**Title: Beyond Standalone Policies: Joint Effects of Nutrition-Specific and Nutrition-Sensitive Programs on Adolescent Health in Resource-Poor Settings**

**Authors**

Disha Bajaj
Sukumar Vellakkal

**Affiliations**

Disha Bajaj, PhD Scholar, Department of Economic Sciences, Indian Institute of Technology Kanpur, Kalyanpur, Uttar Pradesh, India 208016 E-mail: dishab21@iitk.ac.in

Sukumar Vellakkal, Associate Professor, Department of Economic Sciences, Indian Institute of Technology Kanpur, Kalyanpur, Uttar Pradesh, India 208016 E-mail: vellakkal@iitk.ac.in

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**Conflict of Interest:**

The author declares that there is no conflict of interest.

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We use the data from Understanding the Lives of Adolescents and Young Adults (UDAYA) that is publicly available at https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/ZJPKW5

**Beyond Standalone Policies: Joint Effects of Nutrition-Specific and Nutrition-Sensitive Programs on Adolescent Health in Resource-Poor Settings**

*Abstract*

Malnutrition continues to be a major health issue in low- and middle-income countries, highlighting the importance of understanding the individual and combined effects of large-scale public policy interventions, a dimension rarely examined in existing research. In Bihar, one of India's most socioeconomically disadvantaged states, we assess this concern by studying the joint effects of a nutrition-specific intervention—Iron and Folic Acid (IFA) Supplementation with Deworming—and a nutrition-sensitive intervention—the Child Marriage and Dowry Awareness Campaign—on adolescent anemia and Body Mass Index (BMI). Using longitudinal data and a difference-in-differences strategy on a statistically matched sample with individual fixed effects, we find that joint exposure increases hemoglobin levels by 0.44 g/dL and reduces the prevalence of moderate anemia by 12 percentage points, with significant gains among girls, and additionally lowers thinness among boys by 11 percentage points. In contrast, the standalone impact of either program yields no significant improvements. Semi-parametric difference-in-differences as a robustness check provides additional evidence consistent with these findings. The separate implementation of the two programs nonetheless generated behavioral spillovers, most notably greater parental engagement, that amplified their combined effects. These findings underscore the value of multisectoral and multifaceted approaches in improving adolescent health and nutritional outcomes in resource-poor settings.

Keywords: Anemia; BMI; Adolescent Health; Nutrition Interventions; Joint Effects

JEL codes: I150, I180, I120

## 1. Introduction

The burden of malnutrition in all forms, including undernutrition and diet-related non-communicable diseases, hinders social and economic progress, as it causes physical and cognitive impairment that affects a substantial proportion of the world's adolescents (Meenakshi, 2016). Anemia is one of the most widespread micronutrient deficiencies, affecting one in four individuals aged 10–24 globally (~430 million people) (Azzopardi et al., 2019). India has the highest prevalence of anemia in the world, about 72 million adolescents suffer from iron deficiency anemia (Scott et al., 2022), costing up to 4.5% of the annual GDP in developing nations, and 1.8% of India's GDP (NITI AYOG, 2019). Overweight and obesity, another dimension of malnutrition which is a major public health issue for high-income countries, are now emerging as significant health challenges across all age groups—including children and adolescents—in low- and middle-income countries (LMICs), including India. Current estimates show that obesity prevalence has seen a threefold increase worldwide over the past 47 years, since 1975. Overweight has risen to 20% in 2022 among the age group of 5-19 years (WHO, 2020). A recent nationwide nutrition survey reported that the prevalence of overweight and obesity among Indian adolescents exceeds 5% (CNNS, 2019). Regular consumption of high-calorie, low-nutrient foods and beverages due to unhealthy eating behaviors, formed early in the home environment, contributes to obesity (List & Samek, 2015).

In response, a range of interventions have been implemented globally and in India, broadly classified as nutrition-specific and nutrition-sensitive. Nutrition-specific interventions target the immediate causes of malnutrition, such as inadequate dietary intake and poor caregiving practices, through measures like micronutrient supplementation. In contrast, nutrition-sensitive interventions address underlying determinants of malnutrition, including poverty, gender inequality, and social norms, often through social policies, community engagement, and

behavior change communication (BCC). Although a growing body of research has evaluated the impacts of such interventions, most studies have examined them in isolation. Consequently, limited evidence exists on whether a combination of programs can enhance or diminish their overall impact.

In the context of LMICs, existing literature has explored the effects of iron and folic Acid (IFA) supplementation on nutrition, health, and educational outcomes (Gutema et al., 2023; Kanani & Poojara, 2000; Kedir et al., 2024) as well as the role of financial inclusion and gender-sensitive programs (e.g., dowry abolition, child marriage prevention) on labor participation, violence reduction, and intergenerational mobility (Parsons et al., 2015; Srivastava et al., 2024; You, 2013). However, studies examining the interaction effects of large-scale public policy interventions on health and nutritional outcomes remain scarce.

This study investigates the combined effects of a nutrition-specific intervention (Iron and Folic Acid (IFA) Supplementation with Deworming) and a nutrition-sensitive intervention (the Child Marriage and Dowry Awareness Campaign (BVEDMB)) on anemia and Body Mass Index (BMI) among adolescents in Bihar, India. Anemia is assessed using hemoglobin (Hb) levels, focusing on moderate anemia, while BMI is disaggregated into thinness and overweight. We use longitudinal data collected in 2015–16 and 2018–19 to track adolescents' transitions to adulthood. We define the treatment group as adolescents jointly exposed to both programs and construct mutually exclusive control groups comprising individuals exposed to only one or neither intervention. To address selection bias, we employ a propensity score matching difference-in-differences (PSM-DiD) model with fixed effects to estimate the average treatment effect on the treated (ATT).

Our findings reveal that simultaneous exposure to both programs led to measurable improvements in Hb levels by 0.44 g/dL and reduced the prevalence of moderate anemia by 12

percentage points, with the effects being more pronounced among adolescent girls. However, the analyses show no significant impact on BMI. Moreover, the standalone impact of both programs yielded no statistically significant improvements in anemia or BMI. Disaggregating BMI into overweight and thinness reveals opposing effects, with an increase in adolescent overweight but a marked reduction in thinness among boys by 11 percentage points. Parental engagement emerges as a key mediating factor, particularly through its influence on discussing physical changes such as menstruation among girls, thereby improving nutritional outcomes.

Bihar provides an appropriate setting for this analysis due to diverse socioeconomic challenges. As one of India's poorest states, where the per capita income is roughly a third of the national average, 65% of girls and 35 % of boys aged 15-19 years are anemic (NFHS, 2015-16). Despite child marriage and dowry being prohibited nearly a century ago, their prevalence persists even today, with 31.5 % of girls being married before the age of 18 and 9% women in the age group of 15-19 years have either become mothers or are pregnant (NFHS, 2015-16). Early marriage increases the likelihood of underweight, increased fertility and reduced modern family planning, reduced antenatal care, and less safe delivery, mental health disorder, suicide attempts (Efevbera et al., 2019), affecting the indicators of women's empowerment such as 47.8% women with no formal schooling (NFHS, 2015-16) and the lowest female labor force participation rate in the country at 9% (World Bank, 2016). Notably, the state is among the top five in India with the highest crime rates against women. As per National Crime Records Bureau data, 31% cases pertain to cruelty by husband and/or his relatives against women, and 8% are associated with dowry deaths. Dowry, another deeply rooted social norm, reinforces sex selective abortion, leading to a skewed sex ratio at birth (908; SRS 2016). It not only impacts women, but men also have a greater likelihood of acute illness and illness length (Stroope, 2015).

This paper makes three key contributions. First, it provides empirical evidence on the combined effects of two large-scale public health interventions, highlighting the potential of integrated, multisectoral strategies to reduce malnutrition in resource-constrained settings. Recognizing and leveraging complementarities between social programs can improve cost-efficiency and public service delivery (Pace et al., 2018). While much of the prior research has evaluated single interventions, previous studies such as (Attanasio et al., 2014; Banerjee et al., 2018; Banerjee et al., 2011; Bobonis et al., 2006; Cohen & Dupas, 2010; Thomas et al., 2006; Thomas et al., 2003) have examined the effects of IFA supplementation, the evidence remains mixed. Many of these evaluations highlight implementation challenges such as low adherence, limited coverage, and fragmented delivery, which often constrain program impact. Moreover, recent research has drawn attention to broader institutional and cultural factors—for instance, dietary restrictions driven by beef bans—that further reduce iron intake and help explain the persistent burden of anemia among Indian women and adolescents (Dasgupta et al., 2023). By evaluating the combined effects of two large-scale interventions implemented under typical programmatic conditions, our study contributes new evidence on how integrated, context-sensitive strategies may overcome these structural and behavioral barriers in practice.

Second, this study evaluates the real-world effectiveness of these programs using longitudinal data from Bihar, a large and socioeconomically disadvantaged Indian state. Employing PSM-DiD with fixed effects, we estimate the impacts under conditions that reflect routine program implementation. Prior evaluations of the Weekly Iron and Folic Acid Supplementation (WIFS) program have often relied on randomized controlled trials (RCTs), conducted in highly controlled, small-scale environments that limit generalizability. In contrast, our study assesses population-level interventions delivered under standard administrative settings—offering insights into scalability and effectiveness. These programs operate within a context of enabling and constraining factors across both demand and supply sides. For instance, (Berry et al., 2021)

demonstrate that intensive monitoring improves program delivery and reduces anemia, but sustaining such outcomes under routine conditions remains a challenge. By analyzing delivery within typical programmatic frameworks and accounting for contextual constraints, our study helps bridge the gap between efficacy and effectiveness evidence, offering externally valid insights into how large-scale public health interventions can be optimized in real-world settings. While many interventions to improve nutrition have been geared toward adults, there is a growing need to address nutritional decision-making among children and adolescents.

Third, major studies have focused on evaluating the impact of nutrition interventions on women (particularly pregnant or lactating mothers) or children under five years of age, while limited studies have examined adolescents' nutritional status. Adolescents in South Asia, including India, bear a disproportionately high burden of anemia compared with adults (Aguayo et al., 2013). Adolescence is a crucial life stage between childhood and adulthood, marked by behavioral and physiological changes, which constitute vital human capital, and investing in their health can help break the cycle of intergenerational poverty.

The rest of the paper is organized as follows: Section 2 describes the programmatic context. Section 3 presents the conceptual framework. Sections 4 and 5 outline the data and empirical strategy. Section 6 reports results. The final section, section 7, concludes with a discussion of key findings and policy implications.

## 2. Background

This section briefly describes two interventions to motivate empirical analysis: a nutrition-specific program addressing adolescent micronutrient deficiencies and a nutrition-sensitive program targeting harmful gender norms.

### Nutrition-Specific Intervention: Iron and Folic Acid (IFA) Supplementation with Deworming

The government initiatives for IFA distribution to vulnerable groups began in the 1970s, but the efforts are partially successful, as such slow progress is insufficient to make India anemia-free by 2030 (Jose et al., 2020). Launched in 2012 under the National Health Mission, IFA supplementation intervention—originally implemented through the WIFS program aims to disrupt the intergenerational cycle of anemia and enhance human capital development. In 2014, WIFS was integrated into the broader framework of the National Adolescent Health Program (Rashtriya Kishor Swasthya Karyakram, RKSK). The program was implemented nationally across rural and urban areas using a convergent approach that aligns with RKSK strategies, including Adolescent Friendly Health Clinics, Adolescent Health and Wellness Days, and Peer Education Initiatives. Delivered through these platforms, the IFA supplementation with Deworming promotes anemia reduction through a combination of IFA supplementation, deworming, nutrition education, parental engagement, social marketing, and community mobilization. The primary beneficiaries of the intervention are school-going and out-of-school adolescent girls and boys, where IFA was distributed in government, government-aided, and municipal schools or through health centers (anganwadi centers) on every Monday and are administered under the supervision of teachers to ensure they are not taken on an empty stomach.

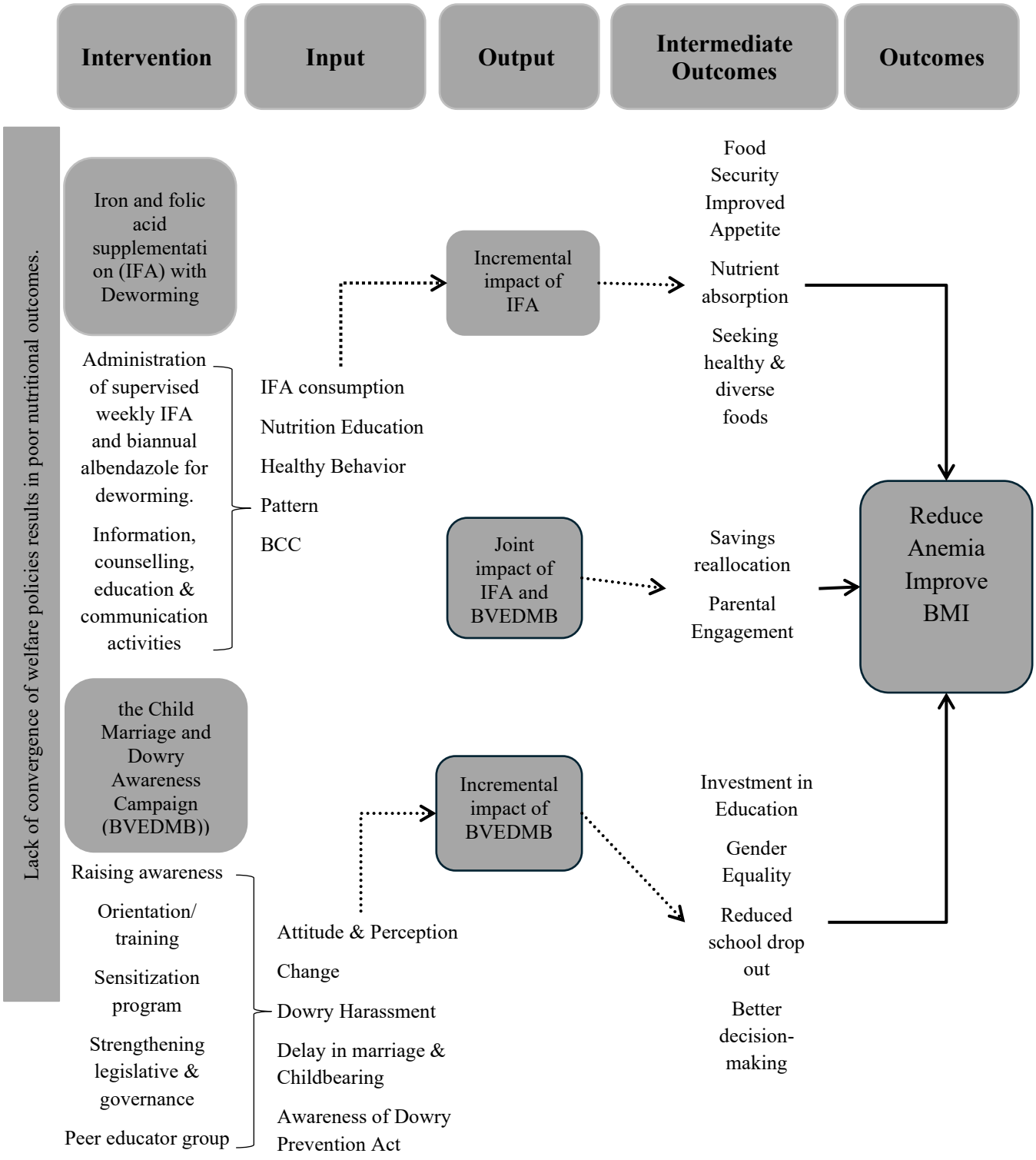
**Nutrition-Sensitive Intervention: The Child Marriage and Dowry Awareness Campaign (Baal Vivah Evam Dahej Mukt Bihar Campaign, BVEDMB)**

Although the government enacted legislation in the mid-20th century to prohibit child marriage and dowry, the incidence of early marriage, though reduced, remains considerably high, highlighting the necessity of interventions at the district and block levels. BVEDMB is a state-led social and behavioral change initiative to change social norms and eliminate child marriage and dowry practices. The campaign's first phase employed a multi-pronged dual strategy to

transform community perceptions and practices, combining mobile vans to disseminate awareness messages across high-burden districts with community-based street plays to promote behavioral change. Sensitization programs were organized during religious gatherings, utilizing community trust and cultural relevance to encourage change in marginalized groups. Activities in phase two include forming adolescent groups and meetings in high-burden districts with focused community mobilization interventions. The primary objectives are to reduce intimate partner violence, enhance girls' educational attainment, increase their labor force participation, and promote the value of the girl child as an asset by tackling harmful social norms.

## 3. Conceptual Framework

Figure 1. Conceptual Framework




Notes: This figure demonstrates the various pathways through which combined effects of nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions improve the micronutrient and anthropometric outcomes.

Building on insights from the existing literature and the defining features of the programs, we constructed a conceptual framework to articulate the interlinkages between the two programs. Even though both programs operate independently, one focuses on the health aspect while the other addresses non-health factors; still, they can work in tandem, thereby aiding the improvement of nutritional status.

Nutrition-specific intervention (IFA) includes distribution and supervision of weekly supplementation of 100 mg elemental iron and 500 µg folic acid using a fixed-day schedule, conducts screening of target groups for moderate to severe anemia with referrals to health facilities as needed, and delivers biannual 400 mg Albendazole deworming tablets, complemented by counseling to improve dietary intake and prevent intestinal worm infestations through to school–going and out–of–school adolescent girls and boys.

All these incentives are expected to result in increased uptake of IFA supplements, thereby improving the appetite and increasing food intake, resulting in promoting growth and cognitive development that positively influence academic performance (Horjus et al., 2005; Kanani & Poojara, 2000; Kedir et al., 2024). Awareness regarding iron–rich foods among adolescents has increased. Recent studies suggested that IFA supplementation improved intelligence test scores irrespective of anemia status in children and adolescents (Chen et al., 2022). Prior research underscores that targeted motivational strategies, including repeated counseling on the benefits and side-effect management of IFA, can substantially enhance compliance in large–scale programs, even in settings with limited supervision (Ghanekar et al., 2002; Vir et al., 2008). Empirical evidence from the past study demonstrates that nutrition education provided through video and printed materials substantially enhanced pregnant women's knowledge, attitudes, and practices, increased adherence to IFA supplementation, and improved Hb levels (Gavaravarapu et al., 2017; Ramachandran et al., 2023).

Results of prior studies indicate that parental behavioral change, facilitated by intervention, is essential for sustaining the benefits of IFA supplementation. Consistent with these findings, prior evidence highlights parental involvement as key to improving children's dietary habits (Haldar et al., 2011; Jha & Singh, 2023; Rathi et al., 2020). Improved nutritional status enhances nutrient absorption and utilization, allowing individuals to maximize returns from limited food resources and strengthening food security.

The other program, a nutrition-sensitive intervention (BVEDMB), aims to end the practice of dowry and child marriage. The campaign employs a multi-platform media strategy, including television, radio, and print outlets, to disseminate awareness messages using jingles, banners, and posters in Hindi, English, and regional languages. Additional outreach tools include mobile awareness vans deployed in rural areas, SMS alerts, brochures, handouts, and pamphlets distributed across all 38 districts of Bihar. One of the essential elements of the campaign is promoting collaboration between government departments, civil society organizations, community leaders, and the media.

The findings from the report reveal that most respondents, particularly unmarried males, expressed willingness to convince their parents against dowry demands (Centre for Catalyzing Change, 2020). A broad mass media campaign can bring structural changes in social attitudes toward girls' education, with measurable effects on delaying marriage age. Media sensitization through people's exposure to television, radio, advertisements, and community–based reproductive health initiatives was positively associated with higher school retention rates due to delay in early marriage. The peer educators group also motivated young people to make healthy choices for youth engagement activities, to develop new skills, and to build their social networks, enabling freedom of expression and movement (Mehra et al., 2018). The studies have shown that early marriage among adolescent girls reinforces gender inequality through

dowry demands, sexual harassment, and a lack of decision-making for work, highlighting the need for child marriage and dowry–awareness programs to delay marriage and reduce intimate partner violence (Pallikadavath & Bradley, 2019; Srivastava et al., 2024).

Integrating nutrition-specific intervention with nutrition-sensitive intervention offers a holistic approach to improving adolescent well-being. While the supplementation program directly addresses nutritional deficiencies, the awareness campaign indirectly focuses on health outcomes. Delaying marriage and increasing permanent savings through awareness campaigns allows parents to allocate resources towards their children's higher education and enables them to ensure adequate nutrition during adolescence, thereby reducing the burden of nutritional deficiencies. Health programs build physical well-being, while awareness programs enhance their knowledge of rights, increasing their human capital of the nation, focusing on health and education indicators.

## 4. Data

We use data from the first comprehensive longitudinal survey on adolescents in India, *Understanding the Lives of Adolescents and Young Adults (UDAYA)*, which tracks adolescents' transition to adulthood. The survey was conducted in two waves, in 2015–16 and 2018–19, with a total sample of 20,594 adolescents who were interviewed in wave I, and 16,292 adolescents (4,428 boys and 11,864 girls) were reinterviewed in wave II across two of India's poorest states. These include Uttar Pradesh, the most populous state with 24.4 million adolescents (10 % of the national total), and Bihar, the third most populous, with 22.5 million adolescents (Paul et al., 2023). The Population Council, New Delhi, implemented the UDAYA survey.

The UDAYA dataset offers several advantages for our analysis. As a longitudinal survey, it enables us to track the same individuals and households over a three-year interval. It includes

detailed information on adolescents' exposure to nutrition-specific and nutrition-sensitive interventions, which are crucial for examining potential joint effects. The dataset also contains rich modules on adolescent health behaviors, substance use, exposure to violence, connectedness, sexual and reproductive health awareness, parental interactions, media exposure, communication, mobility, decision-making, gender attitudes, and self-efficacy. Importantly, it includes biomarker data such as Hb levels, weight, and height, typically scarce in low-resource settings for vulnerable groups like adolescents in India. The first round surveyed unmarried adolescents aged 10–19 and married girls aged 15–19, who were reinterviewed in the second wave. A multistage, stratified, systematic sampling design was used to select 150 primary sampling units (PSUs) from both rural and urban areas in Bihar and Uttar Pradesh, with stratification based on region, village/ward size, the proportion of Scheduled Castes and Scheduled Tribes, and female literacy rates.

For this study, we restrict our sample to adolescents from Bihar who participated in one or both programs under analysis, or none. We exclude individuals missing from the second wave due to migration, refusal, or non-traceability. We also exclude adolescents who reported tobacco, substance, or cigarette use, as well as those who were pregnant, given the effects of these conditions on Hb measurements. Further, we remove observations with missing values and extreme outliers in Hb levels (Hb <4 g/dL or Hb >18 g/dL).

To examine program joint impact, we classify the sample into four mutually exclusive groups: (1) those exposed to both the nutrition-specific (IFA) and nutrition-sensitive interventions (BVEDMB); (2) those exposed to only one of the two programs; (3) those exposed to neither program. We combine groups (2) and (3) into a single comparison group to estimate the net effect of joint program exposure. Because program participation may be influenced by self-

selection and other targeting mechanisms, we retain non-participants in the comparison group to account for potential biases related to exclusion, elite capture, or mis-targeting.

Our analysis estimates the average treatment effect on the treated (ATT) by comparing changes in nutritional outcomes between the treatment group (joint program participants) and the pooled comparison group over the two survey waves.

### 4.1 Nutritional Status

We focus on the following nutrition-related outcomes: (1) Hb levels, (2) moderate anemia, (3) BMI z-scores, (4) overweight, and (5) thinness. Anemia is defined as a Hb level below 12 g/dL for adolescents aged 12–14 and for females aged 15 or older, while moderate anemia is when the Hb level falls in the range of 8.0-10.9 gm/dL. Following WHO guidelines, individuals are classified as anemic if their Hb levels are more than two standard deviations below the mean for healthy peers of the same age, sex, and geographic region. Hb, the oxygen-carrying protein in red blood cells, is a critical biomarker affected by iron intake. Inadequate iron consumption leads to decreased Hb production. In contrast, BMI is a measure of weight relative to height, providing an indicator of undernutrition or excess weight. Standard BMI classifications are as follows: underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), overweight (25.0–29.9 kg/m²), and obesity (≥30 kg/m²). Undernutrition and iron deficiency among adolescents remain significant public health challenges in India; recent estimates indicate that 22% of Indian women experience undernutrition, while 53% suffer from anemia.

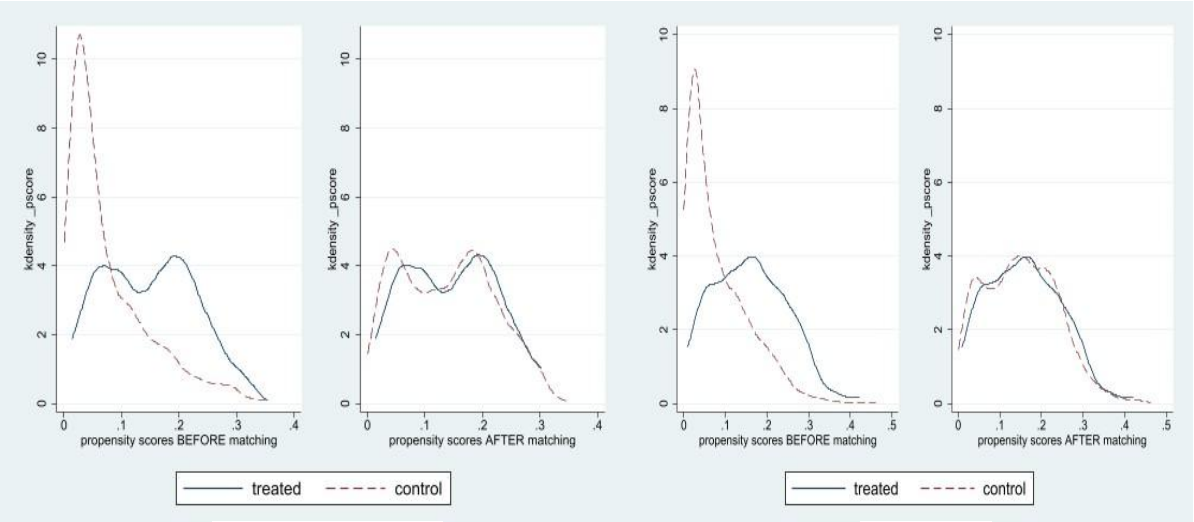
### 4.2 Identification strategy

This study examines whether participating in both nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions improves adolescent health outcomes, particularly anemia and BMI, compared to participating in only one of the programs or not participating in any of the programs. Potentially, two key identification challenges arise. First, program participation

is voluntary and non-random; adolescents enrolling in both the programs can be characteristically different from those not enrolling, thereby giving rise to concerns related to selection bias. For example, adolescents participating in neither of the interventions can self-select out as they are more likely to come from relatively advantaged households (Appendix Table A1). Second, unobserved, time-invariant factors—such as household attitudes or values—may simultaneously influence program participation and health outcomes, leading to potential omitted variable bias.

We address these challenges through a two-step procedure. In the first step, we estimate propensity scores (PS) using kernel density through a probit model applied to both rounds of the panel. The PS are derived from covariates: household wealth, adolescent and maternal education, household size, access to clean water, sanitation, cooking fuel, media exposure, sector (urban/rural), adolescent age, and the provision of health facilities. PS captures the heterogeneity in adolescents' incentives to participate in the program, arising not only between adolescents but also within adolescents over time. We use PS to match beneficiary (joint participation) and non-beneficiary adolescents (either in one program or none), enhancing comparability between the two groups. The PSM method further excludes adolescents who lack comparable counterparts, ensuring a balanced sample for analysis. Employing a matched panel across all estimations enhances the robust estimates. Figure 2 depicts the PS based on the kernel density function for Hb levels while Figure A1 illustrates the same for other outcome variables.

Figure 2. Common Support of PS for Hb Levels Before and After PSM




Panel A Panel B

Notes: This figure illustrates the kernel density plots of PS before and after matching the treatment group, i.e., participation in both the nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions, and the control group, participation in only one intervention or none. Panel A corresponds to Wave 1 (2015–16) and panel B corresponds to Wave 2 (2018–19), for Hb levels.

In the second step, we apply DiD with a fixed-effects model on the matched sample to control for unobservable individual-specific factors that are assumed to remain constant over time. By restricting the analysis to matched individuals, the DiD model exploits within-person variation across waves and controls for unobserved, time-invariant heterogeneity at the individual, household, and community levels.

Our main estimating equation is:

$$Y_{i,t} = \lambda_i + \alpha Post_t + \beta_1 IFA_{i,t} + \beta_2 (Post_t \times IFA_{i,t}) + \gamma_1 BVEDMB_{i,t} + \gamma_2 (Post_t \times BVEDMB_{i,t}) + \gamma_3 \left(IFA_{i,t} \times BVEDMB_{i,t}\right) + \delta \left(Post_t \times IFA_{i,t} BVEDMB_{i,t}\right) + \rho_1 X_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where $Y_{i,t}$ denotes the nutrition outcome of interest for adolescent $i$ residing in year t. $Post_t$ is a dummy variable that takes the value 1 for 2018 and 0 otherwise, $\lambda_i$ captures individual fixed

effects, IFA and BVEDMB are indicator variables, respectively, for exclusive assignment to either IFA or BVEDMB. IFA & BVEDMB are indicator variables for assignment to both IFA & BVEDMB. $X_{i,t}$ is a vector of time-varying covariates. The error term $\varepsilon_{i,t}$ is clustered at the household level to account for intra-household correlation. The parameters of interest are the coefficients, $\beta_2$, $\gamma_2$, and $\delta$, which are, respectively, the treatment effect estimates of IFA for adolescents treated only by IFA, the effect of BVEDMB for adolescents treated only by BVEDMB, and the estimate of the joint impact of IFA and BVEDMB for adolescents treated by both programs. IFA takes the value one if an adolescent is treated exclusively under IFA, zero otherwise. BVEDMB takes the value one if the adolescent is treated exclusively under BVEDMB; otherwise, it takes zero. IFA&BVEDMB takes the value one if the adolescent is treated under both IFA and BVEDMB, zero otherwise (that is, neither of the programs is received, or the adolescent only benefits from one of the programs). This variable does not represent an interaction between IFA and BVEDMB. It means an entirely different group of adolescents. For this reason, the stand-alone impacts of IFA and BVEDMB are, respectively, simply β2 and γ2, and the joint effect of IFA and BVEDMB is δ.

## 5. Results

### 5.1 Descriptive statistics

Table 1 presents descriptive statistics from UDAYA Wave I (2015–16, baseline) and Wave II (2018–19, endline), disaggregated by treatment status. The treatment group includes individuals exposed to both the nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions, while the control group comprises those who participated in either one of the programs or in none.

At baseline, 31% of the treatment group belonged to the poorest consumption quintile, compared to 24% in the control group. Access to non–conventional energy sources (e.g.,

electricity, biogas, LPG) increased in both groups, while improvements in toilet facilities were more pronounced among the treatment group over time. Interestingly, higher educational attainment was more common among the control group at the endline. Additionally, about 72% of mothers in both groups had no formal education. A large proportion of adolescents, approximately 84% in both groups, did not receive health services from anganwadi workers (AWWs).

Table 1. Descriptive Statistics of the Study Sample at Baseline (2015–16) and Endline (2018–19)

| | **Baseline Period (2015–2016)** | | | **Endline Period (2018-2019)** | | |
|---|---|---|---|---|---|---|
| | Control Group | Treatment Group | P-value of mean difference | Control Group | Treatment Group | P-value of mean difference |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| **Panel A: Socioeconomic Characteristics** | | | | | | |
| Gender (Male) | 0.22 | 0.39 | 0.18*** | 0.22 | 0.39 | 0.18*** |
| | (0.41) | (0.49) | (0.03) | (0.41) | (0.49) | (0.03) |
| Adolescent's Age (in years) | 16.09 | 13.92 | -2.17*** | 18.88 | 16.68 | -2.19*** |
| | (2.33) | (2.91) | (0.15) | (2.35) | (2.92) | (0.15) |
| ***Adolescent's Education*** | | | | | | |
| No Education | 0.08 | 0.03 | -0.06*** | 0.08 | 0.03 | -0.06*** |
| | (0.27) | (0.16) | (0.02) | (0.28) | (0.16) | (0.02) |
| Primary | 0.27 | 0.57 | 0.30*** | 0.15 | 0.28 | 0.12*** |
| | (0.44) | (0.50) | (0.02) | (0.36) | (0.45) | (0.02) |
| Secondary | 0.53 | 0.34 | -0.19*** | 0.46 | 0.51 | 0.06* |
| | (0.47) | (0.47) | (0.03) | (0.50) | (0.50) | (0.03) |
| Higher | 0.12 | 0.07 | -0.53*** | 0.30 | 0.18 | -0.12*** |
| | (0.32) | (0.25) | (0.02) | (0.46) | (0.39) | (0.03) |
| Household Size | 6.06 | 6.22 | 0.16 | 6.06 | 6.22 | 0.16 |
| | (2.66) | (2.77) | (0.17) | (2.66) | (2.77) | (0.17) |
| ***Mother's Education*** | | | | | | |
| No Education | 0.67 | 0.70 | 0.02 | 0.67 | 0.70 | 0.02 |
| | (0.47) | (0.46) | (0.03) | (0.47) | (0.46) | (0.03) |
| Primary | 0.11 | 0.09 | -0.02 | 0.11 | 0.09 | -0.02 |
| | (0.31) | (0.29) | (0.02) | (0.31) | (0.29) | (0.02) |
| Secondary | 0.08 | 0.08 | 0.00 | 0.08 | 0.08 | 0.00 |
| | (0.27) | (0.27) | (0.02) | (0.27) | (0.27) | (0.02) |
| Higher | 0.14 | 0.13 | -0.01 | 0.14 | 0.13 | -0.01 |
| | (0.34) | (0.34) | (0.02) | (0.34) | (0.34) | (0.02) |
| Sector (urban) | 0.44 | 0.32 | -0.12*** | 0.44 | 0.32 | -0.12*** |
| | (0.50) | (0.47) | (0.03) | (0.5) | (0.47) | (0.03) |
| Cooking Fuel (Non-Conventional Sources) | 0.31 | 0.17 | -0.14*** | 0.47 | 0.39 | -0.07** |
| | (0.46) | (0.38) | (0.03) | (0.5) | (0.49) | (0.03) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Drinking Water (Improved Sources) | 0.99 (0.09) | 0.98 (0.13) | -0.01** (0.01) | 0.97 (0.16) | 0.98 (0.15) | 0.00 (0.01) |
| ***Toilet Facility*** | | | | | | |
| Unimproved Facility | 0.58 (0.49) | 0.72 (0.44) | 0.14*** (0.03) | 0.34 (0.48) | 0.38 (0.49) | 0.04 (0.03) |
| Improved Facility | 0.34 (0.47) | 0.22 (0.41) | -0.12*** (0.03) | 0.56 (0.50) | 0.54 (0.50) | -0.01 (0.03) |
| Shared Facility | 0.08 (0.28) | 0.06 (0.24) | -0.02 (0.02) | 0.09 (0.29) | 0.08 (0.26) | -0.02 (0.01) |
| Economic Status (Poor) | 0.09 (0.29) | 0.11 (0.31) | 0.01 (0.02) | 0.05 (0.22) | 0.05 (0.22) | 0.0 (0.01) |
| AWW (Received) | 0.14 (0.35) | 0.15 (0.36) | 0.01 (0.02) | 0.22 (0.42) | 0.25 (0.43) | 0.02 (0.03) |
| ***Wealth Quintile*** | | | | | | |
| Poorest | 0.24 (0.43) | 0.31 (0.46) | 0.07** (0.02) | 0.23 (0.42) | 0.24 (0.42) | 0.0 (0.02) |
| Poorer | 0.19 (0.4) | 0.21 (0.41) | 0.01 (0.02) | 0.19 (0.4) | 0.22 (0.41) | 0.02 (0.02) |
| Middle | 0.21 (0.41) | 0.22 (0.42) | 0.0 (0.02) | 0.25 (0.43) | 0.3 (0.46) | 0.07** (0.02) |
| Richer | 0.18 (0.38) | 0.17 (0.37) | -0.01 (0.02) | 0.18 (0.38) | 0.13 (0.33) | -0.06** (0.02) |
| Richest | 0.16 (0.37) | 0.08 (0.28) | -0.07*** (0.02) | 0.15 (0.36) | 0.12 (0.33) | -0.04* (0.02) |
| **Panel B: Outcome Variables** | | | | | | |
| Anemia (Anemic) | 0.49 (0.5) | 0.42 (0.49) | -0.07* (0.04) | 0.56 (0.5) | 0.48 (0.5) | -0.08** (0.04) |
| Anemia (Moderate Anemic) | 0.16 (0.36) | 0.14 (0.34) | -0.02 (0.03) | 0.25 (0.43) | 0.14 (0.35) | -0.10** (0.04) |
| Hb Level (g/dL) | 11.92 (1.71) | 11.94 (1.47) | 0.01 (0.13) | 11.89 (1.94) | 12.32 (1.76) | 0.43*** (0.15) |
| BMI | 18.02 (2.89) | 16.29 (2.28) | -1.72*** (0.20) | 19.23 (2.88) | 18.07 (2.47) | -1.16*** (0.21) |
| BMI Thinness | 0.16 (0.37) | 0.22 (0.42) | 0.06** (0.03) | 0.17 (0.38) | 0.17 (0.37) | 0.0 (0.03) |
| BMI Overweight | 0.02 (0.16) | 0.01 (0.13) | -0.01 (0.01) | 0.03 (0.17) | 0.03 (0.18) | 0.0 (0.01) |

Notes: This table presents sample means with standard deviations in parentheses. All statistics are based on data from the UDAYA Wave I (2015–16) and Wave II (2018–19) surveys, restricted to adolescents in Bihar. The treatment group includes individuals exposed to both the nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions, while the control group comprises those exposed to either one or neither program. Mean differences between groups are tested using two-sided t-tests. Wealth quintile is constructed through principal component analysis (PCA). AWW represents health facilities received from anganwadi workers. Outcome variables follow WHO classifications: anemia is defined as Hb levels <12 g/dL for adolescents aged 12–14 and nonpregnant females aged 15+, moderate anemia is when Hb levels was 8.0-10.9 gm/dL, and nutritional status categories follow BMI cutoffs—underweight/thinness (<18.5 kg/m²), normal (18.5–24.9kg/$m^2$), overweight (25–29.9 kg/$m^2$), and obese (≥30kg/$m^2$).

Descriptive statistics also reveal meaningful differences in outcome indicators. At baseline, the average Hb level was similar across groups (~11.95 g/dL), but by endline, levels improved significantly in the treatment group (12.32 g/dL) while remaining unchanged in the control group. Anemia prevalence rose over time in both groups, though less so among those in both

programs. Moderate anemia increased significantly among the control group. Thinness, as measured by BMI, declined in the treatment group, while overweight status increased statistically. These trends suggest differential changes in nutritional status across groups. Table 1 also reports baseline and endline values for other key variables, including socioeconomic characteristics, sanitation, energy access, and parental education. Group differences are statistically tested using mean comparisons, with standard deviations in parentheses. The Appendix (Table A1) provides a comparative summary of observable characteristics across groups using multinomial logit estimates to quantify the probability of being in each of the four groups. Individuals in the highest consumption quintile are 4 percentage points less likely to enroll in the IFA. With regard to socioeconomic status, individuals residing in urban areas are 8 percentage points more likely not to enroll in any program, 7 percentage points less likely to participate in IFA, and 1 percentage point less likely to participate in both programs. Individuals with any level of education are more likely to participate in both programs and less likely to participate in no program.

**5.2 Main Results**

This section presents the primary findings on the effects of combined exposure to the nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions. We first estimate the joint and individual impact of the programs on key nutrition outcomes using PSM–DiD with fixed effects.

Table 2 presents the effects of dual participation on Hb levels, moderate anemia, and BMI indicators, estimated using equation (1) through PSM- DiD with fixed effects model. Columns (1) and (2) show that joint participation increases Hb level by 0.44 g/dL and reduces the probability of moderate anemia by 12 percentage points. In contrast, individual program participation has not yielded a statistically significant effect on Hb level and moderate anemia.

Columns (3) and (4) show the results for overweight and thinness, estimating the same iterations of equation (1) that are like those in columns (1) and (2). The results suggest that joint program participation raises the likelihood of being overweight by 4 percentage points whereas no significant effect is observed on thinness among adolescents. Individual participation in either IFA or BVEDMB increases the likelihood of being overweight but has no significant impact on thinness among adolescents.

Column (1–4) estimates for the full sample. Additional robustness checks (see Appendix Table A11 and Table A12) exclude married adolescent girls and restrict the sample to individuals aged 10–19.

Table 2. Effects of Combined Exposure to Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions on Micronutrient and Anthropometric Outcomes using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | Moderate anemia | Overweight | Thinness |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| IFA*BVEDMB*Post | 0.445** | -0.120*** | 0.040** | -0.061 |
| | (0.158) | (0.042) | (0.020) | (0.039) |
| IFA*Post | 0.154 | -0.045 | 0.027** | -0.051 |
| | (0.111) | (0.033) | (0.013) | (0.031) |
| BVEDMB*Post | -0.046 | -0.048 | 0.038** | -0.026 |
| | (0.126) | (0.040) | (0.019) | (0.031) |
| Post | 0.626** | -0.056 | -0.029 | -0.003 |
| | (0.269) | (0.075) | (0.038) | (0.078) |
| Time-varying controls | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 3,340 | 1,987 | 2647 | 2647 |
| R-square | 0.041 | 0.049 | 0.024 | 0.026 |

Notes: This table reports the estimates of the full sample from equation (1), evaluating the joint effects of nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions on Hb levels, moderate anemia, overweight, and thinness, using PSM-DiD with fixed effects model. The analysis draws on two waves of the UDAYA survey (2015–16 and 2018–19) from Bihar, India. The treatment group includes adolescents exposed to both interventions, while the control group includes those exposed to either one or neither. The variable *Post* equals 1

for observations from wave II (2018-19). Dependent variables are shown in columns: Hb level (1), moderate anemia (2), and anthropometric outcomes—overweight and thinness (3 and 4 respectively). Time-varying controls include individual and household characteristics including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, age of the adolescent, health facility received through anganwadi workers (AWW). Individual and time fixed effects are included. Standard errors clustered at the household level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

The findings support the hypothesis of joint participation: the interaction terms for Hb level and moderate anemia are statistically significant and substantively large, indicating that the joint effect of the two programs exceeds the individual effects of each intervention alone. These results suggest that nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) function as complementary policy instruments for enhancing Hb level and reducing the prevalence of moderate anemia among adolescents for improving adolescent nutrition outcomes, particularly in reducing anemia.

### 5.3 Identifying Mechanism

Our conceptual framework hypothesizes that BCC is essential in reducing nutritional deficiencies. We empirically test BCC in the form of parental engagement observed after integrating two interventions. We measure parental engagement by assessing whether adolescent girls discuss physical changes, such as the onset of menstruation, with their parents, particularly mothers, who are typically primary caregivers. Table 3 shows positive and statistically significant results, interpreting that after participation in both programs, there is an increase in the discussion among adolescents and their mothers.

Table 3. Potential mechanism explaining the joint impact of Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) interventions using PSM-DiD with Fixed Effects Model

| | Parental Engagement |
|---|---|
| | (1) |
| IFA*BVEDMB*Post | 0.167*** |

| | |
|---|---|
| | (0.045) |
| IFA*Post | -0.003 |
| | (0.029) |
| BVEDMB*Post | 0.067** |
| | (0.031) |
| Post | -0.024 |
| | (0.076) |
| Time-varying controls | Yes |
| Individual Fixed Effects | Yes |
| Observations | 5,864 |
| R-square | 0.065 |

Notes: This table reports the results from equation (1), estimating joint effects the joint effects of nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions on parental engagement as the potential mechanism variable that improves the micronutrient and anthropometric outcomes using PSM-DiD with fixed effects model. The sample is taken from the recent two waves of UDAYA (2015-16 and 2018-19) for Bihar, state of India. The treatment group includes adolescents exposed to both interventions, while the control group includes those exposed to either one or neither. The variable *Post* equals 1 for observations from wave II (2018-19). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, age of the adolescent, health facility received through anganwadi workers (AWW). Individual fixed effects and time fixed effects are included. Standard errors are in parentheses, clustered at the household level. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

### 5.4 Heterogeneity analysis

To deepen our understanding of distributional impacts, we conducted subgroup analyses using pre-intervention levels of household wealth, maternal education, urban/rural residence, and girls & boys.

First, we disaggregate households into two groups: the bottom three and top two wealth quintiles. Table A3 shows that the Hb levels gains and improvement in moderate anemia are primarily driven by adolescents in the bottom three quintiles; however, overweight remains largely unaffected in poorer households and in the top two quintiles. Thinness has been

significantly reduced for the top two wealth quintiles. These results suggest that while both programs target the general population, the nutritional gains are more pronounced for poorer individuals.

Second, we examine heterogeneity by location. Table A4 shows that the positive effects of joint program participation on Hb level and moderate anemia are primarily driven by adolescents residing in rural areas, suggesting that as dowry and child marriage are predominantly rural issues, where enforcement by police and administration is often weaker, the stronger effects of joint participation observed in rural areas provide evidence of the program's positive impact in these contexts. Adolescents in urban regions exhibit a higher probability of being overweight, potentially reflecting increased calorie consumption, easy access to energy-dense foods, and reduced physical activity.

Third, we assess heterogeneity by maternal education (some education vs. none). Table A5 shows that both groups benefit, but the improvements in Hb level and reductions in moderate anemia are larger among adolescents with uneducated mothers. There is an increase in the likelihood of being overweight among adolescents whose mothers are not educated.

Fourth, we assess the heterogeneity based on gender (girls vs boys). Table A6 shows improvement in Hb levels and moderate anemia was more pronounced among girls, whereas thinness has been majorly reduced among boys aged 10-19 years.

**6. Robustness Checks**

We conduct a series of robust checks to ensure that peculiarities in the control group do not drive our findings. First, we refine treatment classification into three categories: (i) nutrition-specific intervention (only IFA), (ii) nutrition-sensitive intervention (only BVEDMB), and (iii) both interventions. Each is compared to a control group with no intervention using PSM-DiD with individual fixed effects. Table A7 shows that only joint participation significantly

increases Hb level by 0.45 g/dL, while standalone programs do not. Similarly, joint participation reduces moderate anemia by 8 percentage points. Individual programs alone have no significant effect on these outcomes. In contrast, the individual participation in any one intervention or joint intervention increases the likelihood of being overweight among adolescents, whereas there is no significant improvement in thinness.

Secondly, we use a semi-parametric difference-in-differences (SDiD) estimator that reweighs the comparison group to match the pre-treatment trends of the treated group. This approach uses inverse-propensity-score weighting based on pre-intervention characteristics—such as household wealth, economic status, adolescent and maternal education, household size, access to clean water, sanitation, cooking fuel, media exposure, AWW (health facilities received from anganwadi workers), and urban/rural status—to construct a counterfactual group that closely resembles the treated population.

Table 4. Effects of Combined Exposure to Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions on Hb level and BMI using SDiD

| | Log (Hb level (g/dL)) | | BAZ | |
|---|---|---|---|---|
| | LPM | SLE | LPM | SLE |
| | (1) | (2) | (3) | (4) |
| IFA*BVEDMB | 0.026** | 0.027** | 0.055 | 0.048 |
| | (0.012) | (0.013) | (0.085) | (0.091) |
| Observations | 1716 | 1716 | 1096 | 1096 |

Notes: This table reports the estimated joint effects of the nutrition-specific intervention (IFA) and the nutrition-sensitive (BVEDMB) interventions on Hb levels (log-transformed) and BMI z-scores (BAZ), using semi-parametric difference-in-differences (SDiD). The sample includes adolescents from Bihar, drawn from two waves of the UDAYA survey (2015–16 and 2018–19). The treatment group comprises individuals who participated in both programs, while the control group included those who participated in either one or neither. Columns (1) and (3) use propensity scores estimated via a linear probability model (LPM); Columns (2) and (4) use the series logit estimator (SLE). BAZ (Body mass index z-scores) are constructed using WHO reference standards. Bootstrapped standard errors are clustered at the household level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Column (1) of Table 3 shows that joint participation in nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions lead to a 2.6 percentage point increase in Hb levels (log-

transformed) relative to participation in one or neither program, using propensity scores estimated through a linear probability model (LPM). Column (2) replicates this result using series logit estimation (SLE), yielding similar effects. Columns (3) and (4) estimate the same models with BMI z-scores (BAZ) as the outcome. However, the results show no statistically significant effect on BMI. The LPM approach excludes extreme scores (<0 or >1), reducing sample size, whereas the SLE includes the whole sample using a logistic function.

The SDiD framework enables us to explore how treatment effects vary across baseline characteristics, using covariates as effect modifiers in ATT estimation (Abadie, 2005; Houngbedji, 2016). Specifically, we examine heterogeneity by household wealth, maternal education, respondent education, fuel type, sanitation, household size, water source, social group, adolescent age, and sector (urban/rural).

Table A2 shows that maternal education significantly enhances the effect of treatment on Hb levels. Adolescents whose mothers have higher levels of education experienced larger gains. Similarly, the treatment effects were more substantial for those with access to improved water or sanitation facilities and adolescents with higher education. The results also show that those who were poorer had improved Hb levels, suggesting the programs disproportionately benefit adolescents from socioeconomically disadvantaged households.

Second, we restrict the analysis to Uttar Pradesh—a demographically comparable state where only IFA was implemented. No statistically significant impacts are found on nutritional outcomes as per Table A8, indicating that the joint program implementation drives the effects observed in Bihar.

These checks reinforce the validity of our main results and confirm that the observed improvements in adolescent nutrition outcomes are attributable to the joint effects of the two complementary programs.

## 7. Discussion and Conclusion

Anemia, a condition marked by a reduced count of healthy red blood cells, affects nearly one-third of the global population. For adolescents aged 10 to 19, a critical phase of physiological and behavioral development defined by the WHO, anemia poses risks to neurocognitive development and infection susceptibility. In cases of adolescent pregnancy, it may also lead to adverse maternal and neonatal outcomes.

In many LMICs, public health programs operate in isolation. However, addressing anemia effectively requires integrating nutrition-specific and nutrition-sensitive approaches. Such synergies can enhance cost–efficiency, expand coverage, and generate long-term societal benefits, aligning with the Sustainable Development Goals. Coordinated program implementation can also reduce inter–policy conflicts and improve overall efficacy (Pang et al., 2020).

Using longitudinal data from the UDAYA survey in Bihar, this study provides the first empirical evidence on the combined effects of a nutrition-specific intervention (IFA) and a nutrition-sensitive intervention (BVEDMB). Although these interventions were not formally integrated, our findings suggest meaningful complementarities. Adolescents exposed to both interventions experienced a 0.44g/dL increase in Hb levels and improvements in overall nutritional status. The results also indicate that BCC plays an important role, although other program components may benefit from strengthening.

The findings, consistent across several estimation strategies, demonstrate that the combined effect of nutrition-specific and nutrition-sensitive programs exceed their individual impacts. These effects are especially pronounced among girls aged 10 to 19, indicating broad relevance across vulnerable subgroups.

In conclusion, integrated approaches that address nutritional deficiencies and gender-based social constraints can substantially improve adolescent health more than fragmented interventions. For India and similar contexts, aligning nutrition-sensitive and social protection programs presents a promising strategy to advance multiple goals related to adolescent well–being, health, and gender equity.

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## Appendix

Table A1. Probability of Participating in Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions using Multinomial Logit Marginal Effects Estimates

| | No Program | Only IFA | Only BVEDMB | Both |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| ***Wealth Quintile (Base: Poorest)*** | | | | |
| Poorer | -0.011 | -0.005 | 0.018 | -0.002 |
| | (0.017) | (0.013) | (0.012) | (0.007) |
| Middle | -0.026 | 0.000 | 0.019 | 0.007 |
| | (0.018) | (0.015) | (0.013) | (0.008) |
| Richer | -0.044* | 0.010 | 0.018 | 0.016 |
| | (0.024) | (0.020) | (0.016) | (0.012) |
| Richest | 0.020 | -0.042* | 0.022 | 0.000 |
| | (0.029) | (0.022) | (0.021) | (0.014) |
| Economic Status (Base: Non-poor) | 0.035* | -0.010 | -0.026** | 0.000 |
| | (0.019) | (0.015) | (0.012) | (0.009) |
| Household Size | -0.001 | -0.001 | 0.001 | 0.000 |
| | (0.002) | (0.002) | (0.002) | (0.001) |
| Sector (Base: Rural) | 0.081*** | -0.078*** | 0.009 | -0.012* |
| | (0.014) | (0.011) | (0.010) | (0.007) |
| ***Adolescent Education (Base: No Education)*** | | | | |
| Primary | -0.093*** | -0.000 | 0.065*** | 0.029*** |
| | (0.024) | (0.020) | (0.015) | (0.010) |
| Secondary | -0.057*** | -0.031* | 0.066*** | 0.022** |
| | (0.021) | (0.018) | (0.013) | (0.009) |
| Tertiary | -0.132*** | 0.001 | 0.066*** | 0.066*** |
| | (0.029) | (0.024) | (0.018) | (0.020) |
| Cooking Fuel (Base: conventional sources) | 0.067*** | -0.046*** | 0.001 | -0.022*** |
| | (0.018) | (0.014) | (0.013) | (0.008) |
| Drinking Water (Base: Unimproved) | 0.070 | 0.004 | -0.017 | -0.056 |
| | (0.066) | (0.052) | (0.048) | (0.040) |
| ***Toilet Facility (Base: Unimproved)*** | | | | |
| Improved facility | 0.013 | 0.023 | -0.017 | -0.019** |
| | (0.020) | (0.017) | (0.013) | (0.009) |
| Shared facility | 0.042* | -0.014 | -0.004 | -0.024** |
| | (0.024) | (0.019) | (0.017) | (0.010) |
| Sex (Base: Female) | -0.025* | -0.034*** | 0.052*** | 0.008 |
| | (0.014) | (0.011) | (0.011) | (0.006) |
| Age of the adolescent (in years) | 0.039*** | -0.017*** | -0.008*** | -0.015*** |

| | | | | |
|---|---|---|---|---|
| | (0.003) | (0.002) | (0.002) | (0.002) |
| ***Mother Education (Base: No education)*** | | | | |
| Primary | 0.007 | 0.002 | -0.003 | -0.007 |
| | (0.019) | (0.016) | (0.013) | (0.008) |
| Secondary | 0.016 | 0.006 | -0.025* | 0.003 |
| | (0.023) | (0.019) | (0.014) | (0.012) |
| Tertiary | -0.028 | 0.013 | -0.001 | 0.016 |
| | (0.021) | (0.018) | (0.014) | (0.012) |
| AWW (Base: Not received) | -0.096*** | 0.084*** | -0.009 | 0.020** |
| | (0.017) | (0.015) | (0.012) | (0.010) |
| Observations | 6,126 | 6,126 | 6,126 | 6,126 |

Notes: This table reports marginal effects from a multinomial logit model estimating the probability of participation in one of four intervention groups. Covariates were at their baseline values, including household socioeconomic status, respondent and maternal education, adolescent's age, gender, household size, urban/rural location, wealth quintile, economic status, cooking fuel, health facility received from anganwadi workers (AWW), sanitation and water access. Standard errors are shown in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A2. Heterogeneous Effects of Nutrition-specific (IFA) and Nutrition-sensitive interventions (BVEDMB) on Hb Levels and BMI using SDiD

| | Log (Hb levels (g/dL)) | | BAZ | |
|---|---|---|---|---|
| | LPM | SLE | LPM | SLE |
| | (1) | (2) | (3) | (4) |
| Wealth quintile (Poorer) | 0.052* | 0.063** | -0.099 | -0.076 |
| | (0.031) | (0.032) | (0.196) | (0.205) |
| Mother education (Higher Education) | 0.078* | 0.074 | -0.643** | -0.630** |
| | (0.045) | (0.049) | (0.263) | (0.287) |
| Adolescent education (Higher Education) | 0.113* | 0.198*** | 0.184 | 0 |
| | (0.066) | (0.074) | (0.339) | 0 |
| Cooking Fuel (Non-Conventional Sources) | -0.055 | -0.037 | -0.135 | -0.167 |
| | (0.035) | (0.039) | (0.280) | (0.306) |
| Toilet facility (Improved) | 0.069** | 0.067** | 0.177 | 0.237 |
| | (0.030) | (0.032) | (0.271) | (0.294) |
| Household size | 0.018 | 0.015 | -0.048 | -0.038 |
| | (0.015) | (0.016) | (0.125) | (0.130) |
| Drinking water (Improved) | 0.113*** | 0.169*** | 0.715 | 1.347 |
| | (0.038) | (0.065) | (0.650) | (0.916) |
| Social group (SC/ST) | 0.051 | 0.045 | -0.015 | -0.004 |
| | (0.039) | (0.041) | (0.187) | (0.207) |
| Sector (Urban) | 0.033 | 0.039 | 0.109 | 0.121 |
| | (0.028) | (0.030) | (0.162) | (0.175) |
| Age of the adolescent (in years) | 0.002 | 0.001 | -0.027 | -0.009 |
| | (0.006) | (0.006) | (0.054) | (0.055) |
| Sex (Male) | 0.009 | 0.012 | 0.048 | 0.072 |
| | (0.027) | (0.028) | (0.168) | (0.176) |
| Constant | -0.171* | -0.228** | -0.307 | -1.192 |
| | (0.098) | (0.114) | (0.921) | (1.194) |
| Observations | 1,716 | 1,716 | 1,096 | 1,096 |

Notes: This table represents heterogeneity in the treatment effects of joint exposure to nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions on Hb levels (log-transformed) and BMI z-scores (BAZ), using semi-parametric difference-in-differences (SDiD) with baseline characteristics drawn from UDAYA Wave 1 (2015–16) for Bihar. The treatment group includes adolescents exposed to both interventions, while the control group comprises those exposed to only one or neither. Coefficients reflect interaction effects between joint program exposure and baseline covariates (e.g., education, household conditions). Bootstrapped standard errors, shown in parentheses, are clustered at the household level. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table A3. Heterogeneity by Household Wealth: Participation in Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions on Micronutrient and Anthropometric Outcomes using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | | Moderate anemia | | Overweight | | Thinness | |
|---|---|---|---|---|---|---|---|---|
| | Bottom3 Wealth Quintiles | Top 2 Wealth Quintile | Bottom3 Wealth Quintiles | Top 2 Wealth Quintile | Bottom3 Wealth Quintiles | Top 2 Wealth Quintile | Bottom3 Wealth Quintiles | Top 2 Wealth Quintile |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| IFA*BVEDMB*Post | 0.466** | 0.523 | -0.133** | -0.197*** | 0.042 | 0.039 | -0.020 | -0.125* |
| | (0.190) | (0.346) | (0.059) | (0.097) | (0.027) | (0.047) | (0.045) | (0.071) |
| IFA*Post | 0.127 | 0.250 | -0.052 | -0.009 | 0.014 | 0.075 | -0.035 | -0.105* |
| | (0.144) | (0.210) | (0.042) | (0.062) | (0.013) | (0.045) | (0.043) | (0.062) |
| BVEDMB*Post | 0.088 | -0.551** | -0.029 | 0.098 | 0.022 | 0.108* | 0.020 | -0.045 |
| | (0.167) | (0.255) | (0.056) | (0.083) | (0.024) | (0.056) | (0.042) | (0.065) |
| Post | 0.438 | 1.232* | -0.105 | 0.017 | -0.067 | 0.068 | -0.105 | 0.052 |
| | (0.329) | (0.687) | (0.087) | (0.196) | (0.049) | (0.087) | (0.090) | (0.235) |
| Time-varying controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,267 | 1073 | 1,310 | 677 | 1810 | 837 | 1810 | 837 |
| R-square | 0.035 | 0.157 | 0.070 | 0.247 | 0.041 | 0.104 | 0.042 | 0.121 |

Notes: This table reports heterogeneity results by household wealth quintile for Hb levels, moderate anemia, overweight, and thinness, estimated using equation (1). The sample is taken from the recent two waves of UDAYA (2015-16 and 2018-19) for Bihar, state of India. The treatment group comprises adolescents participating in both programs, and the control group consists of adolescents participating in either one or neither. The variable *Post* equals 1 for observations from wave II (2018-19). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual fixed effects and time fixed effects are

included. Standard errors are in parentheses, clustered at the household level. *, **, and *** represent 10%, 5% and 1% significance levels, respectively.

Table A4. Heterogeneity by Location: Participation in Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Intervention on Micronutrient and Anthropometric Outcomes using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | | Moderate Anemia | | Overweight | | Thinness | |
|---|---|---|---|---|---|---|---|---|
| | Rural | Urban | Rural | Urban | Rural | Urban | Rural | Urban |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| IFA*BVEDMB*Post | 0.382* | 0.649*** | -0.176*** | -0.056 | 0.041 | 0.031 | -0.080 | -0.020 |
| | (0.198) | (0.259) | (0.061) | (0.064) | (0.026) | (0.035) | (0.053) | (0.056) |
| IFA*Post | 0.209 | 0.221 | -0.105** | 0.066 | 0.007 | 0.071** | -0.046 | -0.056 |
| | (0.143) | (0.199) | (0.044) | (0.057) | (0.014) | (0.031) | (0.040) | (0.052) |
| BVEDMB*Post | 0.156 | -0.340* | -0.096* | 0.010 | 0.007 | 0.082** | -0.052 | 0.011 |
| | (0.176) | (0.205) | (0.056) | (0.058) | (0.025) | (0.031) | (0.043) | (0.050) |
| Post | 0.444 | 0.861** | -0.098 | 0.053 | -0.056 | 0.033 | 0.009 | -0.022 |
| | (0.333) | (0.446) | (0.094) | (0.118) | (0.043) | (0.073) | (0.106) | (0.125) |
| Time-varying controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 1,993 | 1,347 | 1,130 | 857 | 1536 | 1111 | 1536 | 1111 |
| R-square | 0.049 | 0.066 | 0.075 | 0.088 | 0.040 | 0.051 | 0.045 | 0.033 |

Notes: This table reports the results by place of residence for Hb levels, moderate anemia, overweight, and thinness using equation (1). The sample is taken from the recent two waves of UDAYA (2015-16 and 2018-19) for Bihar, state of India. The treatment group comprises adolescents participating in both programs, and the control group consists of adolescents participating in either one or neither. The variable *Post* equals 1 for observations from wave II (2018-19). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual fixed effects and time fixed effects are included. Standard errors are in parentheses, clustered at the household level. *, **, and *** represent 10%, 5% and 1% significance levels, respectively.

Table A5. Heterogeneity by Mother Education: Participation in Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) intervention on Micronutrient and Anthropometric Outcomes using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | | Moderate anemia | | Overweight | | Thinness | |
|---|---|---|---|---|---|---|---|---|
| | No education | Some education | No education | Some education | No education | Some education | No education | Some education |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| IFA*BVEDMB*Post | 0.336* | 0.593** | -0.113** | -0.138 | 0.050** | 0.030 | -0.063 | -0.052 |
| | (0.195) | (0.265) | (0.044) | (0.086) | (0.021) | (0.041) | (0.05) | (0.071) |
| IFA*Post | 0.071 | 0.232 | -0.049 | -0.064 | 0.028* | 0.048 | -0.020 | -0.125*** |
| | (0.140) | (0.193) | (0.038) | (0.074) | (0.015) | (0.030) | (0.042) | (0.047) |
| BVEDMB*Post | -0.023 | -0.147 | -0.052 | -0.066 | 0.009 | 0.129*** | 0.026 | -0.139*** |
| | (0.146) | (0.240) | (0.048) | (0.073) | (0.017) | (0.049) | (0.036) | (0.062) |
| Post | 0.375 | 1.184** | -0.065 | 0.041 | -0.074* | 0.087 | -0.014 | 0.005 |
| | (0.320) | (0.542) | (0.085) | (0.177) | (0.041) | (0.074) | (0.085) | (0.164) |
| Time-varying controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,255 | 1,085 | 1,311 | 676 | 1754 | 893 | 1754 | 893 |
| R-square | 0.046 | 0.069 | 0.056 | 0.139 | 0.055 | 0.080 | 0.035 | 0.081 |

Notes: This table reports the results based on mother's education for Hb levels, moderate anemia, overweight, and thinness using equation (1). The sample is taken from the recent two waves of UDAYA (2015-16 and 2018-19) for Bihar, state of India. The treatment group comprises adolescents participating in both programs, and the control group consists of adolescents participating in either one or neither. The variable *Post* equals 1 for observations from wave II (2018-19). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual fixed effects and time fixed effects are included. Standard errors are in parentheses, clustered at the household level. *, **, and *** represent 10%, 5% and 1% significance levels, respectively.

Table A6. Heterogeneity by Gender: Participation in Nutrition-Specific (IFA) and Nutrition-Sensitive intervention (BVEDMB) on Micronutrient and Anthropometric Outcomes using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | | Moderate anemia | | Overweight | | Thinness | |
|---|---|---|---|---|---|---|---|---|
| | Girls | Boys | Girls | Boys | Girls | Boys | Girls | Boys |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| IFA*BVEDMB*Post | 0.404* | 0.348 | -0.217** | -0.024 | 0.010 | 0.061** | 0.012 | -0.118** |
| | (0.236) | (0.226) | (0.089) | (0.041) | (0.027) | (0.029) | (0.053) | (0.059) |
| IFA*Post | 0.001 | 0.080 | -0.018 | -0.019 | 0.018 | 0.032 | -0.006 | -0.107** |
| | (0.196) | (0.159) | (0.066) | (0.039) | (0.018) | (0.022) | (0.054) | (0.043) |
| BVEDMB*Post | -0.051 | -0.162 | -0.068 | 0.017 | 0.028 | 0.070** | 0.034 | -0.086* |
| | (0.190) | (0.189) | (0.083) | (0.039) | (0.023) | (0.032) | (0.044) | (0.046) |
| Post | 0.230 | 1.50*** | -0.014 | -0.093 | -0.013 | -0.028 | 0.014 | 0.023 |
| | (0.389) | (0.485) | (0.136) | (0.084) | (0.054) | (0.063) | (0.110) | (0.135) |
| Time-varying controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Observations | 1285 | 1227 | 607 | 994 | 1160 | 1119 | 1160 | 1119 |
| R-square | 0.066 | 0.167 | 0.195 | 0.059 | 0.053 | 0.040 | 0.045 | 0.057 |

Notes: This table reports the results based on mother's education for Hb levels, moderate anemia, overweight, and thinness using equation (1). The sample is taken from the recent two waves of UDAYA (2015-16 and 2018-19) for Bihar, state of India. The treatment group comprises adolescents participating in both programs, and the control group consists of adolescents participating in either one or neither. The variable *Post* equals 1 for observations from wave II (2018-19). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual fixed effects and time fixed effects are included. Standard errors are in parentheses, clustered at the household level. *, **, and *** represent 10%, 5% and 1% significance levels, respectively.

Table A7. Joint and Individual Effects of Nutrition-Specific (IFA) and Nutrition-Sensitive intervention (BVEDMB) on Micronutrient and Anthropometric Outcomes using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | | | Moderate anemia | | | Overweight | | | Thinness | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Treat*Post | 0.450*** | -0.046 | 0.138 | -0.086** | -0.050 | -0.023 | 0.04** | 0.03* | 0.03** | -0.052 | -0.022 | -0.050 |
| | (0.164) | (0.127) | (0.114) | (0.043) | (0.040) | (0.032) | (0.020) | (0.020) | (0.013) | (0.040) | (0.031) | (0.032) |
| Post | 0.421 | 0.633* | 0.649** | 0.031 | -0.040 | -0.009 | -0.046 | 0.019 | -0.046 | 0.086 | 0.110 | -0.014 |
| | (0.346) | (0.324) | (0.309) | (0.095) | (0.095) | (0.087) | (0.039) | (0.057) | (0.036) | (0.100) | (0.088) | (0.090) |
| Time-varying controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Individual Fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,219 | 2,390 | 2,543 | 1,297 | 1,406 | 1,484 | 1,689 | 1,805 | 1943 | 1,689 | 1,805 | 1943 |
| R-square | 0.043 | 0.034 | 0.045 | 0.061 | 0.054 | 0.055 | 0.030 | 0.035 | 0.032 | 0.032 | 0.025 | 0.030 |

Notes: This table reports the results using standard Difference-in differences with fixed effects on matched sample, estimating joint and individual effects of nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions on Hb levels, Moderate anemia, Overweight, Thinness. The sample is taken from the recent two waves of UDAYA (2015-16 & 2018-19) for the Bihar, state of India. Column (1), (4), (7) and (10) show the effects of participating in both the programs compared to a specific control group, i.e., participating in neither of the programs. Column (2), (5), (8) and (11) show the effects of participating only nutrition-sensitive intervention compared to a specific control group, participating in no program. Column (3), (6), (9) and (12) show the effects of participating in nutrition-specific intervention compared to a specific control group, participating in no program. We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual fixed effects and time fixed effects are included. Standard errors are in parentheses, clustered at the household level. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table A8. Effects of Nutrition-specific Intervention (IFA) on Micronutrient and Anthropometric Outcomes in Silos using Two-Way Fixed Effects Model

| | Hb levels (g/dL) | Moderate anemia | Overweight | Thinness |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| IFA | -0.120 | 0.030 | -0.012 | 0.021 |
| | (0.093) | (0.033) | (0.009) | (0.025) |
| Post | -0.356 | 0.081 | 0.020 | 0.299** |
| | (0.560) | (0.181) | (0.073) | (0.151) |
| Time-varying controls | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 3,874 | 2,490 | 2977 | 2977 |
| R-square | 0.039 | 0.029 | 0.021 | 0.035 |

Notes: This table reports the results from two-way fixed effects, estimating effects of nutrition-specific intervention (IFA) on Hb levels, moderate anemia, overweight, thinness in Uttar Pradesh, counterfactual state of India. The sample is taken from the recent two waves of UDAYA (2015-16 & 2018-19) for the Uttar Pradesh, state of India. Post is indicator that takes value 1 when we consider data from the second survey round, i.e., for year 2018. It includes whether adolescents received the IFA or not. We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual fixed effects and time fixed effects are included. Standard errors are in parentheses, clustered at the household level. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table A9. Effects of Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions on change in Hb levels and BMI using SDID

| | Change Hb levels (g/dL)) | | BMI | |
|---|---|---|---|---|
| | LPM | SLE | LPM | SLE |
| | (1) | (2) | (3) | (4) |
| IFA*BVEDMB | 0.314** | 0.329** | 0.183 | 0.197 |
| | (0.143) | (0.155) | (0.165) | (0.177) |
| Observations | 1716 | 1716 | 1854 | 1854 |

Notes: This table reports the estimated joint effects of the nutrition-specific intervention (IFA) and the nutrition-sensitive (BVEDMB) interventions on change in Hb and BMI levels using SDiD. The sample includes adolescents from Bihar, drawn from two waves of the UDAYA survey (2015–16 and 2018–19). The treatment group comprises individuals who participated in both programs, while the control group included those who participated in either one or neither. Columns (1) and (3) use propensity scores estimated via a linear probability model (LPM); Columns (2) and (4) use the series logit estimator (SLE). BMI are constructed using WHO reference standards. Bootstrapped standard errors are clustered at the household level. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively.

Table A10. Effects of Combined Exposure to Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions on Micronutrient and Anthropometric Outcomes on the Age Group of 10-19 years using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | Moderate anemia | Overweight | Thinness |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |

| | | | | |
|---|---|---|---|---|
| IFA*BVEDMB*Post | 0.354** | -0.070* | 0.040** | -0.061 |
| | (0.172) | (0.038) | (0.020) | (0.039) |
| IFA*Post | 0.154 | -0.011 | 0.027** | -0.051 |
| | (0.130) | (0.036) | (0.013) | (0.031) |
| BVEDMB*Post | -0.086 | 0.018 | 0.038** | -0.026 |
| | (0.155) | (0.043) | (0.019) | (0.031) |
| Post | 0.903*** | -0.062 | -0.029 | -0.003 |
| | (0.338) | (0.090) | (0.038) | (0.078) |
| Time-varying controls | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 2,867 | 1,757 | 2647 | 2647 |
| R-square | 0.045 | 0.060 | 0.024 | 0.026 |

Notes: This table reports estimate of adolescents of age10-19 years from equation (1), evaluating the joint effects of nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions on Hb levels, moderate anemia, overweight, and thinness, using a difference-in-differences (DiD) framework with propensity score matching (PSM). The analysis draws on two waves of the UDAYA survey (2015–16 and 2018–19) from Bihar, India. The treatment group includes adolescents exposed to both interventions, while the control group includes those exposed to either one or neither. The variable *Post* equals 1 for observations from the second wave (2018). Dependent variables are shown in columns: Hb level (1), moderate anemia (2) and anthropometric outcomes—overweight and thinness (3,4). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual and time fixed effects are included. Standard errors clustered at the household level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

Table A11. Effects of Combined Exposure to Nutrition-Specific (IFA) and Nutrition-Sensitive (BVEDMB) Interventions on Micronutrient and Anthropometric Outcomes Excluding Married Adolescent Girls using PSM-DiD with Fixed Effects Model

| | Hb levels (g/dL) | Moderate anemia | Overweight | Thinness |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| IFA*BVEDMB*Post | 0.442*** | -0.080** | 0.040** | -0.058 |
| | (0.166) | (0.038) | (0.020) | (0.040) |
| IFA*Post | 0.127 | -0.023 | 0.027** | -0.050 |
| | (0.129) | (0.035) | (0.013) | (0.031) |
| BVEDMB*Post | -0.077 | -0.004 | 0.044** | -0.024 |
| | (0.141) | (0.036) | (0.019) | (0.032) |
| Post | 0.861*** | -0.062 | -0.017 | 0.0007 |
| | (0.329) | (0.072) | (0.038) | (0.084) |
| Time-varying controls | Yes | Yes | Yes | Yes |
| Individual Fixed Effects | Yes | Yes | Yes | Yes |
| Observations | 2,512 | 1,601 | 2279 | 2279 |
| R-square | 0.048 | 0.058 | 0.024 | 0.026 |

Notes: This table reports estimate excluding married adolescent girls from equation (1), evaluating the joint effects of nutrition-specific (IFA) and nutrition-sensitive intervention (BVEDMB) on Hb levels, moderate anemia, overweight, and thinness, using a difference-in-differences (DiD) framework with propensity score matching

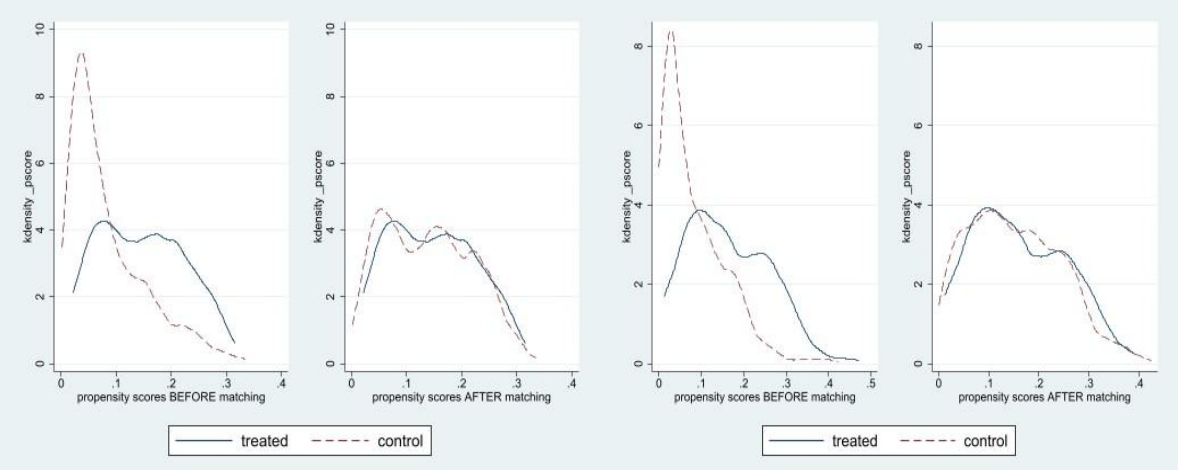
(PSM). The analysis draws on two waves of the UDAYA survey (2015–16 and 2018–19) from Bihar, India. The treatment group includes adolescents exposed to both interventions, while the control group includes those exposed to either one or neither. The variable *Post* equals 1 for observations from the second wave (2018). Dependent variables are shown in columns: Hb level (1), moderate anemia (2) and anthropometric outcomes—overweight and thinness (3 and 4 respectively). We use individual, household controls, including education, economic status, wealth quintile, household size, drinking water, toilet facility, cooking fuel, adolescent age, and health facility received through an anganwadi workers (AWW). Individual and time fixed effects are included. Standard errors clustered at the household level are in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively

Table A12. Definition of Covariate Variables

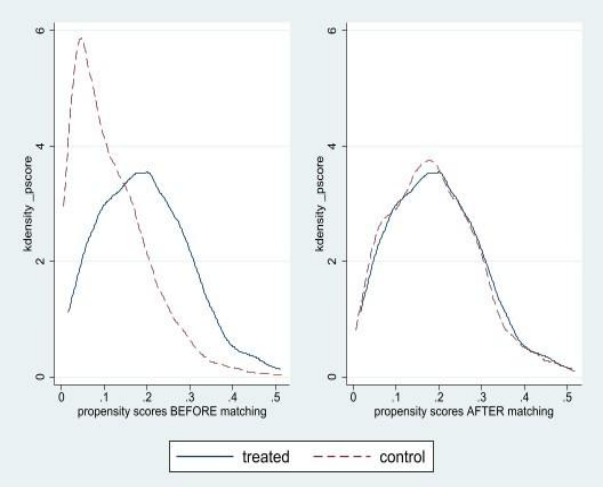
| Variables | Definition |
|---|---|
| Covariates | |
| Household size | A continuous variable indicates an average number of members in the household |
| Cooking fuel | A binary variable that takes value 1 for non-conventional sources (electricity, liquefied petroleum gas (LPG), biogas), 0 for conventional sources (wood, kerosene). |
| Drinking water | A binary variable that takes value 1 for improved sources (own or other's piped water /hand pump/covered well, rainwater, tanker truck), 0 for unimproved sources (open well, surfacewater/spring/river/stream/pond/lake/dam, and others). |
| Toilet facility | A binary variable that takes the value 1 for improved facility (own/shared pit, no facility, others), 0 for unimproved facility (own flush toilet) and 2 for shared facility (shared flush toilet). |
| Economic status | A binary variable that takes the value 1 for poor (struggle to have food/skips the meals), 0 for non-poor (very rich/rich/ comfortable but no money aside from necessities). |
| AWW (Anganwadi workers) | A binary variable that takes value 1 for health facilities received from anganwadi workers. |

Notes: This table shows construction of all covariate variables.

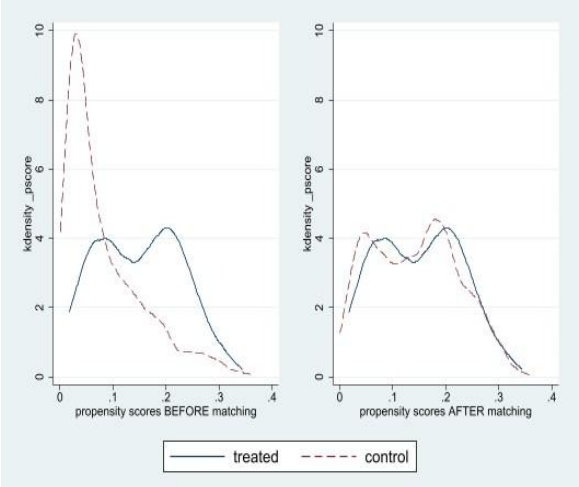
Figure A1. Common Support of PS for Micronutrient and Anthropometric Outcomes Before and After PSM



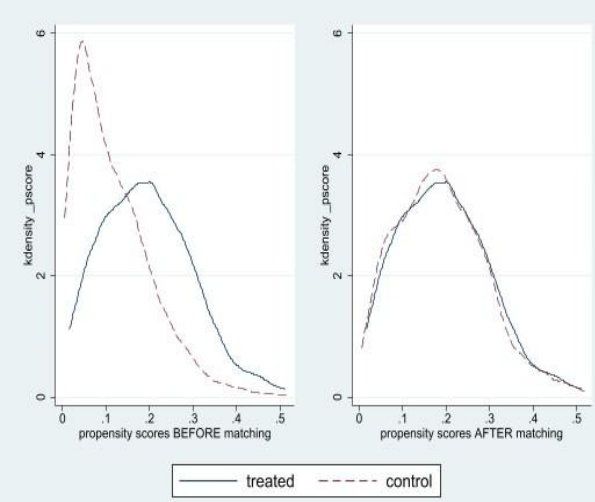

Panel A Panel B



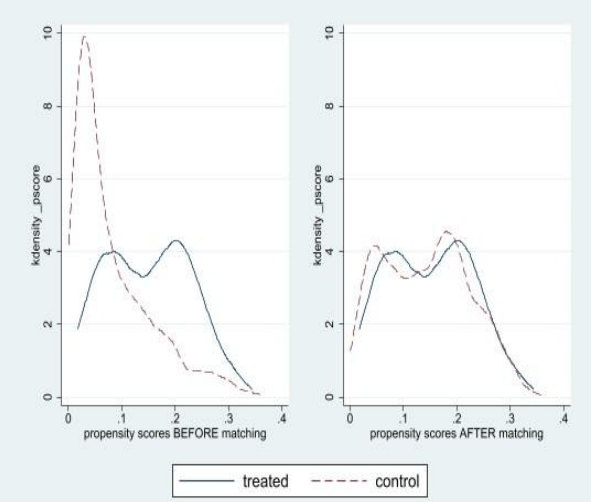

Panel C




Panel D




Panel E




Panel F

Notes: This figure illustrates the kernel density plots of PS before and after matching the treatment group, i.e., participation in both the nutrition-specific (IFA) and nutrition-sensitive (BVEDMB) interventions, and the control group, participation in only one intervention or none. Panels A–B show moderate anemia in Wave 1 (2015–16) and Wave 2 (2018–19). Panels C–D show overweight in Waves 1 and 2, and Panels E–F show thinness in Waves 1 and 2.