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# Nursing Assistance in Reducing Childhood Anemia: Evidence from the Democratic Republic of Congo

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## Abstract

In the Democratic Republic of Congo (DRC), poverty, malnutrition, and limited healthcare infrastructure persist, and childhood anemia remains a critical public health issue. Using data from the 2013-2014 Demographic and Health Survey, this study examines how nursing assistance affects anemia among children under 5 years old. Using insights from medical and nutritional interventions, we analyze the extent to which social engagement mitigates pediatric anemia. Propensity score matching was used to estimate the treatment effect of nursing support for mothers on child health outcomes. The results show that children whose mothers received nursing assistance were 7.2% less likely to be anemic. Moreover, micronutrient supplementation and food-based interventions (including tubers and meat) combined with nursing assistance were significantly associated with a reduced prevalence of anemia. Because food-based interventions are less dependent on industrial supply chains, they are encouraged in resource-limited settings. Given the shortage of health professionals in the DRC, establishing a local healthcare capacity with nurses and community health workers could help reduce the prevalence of childhood anemia. Strengthening local health systems, combined with supplementation and a nutritious diet, may be effective in improving child health and supporting long-term human capital development in resource-constrained settings such as the DRC.

**Discipline:** Social Science
**Additional key words**: health sector, micronutrients

## Introduction

Anemia is a major global public health problem and is often classified as an iron-deficiency-related disorder (Hisa et al. 2019). Globally, it affects approximately 40% of children under five, 37% of pregnant women, and 30% of women of reproductive age (15-49 years) (World Health Organization 2025). Although the prevalence of iron deficiency, one of the most common micronutrient deficiencies, has been declining worldwide, many countries in sub-Saharan Africa continue to struggle with it (Han et al. 2022). Micronutrient deficiencies, often referred to as hidden hunger, have gained global attention, yet remain unresolved.

Anemia imposes substantial health and economic burdens, reducing adult productivity and impairing a child's physical and cognitive development, thereby affecting human capital development (Coffey et al. 2018). Significant associations have been documented between pediatric anemia and early childhood development, including social-emotional and physical development (Benedict et al. 2024). Evidence reveals that children with anemia or low hemoglobin levels are more likely to underperform on mathematics examinations (Lili et al. 2018). School participation is similarly affected by anemia, particularly among girls. Consequently, in addition to being a health problem, anemia is a contributing factor to educational disparity (Bobonis et al. 2006).

Several interventions have been proposed to address micronutrient deficiencies. Iron supplementation is one of the most widely implemented strategies (Rehman et al. 2025), yet its effectiveness is often limited and varies across contexts. Additional recommended approaches include other micronutrient supplementation, educational interventions, and food-based strategies (Helmyati et al.

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2025). Maternal nutrition knowledge influences the prevalence of anemia among young children, as a better understanding of appropriate feeding practices enhances the provision of nutritionally adequate meals and helps reduce anemia (Mahmudiono et al. 2017).

Community-based health services are another important approach for reducing pediatric anemia. In India, expanding community touchpoints through schools and household visits is recommended (Teckchandani & Patel 2025). Caregiver nutrition counseling influenced maternal behaviors and improved diet quality. In many African countries, NGOs and community health service providers are critical, especially in reaching hard-to-access populations. They also address cultural misconceptions about childhood illnesses that often contribute to inappropriate healthcare-seeking behaviors (Davis 2025). However, these services are constrained by multiple factors, such as limited literacy among potential workers, inadequate transportation, and insufficient financial resources (Chirande et al. 2025).

The Democratic Republic of the Congo (DRC) is one of the sub-Saharan African countries experiencing pediatric anemia. Although iron deficiency is the leading cause of anemia, malaria is the primary driver in the DRC. In Popokabaka, where malaria is highly prevalent, 68.1% of surveyed children were found to be anemic (Mbunga et al. 2021). In Katanga province, lipid-based nutrient supplements, combined with nutrition education, reduced childhood anemia, although malaria remained positively associated with anemia (Yaw Addo et al. 2020). While research has found that dietary iron intake is inadequate in South Kivu and Kongo Central (Moumin et al. 2020), biochemical iron deficiency among children is relatively low (Harvey-Leeson et al. 2016). As iron deficiency appears to play a limited role in directly causing anemia in this context, iron supplementation is not a consistently effective approach for resolving pediatric anemia, particularly in malaria-endemic areas (Michaux et al. 2022, Yaw Addo et al. 2020). In some cases, its use may even pose risks (Makulo et al. 2019). Given these contradictory patterns, providing micronutrients, especially zinc and vitamin A, through diversified diets and bio-fortified crops, rather than relying solely on supplementation, is recommended. However, access to nutritious foods and the degree of dietary diversity vary significantly across household conditions, including wealth, maternal education, and nutrition knowledge (Qi et al. 2022).

Food-based interventions are another promising pathway for addressing pediatric anemia. Consumption of iron-fortified foods such as beans, millet, and rice improves iron levels among children in Rwanda, India, and the Philippines (Michaux et al. 2022). These crops are also linked to improved cognitive performance in India (Scott et al. 2018). Large-scale food fortification is widely recommended as a powerful and cost-effective strategy to combat micronutrient deficiencies, including iron deficiency.

Given the wide range of interventions proposed to address pediatric anemia, including medical and nutritional approaches, food-based measures are also garnering attention. These cost-effective strategies are less dependent on industrial supply chains (Michaux et al. 2022), making them highly relevant in resource-limited settings. As discussed above, medical and nutritional interventions have been implemented in the DRC, yet the effectiveness of community-based services and food-based interventions remains unassessed. To the best of our knowledge, no previous study has examined this issue. As community health workers (CHWs) are still being established in the DRC, we evaluated the effectiveness of nursing assistance for mothers on the prevalence of childhood anemia. This study examines children's dietary intake in combination with nursing assistance to mothers. Pediatric anemia is a complex condition with a number of medical, nutritional, and social determinants. Drawing on evidence from medical and nutritional interventions, the role of social engagement in reducing pediatric anemia is investigated. Through our findings, the goal is to identify effective policies to address pediatric anemia and strengthen the country's human capital.

Following this introduction, Section 2 provides background information on the DRC, Section 3 outlines the data and methodology used to assess the effectiveness of nursing assistance to mothers in reducing childhood anemia, Section 4 presents the estimation results, and Section 5 concludes the study and discusses policy implications.

## Background

### 1. Pediatric anemia and the health sector in the DRC

The DRC is one of the least developed countries in sub-Saharan Africa, characterized by widespread poverty and persistent malnutrition among children. Several studies on pediatric anemia across Africa, including the DRC, have identified significant associations between malnutrition, anemia, and iron deficiency (Harvey-Leeson et al. 2016, Rahman et al. 2019, Thakur et al. 2014). Although anemia prevalence in the DRC has declined from 52.9% in 2007 to 46.4% and 42.4% in 2012 and 2019, respectively, it remains a major public health concern (Soda et al. 2024).

In 2022, the DRC had approximately 115,900 nurses serving a population of over 85 million, equivalent to 1.2 nurses per 1,000 population, a ratio well below the World Health Organization's (WHO's) recommended standard of 4.45 nurses per 1,000 population (WHO 2016, World Bank Group 2026). The country's health sector faces substantial challenges, including insufficient funding, inadequate healthcare infrastructure, and limited institutional capacity, especially in rural areas. Nurses are heavily concentrated in Kinshasa, where 45% of the national nursing workforce serves 14 million residents, which is only 12.5% of the country's population (Shin & Tshimbombu 2024). Armed conflict and regional political instability contribute to unsafe working conditions for local nurses. Additionally, nurses earn low salaries, have few training opportunities, and lack professional recognition, all of which reduce incentives to remain in the profession.

Despite these constraints, nurses are critical supporters of mothers and children, providing maternal and newborn primary care, family planning services, and general health promotion. While internal medicine, hospitalization, and emergency care are provided at hospitals as part of the Essential Health Package (EHP) (Shin & Tshimbombu 2024), key EHP components, such as maternal and child primary healthcare, are delivered through local health facilities and CHWs (Bisimwa 2024). For instance, nurse counseling during the postpartum period increases modern birth control usage and reduces unintended pregnancies (Zivich et al. 2019). However, studies have reported that the knowledge of nurses in the DRC is limited, and their skills and competencies require regular updating (Ndela et al. 2024).

### 2. Nursing assistance and CHWs

While most nurses in the DRC are stationed in health facilities (Shin & Tshimbombu 2024), CHWs serve as the primary link to mothers, delivering essential health interventions (Baatiema et al. 2016). However, they face several challenges (Community Health Delivery Partnership 2021). Transportation and related costs of services are not covered, forcing participants to walk long distances to reach patients (Raven et al. 2022). A study in Kasaï-Oriental Province reported that vitamin A supplements are distributed through CHWs, but mothers often do not receive them due to limited knowledge, misunderstandings, or local beliefs opposing vitamin supplementation (Egbende et al. 2025). In some cases, traditional healers are more widely available and often function as de facto CHWs in the DRC (Dalglish et al. 2019), with many people in rural areas seeking care from these healers, though such practices can be harmful or delay access to appropriate treatment (Singh et al. 2025).

However, once mothers understand the importance of supplementation, they tend to visit health centers, where they can also receive additional information on vaccinations and deworming. Thus, prenatal counseling is a critical touchpoint between mothers and CHWs (Egbende et al. 2025). Access to nursing assistance can enhance maternal knowledge of child care, and expand the opportunity to receive medical treatment. However, mothers who live in poverty or lack trust in CHWs are often reluctant to bring their children to health centers (Diese et al. 2018).

Strengthening nursing assistance and CHW programs across Africa is key to improving child health (Baatiema et al. 2016, Ssetaala et al. 2022), as CHWs and nursing assistance play an essential role in enhancing maternal nutrition knowledge and promoting healthy dietary practices.

## Data and methods

### 1. Data and study population

This study uses cross-sectional data from the Demographic and Health Survey (DHS) conducted in the Democratic Republic of the Congo (DRC) between August 2013 and February 2014. The DHS is a nationally representative survey designed to provide reliable information on population and health conditions.

At the first stage, sampling units were selected based on population size. In urban areas, neighborhoods were selected from a complete list of all neighborhoods, while in rural areas, sectors or chiefdoms were selected. In urban areas, 34 households were then selected within each chosen neighborhood. In rural areas, villages were first selected within the relevant sectors or chiefdoms, followed by the selection of 34 households within each village. The final sampling unit was the cluster (neighborhood or village), and a total of 540 clusters were selected. The resulting sample included 18,360 households: 5,474 households across 161 clusters in urban areas and 12,886 households across 379 clusters in rural areas.

This sampling design ensures national representativeness; however, some territories do not contain any clusters. Clusters tend to be concentrated in densely populated regions, such as North and South Kivu and the Kasai region, and are more dispersed in sparsely populated rural areas. As a result, certain territories have no sample clusters. In fact, in some territories (e.g., Oshwe, Ango, Bafwasende, and Kalemie), no clusters are present due to the sampling design (Fig. 1), which does not guarantee representation at the territorial level.

Additionally, the spatial displacement of GPS coordinates for confidentiality contributes to the absence of clusters in these areas (Ministry of Planning and Monitoring of the Implementation of the Revolution of Modernity et al. 2014).

The study sample comprised 3,926 children aged 0-59 months, among whom 2,719 had mothers with access to nursing assistance during the antenatal (mother's pregnancy), delivery, or postnatal (within the first 2 months after delivery) periods.

**2. Assistance periods**

Access to nursing assistance ('treatment') indicates whether the mother received support during the antenatal, delivery, or postnatal periods. Table 1 presents anemia prevalence across alternative patterns of nursing assistance. Children whose mothers received assistance during only the prenatal period (Row 2) or only during delivery (Row 3) show a high prevalence of anemia at 65.9% and 65.5%, respectively. Prevalence is 61.9% among those receiving postnatal assistance only (Row 4), and it is even lower among children whose mothers received postnatal assistance combined with other periods (Rows 6-8). More frequent interactions between mothers and nurses are associated with a lower prevalence of anemia. This reflects increased opportunities for nurses to directly observe children, identify anemia presence, and provide timely management. Note, however, that 1,207 children have mothers who did not receive any nursing assistance, and their anemia prevalence is the highest.

Our conversations with health personnel in the DRC reveal that some mothers must walk several hours to reach a health facility, which is especially difficult among pregnant women and those with young children. Only 16.4% of mothers (644 out of 3,926) received postnatal assistance, indicating that most stopped receiving support after giving birth. Notably, 2,436 mothers received no

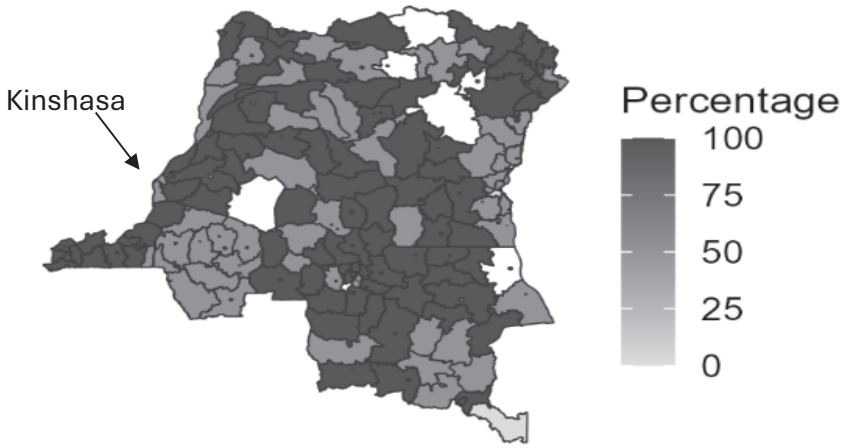



**Fig. 1. Anemia prevalence in DRC**
Territories shown in white indicate no available observations.

**Table 1. Childhood anemia prevalence by timing of nursing assistance**

| Period of assistance | Number of observations | Childhood anemia prevalence |
|---|---|---|
| (1) No assistance | 1,207 | 70.4 |
| (2) Prenatal only | 861 | 65.9 |
| (3) Delivery only | 194 | 65.5 |
| (4) Postnatal only | 215 | 61.9 |
| (5) Prenatal + Delivery | 1,020 | 62.6 |
| (6) Prenatal + Postnatal | 153 | 57.5 |
| (7) Delivery + Postnatal | 61 | 57.4 |
| (8) Prenatal + Delivery + Postnatal | 215 | 57.7 |
| Total | 3,926 | 65.1 |

assistance from nurses even during delivery, as home births remain common in the DRC.

## 3. Method

Our study estimates the effect of nursing assistance on childhood anemia. The treatment effect $\tau_i$ is written as follows:

$$\tau_i = Y_i(D_i = 1) - Y_i(D_i = 0), \quad (1)$$

where $Y_i(D_i)$ denotes the anemia outcome for child $i$; $D_i = 1$ indicates that child *i*'s mother had access to nursing assistance (the treatment group); and $D_i = 0$ indicates that child *i*'s mother had no access to a nurse (the control group). Thus, $Y_i(D_i = 1)$ represents the anemia outcome of child *i* when his/her mother is treated, while $Y_i(D_i = 0)$ denotes the child's anemia outcome when the mother is not treated. $\tau_i$ is the treatment effect on child *i*. However, we observe either outcome, $Y_i(D_i = 1)$ or $Y_i(D_i = 0)$, not both, on the same child *i*.

$$ATT_i = E[Y_{1i} - Y_{0i}|D_i = 1] + \{E[Y_{0i}|D_i = 1] - E[Y_{0i}|D_i = 0]\} \quad (2)$$

Thus, we estimate the average treatment effect on the treated (ATT), as depicted in equation (2), where the second term represents bias, which arises from self-selection (selection bias). If the treatment is randomly assigned, meaning that nursing assistance to mothers is randomly assigned, selection bias is negligible. However, this is generally not the case. Access to nursing assistance often varies due to family or household conditions. Mothers' decisions to receive nursing assitance depend on their knowledge, family and child's conditions, so treatment assignment is often non-random, and the treatment effect from such non-random assignments results in biased estimates.

Using the matching method, we develop a control group which is similar to the treatment group based on observed characteristics $X_i$. When the characteristics are many, matching based on propensity score $p(X_i)$ is as good as matching on $X_i$, given certain conditions (Khandker et al. 2009, Rosenbaum & Rubin 1983).

The key assumptions of propensity score matching (PSM) are conditional independence (CIA) and common support. CIA indicates that outcome $Y_i$ from the control and treatment, $Y_{0i}, Y_{1i}$, and the assignment of treatment $D_i$ (nursing assistance) are independent, equation (3). CIA holds for the scalar function of covariates, $p(X_i)$, as presented in equation (4).

$$\{Y_{0i,}\, Y_{1i}\} \perp\!\!\!\perp D_i |\, p(X_i), \quad (3)$$

$$p(X_i) = \text{prob}\,(D_i = 1|X_i)\ \ (0 < p(X_i) < 1). \quad (4)$$

This is called unconfoundedness (Khandker et al. 2009, Rosenbaum & Rubin 1983). Propensity score is often estimated with a logit or probit function employing observed covariates $X_i$. Using the estimated propensity scores $\hat{p}(X_i)$, PSM selects a control for each of those treated, and construcs matched pairs. Given assumption (3), exact matching implies that matched samples result in the identical distribution of the observed covariates. This common support assumption is investigated by comparing the distributions of propensity scores between control and treatment groups.

Another concern is potential bias arising from unobserved characteristics. If the treatment assignment is based on such factors, CIA will be violated, and PSM becomes inappropriate (Rosenbaum & Rubin 1983). As shown later, we include as many relevant observed characteristics as possible in the propensity score estimation, however, we still assess the potential bias using a sensitivity test. The empirical results of common support and sensitivity analysis are presented in the result section.

We estimated the propensity score using probit regression and matched children whose mothers did and did not receive nursing support based on these scores. The matched sample allows us to estimate the treatment effect, and further stratification of the matched sample enables us to examine how the effect varies when combined with supplementation and food-based approaches (Jalan & Ravallion 2003).

## 4. Covariates

The covariates included child- and maternal-related variables, and household-related characteristics. Table 2 presents the definitions of the variables. Descriptive statistics for children, stratified by mothers' access to nursing assistance, are presented in Table 3. Tables 2 and 3 also include variables for the after-matching analysis, such as supplementation and feeding practices.

Overall, 69.3% of the children's mothers received at least some form of nursing assistance during the antenatal, delivery, or postnatal period whereas 30.7% did not. The prevalence of anemia was higher among children whose mothers did not receive nursing assistance (70.4%) than among those whose mothers received assistance (62.9%). The map in Figure 1 shows that

childhood anemia is prevalent nationwide. The mean birth order of a child is 4.12, and the mean weight is 10.1 kg.

The mean mother's age was 29.4, though it was significantly higher among those who were unassisted (30.0) than those assisted (29.1). Further, 34.9% of

**Table 2. Definition of variables**

| Variable | Definition |
|---|---|
| *nursing assistance* | 1 = either during prenatal, delivery, or postnatal, 0 = otherwise |
| *c_anemia* | 1 = severe, moderate, or mild anemia, 0 = otherwise |
| **Child-related variables** | |
| *c_age* | age of children in months (from 0 to 59 months old) |
| *c_female* | female = 1, male = 0 |
| *c_order* | continuous variable representing the birth order of children in a household |
| *c_weight* | continuous variable representing the weight of a child measured in kilograms with one decimal unit |
| **Mother-related variables** | |
| *m_age* | age of the mother (15 - 49 years old) |
| *m_education* | 1 = highest education is secondary school and above, 0 = otherwise |
| *m_occupation* | 1 = has an occupation, 0 = otherwise |
| *m_literacy* | 1 = able to read at least a sentence, 0 = otherwise |
| *m_ethnicity* | 1 = Swahili spoken, 0 = otherwise |
| *m_religion* | 1 = catholic or protestant, 0 = otherwise |
| *m_anemia* | 1 = severe, moderate, or mild anemia, 0 = otherwise |
| *m_pregnancy* | 1 = mother is pregnant, 0 = otherwise |
| *m_wanted the last child* | 1 = mother wanted the last child then, 0 = otherwise |
| *m_permission_hos* | 1 = receiving permission from husband or household head is a big problem for mother, 0 = otherwise |
| *m_visit hos* | 1 = visited hospital in the last 12 months, 0 = otherwise |
| **Household-related variables** | |
| *h_rural* | 1 = household lives in a rural area, 0 = otherwise |
| *h_safe water* | 1 = access to piped water in dwelling or yard, public tap water, or piped water from neighbor, 0 = otherwise |
| *h_time water* | 1 = from 0 to 29 minutes, 0 = otherwise |
| *h_toilet* | 1 = household meets basic sanitation requirement, 0 = otherwise |
| *h_floor* | 1 = earth or dung, 0 = otherwise |
| *h_wall* | 1 = cement blocks, adobe covered, bricks, stone with mud, 0 = otherwise |
| *h_roof* | 1 = metal, tiles, zinc, or cement fiber, 0 = otherwise |
| *h_wealth* | household well-being by assets, where 1 = poorest or poor, 0 = otherwise |
| *h_news* | 1 = at least access toTV, radio, or newspaper, 0 = otherwise |
| *h_transport* | 1 = at least own a bicycle, a motorbike, or a car, 0 = otherwise |
| *h_female* | Household head is, 1 = femal, and 0 = male |
| *d_west* | 1 = Kinshasa, Kwilu, Kwango, Kongo-central, and Mai-Ndombe provinces, 0 = otherwise |
| **Supplementation variables** | |
| *m_iron* | 1 = mother received or bought iron tablets/syrup during pregnancy, 0 = otherwise |
| *m_vitamin A* | 1 = mother received vitamin A within the first 2 months after delivery, 0 = otherwise |
| *s_both* | 1 = combined *m_iron and m_vitamin A, 0 = otherwise* |
| *c_vitamin A* | 1 = child received vitamin A within six months after birth |
| **Feeding variables** | |
| *d_tubers* | 1 = mother gave child potatoes, cassava, or other tubers, 0 = otherwise |
| *d_meat* | 1 = mother gave child meat (beef, pork, chicken, or lamb), 0 = otherwise |
| *d_both* | 1 = mother gave child tubers and meat |

**Table 3. Descriptive statistics**

| Variable | Full sample means (3,926)[a] | Dummy | Sample size | Mean for children whose mothers lack access to nursing assistance (1,207) | Mean for children whose mothers have access to nursing assistance (2,719) | Mean differences[b] |
|---|---|---|---|---|---|---|
| **Child-related variables** | | | | | | |
| *c_anemic* | 0.653 | 1 | 2,562 | 0.704 (850) | 0.629 (1,712) | 0.075*** |
| | | 0 | 1,364 | 0.295 (357) | 0.370 (1,007) | |
| *c_age* | 23.0 | | 3,926 | 23.7 (1,207) | 22.6 (2,719) | 1.04** |
| *c_female* | 0.499 | 1 | 1,960 | 0.486 (586) | 0.505 (1,374) | −0.020 |
| | | 0 | 1,966 | 0.514 (621) | 0.494 (1,345) | |
| *c_order* | 4.12 | | 3,926 | 4.186 (1,207) | 4.076 (2,719) | 0.111 |
| *c_weight* | 101.1 | | 3,926 | 100.9 (1,207) | 101.2 (2,719) | −0.210 |
| **Mother-related variables** | | | | | | |
| *m_age* | 29.4 | | 3,926 | 30.0 (1,207) | 29.1 (2,719) | 0.916*** |
| *m_education* | 0.349 | 1 | 1,372 | 0.291 (351) | 0.376 (1,021) | −0.085*** |
| | | 0 | 2,554 | 0.709 (856) | 0.624 (1,698) | |
| *m_occupation* | 0.835 | 1 | 3,281 | 0.848 (1,023) | 0.830 (2,258) | 0.017 |
| | | 0 | 645 | 0.152 (184) | 0.170 (461) | |
| *m_literacy* | 0.513 | 1 | 2,014 | 0.439 (531) | 0.545 (1,483) | −0.105*** |
| | | 0 | 1,912 | 0.560 (676) | 0.455 (1,236) | |
| *m_ethnicity* | 0.436 | 1 | 1,713 | 0.437 (527) | 0.436 (1,186) | 0.0004 |
| | | 0 | 2,213 | 0.563 (680) | 0.564 (1,533) | |
| *m_religion* | 0.563 | 1 | 2,211 | 0.579 (700) | 0.556 (1,511) | 0.024 |
| | | 0 | 1,715 | 0.420 (507) | 0.444 (1,208) | |
| *m_anemia* | 0.408 | 1 | 1,602 | 0.437 (528) | 0.395 (1,074) | 0.042** |
| | | 0 | 2,324 | 0.563 (679) | 0.605 (1,645) | |
| *m_pregnancy* | 0.184 | 1 | 722 | 0.193 (233) | 0.180 (489) | 0.013 |
| | | 0 | 3,204 | 0.807 (974) | 0.820 (2,230) | |
| *m_wanted the last child* | 0.703 | 1 | 2,761 | 0.735 (887) | 0.689 (1,874) | 0.046*** |
| | | 0 | 1,165 | 0.265 (320) | 0.311 (845) | |
| *m_permission_hos* | 0.348 | 1 | 1,368 | 0.331 (400) | 0.356 (968) | −0.025 |
| | | 0 | 2,558 | 0.669 (807) | 0.644 (1,751) | |
| *m_visit hos* | 0.429 | 1 | 1,688 | 0.354 (427) | 0.464 (1,261) | −0.110*** |
| | | 0 | 2,238 | 0.646 (780) | 0.536 (1,458) | |
| **Household-related variables** | | | | | | |
| *h_rural* | 0.712 | 1 | 2,796 | 0.793 (957) | 0.676 (1,839) | 0.117*** |
| | | 0 | 1,130 | 0.207 (250) | 0.324 (880) | |
| *h_safe water* | 0.382 | 1 | 1,499 | 0.322 (389) | 0.408 (1,110) | −0.086*** |
| | | 0 | 2,427 | 0.678 (818) | 0.592 (1,609) | |
| *h_time water* | 0.418 | 1 | 1,641 | 0.400 (483) | 0.426 (1,158) | −0.026 |
| | | 0 | 2,285 | 0.599 (724) | 0.574 (1,561) | |
| *h_toilet* | 0.374 | 1 | 1,468 | 0.357 (431) | 0.381 (1,037) | −0.024 |
| | | 0 | 2,458 | 0.643 (776) | 0.619 (1,682) | |
| *h_floor* | 0.872 | 1 | 3,422 | 0.923 (1,115) | 0.848 (2,307) | 0.075*** |
| | | 0 | 504 | 0.076 (92) | 0.152 (412) | |
| *h_wall* | 0.209 | 1 | 824 | 0.146 (176) | 0.238 (648) | −0.093*** |
| | | 0 | 3,102 | 0.854 (1,031) | 0.761 (2,071) | |

(Continued on next page)

**Table 3. Descriptive statistics** (Continued)

| Variable | Full sample means (3,926)[a] | Dummy | Sample size | Mean for children whose mothers lack access to nursing assistance (1,207) | Mean for children whose mothers have access to nursing assistance (2,719) | Mean differences[b] |
|---|---|---|---|---|---|---|
| *h_roof* | 0.278 | 1 | 1,091 | 0.179 (216) | 0.322 (875) | −0.143*** |
| | | 0 | 2,835 | 0.821 (991) | 0.678 (1,844) | |
| *h_wealth* | 0.498 | 1 | 1,954 | 0.577 (697) | 0.462 (1,257) | 0.115*** |
| | | 0 | 1,972 | 0.423 (510) | 0.538 (1,462) | |
| *h_news* | 0.382 | 1 | 1,499 | 0.304 (367) | 0.416 (1,132) | −0.112*** |
| | | 0 | 2,427 | 0.696 (840) | 0.584 (1,587) | |
| *h_transport* | 0.317 | 1 | 1,246 | 0.315 (380) | 0.319 (866) | −0.004 |
| | | 0 | 2,680 | 0.685 (827) | 0.682 (1,853) | |
| *h_female* | 0.240 | 1 | 944 | 0.252 (305) | 0.235 (639) | 0.018 |
| | | 0 | 2,982 | 0.747 (902) | 0.765 (2,080) | |
| *d_west* | 0.256 | 1 | 1,004 | 0.217 (262) | 0.273 (742) | −0.056*** |
| | | 0 | 2,922 | 0.783 (945) | 0.727 (1,977) | |
| **Supplementation variables**[c] | | | | | | |
| *m_iron* | 0.552 (3,905) | 1 | 2,157 | 0.436 (524) | 0.604 (1,633) | −0.168*** |
| | | 0 | 1,748 | 0.564 (678) | 0.400 (1,070) | |
| *m_vitamin A* | 0.266 (3,896) | 1 | 1,038 | 0.175 (211) | 0.307 (827) | −0.131*** |
| | | 0 | 2,858 | 0.825 (991) | 0.693 (1,867) | |
| *c_vitamin A* | 0.657 (3,891) | 1 | 2,558 | 0.579 (693) | 0.693 (1,865) | −0.114*** |
| | | 0 | 1,333 | 0.422 (505) | 0.308 (828) | |
| **Feeding variables**[c] | | | | | | |
| *d_tubers* | 0.295 (2,303) | 1 | 679 | 0.274 (186) | 0.304 (493) | −0.030 |
| | | 0 | 1,624 | 0.727 (494) | 0.696 (1,130) | |
| *d_meat* | 0.145 (2,302) | 1 | 333 | 0.139 (95) | 0.146 (238) | −0.007 |
| | | 0 | 1,969 | 0.860 (584) | 0.853 (1,385) | |

[a] Numbers in parentheses represent the number of observations in each category.
[b] ** and *** indicate statistical significance at the 5% and 1% levels, respectively.
[c] Sample size (shown in parentheses) of supplementation and feeding variables is smaller than others because the respondents did not answer the corresponding questions.

mothers had an education higher than secondary, and this proportion was higher among those who were nurse-assisted (37.6%) than those without assistance (29.1).

Household living conditions notably varied between the two groups, with 71.2% of the children living in rural areas and only 38.2% having access to safe water. Lack of access to safe drinking water was more common among children whose mothers did not receive assistance (67.8%) than among those whose mothers had it (59.2%). Overall, 24.0% of the children resided in female-headed households, and the materials used for the floors, walls, and roofs of homes were significantly different between the two stratified samples.

Among children, 55.2% had mothers who received iron supplements, whereas only 26.6% had mothers who received vitamin A. In contrast, 65.7% of children themselves received vitamin A supplementation. Among children, who received supplements or whose mothers received them, the proportion whose mothers had nursing assistance is significantly higher than among those without such assistance. Regarding diet, 29.5% of children were fed tubers, and 14.5% were fed meat. Although the differences are smaller than those observed for supplementation, the share of children whose mothers received nursing assistance is still higher than among those who did not. The sample sizes of the supplementation and feeding variables are different from 3,926, as these variables are used only in the postmatching analysis.

## Results

### 1. Propensity score matching

Table 4 presents the regression results of the probit model. Based on these results, propensity scores were calculated and children of mothers with the closest propensity score between the groups with and without nursing support were matched one-to-one, using nearest-neighbor matching *with replacement*. The treated group had a sample size of 2,719, whereas the control group initially included only 1,207 children (Table 3). Accordingly, the matching procedure requires replacement, and 863 of the 1,207 control observations were used to construct the control group. Thus, the sample size of the control group becomes 2,719, the same as that of the treated group although it included duplicated observations.

Using this matched sample, we conducted a balance test to assess whether the background characteristics of the two groups were comparable. Table 5 shows that the standardized differences for all covariates are below 0.1 in the matched sample. This indicates that the differences between the groups are statistically negligible, confirming that the matching procedure achieves balance (Austin 2011). The matched distribution is shown in Figure 2 and demonstrates sufficient overlap (common support).

We also conducted a sensitivity analysis using Rosenbaum bounds. Sensitivity analysis addresses the potential impact of the unobserved confounders (Table 6) by exploring how biases might robustly alter the estimated treatment effect (DiPrete & Gangl 2004). The result that $sig^{-} = sig^{+} = 0$ indicates that unobserved confounders would not affect the treatment effect even if they were to increase by 500% (Gamma = 5). Thus, our result indicates that the treatment effect is not sensitive to potential unobserved confounders. However, the test results do not entirely rule out potential bias from unobserved unconfounders (Diprete & Gangl 2004, Khandker et al. 2009).

### 2. Effectiveness of nursing assistance on childhood anemia

We investigate the effectiveness of nursing assistance on childhood anemia (Table 7). The anemia prevalence was approximately 70.1% among children whose mothers lacked nursing assistance compared with 62.9% among children whose mothers had assistance. Thus, nursing support for mothers reduced anemia prevalence by 7.2%.

### 3. Supplementation

Table 8 shows the results of mineral supplementation among both mothers and children combined with nursing support. Among children whose mothers received no supplement (neither iron nor vitamin A), those whose mothers received nursing assistance show a lower anemia prevalence (7.6%). This indicates that nursing assistance solely contributes to reducing child anemia. When nursing assistance is combined with supplementation, the reduction becomes larger, reaching 9.1% with vitamin A supplementation. Among children whose mothers received both vitamin A and iron, the reduction reached 9.2% between the treated and control groups. These

**Table 4. Probit regression**

| | Coefficient | Std. | Level of significance[a] |
|---|---|---|---|
| *c_age* | −0.004 | 0.003 | |
| *c_female* | 0.049 | 0.043 | |
| *c_order* | 0.085 | 0.032 | *** |
| *c_weight* | 0.002 | 0.001 | * |
| *m_age* | −0.020 | 0.005 | *** |
| *m_education* | −0.060 | 0.068 | |
| *m_occupation* | 0.037 | 0.060 | |
| *m_literacy* | 0.126 | 0.063 | ** |
| *m_ethnicity* | 0.031 | 0.052 | |
| *m_religion* | 0.002 | 0.044 | |
| *m_anemia* | −0.120 | 0.044 | *** |
| *m_pregnancy* | −0.040 | 0.058 | |
| *m_wanted the last child* | −0.040 | 0.049 | |
| *m_permission_hos* | 0.128 | 0.046 | *** |
| *m_visit hos* | 0.245 | 0.044 | *** |
| *h_rural* | −0.110 | 0.065 | * |
| *h_safe water* | −0.012 | 0.055 | |
| *h_time water* | 0.092 | 0.044 | ** |
| *h_toilet* | −0.009 | 0.046 | |
| *h_floor* | −0.047 | 0.096 | |
| *h_wall* | 0.008 | 0.076 | |
| *h_roof* | 0.300 | 0.076 | *** |
| *h_wealth* | −0.021 | 0.059 | |
| *h_news* | 0.102 | 0.051 | *** |
| *h_transport* | −0.036 | 0.050 | |
| *h_female* | −0.044 | 0.051 | |
| *d_west* | 0.155 | 0.060 | ** |
| *constant* | 0.567 | 0.201 | *** |
| Log likelihood | −2,322.58 | | |
| Number of observations | 3,926 | | |

[a] *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

findings suggest that supplementation combined with nursing assistance is more effective than cases without supplementation. Vitamin A supplementation for children also demonstrates a reduction pattern similar to that observed among mothers (5.3%).

Regular contact between mothers and nurses is likely to prevent anemia among children. Nursing support provides primary care, strengthens maternal practices, and improves maternal adherence to micronutrients, thereby reducing the prevalence of childhood anemia. Nevertheless, 38.4% of the mothers received neither iron nor vitamin A supplementation.

### 4. Food-based approach

We further investigated the effect of nursing support when combined with a food-based approach, such as a feeding practice (Table 9). The consumption rate of tubers is 28.2%. Cassava and potatoes are staple foods widely produced and consumed in the DRC. When children are fed such tubers, the prevalence rate decreases to 8.4% once mothers receive support. In the DRC, some collect young cassava leaves, smash them, and boil them with water or palm oil. Cassava leaves are richer in iron and other minerals than the roots (Lambebo et al. 2025). Nursing support helps mothers learn appropriate feeding practices, which contributes to reducing the prevalence of anemia.

The meat consumption rate is 16.0%. Nursing support is more effective in reducing anemia prevalence when children are fed meat (19.7%). However, domestic meat production remains limited, and imported meat is mostly available in Kinshasa (Fig. 3). Nursing-led interventions can promote dietary diversity and effectively reduce childhood anemia. A food-based approach is an important option.

**Table 5. Standardized differences**

| | Access to a nurse (Y) | Access to a nurse (N) | Stand. diff. |
|---|---|---|---|
| *c_age* | 22.647 | 22.628 | 0.002 |
| *c_female* | 0.505 | 0.515 | −0.02 |
| *c_order* | 2.218 | 2.263 | −0.04 |
| *c_weight* | 101.2 | 101.3 | −0.006 |
| *m_age* | 29.077 | 29.031 | 0.006 |
| *m_education* | 0.376 | 0.387 | −0.023 |
| *m_occupation* | 0.830 | 0.843 | −0.035 |
| *m_literacy* | 0.545 | 0.548 | −0.005 |
| *m_ethnicity* | 0.436 | 0.433 | 0.007 |
| *m_religion* | 0.556 | 0.554 | 0.004 |
| *m_anemia* | 0.395 | 0.402 | −0.015 |
| *m_pregnancy* | 0.180 | 0.196 | −0.042 |
| *m_wanted the last child* | 0.689 | 0.691 | −0.003 |
| *m_permission_hos* | 0.356 | 0.350 | 0.012 |
| *m_visit hos* | 0.464 | 0.463 | 0.002 |
| *h_rural* | 0.676 | 0.687 | −0.025 |
| *h_safe water* | 0.408 | 0.399 | 0.02 |
| *h_time water* | 0.426 | 0.408 | 0.036 |
| *h_toilet* | 0.381 | 0.402 | −0.042 |
| *h_floor* | 0.848 | 0.852 | −0.01 |
| *h_wall* | 0.238 | 0.231 | 0.019 |
| *h_roof* | 0.322 | 0.323 | −0.003 |
| *h_wealth* | 0.462 | 0.456 | 0.012 |
| *h_news* | 0.416 | 0.426 | −0.021 |
| *h_transport* | 0.319 | 0.320 | −0.002 |
| *h_female* | 0.235 | 0.233 | 0.005 |
| *d_west* | 0.273 | 0.263 | 0.024 |

## Conclusions

This study has investigated the effectiveness of nurse-assisted care in reducing pediatric anemia in the DRC. Early-childhood health strongly influences long-term well-being and micronutrient deficiencies remain a major concern in the DRC. In malaria-endemic areas, simple micronutrient supplementation alone is often insufficient to reduce pediatric anemia, making nutritional interventions an important complement to medical treatment.

In many African countries, CHWs are critical in delivering primary care to mothers and children, especially in hard-to-reach communities. Given the current shortage and underdevelopment of CHWs in the DRC, this study examines whether nursing assistance to mothers can help reduce the prevalence of pediatric anemia. Our findings show that nursing assistance significantly lowers the prevalence of anemia among children. Combined with micronutrient supplementation and improved nutritional feeding practices are particularly effective.

Notably, the prevalence of anemia remains high even with nursing assistance. Access to nurses is limited due to poor road infrastructure, weak incentives for nurses, and a shortage of trained health professionals. Although financial resources in the DRC are limited, investing in health is urgently needed as human capital generates substantial positive externalities. Expanding community health programs such as local health centers with nurses and CHWs is a promising option for supporting child health. Strengthening local health personnel and their capacity through international initiatives, and promoting food-based interventions,

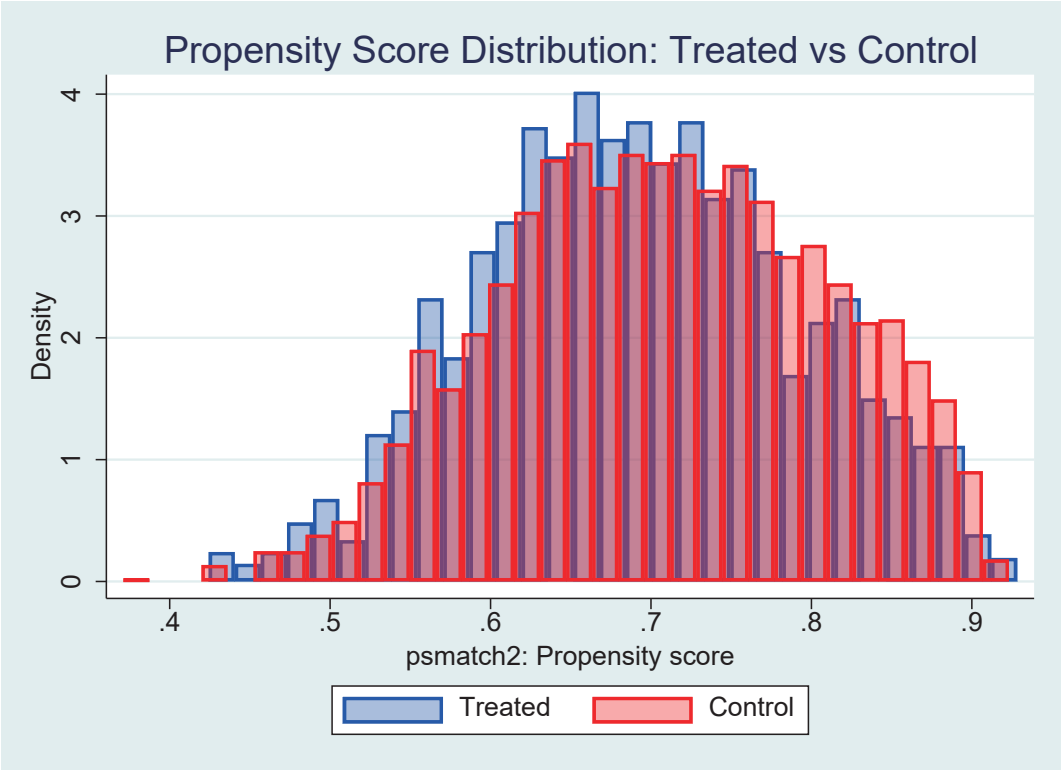



**Fig. 2. Density plot of propensity scores**

**Table 6. Rosenbaum sensitivity analysis**

| Gamma | Significant level | | Hodges-Lehmann | | Confidence interval at 5% | |
|---|---|---|---|---|---|---|
| | upper | lower | upper | lower | upper | lower |
| 1 | 0 | 0 | 0.5 | 0.5 | 0.5 | 0.5 |
| 2 | 0 | 0 | 0.5 | 1 | 0.5 | 1 |
| 3 | 0 | 0 | 0.5 | 1 | 0.5 | 1 |
| 4 | 0 | 0 | 0.5 | 1 | 0.5 | 1 |
| 5 | 0 | 0 | 0.5 | 1 | 0.5 | 1 |

**Table 7. Effectiveness of nursing assistance in reducing child anemia**

| | Sample | Mean for children whose mothers lack access to nursing assistance | Mean for children whose mothers have access to nursing assistance | Difference | Std. Error | Level of significance[c] |
|---|---|---|---|---|---|---|
| Child with anemia | 5,438 | 0.701 (2,719)[a, b] | 0.629 (2,719) | 0.072 | 0.022 | *** |
| Matching method | Neighbor (1:1) with replacement | | | | | |
| Common support | Yes | | | | | |

[a] Numbers in parentheses indicate the sample size.
[b] Control group after matching includes duplicated observations.
[c] *** indicates statistical significance at the 1% level.

**Table 8. Childhood anemia prevalence (%) by supplementation**

| | Mean for children whose mothers lack access to nursing assistance[b] | | Mean for children whose mothers have access to nursing assistance | | Difference[a] | |
|---|---|---|---|---|---|---|
| Maternal supplementation (n = 5,386) | | | | | | |
| Neither (2,066) | 72.2 | (1,249) | 64.6 | (1,645) | 7.6 | *** |
| Iron during pregnancy (1,960) | 68.2 | (916) | 64.6 | (1,044) | 3.6 | * |
| Vitamin A within the first two months after delivery (388) | 75.8 | (141) | 66.8 | (247) | 9.1 | * |
| Both (972) | 65.4 | (396) | 56.3 | (576) | 9.2 | *** |
| Supplement for children (n = 3,573)[c] | | | | | | |
| Vitamin A in six months (3,573) | 66.6 | (1,708) | 61.3 | (1,865) | 5.3 | *** |

[a] * and *** indicate statistical significance at the 10% and 1% levels, respectively.
[b] Numbers in parentheses indicate the number of observations.
[c] Number of observations under supplementations is less than 5,438 because of missing answers to these questions.

**Table 9. Childhood anemia prevalence (%) by feeding practices**

| | Mean for children whose mothers lack access to nursing assistance[b] | | Mean for children whose mothers have access to nursing assistance | | Difference[a] | |
|---|---|---|---|---|---|---|
| Total (n = 3,258)[c] | | | | | | |
| Neither (1,989) | 76.2 | (1,008) | 71.3 | (981) | 4.9 | ** |
| Tubers (748) | 70.7 | (348) | 62.3 | (400) | 8.4 | ** |
| Meat (349) | 78.2 | (202) | 58.8 | (147) | 19.7 | *** |
| Both (172) | 69.1 | (81) | 60.4 | (91) | 8.7 | |

[a] ** and *** indicate statistical significance at the 5% and 1% levels, respectively.
[b] Numbers in parentheses indicate the number of observations.
[c] Number of observations is less than 5,438 because of missing answers to these questions.




**Fig. 3. Consumption of tubers and meat**
Territories shown in white indicate missing data.

including nutrition-sensitive agriculture, are key policy strategies for advancing national development goals.

Finally, it is important to acknowledge several limitations of the study. The data we employed here were collected in 2013-2014, though only recently available and are often used in related studies. Moreover, propensity score matching does not establish rigorous causal inference. As the DRC is among the data-poor countries in Africa, data from detailed field surveys or experiments is also needed.

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