



Training healthcare workers increases IFA use and adherence: Evidence and cost-effectiveness analysis from Bangladesh

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Abstract

Iron and folic acid (IFA) supplementation programmes are important for preventing and controlling anaemia among pregnant women in low- and middle-income countries. However, frontline health care workers often have limited capacity and knowledge, which can compromise such programmes' effectiveness. Between 2012 and 2014, Nutrition International and the Government of Bangladesh implemented a programme intended to increase IFA supplement consumption during pregnancy. The programme provided frontline health care workers with training on the benefits of IFA supplementation, the use of interpersonal communication and health promotion materials during antenatal care visits and health management information systems to track reported adherence to IFA supplementation. Using a quasi-experimental design, this study investigates the programme's effectiveness and cost-effectiveness at increasing IFA supplement consumption and adherence among pregnant women. The difference-in-differences regression analysis comparing outcomes in an intervention and comparison group concluded that the programme increased IFA consumption by an average of 45.05 supplements (P value = 0.018) and increased the share of women that reported adherence to a regime of at least 90 supplements by 40.35 percentage points (P value = 0.020). Knowledge of IFA supplement dosage and benefits also increased among frontline health care workers and pregnant women. The programme cost \$47.11 USD (2018) per disability-adjusted life year averted, which is considered highly cost-effective when evaluated against several cost-effectiveness thresholds. This study suggests that the capacity building of frontline health care workers is an effective and cost-effective method of preventing and controlling anaemia among pregnant women in resource-constrained areas.

KEYWORDS

adherence, anaemia, Bangladesh, cost-effectiveness analysis, health care worker training, interpersonal communication, iron and folic acid supplements, pregnancy, programme evaluation

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1 | INTRODUCTION

Micronutrient interventions such as prenatal iron and folic acid (IFA) supplementation programmes are a fundamental component of global efforts to reduce the prevalence of anaemia among women (WHO & UNICEF, 2018). Such programmes are an important tool to substantially improve the health of mothers and children, reducing maternal and child mortality and improving health and nutrition, including reductions in low birth weight and stunting (Peña-Rosas, De-Regil, Garcia-Casal, & Dowswell, 2015; Rasmussen & Stoltzfus, 2003). Despite the popularity of IFA supplement programmes and evidence that they can be a highly cost-effective means of reducing anaemia among pregnant women (da Silva Lopes, Takemoto, Garcia-Casal, & Ota, 2018; Kashi et al., 2019), the programmes have not always been as effective as advocates for such programmes have hoped. In Bangladesh, for example, nearly half (45.7%) of all pregnant women are anaemic (WHO, 2017) despite an IFA supplementation programme in place since 1988 and health infrastructure investment by the public and private sectors (UK Department for International Development, PwC, EPPI-Centre, 2017). Current trends suggest the World Health Assembly's targets to reduce anaemia by 50% in women of reproductive age between 2012 and 2025 will not be achieved (WHO & UNICEF, 2018).

One challenge faced by IFA supplement programmes is that ensuring that pregnant women have access to IFA supplements does not guarantee that they will use them. Lack of adherence often occurs because people do not fully understand the benefits or risks associated with the supplements. In Bangladesh, for example, the most-common justification for not taking IFA supplements was that women believed they were unnecessary (Rashid, Flora, Moni, Akhter, & Mahmud, 2010), while other pregnant women did not consume the recommended number of supplements because they believed IFA supplements would increase foetus size and result in birth complications (Alam et al., 2015). These misconceptions cannot always be addressed by frontline health care workers, who themselves often do not understand the costs and benefits of the supplements. Alam et al. (2015) found that many frontline health care workers lacked knowledge about the importance of IFA supplements for pregnant women. Vaughan, Kok, Witter, and Dieleman (2015) showed that there is high variance in the quality and effectiveness of frontline health workers, including community health workers (CHWs) in low- and middle-income countries (LMICs).

Improved health care worker training can potentially affect patient behaviour and attitudes. A systematic review of studies in LMICs (8082 studies were screened; 14 were included in the final analysis) found that interventions aimed at improving the performance of health workers led to behaviour change among patients, including increased use of available health care services and improved nutrition practices for themselves and their young children (Ballard & Montgomery, 2017). For example, a randomized control cluster trial in Pakistan showed that training of frontline health workers increased the share of pregnant women that attended checkups, stopped routine heavy work during pregnancy, provided colostrum to newborn

Key messages

- A quasi-experimental nonequivalent control group study examined the effects of capacity building of frontline health care workers on iron and folic acid (IFA) supplementation reported consumption and adherence by pregnant women in the Bangladeshi regions of Satkhira and Narsingdi between the years 2012 and 2014.
- Capacity building of frontline health care providers was effective at increasing IFA consumption by an average of 45.05 IFA supplements and adherence to a regime of at least 90 tablets by 40.35 percentage points.
- The capacity building intervention cost \$47.11 USD (2018) per DALY averted, which is considered very cost-effective when evaluated against several globally adopted cost-effectiveness thresholds.
- Frontline health care provider training complements other policies and programmes related to the provision of IFA supplements and improving adherence.

babies and exclusively breastfeed for the first 4 months (Omer, Mhatre, Ansari, Laucirica, & Andersson, 2008). Some studies have considered the effectiveness of frontline health care worker training programmes designed to improve IFA supplement adherence; however, these past studies were generally observational. For example, cross-sectional studies in Kenya (Kamau, Mirie, & Kimani, 2018) and Ethiopia (Arega Sadore, Abebe Gebretsadiq, & Aman Hussen, 2015) revealed an association between IFA supplement compliance and IFA supplement counselling. Likewise, a pre-post study in Vietnam found a reduction in the prevalence of anaemia in pregnant women from 37.0% to 19.5% following the training of health staff and the use of educational materials (Phuc et al., 2009). While such results are promising, the lack of a counterfactual is a major limitation in the context of LMICs, where communities are often exposed to multiple interventions and may experience rapid changes in political, economic and environmental conditions that can affect nutritional outcomes and therefore confound the conclusions of such studies. Moreover, little is known regarding the cost-effectiveness of such programmes.

The purpose of this current study is twofold. First, the study uses a quasi-experimental evaluation to assess a programme implemented in Bangladesh that provided frontline health care worker training about IFA supplementation and its benefits during pregnancy and how to communicate these benefits to pregnant women. The primary outcomes of interest include the programme's impact on IFA supplement adherence and consumption among pregnant women. Secondary outcomes of interest included changes in knowledge of IFA and related topics (among pregnant women and frontline health care workers), among others. Second, the study evaluates the cost-effectiveness of the programme. In the context of implementation

research, this study informs options for preventing and controlling anaemia among pregnant women in resource-constrained areas.

2 | METHODS

2.1 | Intervention

Nutrition International (NI, formerly Micronutrient Initiative) and the Government of Bangladesh implemented a programme between April 2012 and April 2014 designed to increase the use of IFA supplements among pregnant women. The programme developed a training manual and then trained frontline health care workers on the benefits of IFA supplementation and related topics, on methods for effectively communicating these benefits to patients (through the use of behaviour change communication [BCC], interpersonal communication [IPC], counselling and health promotion materials) during ANC contacts and on how to use health management information systems to track coverage and reported consumption of IFA supplementation in programme districts. BCC involves the use of targeted messages and evidence-based, tailored approaches to promote healthy behaviour. The BCC materials included brochures and a wall-hanging (festoon), with colourful, easy-to-understand messages about IFA dosage and benefits. Training and retraining occurred every 6 months, and there was an ongoing supportive supervision to strengthen health care worker practices. Training was also offered to district supervisory staff to improve supply chain management at the district level. The programme was implemented in two districts: Satkhira and Narsingdi.

2.2 | Survey and sample selection

The data used in the study come from surveys conducted within the treatment communities within the two intervention districts (Satkhira and Narsingdi) and within comparable communities within two comparison districts not exposed to the intervention (Mymensingh and Jessore). The surveys included both frontline health care workers and women who gave birth within the previous 6 months. The random selection procedure, which we describe in detail in Appendix S1, resulted in a survey of 800 women at baseline and 1200 women at endline, split evenly between treatment and comparison locations. It also resulted in a survey of 174 frontline health care workers at baseline (with 48% being in treatment locations) and 360 at endline (split evenly between treatment and comparison locations). Table S1 provides minimum detectable effect size estimates for various comparisons based on 95% confidence level, 80% power and the sample sizes, clusters and initial proportions from the data.

2.2.1 | IFA consumption and adherence

The primary variable of interest collected during the surveys was the total number of IFA supplements consumed during the previous

pregnancy. We use this variable as its own outcome of interest and also use it to define the adherence variable indicating whether consumption was at least 90 tablets. This adherence threshold is the standard often aimed for by governments (SPRING, 2014); it has been shown to lead to clinically meaningful increases in haemoglobin levels (Batu, Toe, Pe, & Nyunt, 1976).

2.2.2 | Effective communication and knowledge of IFA

The secondary outcomes of interest collected during the surveys give insights into the pathway of behaviour change, including measures of frontline health care worker knowledge and service provision and the exposure of women to improved service and knowledge. Therefore, the secondary outcomes of interest for pregnant women included the proportion of women reporting: (1) receiving counselling on IFA supplementation, (2) exposure to BCC materials on IFA supplementation, (3) knowledge of anaemia, (4) knowledge of anaemia prevention, (5) knowledge of correct daily dosage of IFA (1/day), (6) experience of side effects due to IFA, (7) month of first ANC checkup or registry and (8) number of ANC visits in last pregnancy. For frontline health care workers, the secondary outcomes of interest included the proportion of frontline health care workers reporting: (1) provision of IFA supplements, (2) use of counselling, (3) use of BCC material for counselling, (4) knowledge of anaemia prevention, (5) knowledge of correct daily dosage of IFA (1/day), (6) knowledge of methods to overcome side effects and (7) knowledge of month of pregnancy to initiate IFA.

2.3 | Preliminary empirical analysis

We conducted a preliminary data analysis to assess the comparability of the intervention and comparison districts at each time point and identify preliminary associations between variables of interest. Depending on the type of data analysed (i.e., categorical or continuous), appropriate statistical bivariate analyses were applied (*t* tests, ANOVA, chi-square). For women who recently gave birth, the exploratory data analysis examined demographic characteristics in the intervention and comparison districts at each time point.

2.4 | Difference-in-differences empirical analysis

We used difference-in-differences (DiD) regression analyses to estimate the programme's effect on primary and secondary outcomes for women and frontline health care workers. The method allows for causal inference even when other unobserved factors may be driving changes in the outcome variables of interest, as long as these other factors affect the treatment and comparison groups in similar ways (parallel trends assumption). This is an important consideration in our analysis as the government was implementing nationwide improvements in the IFA supply chain and packaging during the study period,

which are expected to have affected the treatment and comparison areas similarly. The analysis assumes that improvements in outcomes within the comparison group provide an approximation of the improvements that would have been experienced by the treatment group without the programme. DiD regression analysis is a standard econometric method used to evaluate interventions where randomized control trials are impractical or unethical (Wing, Simon, & Bello-Gomez, 2018).

2.4.1 | Clustering robust standard errors

Due to the sampling design, wild cluster bootstrapped *P* values and confidence intervals (Esarey & Menger 2019; MacKinnon 2019) were computed using the clusterSE package in R. Clustering was defined at the upazila (administrative district) level, and 1000 bootstrap samples were drawn. This method was selected due to the small number and composition of the clusters.

2.5 | Cost-effectiveness analysis

The programme's cost-effectiveness is defined by its financial cost per disability-adjusted life-year (DALY) averted. A DALY represents one lost year of life in perfect health. Once calculated, the programme's cost-effectiveness allows for a comparison with the cost-effectiveness of other health and nutrition interventions by comparing the results with standard criteria for determining whether a programme provides good value for money.

2.5.1 | Cost estimates

The costing analysis of the programme followed a programme costing approach. The programme's total cost and the cost of each of the programme components were determined from NI's project documentation. Components included the following: IPC and health promotion material costs (including research, modification and production of materials) and frontline health care worker training costs (including planning meetings, review and revision of training materials and delivery of training). The programme targeted 80% of frontline health care workers in the programme districts. All costs are adjusted to 2018 USD dollars.

2.5.2 | DALYs averted

The empirical analysis estimates the programme's impact on the proportion of women who adhere to an IFA supplement regime. We use this value based on our sample population to estimate the programme's overall impact on adherence across the entire treatment districts and then estimate the effect of this increase in adherence on

DALYs within the population. The health literature estimates the extent to which IFA adherence leads to improvements in maternal mortality, maternal anaemia, neonatal mortality, preterm birth and low birth weight (Peña-Rosas, De-Regil, Garcia-Casal, & Dowswell, 2015), which we aggregate into a total impact of adherence on a reduction in DALYs across mothers and children. To estimate DALYs averted due to increased IFA supplement adherence, we used relative risks (RRs) from systematic reviews on the effect of iron supplements. The impact of iron served as a proxy for the impact of IFA. Appendix S1 documents the selection of RRs and other data required to calculate DALYs averted (prevalence, disability weights and duration of effect). DALYs averted were calculated for the programme period (2012–2014) and discounted using the standard annual health discount rate of 3%.

2.5.3 | Cost-effectiveness comparisons

The resulting cost-per-DALY averted was compared against several cost-effectiveness thresholds. The demand-side threshold, which captures society's willingness to pay for gains in health, included the WHO's one-to-three times GDP per capita threshold under which a programme is deemed 'very cost effective' when it costs less than one times GDP per capita for each DALY averted and 'cost effective' when it costs less than three times GDP per capita for each DALY averted (Leech, Kim, Cohen, & Neumann, 2018). In Bangladesh, this implies a 'very cost-effective' threshold of \$4900 USD and a 'cost-effective' threshold of \$14 700 USD (2018 PPP). The supply-side cost-effectiveness threshold, which captures the opportunity costs of funds, follows the standard proposed by Woods, Revill, Sculpher, and Claxton (2016), which found that for Bangladesh the threshold for high cost-effectiveness is \$100 and the threshold for cost-effectiveness is \$1400 USD (2018 PPP).

2.6 | Sensitivity and robustness analysis

In the empirical analysis, we conduct sensitivity analyses around the robustness of results to alternative adherence thresholds, including alternatives of 100+, 120+ and 180+ supplements. The 180 threshold is consistent with the WHO recommended level (WHO, 2012) but is certainly above the minimum level of adherence necessary to experience a meaningful impact.

For the cost-effectiveness analysis, we conducted a probabilistic analysis using Monte Carlo simulations to generate a level of uncertainty around the intervention's cost-effectiveness estimates. This analysis factors for uncertainty in health outcomes, prevalence and disability weights and was conducted on 100 000 simulations. All analyses were conducted using R version 3.5.0 (R Core Team, 2017).

Furthermore, we conducted one-way sensitivity analyses to characterize the amount of uncertainty around the results. The

TABLE 1 Demographics of women who recently gave birth

Indicator	Baseline			Endline ^a		
	IG	CG	P value ^b	IG	CG	P value ^b
Age (mean)	23.52	23.56	0.914	24.18	24.48	0.176
# of children (mean)	1.93	2.02	0.300	-	-	-
Ever attended school (%)	90.0%	85.3%	0.473	-	-	-
Completed grade 12 or higher (%)	6.5%	5.3%	0.466	-	-	-
Currently married (%)	99.8%	100.0%	0.972	-	-	-
Primary occupation (housewife) (%)	85.0%	98.5%	0.046	-	-	-

Abbreviations: CG, comparison group; IG, intervention group.

^aApart from age, demographic data were not collected at the endline. Since these data were collected as part of a programme implementation, there were some constraints (see methods). Shortening the survey at endline enabled a larger sample to be surveyed.

^bFor continuous indicators (age, mean # of children) this is the *t* test *P* value. For categorical variables reported in proportions (all other indicators) this is the chi-square test *P* value.

government of Bangladesh provides IFA supplements to pregnant women from the second trimester to 42 days after pregnancy. The Institute of Public Health Nutrition conducts forecasting and quantification of IFA supplements. We relied on these estimates but also conducted sensitivity analysis to consider scenarios involving higher commodity costs for IFA supplements for all new adherence cases. Unit costs of IFA supplementation provision (including the supplement cost itself) was \$2.04 USD (Shekar et al., 2017). Other one-way sensitivities explored included deviations from the estimated programme effect on adherence.

2.7 | Ethical considerations

Ethical clearance was obtained from Bangladesh Medical Research Council (BMRC). Informed consent (verbal or written) was obtained from all participants. Voluntary participation and confidentiality were ensured.

3 | RESULTS

3.1 | Summary statistics

The mean age of women was 24 years old at baseline and endline in both the intervention group (IG) and comparison group (CG). No additional demographic data were collected at endline due to a decision by the project implementer to decrease the length of the survey to help offset the added costs of a larger sample size. Table 1 shows that the IG and CG were not significantly different across a range of demographic indicators for which data were available at baseline.

At endline, 100% and 20% of frontline health care workers reported receiving training in the IG and CG, respectively. The reported training of some health care workers in the CG districts

could indicate some degree of programme spillover from intervention districts, potentially attenuating the measured impact.

3.2 | Primary outcomes

As reported in Table 2, at baseline, mean IFA supplement consumption was higher in the CG (70.81 supplements) compared with the IG (61.62 supplements). At endline, the mean IFA supplement consumption increased to 92.24 supplements in the CG and to 127.01 supplements in the IG, representing a substantially higher increase in IFA consumption within the IG. After accounting for general time trends, we estimate that 68.9% of the IG increase is attributable to exposure to the programme. The resulting DiD estimator suggests that the programme significantly increased IFA supplement consumption by 45.05 supplements per pregnant woman, on average. Adherence also significantly increased due to the programme. At baseline, the CG had a 10 percentage point higher rate of adherence than the IG (0.46 vs. 0.36). At endline, reported adherence increased to 0.84 and 0.52 in the IG and CG, respectively. The resulting DiD estimator suggests that the programme increased IFA adherence by 40.3 percentage points.

3.3 | Secondary outcomes

The programme also had a substantial impact on several secondary outcomes for women (Table 3) and frontline health workers (Table 4). Among women, the programme resulted in a 34.3 percentage point increase in the share who reported receiving counselling on IFA, a 45.9 percentage point increase in reported exposure to BCC materials on IFA, a 39.0 percentage point increase in the share with knowledge of correct IFA dosage (1/day) and an average increase of 1.26 ANC visits in their last pregnancy. Among frontline health care workers, the programme resulted in a 12.5 percentage point increase in the share

TABLE 2 Estimated impact of programme (primary outcomes): Women who recently gave birth

Indicator	Baseline			Endline			DiD estimator			Adjusted ^a		
	IG	CG	Diff	P value	IG	CG	Diff	P value	Est	95% CI	P value	95% CI
# of IFA supplements consumed (mean, (SD))	61.62 (70.13)	70.81 (69.11)	9.19	0.063	127.01 (52.89)	92.24 (55.56)	34.76	<0.0001	45.05	33.97, 56.14	<0.0001	6.35, 83.76
Adherence (90+ IFA) (%)	0.355	0.455	0.100	0.026	0.840	0.515	0.325	<0.0001	0.403	0.325, 0.482	<0.0001	0.162, 0.645

Abbreviations: 95% CI, 95% confidence interval; CG, comparison group; DiD, difference-in-differences; Diff, difference between IG and CG; Est, DiD estimator value; IG, intervention group.
^aWild cluster bootstrapped confidence interval and P value estimates.

TABLE 3 Estimated impact of programme (secondary outcomes): Women who recently gave birth

Indicator ^a	Baseline			Endline			DiD estimator			Adjusted ^b		
	IG	CG	Diff	P value	IG	CG	Diff	P value	Est	95% CI	P value	95% CI
Received counselling on IFA (%)	0.375	0.583	0.208	0.012	0.935	0.800	0.135	0.012	0.343	0.270, 0.415	<0.0001	0.088, 0.597
Exposed to BCC on IFA (%)	0.003	0.010	0.008	<0.0001	0.825	0.373	0.452	<0.0001	0.459	0.398, 0.520	<0.0001	0.011, 0.418
Knowledge of anaemia (%)	0.733	0.763	0.030	0.727	0.977	0.997	0.020	0.727	0.010	-0.042, 0.062	0.705	-0.159, 0.179
Knowledge of anaemia prevention (%)	0.610	0.653	0.043	0.017	0.902	0.775	0.127	0.017	0.209	0.137, 0.281	<0.0001	-0.091, 0.510
Knowledge of correct IFA dosage (%)	0.548	0.603	0.055	<0.0001	0.963	0.628	0.335	<0.0001	0.390	0.314, 0.466	0.000	0.203, 0.577
Reported side effects (%)	0.223	0.159	0.065	0.441	0.336	0.325	0.011	0.441	-0.054	-0.144, 0.036	0.238	-0.348, 0.250
Month of first ANC (mean, SD)	4.34 (2.85)	4.50 (2.08)	0.06	0.724	3.91 (1.38)	4.49 (1.45)	0.59	<0.0001	-0.53	-0.87, -0.18	0.003	-2.16, 1.11
# ANC visits in last pregnancy (mean, SD)	2.63 (2.28)	3.48 (2.00)	0.86	<0.0001	3.86 (1.43)	3.46 (1.43)	0.40	<0.0001	1.255	0.94, 1.57	<0.0001	0.44, 2.08

Abbreviations: 95% CI, 95% confidence interval; CG, comparison group; DiD, difference-in-differences; Diff, difference between IG and CG; Est, DiD estimator value; IG, intervention group.
^aFor knowledge questions, this is the proportion of women who reported knowledge of anaemia, one or two methods of anaemia prevention (supplementation and consumption of iron rich foods), and knowledge of correct dosage (1/day), respectively.
^bWild cluster bootstrapped confidence interval and P value estimates.

TABLE 4 Estimated impact of programme (secondary outcomes): Frontline health care workers

Indicator ^a	Baseline			Endline			DiD estimator			Adjusted ^b		
	IG	CG	P value	IG	CG	P value	Est	95% CI	P value	95% CI	P value	
Provision of IFA supplements (mean, SD)	30.78 (9.85)	34.00 (16.46)	0.481	33.67 (14.34)	27.31 (16.43)	0.002	10.86	3.17, 18.54	0.006	-2.08, 23.79	0.095	
Use of counselling for IFA (%)	0.702	0.767	0.064	0.994	0.933	0.555	0.125	0.019, 0.232	0.021	0.003, 0.247	0.042	
Knowledge of correct IFA dosage (%)	0.357	0.200	0.157	0.961	0.578	<0.0001	0.226	0.081, 0.371	0.002	0.036, 0.416	0.025	
Knowledge of methods to reduce side effects (%)	0.964	0.978	1.349	1.000	96.111	0.039	0.052	-0.001, 0.106	0.056	0.00, 0.10	0.047	
Assumed month of pregnancy to initiate IFA (mean, SD)	4.20 (0.96)	4.20 (0.95)	0.01	2.28 (2.41)	3.03 (1.84)	<0.0001	-0.75	-1.43, -0.07	0.031	-1.78, 0.30	0.144	

Abbreviations: 95% CI, 95% confidence interval; CG, comparison group; DiD, difference-in-differences; Diff, difference between IG and CG; Est, DiD estimator value; IG, intervention group.

^aQuestions where the answer is yes/no, the reported value is the proportion of health care workers that respond 'yes'. 1 or two methods of anaemia prevention (supplementation and consumption of iron rich foods), knowledge of correct dosage (1/day).

^bWild cluster bootstrapped confidence interval and P value estimates.

that reported providing counselling for IFA and a 22.6 percentage point increase in the share who demonstrated knowledge of correct IFA dosage. Furthermore, use of BCC materials among health care workers was higher in the intervention group at endline, with, for example, those in IG being much more likely than those in the CG to report using a festoon (69.4% vs. 11.1%), a brochure (48.8% vs. 8.9%) or both (86.7% vs. 16.7%). The impact of the programme on other outcomes reported by women and frontline health care workers was not statistically significant after clustering for standard errors. This is in part due to relatively small sample sizes for the frontline health worker survey. However, the coefficient values are consistent with the programme leading to improved service and knowledge. Of note, frontline health care workers reported delivering IPC at much higher rates than women reported receiving IPC.

3.4 | Empirical sensitivity analysis

In robustness checks, the analysis considers alternative thresholds of adherence than the standard 90+ supplements. The programme increased the probability that women reported taking 100+, 120+ and 180+ supplements during their previous pregnancy by 40.3, 42.3 and 15.6 percentage points, respectively. On average, those who increased adherence due to the programme consumed more than 90 supplements at endline. We also show that the programme had a significant impact on the share of women to adhere to the standard of 180+ supplements recommended by the WHO (WHO, 2012).

3.5 | Cost-effectiveness analysis

The total cost of the programme implemented across two districts was \$238 300 (all figures are adjusted for 2018 USD values). This comprised IPC and health promotion material costs including research, modification and production of materials (\$54 187) and frontline health care worker training costs including planning meetings, the review and modification of training materials and the delivery of trainings (\$184 113).

Based on the estimated increase in adherence, the programme is estimated to have averted 5060 DALYs in the programme districts during the programme. This can be broken down to 2875 DALYs averted due to decreases in years lost of life (YLL) and 2185 DALYs averted due to decreases in years lost to disability (YLD). Table 5 further breaks down the DALYs averted, showing that the most significant gains come from decreases in neonatal mortality followed by decreases in maternal mortality. The fewest DALYs averted were attributable to maternal anaemia, which is not surprising since this benefit is only accrued over the relatively short time period in which women consume IFA supplements, whereas other benefits can be accrued from the other health outcomes over the beneficiaries' entire life time.

The cost per expected DALY averted was \$47.11, which falls substantially below both supply-side (\$100 USD 2018 PPP) and

TABLE 5 DALYs averted by health outcome

Health outcome	DALYs averted (expected)	DALYs averted (lower bound) ^a	DALYs averted (upper bound)
Years of life lost (YLL)			
Maternal mortality	1108	-11 887	1637
Neonatal mortality	1767	-3534	5694
Total YLL	2875	-15 421	7331
Years lived with disability (YLD)			
Maternal anaemia	565	436	653
Preterm birth	843	-361	2047
Low birth weight ^b	777	-146	1505
Total YLD	2185	-71	4205
Total DALYs averted	5060	-15 492	11 536

^aSome of the lower bound estimates are negative. This occurs when the upper confidence interval of IFA's effect on a given health outcome is an RR > 1 (see Appendix S1). A negative value can be interpreted as 'gaining' DALYs, rather than 'averting' DALYs.

^bAdjusted for double counting with preterm birth.

demand-side (\$4900 USD 2018 PPP) thresholds for high cost-effectiveness.

3.5.1 | Sensitivity and probabilistic analysis: Cost-effectiveness

The programme remains cost-effective under alternative assumptions around changes in adherence or the addition of IFA supplement costs. For example, given the relatively low costs of the programme, under demand-side cost-effectiveness thresholds, if adherence increased by only 0.45 percentage points (instead of the 40.3 percentage points observed), the programme would remain highly cost-effective. If the cost of IFA supplementation is included in the model, the cost per DALY averted would go from \$47.11 to \$60.79 USD.

4 | DISCUSSION

Bangladesh has had an active IFA supplementation programme in place since 1988 and has seen significant health infrastructure investments by the public and private sectors (UK Department for International Development, PwC, EPPI-Centre, 2017). Despite this, nearly half (45.7%) of all pregnant women remain anaemic (WHO, 2017). Other countries face similar challenges, with many seeing persistent levels of anaemia despite implementing extensive IFA supplementation programmes (WHO & UNICEF, 2018).

Using data from a training programme implemented in Bangladesh from 2012 to 2014, we show that capacity building in through frontline health care worker training significantly increased IFA supplement consumption and adherence during pregnancy. This was accompanied by higher reported implementation and comprehensiveness of IPC following training and increased knowledge of frontline health care workers and women around IFA, which are known to affect consumption (e.g., Sendeku, Azeze, & Fenta, 2020).

Our results highlight the critical importance of strengthening health systems and health care worker capacity. Such activities can be implemented in parallel with the delivery or scale-up of IFA delivery programmes or demand-side interventions. Our findings are consistent with evidence that inadequate skills and training of health care providers are a barrier to adherence (Siekman, Roche, Kung'u, Desrochers, & De-Regil, 2018). They are also consistent with Kavle and Landry (2018), who reviewed the best practices in the community distribution of IFA supplements and recommended interventions that use community health workers to counsel pregnant women on IFA supplementation benefits and dosage and manage supply systems. Such practices are associated with increased maternal supplement consumption (Nguyen et al., 2017).

Although others have considered the impact of similar frontline health care worker training programmes involving IFA supplementation in LMICs, the past studies are generally observational in methodology (Arega Sadore, Abebe Gebretsadik, & Aman Hussen, 2015; Kamau, Mirie, & Kimani, 2018; Phuc et al., 2009). In contrast, the current paper uses a quasi-experimental design, identifying a comparison group to estimate a counterfactual against which the intervention locations can be compared. Such an empirical estimation strategy allows us to estimate the changes in reported IFA supplement consumption and adherence caused by the programme. Of note, this research was conducted in the context of a real-world programme, and therefore, it was not immune to the challenges of implementation, but it offers a more realistic and externally valid insight into the expected impact of such programmes.

We found that the intervention cost \$47.11 USD (2018) per DALY averted, which is highly cost-effective when evaluated against several cost-effectiveness thresholds. This may be an overestimation of the costs (underestimation of the cost-effectiveness) of the programme, if the cost per DALY declines as the programme scales up to new locations. The general results were robust across various scenarios and alternative assumptions. However, our estimates do not incorporate certain decision-making criteria that may be important for policymakers, such as equity, feasibility and affordability.

This study had some limitations. First, there were minor changes in sampling methodologies between baseline and endline; although this is not expected to introduce selection bias, the lack of endline demographic data does allow for a comparison of sample characteristics over time. Second, the cost-effectiveness study used secondary data to predict the likely change in health outcomes, rather than directly measuring changes in health among participants. Third, there was likely survey response and/or recall bias, but the directionality of the bias introduced is unclear. Among women, we expect any response or recall bias to be nondifferential between the intervention and comparison group. There was a discrepancy between health care worker responses and those of women regarding the frequency of IPC, with frontline health care workers systematically reporting providing more IPC than women reported receiving. Possible reasons for this include different perceptions of IPC or frontline health care providers answering affirmatively to appear adequate in their jobs. Fourth, the cut-off for adherence was selected as the consumption of 90 or more IFA supplements in accordance with country standards and the evidence base around the minimum required number of IFA during pregnancy to prevent and control anaemia. However, this implies that those who consumed below this threshold, even if they made statistically significant jumps in consumption, were classified as 'non-adherent'. Anyone above, by any magnitude, was classified as 'adherent'. Even with these limitations, the cost-effectiveness results were highly robust to alternative cost and benefit variables. Investing in frontline health care worker training regarding IFA with focus on use of IPC and BCC is cost-effective.

The WHO, in their updated recommendations for a positive pregnancy experience (2020) noted that a lack of appropriate training of health workers was a barrier to supplementation programmes in LMICs. This research offers promising opportunities to course correct current strategies towards achieving global nutrition targets and strengthen supplementation programmes in LMICs.

5 | CONCLUSION

This study found that health-clinic-level investments in frontline health care worker training are a cost-effective way to help address demand and supply-side barriers to IFA supplement consumption and adherence in Bangladesh, a region with a high burden of anaemia. Future efforts to scale nutrition programming should focus on policy, health-system and health clinic-level investments, including frontline health care worker capacity.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest relevant to this article to disclose.

CONTRIBUTIONS

The manuscript was conceived by ZK, CC, AV and JBH. The paper was written by ZK and CC. AV, JBH and BK reviewed and provided extensive comments and feedback on the analysis and paper. ZK additionally conducted the majority of the analysis and coordinated the research team; CC additionally designed the empirical methodology and was engaged in the analysis; and NM conducted the literature review and assisted in the analysis. All authors read and approved the final manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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