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NO. 690
July 2023

ADB ECONOMICS WORKING PAPER SERIES

ASIAN DEVELOPMENT BANK

ADB Economics Working Paper Series

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Elan Satriawan (esatriawan@ugm.ac.id; elan.satriawan@tnp2k.go.id) is an associate professor at Universitas Gadjah Mada and the chief of the Policy Group of National Team for Acceleration of Poverty Reduction (TNP2K), Office of the Vice President, Republic of Indonesia. Ranjan Shrestha (rshrestha@wm.edu) is a lecturer at William & Mary. Firman Witoelar (firmanwitoelar.kartaadipoetra@anu.edu.au) is a fellow at the Crawford School of Public Policy, Australian National University. Takashi Yamano (tyamano@adb.org) is a principal economist at the Economic Research and Development Impact Department, Asian Development Bank.

ASIAN DEVELOPMENT BANK

6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
www.adb.org

ISSN 2313-6537 (print), 2313-6545 (electronic)
Publication Stock No. WPS230253-2
DOI: http://dx.doi.org/10.22617/WPS230253-2

ABSTRACT

We study the determinants of hemoglobin concentration in women throughout their life cycle and ask whether anemia during adolescence persists into adulthood. Using a panel of individuals from the Indonesian Family Life Survey (IFLS), we find that although about 30% of our sample was anemic during a given survey wave, 63% experienced anemia at least once over the four survey waves, suggesting a high burden of anemia among Indonesian women. Furthermore, the high prevalence of anemia is not limited to poor women but is also observed in the wealthier segments of the population. Using a dynamic panel framework, we find a significant relationship between current hemoglobin concentration and its measurement in the preceding survey wave, suggesting some persistence of anemia status across survey waves. However, a small autoregressive coefficient suggests that hemoglobin concentration and the likelihood of anemia converge across women over time. We find a few variables that are significant determinants of hemoglobin concentration. Among them, household socioeconomic status and wages of women compared with men in the community are positively associated with hemoglobin concentration.

Keywords**:** anemia, hemoglobin concentration, Indonesian Family Life Survey, female adolescent health

JEL codes**:** I15, I18

The grant fund for this study was received from the Japan Fund for Prosperous and Resilient Asia and the Pacific financed by the Government of Japan through the Asian Development Bank.

I. Introduction

Anemia is characterized by low hemoglobin concentration or the number and size of erythrocytes (red blood cells), resulting in a decreased capacity of the blood to transport oxygen throughout the body, and is largely associated with nutrition, infectious diseases, and genetics (Balarajan et al. 2011).[1] Symptoms of anemia include fatigue, lethargy, and shortness of breath. As in many low- and middle-income countries, there is a high prevalence of anemia in Indonesia—about a quarter of the population is anemic at any given time, with higher prevalence in women and children.[2] This high prevalence of anemia among women could have an impact on their educational attainment and labor market outcomes, as well as maternal and child health. Hence, understanding the socioeconomic determinants of anemia in women has important implications for well-being.

In this study, we track a group of women from adolescence through adulthood to examine the extent to which poor health in adolescence has consequences throughout the life cycle. The adolescent years are an important formative period in which individuals develop capabilities that affect their health and well-being throughout the life cycle (Patton et al. 2016). During these years, individuals develop the foundations of human capital that enable them to successfully transition to independent, healthy lifestyles. The results of this study will therefore provide policy-relevant insights into whether greater investment in adolescent health is needed.

The longitudinal aspect of the Indonesian Family Life Survey (IFLS) along with the extensive health and socioeconomic information collected in the survey, allows us to study the determinants of anemia in women throughout their life cycle. Because the IFLS has measured respondents' hemoglobin concentrations since the second round of the survey in 1997 (IFLS2), the longitudinal nature of the survey allows us to examine the prevalence of anemia over time for the same group of individuals. We follow women who were adolescents (10–19 years old) in IFLS2 into adulthood and through the latest round of the survey in 2014 (IFLS5).

We find a high burden of anemia among Indonesian women in different income groups. The prevalence of anemia in our sample ranged from 23% to 34% in each survey wave. However, tracking the same women over a longer period suggests a higher burden of anemia, as about 65% of our sample was anemic at least once in the four survey waves conducted between 1997 and 2014. Furthermore, anemia is not limited to the poor or disadvantaged groups, but is also prevalent in higher income groups.

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[1] The normal hemoglobin levels vary according to age, gender, and stage of pregnancy. We use the following cutoff values for hemoglobin concentration (WHO 2001) to classify whether a person is anemic: children younger than 5 years: 11.0 g/dL; children 6–11 years: 11.5 g/dL; children 12–14 years: 12.0 g/dL; adult men: 13.0 g/dL; adult (nonpregnant) women: 12.0 g/dL; adult (pregnant) women: 11.0 g/dL.

[2] In the 2014 Indonesian Family Life Survey (IFLS) sample, 40% of children aged 5–12 years are anemic, while 32% of nonpregnant women and 42% of pregnant women are anemic.

We use a dynamic panel framework to model the socioeconomic determinants of hemoglobin concentration and its persistence throughout the life cycle of women. We estimate a dynamic conditional health demand function in which current hemoglobin concentration is a function of lagged hemoglobin concentration along with individual, household, and community characteristics. The coefficient on lagged hemoglobin concentration provides information on the extent to which anemia persists throughout the life cycle. The difficulty in estimating this specification is that lagged hemoglobin concentration is likely to be correlated with unobserved characteristics such as innate health, parental preferences, and community characteristics, making it difficult to obtain unbiased estimates. We use the difference generalized method of moments (GMM) and the system GMM approaches to account for the endogeneity of lagged hemoglobin concentration.

We find a significant relationship between the lagged hemoglobin concentration and the current hemoglobin concentration, suggesting some persistence of anemia. However, a small coefficient on lagged hemoglobin concentration suggests that women's hemoglobin concentration and anemia risk converges over time. Only a few variables in our empirical specification are able to predict hemoglobin concentration. Among them, we find that hemoglobin concentration has a positive relationship with household socioeconomic status and women's wages compared with men's in the community, suggesting that women's income potential and economic status in the community may be related to the prevalence of anemia in women.

This paper is organized as follows. The next section discusses the dynamic panel framework used to estimate the socioeconomic determinants of hemoglobin concentration. It is followed by a discussion of the IFLS sample used for the analysis, which consists of women who were adolescents in 1997 and were tracked in subsequent waves. Next, we discuss the results of the analysis on the persistence of hemoglobin concentration. Finally, we conclude with possible policy implications for addressing anemia among women.

II. Empirical Methodology

Following Strauss and Thomas (2008), a dynamic conditional health demand function can be derived using a life-cycle optimization problem where individuals maximize utility subject to a budget and time constraint, as well as a dynamic health production function. The empirical representation of the dynamic conditional health demand function can be expressed as follows:

$$H_{it} = \beta_0 + \beta_1 H_{it-1} + \sum_{j=2}^{R} \beta_j X_{jit} + \sum_{j=1}^{S} \beta_j^Z Z_{ji} + \varepsilon_{it}$$

The dependent variable, H_{it}, is the health status of the individual at time t while the lagged dependent variable, H_{it-1}, is the health status of the individual in the preceding period, $t-1$. In our case, an individual's health status is their hemoglobin concentration. The X values are time-varying regressors that capture individual characteristics such as age, education level, household per capita expenditure, and community characteristics such as prices and infrastructure development. The Z values are time-invariant regressors such as the mother's education and household and community characteristics that do not change over time.

The coefficient on the lagged dependent variable (β_1) provides us with an estimate of the persistence of hemoglobin concentration throughout the life cycle. If β_1 is closer to zero, then there is low persistence of hemoglobin concentration. A woman with a low hemoglobin concentration in one period is unlikely to have a low hemoglobin concentration in the next period, implying that anemia is not highly persistent over the life cycle. On the other hand, higher values of β_1 that are closer to one would imply a high degree of persistence, so a woman with low hemoglobin concentration in one period will also have low hemoglobin concentration in the next period.

The error term, ε_{it}, has two components: the fixed effects, μ_i, and the idiosyncratic shocks, ν_{it}, which are assumed to be uncorrelated across observations.

$$\varepsilon_{it} = \mu_i + \nu_{it}$$

The fixed effects, μ_i, capture time-invariant unobserved factors that include individual-specific factors such as innate health and genetic endowments, household-specific factors such as preferences and discount rates, and community-specific factors such as geographic characteristics and cultural institutions.

Because the lagged dependent variable is correlated with the fixed effects in the error term, ordinary least squares (OLS) estimates will be biased. Furthermore, fixed effects estimation will be biased because the within-group transformation of the lagged dependent variable is still correlated with the transformation of the error term (Nickell 1981; Bond 2002).

The difference GMM approach—based on Holtz-Eakin, Newey, and Rosen (1988) and Arellano and Bond (1991)—involves taking the first difference which removes the fixed effects.

$$H_{it} - H_{it-1} = \beta_1(H_{it-1} - H_{it-2}) + \sum_{j=2}^{R} \beta_j\left(X_{jit} - X_{jit-1}\right) + (\nu_{it} - \nu_{it-1})$$

Although the individual-specific fixed effect is no longer present in the differenced equation, its estimation is complicated by the correlation of the difference in the lagged dependent variable $(H_{it-1} - H_{it-2})$ with the differenced error term $(\nu_{it} - \nu_{it-1})$, as H_{it-1} is correlated with ν_{it-1}. In this case, the OLS estimation is inconsistent. However, $(H_{it-1} - H_{it-2})$ can be instrumented by H_{it-2} or higher-order lags of the dependent variable.

However, the lagged levels may be weakly correlated with the first-differenced lagged variables, especially if the endogenous variable is persistent. The system GMM approach, based on Blundell and Bond (1998) and Arellano and Bover (1995), improves efficiency over the difference GMM approach by adding additional moment restrictions based on instrumenting the levels of the regressors with lagged differences of the instruments. While the difference GMM approach differences the regressors to remove the fixed effects, the system GMM approach augments the difference GMM approach by differencing the instruments to make them exogenous to the fixed effects.

III. Data

The Indonesian Family Life Survey (IFLS), an extensive longitudinal survey that provides us with information at the individual, household, and community levels, is the primary dataset we use for our analysis. The first wave (IFLS1), conducted in 1993, surveyed over 7,000 households from 13 of the 27 provinces, representing 83% of the population. Subsequent waves interviewed target members of the original IFLS1 households as well as split-off households with recontact rates above 90%, and were conducted in 1997, 2000, 2007, and 2014 (Strauss et al. 2004; Strauss et al. 2009; Strauss, Witoelar, and Sikoki 2016).

We track female adolescents ages 10–19 during the second wave of the IFLS, which was conducted in 1997. We begin tracking adolescents from the second wave because the IFLS only began collecting hemoglobin concentration using a pinprick blood sample during this wave, so we can only determine anemia status starting from this survey wave. The blood sample was collected along with other health measurements by trained medical personnel, usually nurses or recently trained paramedics, so we can be confident with these objective health measurements, which, unlike subjective health measures, are not affected by respondent recall bias.

In the 1997 wave, the IFLS interviewed 3,365 female adolescents between the ages of 10 and 19. For the analysis, we further restrict the sample to those who were interviewed in all subsequent IFLS waves to create a balanced panel. In addition, we drop individuals who were pregnant during any of the surveys to reduce confounding due to pregnancy-related issues. After excluding some additional observations with inconsistent ages and birth years and with missing values, the final analysis sample consists of 1,453 adolescents.[3]

[Table 1 here]

Table 1 presents the descriptive statistics for this balanced panel for each of the survey years. Of the adolescents interviewed, 57% are in the 10- to 14-year-old age group (hereafter referred to as early adolescents) and 43% are in the 15- to 19-year-old age group

[3] Comparing the descriptive statistics of adolescents in the 1997 balanced panel with those of adolescents not included in the analysis because of attrition in subsequent rounds, we find that although slight differences exist in log per capita expenditure and education between these two groups, suggesting slightly higher attrition among the better-off adolescents, the hemoglobin concentration and anemia prevalence are similar in these two groups.

(late adolescents). Of these adolescents, 29% were anemic at the time of the 1997 survey. Tracking the anemia status of these women in subsequent years indicates a very high prevalence of anemia over the life cycle of an Indonesian woman, as 63% of the sample was anemic at least once in the four waves of the survey. Prevalence has also changed over time; it was highest in 2000, when 34% of the sample was anemic, possibly reflecting the persistent negative effects of the 1998 financial crisis, and it was lowest in 2007, when 23% were anemic. Another notable observation is that prevalence has in fact increased in recent years, from 23% in 2007 to 27% in 2014.

Descriptive statistics for various household characteristics indicate significant improvements in living conditions between 1997 and 2014. The share of households with electricity increased from 86% to 99%, the share of households with their own toilet increased from 60% to 84%, and the share of households with a television increased from 60% to 94%. Significant changes were also observed in the ownership of household appliances that could play a role in food preparation and nutrition, such as ownership of refrigerators and electric or gas stoves. The share of those who reported not owning a refrigerator decreased from 73% in 1997 to 30% in 2014, while the share of those who owned a gas or electric stove increased from 6% to 78% over the same period.

[Table 2 here]

Table 2 presents descriptive statistics for the adolescents separated by anemia status in 1997. The mean characteristics look similar for the two groups, except for slight differences in living conditions that suggest that the nonanemic adolescents have slightly better living conditions, with slightly higher educational attainment of household heads and slightly lower incidence of poverty (defined as having household per capita expenditure in the bottom 30%) and living in cement/brick houses. The high prevalence of anemia throughout the life cycle is also reflected in the fact that those who were not anemic during adolescence have a high chance of becoming anemic later in life; 48% of the adolescents who were not anemic in 1997 were anemic in one of the subsequent survey rounds, which reinforces the fact that the burden of anemia is widespread in the female population.

[Table 3 here]

Table 3 shows the transition matrix of anemia status for our panel respondents from one survey year to the next. For state 1, which is non-anemic, and state 2, which is anemic, we note significant movement from one state to the other. For example, the probability that a person became anemic in 2000 was 0.28 if he or she was not anemic in 1997. On the other hand, the probability that a person who was anemic in 1997 remained anemic in 2000 was

0.49, suggesting some persistence in anemia status. While the transition probability of moving into an anemic state from a non-anemic state and that of remaining in an anemic state both fell for 2000–2007 (0.16 and 0.35, respectively), these probabilities once again rose for 2007–2014 (0.22 and 0.46).

[Figures 1 and 2 here]

Figures 1 and 2 plot locally weighted mean values for anemia and for hemoglobin concentration in relation to household per capita expenditure (PCE). Because households are likely to smooth their consumption, PCE is a proxy for their permanent income. We find that the high prevalence of anemia is not restricted to women from low-income households, but that prevalence is high among women across the PCE distribution. In 1997, the prevalence of anemia in early adolescents has a clear negative relationship with PCE; the incidence of anemia decreases with increasing PCE, whereas hemoglobin concentration increases with PCE. Among late adolescents, however, prevalence is highest in households with the highest PCE. In subsequent survey years, as adolescents grow older, prevalence remains high across the entire PCE distribution.

[Figures 3 to 6 here]

Figures 3–6 present locally weighted mean values of the likelihood of anemia and hemoglobin concentration levels over time for the 1997 adolescents who were anemic and for those who were not anemic. All figures show some convergence in the likelihood of anemia and hemoglobin levels over time for these two groups. The convergence over time is stronger for the early adolescents. However, a slight gap in the likelihood of anemia and hemoglobin levels persists in the later years for these two groups, with a larger gap remaining in the late adolescents.

IV. Results

We first present the results for our full sample of 1997 female adolescents (10–19 years old) in Table 4. We then present results separately for those who were in early adolescence (10–14 years old) in 1997 in Table 5 and those who were in late adolescence (15–19 years old) in 1997 in Table 6. The first column of all tables contains the OLS estimates. The OLS coefficients for lagged hemoglobin concentration are large and significant: 0.30 for the full sample, 0.26 for the early adolescent sample, and 0.37 for the late adolescent sample. However, these estimates are likely to be biased upward as the lagged dependent variable is correlated with the fixed effects in the error term.

[Table 4 here]

To account for the bias that arises in an OLS framework when we have a lagged dependent variable as a regressor, we use the difference GMM and the system GMM approaches. We use two different specifications for the difference GMM approach which are presented in two separate columns. For the system GMM approach, we use three different specifications, the first two of which are the same as that used for the difference GMM approach. In the first specification (presented in columns 2 and 4), all regressors except the lagged dependent variable are treated as exogenous. The second specification (columns 3 and 5) treats per capita expenditure and education as endogenous and uses their lags as instruments. The third specification for the system GMM (column 6) adds on the second specification by using individual, household, and community characteristics from 1997 as instruments. These instruments include age, mother's education, type of floor and outer wall, number of rooms, presence of waste and trash around the house, and number of *posyandus* (village health posts) in the community, all measured in 1997.

[Table 5 here]

As expected, the difference between the GMM and the system GMM estimates of the coefficient on lagged hemoglobin concentration was smaller compared with the difference between the GMM and the OLS estimates. Difference GMM estimates range from 0.086 to 0.113 for early adolescents and 0.116 to 0.127 for late adolescents. Similarly, system GMM estimates range from 0.068 to 0.083 for early adolescents and 0.119 to 0.153 for late adolescents. The coefficients are statistically significant for all specifications. This suggests that some persistence exists for hemoglobin concentration over the life cycle. However, the small autoregressive coefficients suggest that the level of hemoglobin concentration converges over time for the women in our sample.

We find that few other regressors are statistically significant. The number of years of education has a negative coefficient, but it is significant in only one specification. The relative wages of females compared to males in the community have a significant positive relationship for early adolescents but are not significant for late adolescents. These results suggest that women's income potential and economic status may be related to the prevalence of anemia in the community, especially for the younger cohort. Furthermore, the results suggest some regional differences in anemia prevalence. The coefficients for Sumatra and the outer islands are significant and positive for early adolescents for some specifications, suggesting lower anemia prevalence in these regions compared with Java and Bali, the excluded region.

We also find a positive and statistically significant relationship between socioeconomic status and hemoglobin concentration for the older cohort but not for the younger cohort.[4] Using a different specification that includes housing characteristics but not socioeconomic status (tables not provided here), we also find that ownership of household appliances related to food preparation and nutrition—ownership of a refrigerator and a gas or electric stove—has a significant negative relationship with hemoglobin concentration among early adolescents. This finding suggests that there is additional scope to explore whether the prevalence of anemia in different income groups is driven by different factors. For example, it is likely that the prevalence of anemia in the low-income group is driven by the inability to afford a diverse micronutrient-rich diet. On the other hand, it could be that the prevalence of anemia in the higher-income groups is driven by dietary changes associated with economic development and modernization.

V. Conclusion

This paper examined the determinants of women's hemoglobin concentration throughout their life cycle using the Indonesian Family Life Survey. Tracking adolescents from the second survey wave in subsequent waves revealed a high prevalence of anemia with some variation in prevalence over time. However, the high prevalence recorded at a single point in time does not fully capture the true risk of anemia among Indonesian women. Among those we track over the survey years, about 63% were anemic in at least one of the four survey rounds between 1997 and 2014.

Using a dynamic panel GMM approach, we find a significant relationship between a woman's hemoglobin concentration in one period and her hemoglobin concentration in the preceding period. However, the small size of the coefficient suggests that women's hemoglobin concentration converges over the long term, so that the differences observed in one period become smaller over time. We find that socioeconomic status and relative wages of women in the community are positively associated with hemoglobin concentration.

The results of this study may provide guidance to policy makers on how best to address the problem of anemia among Indonesian women. The results suggest a high burden of anemia among Indonesian women, with the majority of women likely to be anemic at some point in their life cycle. The high prevalence of anemia is observed not only among women in the poorest households, but also among those in households at the upper end of the per capita expenditure distribution. This suggests that a broad-based approach that raises awareness of the risks and symptoms of anemia, as well as an approach that brings about changes in health behaviors, may be needed to address the prevalence of anemia among Indonesian women.

[4] The socioeconomic status index was constructed using principal components analysis on a list of variables that captured household assets and housing characteristics; these variables included the type of house (single, duplex, multiple units), whether the house was rented or owned, number of rooms, access to electricity, ownership of a television, type of floor and outer wall, source of drinking water, ownership of a refrigerator, type of cooking stove, type of toilet, and presence of waste or trash in the house.

TABLES AND FIGURES

Table 1: Descriptive Statistics (1997 Female Adolescents Balanced Panel)

	1997		2000		2007		2014	
	Mean	sd	Mean	sd	Mean	sd	Mean	sd
Age	14.12	2.75	16.89	2.85	24.32	2.88	31.21	2.90
10–14 year olds in 1997	0.57	0.49	0.57	0.49	0.57	0.49	0.57	0.49
15–19 year olds in 1997	0.43	0.49	0.43	0.49	0.43	0.49	0.43	0.49
Hemoglobin concentration	12.47	1.38	12.37	1.32	12.69	1.36	12.59	1.32
Anemic	0.29	0.45	0.34	0.47	0.23	0.42	0.27	0.45
Ever anemic (1997–2014)	0.63	0.48	0.63	0.48	0.63	0.48	0.63	0.48
Fasting	0.03	0.16	0.02	0.13	0.03	0.17	0.05	0.23
Married	0.06	0.24	0.15	0.36	0.62	0.49	0.90	0.30
Separated/divorced	0.00	0.06	0.01	0.07	0.04	0.19	0.04	0.20
Years of education	6.38	2.84	8.47	2.81	10.17	3.44	10.34	3.62
Currently in school	0.75	0.43	0.49	0.50	0.05	0.22	0.01	0.12
Completed primary school	0.62	0.49	0.90	0.30	0.93	0.25	0.93	0.25
Completed junior high school	0.24	0.43	0.51	0.50	0.75	0.43	0.77	0.42
Completed senior high school	0.05	0.22	0.18	0.39	0.53	0.50	0.53	0.50
Log per capita expenditure	11.25	0.73	11.97	0.69	12.95	0.69	13.71	0.68
Bottom 30% PCE	0.35	0.48	0.39	0.49	0.34	0.47	0.34	0.47
Bottom 30% SES index	0.28	0.45	0.27	0.44	0.30	0.46	0.36	0.48
Moved out of village	0.06	0.23	0.12	0.32	0.40	0.49	0.35	0.48
Household head age	45.86	10.91	45.23	12.30	40.38	14.67	41.02	11.98
Household head male	0.88	0.32	0.85	0.36	0.79	0.41	0.86	0.35
Household head education (years)	5.73	4.10	6.32	4.23	8.16	4.34	9.20	4.30
Household size	5.67	2.05	5.35	2.11	4.29	2.02	4.32	1.71
Number of 0–5 year olds	0.50	0.71	0.45	0.65	0.70	0.69	0.83	0.70
Household member in farming	0.37	0.48	0.40	0.49	0.32	0.47	0.32	0.47
SES index	-0.05	2.16	0.01	2.12	-0.16	2.06	-0.31	2.09
Own house	0.86	0.34	0.83	0.38	0.68	0.46	0.73	0.44
Electricity	0.86	0.35	0.93	0.26	0.97	0.17	0.99	0.08
Piped water	0.20	0.40	0.23	0.42	0.22	0.41	0.16	0.36
Own toilet	0.60	0.49	0.65	0.48	0.76	0.43	0.84	0.37
No refrigerator	0.73	0.44	0.74	0.44	0.60	0.49	0.30	0.46
Stove: gas/electric	0.06	0.24	0.11	0.31	0.19	0.39	0.78	0.41
Television	0.60	0.49	0.62	0.48	0.79	0.41	0.94	0.23
Waste around house	0.09	0.29	0.09	0.28	0.06	0.23	0.08	0.26
Trash around house	0.12	0.33	0.13	0.33	0.08	0.27	0.09	0.28
Number of rooms	5.18	1.99	5.54	2.45	5.45	2.48	5.81	2.43
Floor: ceramic/marble/granite	0.08	0.27	0.15	0.36	0.36	0.48	0.53	0.50
Outer wall: cement/bricks	0.61	0.49	0.66	0.47	0.76	0.42	0.81	0.39
Log community male wages (monthly)	11.94	0.57	12.50	0.56	13.34	0.59	14.10	0.62
Log community female wages (monthly)	11.30	0.92	11.91	0.87	12.85	0.79	13.49	0.91
Community female–male wage ratio	0.71	0.62	0.83	1.18	0.78	0.59	0.74	1.03
Asphalt road	0.75	0.43	0.80	0.40	0.90	0.30	0.94	0.24
Electricity (%)	77.77	27.83	83.44	22.80	91.41	16.18	96.90	6.89
Number of *posyandus*	7.20	5.58	7.51	6.48	8.01	7.05	8.00	6.15
Log price of rice (med)	7.11	0.26	7.64	0.19	8.52	0.15	9.15	0.17
Rural	0.56	0.50	0.54	0.50	0.47	0.50	0.40	0.49
Java/Bali	0.60	0.49	0.60	0.49	0.61	0.49	0.61	0.49
Sumatra	0.20	0.40	0.20	0.40	0.20	0.40	0.19	0.40
Outer islands	0.20	0.40	0.20	0.40	0.20	0.40	0.20	0.40
Observations	1,453		1,453		1,453		1,453	

IFLS = Indonesian Family Life Survey, PCE = per capita expenditure, sd = standard deviation, SES=socioeconomic status.

Note: Table presents descriptive statistics from the 1997, 2000, 2007, and 2014 rounds of IFLS for 1997 adolescents who were interviewed in all rounds (excluding observations with missing values and those who were ever pregnant in any of the survey waves).

Source: Authors.

Table 2: Characteristics of Anemic and Non-Anemic Adolescents (1997)

	Anemic		Non-anemic	
	Mean	sd	Mean	sd
10–14 year olds in 1997	0.58	0.49	0.57	0.50
15–19 year olds in 1997	0.42	0.49	0.43	0.50
Ever anemic (1997–2014)	1.00	0.00	0.48	0.50
Mother's education (1997)	4.66	3.63	4.56	3.69
Age	14.13	2.68	14.12	2.78
Hemoglobin concentration	10.83	1.04	13.12	0.87
Fasting	0.03	0.16	0.03	0.16
Height (cm)	143.47	10.45	143.98	10.09
Married	0.07	0.25	0.06	0.23
Separated/divorced	0.01	0.10	0.00	0.03
Years of education	6.41	2.84	6.37	2.85
Currently in school	0.73	0.44	0.75	0.43
Log per capita expenditure	11.23	0.76	11.26	0.71
Bottom 30% PCE	0.37	0.48	0.35	0.48
Bottom 30% SES index	0.29	0.46	0.27	0.45
Moved out of village	0.06	0.23	0.06	0.23
Household head age	46.28	11.24	45.70	10.78
Household head male	0.87	0.34	0.89	0.31
Household head education (years)	5.40	4.14	5.85	4.08
Household size	5.69	2.21	5.67	1.98
Number of 0–5 year olds	0.47	0.70	0.50	0.71
Household member in farming	0.35	0.48	0.38	0.48
SES index	-0.12	2.17	-0.01	2.15
Own house	0.84	0.37	0.87	0.33
Electricity	0.86	0.35	0.86	0.35
Piped water	0.20	0.40	0.20	0.40
Own toilet	0.58	0.49	0.61	0.49
No refrigerator	0.74	0.44	0.73	0.44
Stove: gas/electric	0.06	0.23	0.07	0.25
Television	0.61	0.49	0.59	0.49
Waste around house	0.10	0.30	0.09	0.29
Trash around house	0.13	0.34	0.12	0.32
Number of rooms	5.15	1.86	5.19	2.04
Floor: ceramic/marble/granite	0.07	0.26	0.08	0.27
Outer wall: cement/bricks	0.56	0.50	0.63	0.48
Log community male wages (monthly)	11.94	0.57	11.93	0.57
Log community female wages (monthly)	11.31	0.93	11.29	0.92
Community female–male wage ratio	0.72	0.65	0.70	0.61
Asphalt road	0.76	0.43	0.75	0.43
Electricity (%)	78.60	27.83	77.43	27.83
Number of *posyandus*	7.38	6.02	7.13	5.40
Log price of rice (med)	7.10	0.26	7.11	0.26
Rural	0.54	0.50	0.57	0.49
Java/Bali	0.64	0.48	0.58	0.49
Sumatra	0.19	0.39	0.21	0.41
Outer islands	0.17	0.38	0.21	0.41
Observations	416		1,037	

IFLS = Indonesian Family Life Survey, cm = centimeter, sd = standard deviation, PCE = per capita expenditure, SES = socioeconomic status.

Note: The table presents descriptive statistics of the adolescents who were interviewed by the 1997 and subsequent IFLS surveys.

Source: Authors.

Table 3: Transition Matrix of Anemia Status

	Frequency				Probability			
Year	f11	f12	f21	f22	p11	p12	p21	p22
1997	744	293	214	202	0.72	0.28	0.51	0.49
2000	803	155	323	172	0.84	0.16	0.65	0.35
2007	883	243	175	152	0.78	0.22	0.54	0.46

f = frequency, IFLS = Indonesian Family Life Survey, p = probability.

Notes: This table presents the transition probabilities of anemia status from one IFLS survey year to the subsequent survey year. The sample consists of 1997 adolescents who were interviewed in all IFLS survey rounds from 1997 to 2014 and were never pregnant at the time of the survey.

State 1 refers to non-anemic and state 2 refers to anemic. For example, p11 refers to the probability of staying non-anemic from the given year to the following survey year, and p12 refers to the probability of moving from non-anemic to anemic state between those years.

Source: Authors.

Table 4: Hemoglobin Concentration (10- to 19-Year-Old 1997 Adolescents)

	OLS	Diff GMM		System GMM		
	(1)	(2)	(3)	(4)	(5)	(6)
	Hb	Hb	Hb	Hb	Hb	Hb
Lagged hemoglobin concentration	0.303***	0.105***	0.122***	0.0885***	0.0929***	0.0941***
	(0.0182)	(0.0305)	(0.0345)	(0.0280)	(0.0276)	(0.0274)
Log per capita expenditure	0.00312	0.00340	-0.549	0.00764	-0.354	0.140
	(0.0332)	(0.0555)	(0.447)	(0.0386)	(0.389)	(0.204)
Years of education	-0.00965	-0.0219	-0.0312	-0.00992	-0.0113	-0.0267*
	(0.00705)	(0.0175)	(0.0567)	(0.00792)	(0.0192)	(0.0154)
2007	0.301**	0.497	1.013*	0.242	0.460*	0.207
	(0.145)	(0.400)	(0.581)	(0.163)	(0.257)	(0.196)
2014	0.115	0.562	1.518	0.0823	0.495	-0.0185
	(0.246)	(0.749)	(1.094)	(0.283)	(0.504)	(0.363)
Age	-0.00111	-0.0366	-0.0404	-0.0000537	0.00218	-0.00478
	(0.0118)	(0.0500)	(0.0538)	(0.0144)	(0.0152)	(0.0142)
Married	0.111*	0.133	0.0730	0.117*	0.0760	0.152**
	(0.0631)	(0.0823)	(0.106)	(0.0675)	(0.0869)	(0.0726)
SES index	0.0192**	0.0215*	0.0186	0.0224**	0.0168	0.0238**
	(0.00965)	(0.0122)	(0.0128)	(0.0102)	(0.0116)	(0.0102)
Moved out of village	0.0573	0.0544	0.0804	0.0407	0.0630	0.0368
	(0.0493)	(0.0689)	(0.0766)	(0.0560)	(0.0611)	(0.0564)
Household size	-0.0311**	-0.0174	-0.0869	-0.0273**	-0.0689	-0.0142
	(0.0122)	(0.0182)	(0.0580)	(0.0138)	(0.0457)	(0.0269)
Asphalt road	0.0623	0.0192	-0.0329	0.0356	0.0129	0.0492
	(0.0632)	(0.0900)	(0.0996)	(0.0668)	(0.0724)	(0.0690)
Electricity (%)	0.000712	0.00259	0.00448*	0.00165	0.00281	0.00154
	(0.00136)	(0.00181)	(0.00235)	(0.00141)	(0.00178)	(0.00150)
Log price of rice (med)	-0.0236	0.0431	0.0250	0.0115	0.0814	-0.00802
	(0.118)	(0.168)	(0.179)	(0.126)	(0.147)	(0.130)
Community female–male wage ratio	0.0499***	0.0800**	0.0939**	0.0608**	0.0680**	0.0594**
	(0.0185)	(0.0352)	(0.0384)	(0.0261)	(0.0282)	(0.0245)
Rural	0.0468	-0.0697	-0.167	0.0355	-0.0308	0.0415
	(0.0462)	(0.0791)	(0.105)	(0.0525)	(0.0785)	(0.0608)
Sumatra	0.0880	-0.0413	-0.0432	0.109	0.140*	0.118*
	(0.0577)	(0.300)	(0.335)	(0.0685)	(0.0742)	(0.0698)
Outer islands	0.0494	0.0658	0.164	0.0860	0.0801	0.0895
	(0.0499)	(0.580)	(0.605)	(0.0615)	(0.0615)	(0.0617)
Observations	4334	2874	2874	4334	4334	4325
Number of groups		1446	1446	1453	1453	1450
Hansen chi-sq		0.122	2.157	1.040	3.606	9.644
Hansen p		0.727	0.540	0.595	0.730	0.842
Number of instruments		24	26	27	31	40

Diff = difference, Hb = hemoglobin concentration, GMM = generalized method of moments, OLS = ordinary least squares.

Notes: Robust standard errors in parentheses: * $p < .10$, ** $p < .05$, *** $p < .01$. We use two different specifications for difference GMM and three different specifications for system GMM. In the first specification (in columns 2 and 4) all regressors except the lagged dependent variable are treated as exogenous. The second specification (columns 3 and 5) treats per capita expenditure and years of education as endogenous and uses their lags as instruments. The third specification (column 6) adds on the second specification by using individual, household, and community characteristics from 1997 as instruments. These instruments include age, mother's education, type of floor and outer wall, number of rooms, presence of waste and trash around house, and number of *posyandus* (village health posts) in the community, all measured in 1997. Additional covariates included in the regressions were age, marital status, moving out of the village between survey waves, characteristics of the household head (age, male, years of education), community characteristics (asphalt road, electricity, price of rice), and dummies for year of survey.

Source: Authors.

Table 5: Hemoglobin Concentration (10- to 14-Year-Old 1997 Adolescents)

	OLS	Diff GMM		System GMM		
	(1) Hb	(2) Hb	(3) Hb	(4) Hb	(5) Hb	(6) Hb
Lagged hemoglobin concentration	0.259***	0.0863**	0.113**	0.0678*	0.0826**	0.0781**
	(0.0242)	(0.0398)	(0.0479)	(0.0351)	(0.0364)	(0.0344)
Log per capita expenditure	0.00218	-0.0289	-1.054*	-0.00407	-0.794	-0.00141
	(0.0442)	(0.0766)	(0.622)	(0.0529)	(0.513)	(0.250)
Years of education	-0.00718	-0.00997	-0.146	-0.00433	-0.000852	-0.0248
	(0.0102)	(0.0232)	(0.130)	(0.0115)	(0.0265)	(0.0185)
SES index	0.00751	0.0185	-0.00301	0.0164	0.00494	0.0140
	(0.0129)	(0.0168)	(0.0234)	(0.0137)	(0.0157)	(0.0133)
Household size	-0.0290*	-0.00545	-0.127*	-0.0202	-0.108*	-0.0240
	(0.0168)	(0.0245)	(0.0763)	(0.0190)	(0.0581)	(0.0331)
Electricity (%)	0.000932	0.00439*	0.00772**	0.00232	0.00513**	0.00243
	(0.00164)	(0.00232)	(0.00340)	(0.00176)	(0.00258)	(0.00196)
Log price of rice	-0.0249	0.162	0.0594	0.0599	0.132	0.0453
	(0.155)	(0.200)	(0.230)	(0.155)	(0.171)	(0.154)
Community female–male wage ratio	0.0763**	0.154***	0.190***	0.111***	0.135***	0.106***
	(0.0316)	(0.0512)	(0.0599)	(0.0365)	(0.0418)	(0.0355)
Rural	0.0699	-0.146	-0.372**	0.0294	-0.137	0.00317
	(0.0624)	(0.108)	(0.164)	(0.0712)	(0.116)	(0.0835)
Sumatra	0.102	0.0137	-0.0985	0.130	0.209*	0.163*
	(0.0771)	(0.392)	(0.509)	(0.0920)	(0.107)	(0.0943)
Outer islands	0.0938	1.052	0.972	0.153*	0.131	0.148*
	(0.0670)	(1.107)	(1.386)	(0.0827)	(0.0896)	(0.0830)
Observations	2475	1640	1640	2475	2475	2466
Number of groups		827	827	831	831	828
Hansen chi-sq		0.352	2.482	0.649	2.644	11.06
Hansen p		0.553	0.478	0.723	0.852	0.749
Number of instruments		24	26	26	30	39

Diff = difference, GMM = generalized method of moments, Hb = hemoglobin concentration, OLS = ordinary least squares, SES = socioeconomic status.

Notes: Robust standard errors in parentheses: * $p < .10$, ** $p < .05$, *** $p < .01$.

We use two different specifications for difference GMM and three different specifications for system GMM. In the first specification (in columns 2 and 4), all regressors except the lagged dependent variable are treated as exogenous. The second specification (columns 3 and 5) treats per capita expenditure and years of education as endogenous and uses their lags as instruments. The third specification (column 6) adds on the second specification by using individual, household, and community characteristics from 1997 as instruments. These instruments include age, mother's education, type of floor and outer wall, number of rooms, presence of waste and trash around the house, and number of *posyandus* (village health posts) in the community, all measured in 1997.

Additional covariates included in the regressions were age, marital status, moving out of the village between survey waves, household head characteristics (age, male, education), community characteristics (asphalt road, electricity, price of rice), and dummies for year of survey.

Source: Authors.

Table 6: Hemoglobin Concentration (15- to 19-Year-Old 1997 Adolescents)

	OLS	Diff GMM		System GMM		
	(1)	(2)	(3)	(4)	(5)	(6)
	Hb	Hb	Hb	Hb	Hb	Hb
Lagged hemoglobin concentration	0.365***	0.127***	0.116**	0.123***	0.119***	0.153***
	(0.0240)	(0.0481)	(0.0522)	(0.0434)	(0.0436)	(0.0459)
Log per capita expenditure	0.00901	0.0582	0.452	0.0311	0.279	0.0600
	(0.0506)	(0.0765)	(0.684)	(0.0556)	(0.442)	(0.264)
Years of education	-0.00959	-0.0333	0.0405	-0.00934	-0.0215	-0.0105
	(0.0106)	(0.0373)	(0.495)	(0.0121)	(0.0307)	(0.0268)
SES index	0.0375**	0.0339*	0.0398	0.0366**	0.0387**	0.0357**
	(0.0151)	(0.0187)	(0.0410)	(0.0156)	(0.0169)	(0.0163)
Household size	-0.0344*	-0.0362	0.0165	-0.0378*	-0.00893	-0.0349
	(0.0178)	(0.0271)	(0.100)	(0.0199)	(0.0570)	(0.0362)
Electricity (%)	0.000852	0.000550	-0.000324	0.00123	0.000912	0.000689
	(0.00251)	(0.00290)	(0.00349)	(0.00240)	(0.00247)	(0.00245)
Log price of rice	-0.000867	-0.127	-0.134	-0.0221	-0.101	-0.0145
	(0.181)	(0.301)	(0.300)	(0.212)	(0.262)	(0.225)
Community female–male wage ratio	0.0357*	0.0398	0.0305	0.0331	0.0300	0.0295
	(0.0194)	(0.0372)	(0.0436)	(0.0280)	(0.0277)	(0.0282)
Rural	0.0162	0.00203	0.0482	0.0282	0.0650	0.0372
	(0.0684)	(0.112)	(0.131)	(0.0750)	(0.0937)	(0.0791)
Sumatra	0.0742	-0.159	-0.154	0.0903	0.0788	0.0732
	(0.0860)	(0.425)	(0.513)	(0.102)	(0.106)	(0.102)
Outer islands	-0.00166	-0.556	-0.667	0.0130	0.00886	0.0277
	(0.0757)	(0.405)	(0.414)	(0.0902)	(0.0920)	(0.0908)
Observations	1859	1234	1234	1859	1859	1859
Number of groups		619	619	622	622	622
Hansen chi-sq		0.00139	0.418	0.506	1.347	13.34
Hansen p		0.970	0.936	0.776	0.969	0.576
Number of instruments		24	26	26	30	39

Diff = difference, GMM = generalized method of moments, Hb = hemoglobin concentration, OLS = ordinary least squares, SES = socioeconomic status.

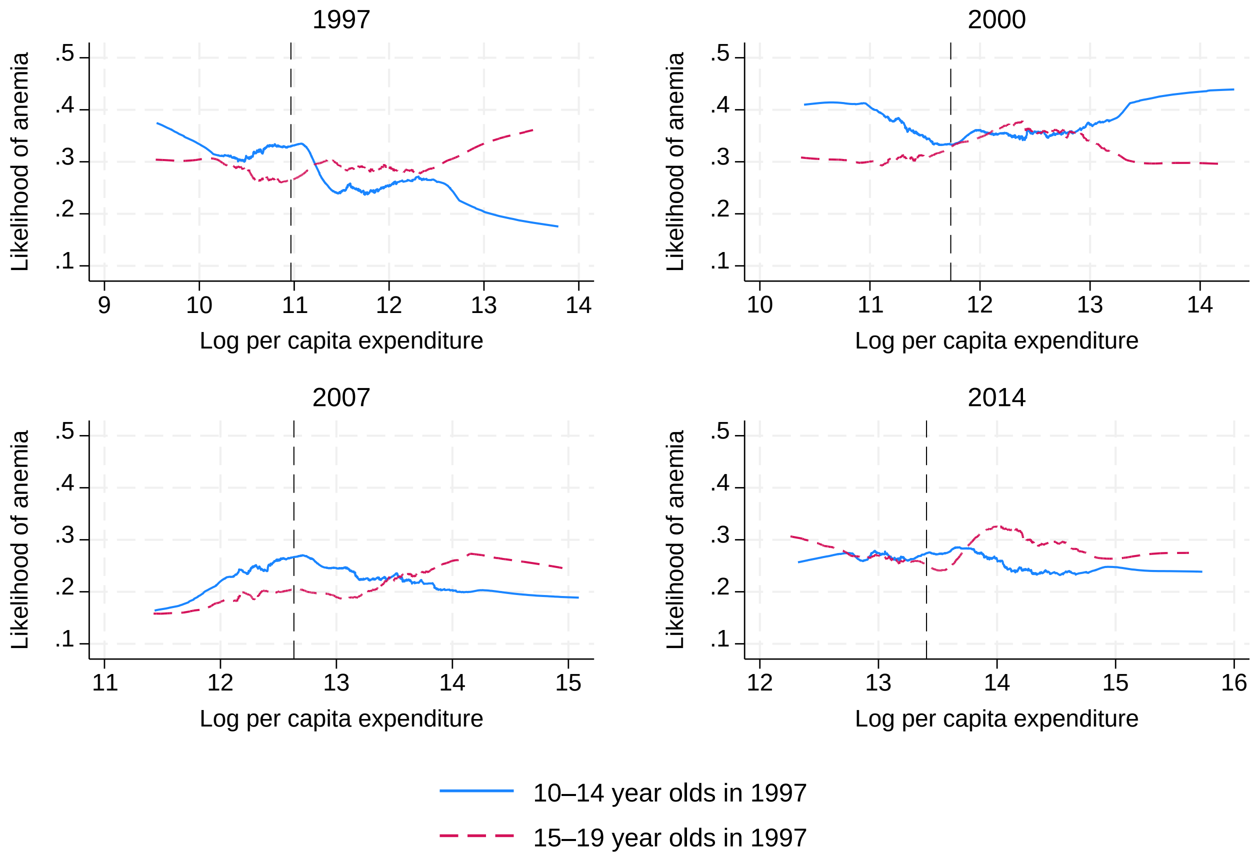
Notes: Robust standard errors in parentheses: * *p* < .10, ** *p* < .05, *** *p* < .01.

We use two different specifications for the difference GMM and three different specifications for the system GMM. In the first specification (in columns 2 and 4), all regressors except the lagged dependent variable are treated as exogenous. The second specification (columns 3 and 5) treats per capita expenditure and years of education as endogenous and uses their lags as instruments. The third specification (column 6) adds on the second specification by using individual, household, and community characteristics from 1997 as instruments. These instruments include age, mother's education, type of floor and outer wall, number of rooms, presence of waste and trash around house, and number of *posyandus* (village health posts) in the community, all measured in 1997.

Additional covariates included in the regressions were age, marital status, moving out of the village between survey waves, household head characteristics (age, male, education), community characteristics (asphalt road, electricity, price of rice), and dummies for year of survey.

Source: Authors.

Figure 1: Anemia Prevalence among 1997 Adolescents across IFLS Waves

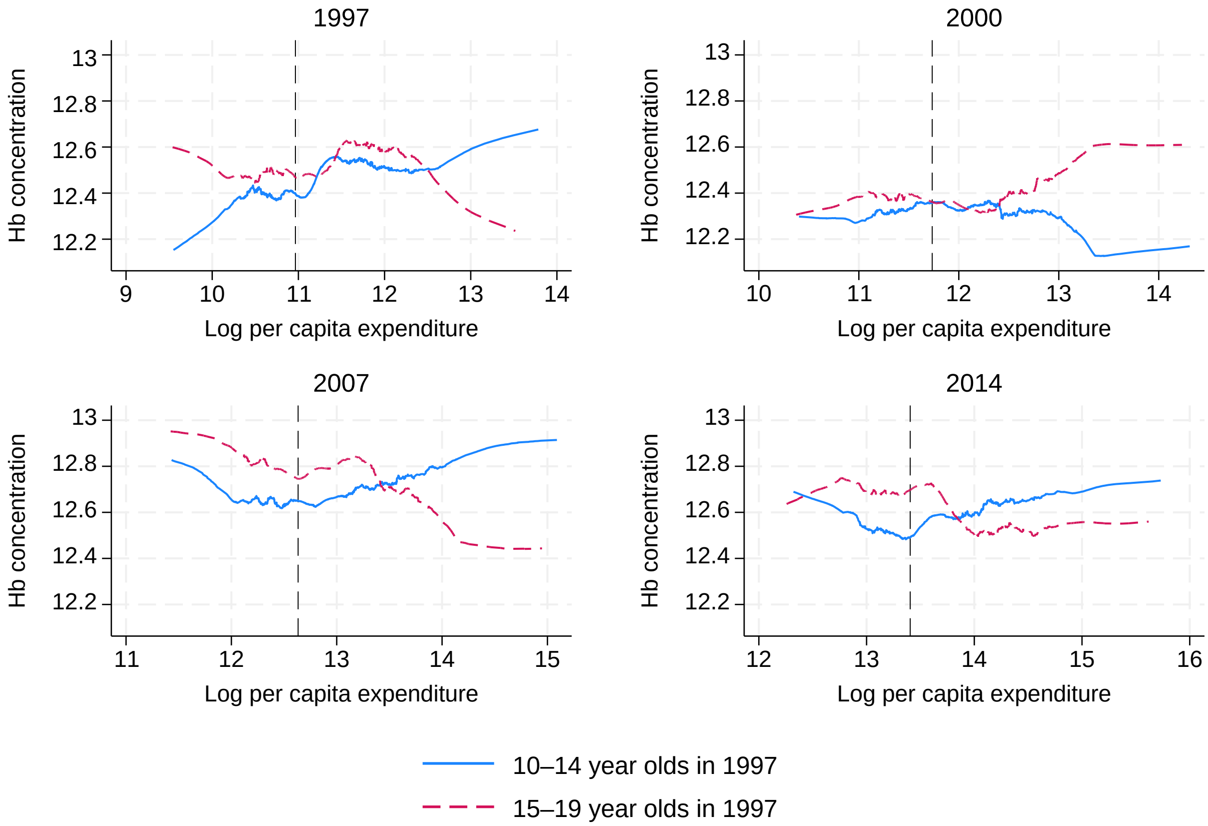


IFLS = Indonesian Family Life Survey.

Note: Locally weighted means using a tricube weighting function with a bandwidth of 0.4. The vertical lines represent the bottom 30% per capita expenditure thresholds for the respective years.

Source: Authors.

Figure 2: Hemoglobin Concentration among 1997 Adolescents across IFLS Waves

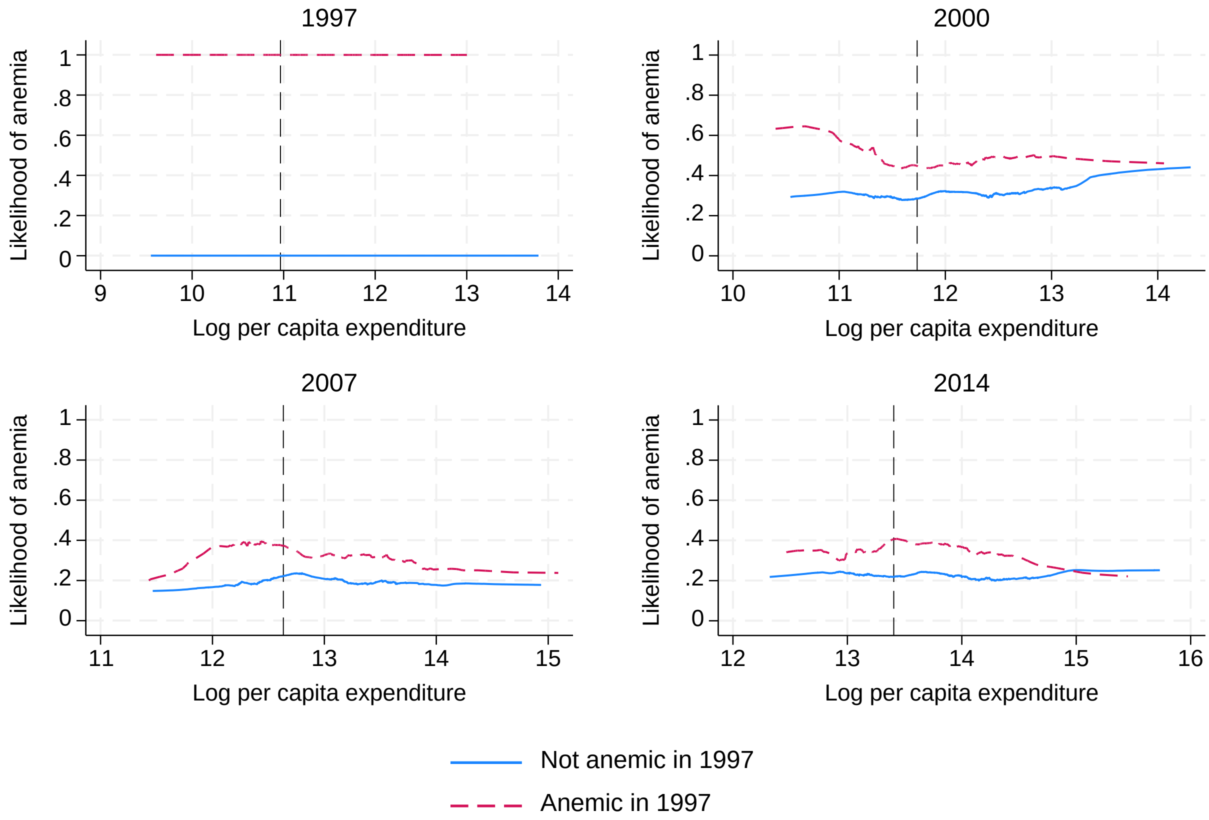


Hb = hemoglobin, IFLS = Indonesian Family Life Survey.

Note: Locally weighted means using a tricube weighting function with a bandwidth of 0.4. The vertical lines represent the bottom 30% per capita expenditure thresholds for the respective years.

Source: Authors.

Figure 3: Anemia Prevalence in 10- to 14-Year-Old 1997 Adolescents across the IFLS Waves

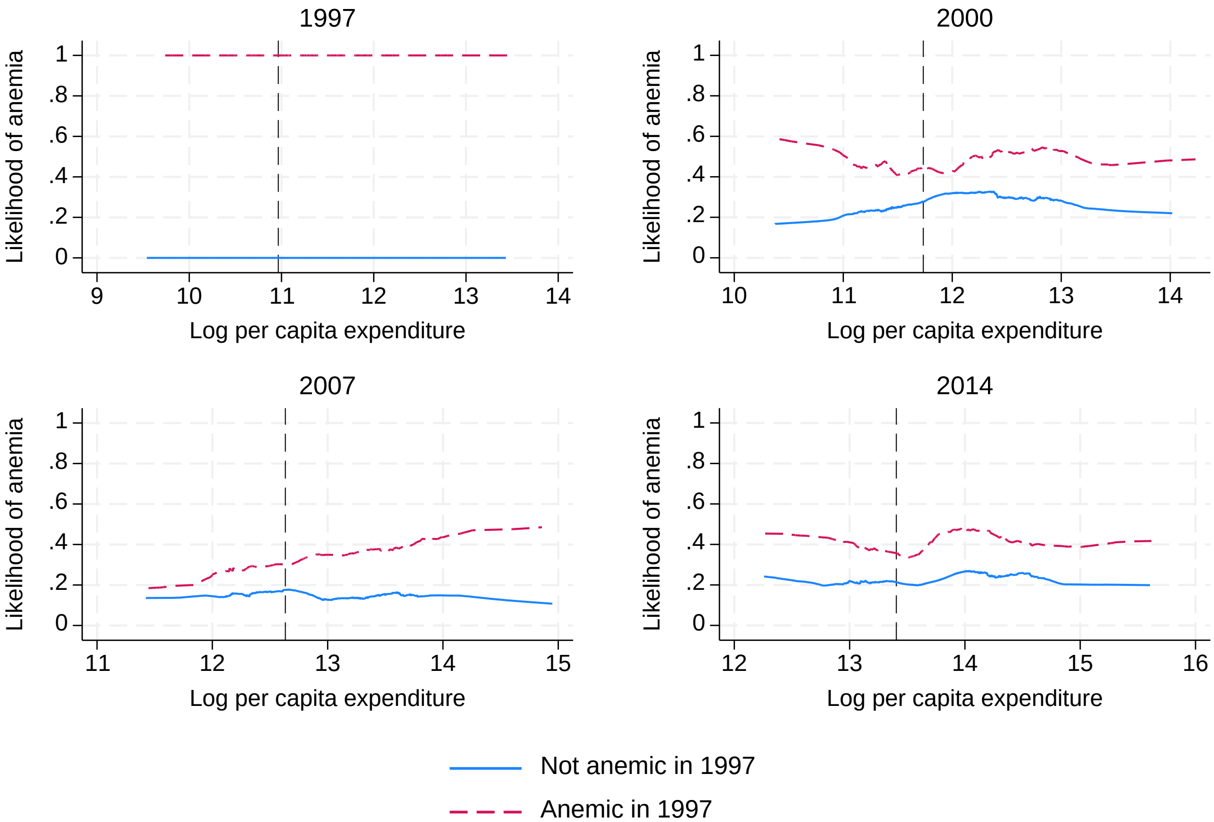


IFLS = Indonesian Family Life Survey.

Note: Locally weighted means using a tricube weighting function with a bandwidth of 0.4. The vertical lines represent the bottom 30% per capita expenditure thresholds for the respective years.

Source: Authors.

Figure 4: Anemia Prevalence in 15- to 19-Year-Old 1997 Adolescents across the IFLS Waves

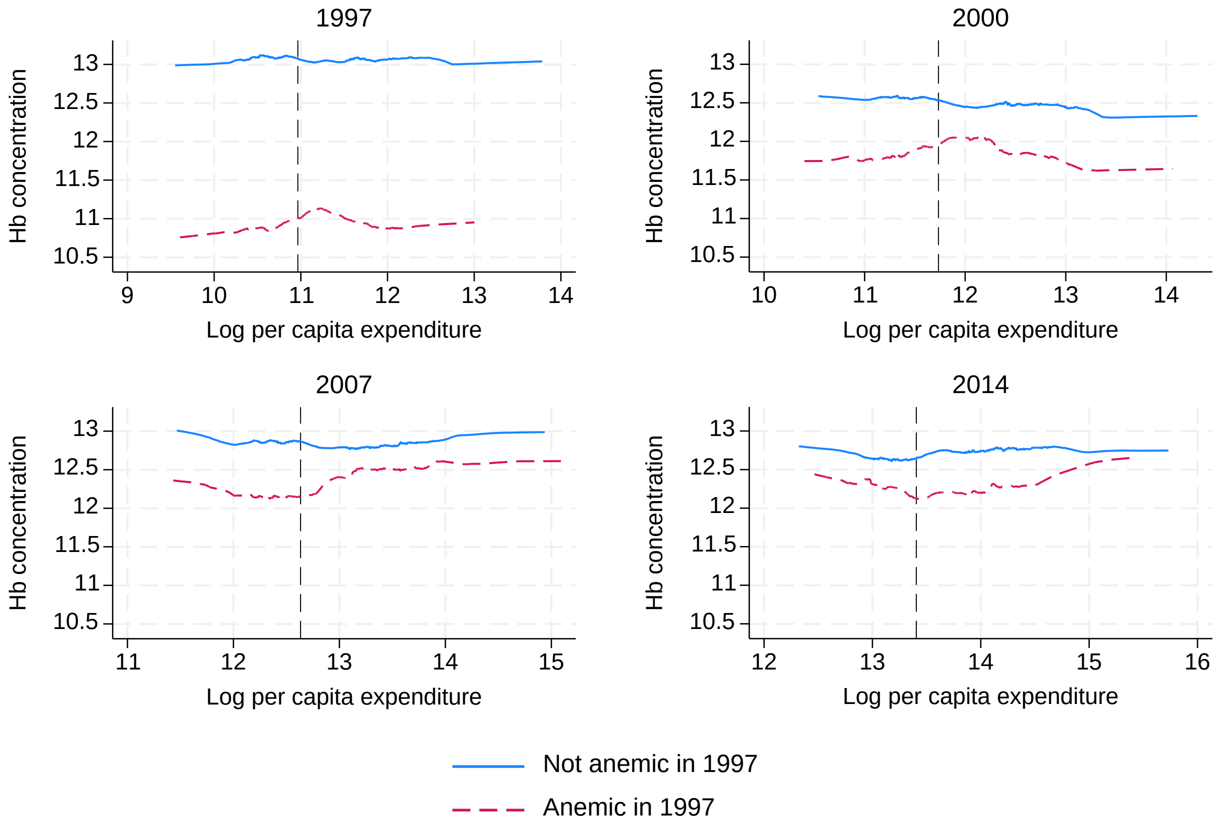


IFLS = Indonesian Family Life Survey.

Note: Locally weighted means using a tricube weighting function with a bandwidth of 0.4. The vertical lines represent the bottom 30% per capita expenditure thresholds for the respective years.

Source: Authors.

Figure 5: Hemoglobin Concentration of 10- to 14-Year-Old 1997 Adolescents across IFLS Waves

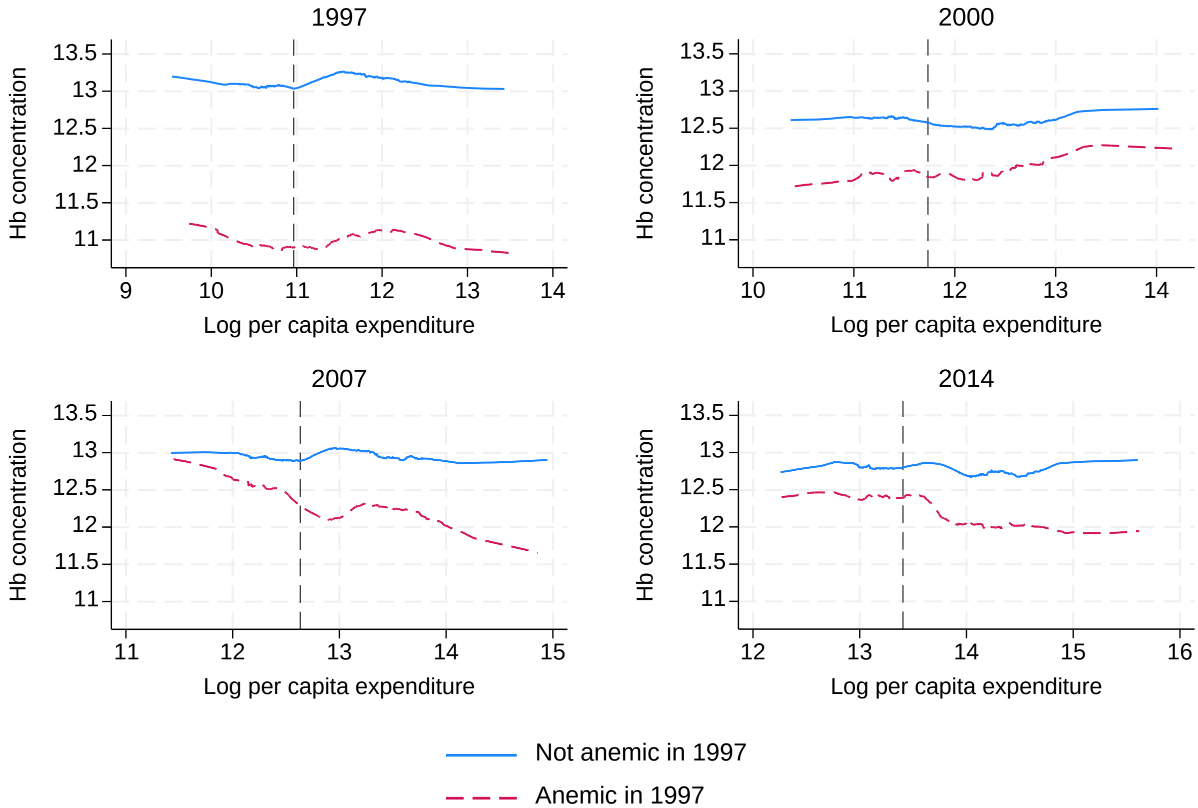


Hb = hemoglobin, IFLS = Indonesian Family Life Survey.

Note: Locally weighted means using a tricube weighting function with a bandwidth of 0.4. The vertical lines represent the bottom 30% per capita expenditure thresholds for the respective years.

Source: Authors.

Figure 6: Hemoglobin Concentration of 15- to 19-Year-Old 1997 Adolescents across the IFLS Waves



Hb = hemoglobin, IFLS = Indonesian Family Life Survey.

Note: Locally weighted means using a tricube weighting function with a bandwidth of 0.4. The vertical lines represent the bottom 30% per capita expenditure thresholds for the respective years.

Source: Authors.

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Does Adolescence Anemia Persist over a Woman's Life Cycle?

Evidence from the Indonesian Family Life Survey

This study analyzes the determinants of anemia in Indonesian women throughout their life cycle. By tracking a group of women from adolescence into adulthood, the study finds a high burden of anemia among women across income groups; that there is some persistence of anemia throughout their life cycle; and women's income potential and economic status may be related to the prevalence of anemia.

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