0.055	1.260 (0.852–1.865)	0.247
Middle school	1.083 (0.697–1.683)	0.723	0.950 (0.667–1.354)	0.778	1.094 (0.681–1.758)	0.709	0.863 (0.592–1.259)	0.446
Secondary or above	Ref.		Ref.		Ref.		Ref.	
Household income								
Low	0.880 (0.537–1.442)	0.611	*1.643 (1.050–2.570)*	*0.030*	0.659 (0.390–1.116)	0.121	1.191 (0.743–1.910)	0.467
Middle	1.108 (0.673–1.823)	0.687	1.493 (0.946–2.354)	0.085	0.933 (0.555–1.568)	0.792	1.189 (0.741–1.909)	0.474
High	Ref.		Ref.		Ref.		Ref.	
Decides how household money is spent								
Mother	1.107 (0.290–4.232)	0.882	1.220 (0.394–3.773)	0.730	1.005 (0.257–3.928)	0.994	1.117 (0.353–3.542)	0.850
Husband	0.835 (0.478–1.458)	0.526	0.815 (0.509–1.305)	0.394	0.867 (0.485–1.549)	0.630	0.764 (0.469–1.245)	0.280
Others in household	0.647 (0.377–1.111)	0.115	*0.589 (0.373–0.930)*	*0.023*	0.612 (0.346–1.082)	0.091	*0.602 (0.373–0.971)*	*0.037*
Jointly with others in household	Ref.		Ref.		Ref.		Ref.	
Health/life insurance								
Uninsured	0.974 (0.642–1.477)	0.901	1.384 (0.956–2.002)	0.085	1.005 (0.650–1.553)	0.984	1.456 (0.987–2.148)	0.058
Insured	Ref.		Ref.		Ref.		Ref.	
Previous pregnancies								
Yes	*1.356 (1.038–1.771)*	*0.026*	*1.446 (1.158–1.806)*	*0.001*	1.288 (0.942–1.761)	0.112	*1.322 (1.019–1.715)*	*0.036*
No	Ref.		Ref.		Ref.		Ref.	
Antenatal checkups								
Less than 4	1.205 (0.650–2.234)	0.554	*1.758 (1.075–2.874)*	*0.025*	1.163 (0.587–2.303)	0.666	1.631 (0.947–2.808)	0.078
4 or more	Ref.		Ref.		Ref.		Ref.	
Delivery place								
Home	1.493 (0.653–3.413)	0.342	*2.635 (1.338–5.189)*	*0.005*	0.969 (0.398–2.364)	0.946	1.617 (0.795–3.292)	0.185
Public institution	0.973 (0.738–1.283)	0.846	*1.328 (1.052–1.677)*	*0.017*	0.893 (0.669–1.194)	0.446	1.186 (0.929–1.516)	0.172
Private institution	Ref.		Ref.		Ref.		Ref.	
Delivery type								
Cesarean	*0.628 (0.434–0.908)*	*0.013*	*0.579 (0.428–0.784)*	*< 0.001*	0.652 (0.420–1.013)	0.057	*0.681 (0.473–0.980)*	*0.039*
Vaginal	Ref.		Ref.		Ref.		Ref.	
Delivery/birth complications								
Yes	0.806 (0.613–1.060)	0.123	*0.757 (0.603–0.950)*	*0.016*	0.985 (0.716–1.357)	0.928	0.943 (0.721–1.233)	0.666
No	Ref.		Ref.		Ref.		Ref.	

Anemia during pregnancy: *normal*, Hemoglobin (Hb) ≥110 g/liter (g/l); *mild*, 100 ≤ Hb < 110, *moderate/severe*, Hb < 100 g/l.
Education: *Primary* = 1–8 years; *middle school* = 9–10 years; *secondary or above* = 11+ years.
Monthly household income: *low* ≤ 4000 Indian Rupees (INRs), *middle* 4,001–10,000 INRs, *high* > 10,000 INRs.
1 United States dollar (USD) = 55.6 INR.
Place of delivery: *public institution* includes sub-centers, primary health centers, district health hospitals; *private institution* includes maternity homes, private nursing homes, and other facilities.
Delivery/birth complications were defined as at least one of the following: prolonged labor; excessive bleeding, convulsions, or fever among the mothers; cord around baby's neck; jaundice, difficulty breathing, convulsions, fever, crying excessively, skin lesions, bleeding easily, high fever, low body temperature, poor feeding, or diarrhea among the babies; low birth weight baby; admission of the infant to ICU after delivery; hospitalization of mother for more than 72 hours after delivery; or mother received blood transfusion while hospitalised after delivery.
Low birth weight (LBW) defined as < 2500 g.
* Reference category.
† Analyses adjusted for mother's age

comes (VIF = 1.65 and VIF = 1.42, r = 0.528); the latter variable was excluded from the model. Slight multicollinearity was also present between childbirth or birth complications and type of delivery (VIF = 1.33 and VIF = 1.39, respectively; r = 0.49); and between previous pregnancies and mother's age (VIF = 1.26 and VIF = 1.22, respectively; r = 0.40). The authors were willing to accept this level of multicollinearity due to the relevance of the variables to the study, and therefore all four variables were included in the model.

Correlates of mild anemia

Results of the multinomial logistic regression analyses are presented in Table 3. Results of the adjusted analyses are discussed below. Although nonsignificant, decision making power over household expenditures and spouse's education were correlates of mild anemia compared to normal Hb levels. Women who lived in a household in which they shared decision making power with other members had greater odds of mild anemia compared with those who lived in a household in which other members (excluding the women themselves and their husbands) held decision making power (AOR = 1.63; CI = 0.924–2.89). Women whose husbands were uneducated (AOR = 1.59; CI = 0.96–2.64) or only completed primary education (AOR = 1.61; CI = 0.99–2.63) had greater odds of mild anemia compared with those whose husbands had at least a secondary education.

Correlates of moderate/severe anemia

Decision making power over household expenditures, previous pregnancies, and delivery type were significant correlates of moderate/severe anemia compared to normal Hb levels. Women who lived in a household in which they shared decision making power with other members had greater odds of moderate/severe anemia compared with those who lived in a household in which other members (excluding the women themselves and their husbands) held decision making power (AOR = 1.66; CI = 1.03–2.68). Multiparous women (AOR = 1.32; CI = 1.02–2.72) and women who delivered vaginally (AOR = 1.47; CI = 1.02–2.11) also had greater odds of moderate/severe anemia. In addition, women who lived in households that lacked health or life insurance (AOR = 1.46; CI = 0.987–2.15); and women who completed less than four ANCs during pregnancy (AOR = 1.63; CI = 0.95–2.81) had greater odds of moderate/severe anemia, although these findings were only borderline significant.

Household income and place of delivery were correlates of moderate/severe anemia compared to mild anemia (data not shown). Women from low-income households had greater odds of moderate/severe anemia compared to those from high-income households (AOR: 1.81; CI: 1.07–3.05; p = 0.027). Greater odds of moderate/severe anemia were also observed among women who delivered at public institutions compared to those that delivered at a private institution (AOR = 1.33; CI = 1.01–1.75; p = 0.043).

Discussion

The purpose of this study was to investigate the social, economic, and health-related factors that contribute to anemia in pregnant South India women. At 67%, the prevalence of anemia among this sample of pregnant women was high although it falls within the range described in other studies in India (Sharma et al., 2003; Sinha et al., 2006; Pathak et al., 2007; Toteja et al., 2008; Bora et al., 2014). Lower education level of spouse, multiparity, delivery type, and lack of involvement in household decision-making were independently associated with anemia after adjusting for other variables in a multinomial regression model.

This is one of the first studies in India to look at the impact of financial decision-making on anemia status of pregnant women, however other research points to this impact, as lack of control over household resources can limit women's autonomy in seeking healthcare or purchasing nutritious food items (Bentley and Griffiths, 2009). Since a major cause of anemia in pregnancy is poor nutritional status, the results suggest that educational interventions should target actual household decision makers with information about preventing anemia and poor maternal and infant health outcomes. In many south Indian households either the husband, mother, or the mother-in-law decide what items are purchased and consumed by a family, suggesting that they are important stakeholders in addressing pregnancy-related nutrition issues. In addition, women must also be empowered to protect their health and the health of their child by consuming foods rich in critical micronutrients. Such interventions must be placed in the context of Indian culture and religion, both of which play an important role for maternal-infant health in this community (Placek and Madhivanan, 2017; Placek et al., 2017).

This study has several strengths: it used a systematically selected community-based sample of pregnant women. In addition, study participants were followed for up to one year after childbirth resulting in high quality longitudinal data. There were limitations, however. We did not collect data on the parasitic infestation and nutritional intake so we are unable to examine the relationship with anemia. In addition, risk factors were self-reported and it is possible that this may have led to a misclassification of risk behaviors. Because the survey involved collection of temporally distant variables and data on economic variables there is a possibility of measurement error leading to residual confounding that could potentially obscure relationships. Also, we were interested in examining the effect of the interaction between education and decision making power on anemia in pregnancy. However, few women in our study were sole decision makers in the households, and after stratified by education, insufficient numbers prevented such analysis. Finally, there is a potential for selection bias as the study used a non-random sample and findings may not be generalizable to other populations.

Despite these limitations, study results emphasise the important role family decision-making plays in anemia in pregnancy. This is of particular importance because current Government of India programs have had little impact on the prevalence of anemia suggesting the need for new approaches (IIPS, 2007, 2006; Bharati et al., 2012). The current paradigm supports nutrition counseling of pregnant women during antenatal care, an approach that may be ineffective if they have no control over household purchases. Increasing the knowledge and involvement of spouses and extended family may be the most practical

solution to addressing this important public health problem and its sequelae in India.

Acknowledgments

For their generous assistance on this project, the authors would like to thank the Project *Kisalaya* team, physicians and nurses at Public Health Research Institute of India. We are also grateful to Dr. Raghu Kumar, the Mysore District AIDS Prevention and Control Officer for his support. We are thankful to all the women who took the time to participate in this program. This work was supported by Elizabeth Glaser Pediatric AIDS Foundation International Leadership Award and Positive Action for Children Fund.

Ethical approval

The protocol for the study was reviewed and approved by the Institutional Review Boards of Vikram Hospital and Public Health Research Institute of India in Mysore, India. All participants underwent an informed consent process and gave written consent for participation.

Conflict of interest

None declared.

Funding sources

This program was funded by the Elizabeth Glaser Pediatrics AIDS Foundation International Leadership Award to Purnima Madhivanan and Positive Action for Children Fund. Karl Krupp and Caitlyn Placek were funded by the Global Health Equity Scholars Training grant from the Fogarty International Center at the National Institutes of Health [D43 TW010540 & R25 TW009338]. The funders had no role in the study design, conduct, collection, management, analysis, or interpretation of the data, preparation, review, or approval of the manuscript.

Clinical trial registry and registration number

Not applicable.

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