

# The impact of antenatal care on child mortality in Ethiopia: a difference-in-differences analysis

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## Research

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# Abstract

## Background

This article examines the impact of antenatal care on child health outcome. We specifically investigated if women visits to antenatal care services has a positive effect in the reduction of under-five mortality.

## Methods

We employ a difference-in-differences design with propensity score matching to identify direct causal effects of antenatal care on under-five mortality based on the Ethiopian Demographic Health Survey data of 2011 and 2016. Our sample includes 22 295 women between the ages of 14-49 years who have at least one antenatal care visit before delivery (treatment group) or had no antenatal care visit before delivery (control group).

## Results

The study revealed 1 481 cases of reported under-five mortality. 83.7% of that is by women who never had any antenatal care visit while the remaining 16.3% are by women who had at least one antenatal visit during their pregnancy. Antenatal care visit decreases the likelihood of under-five mortality in Ethiopia by 29% (CI = 1.3-56%, P= 0.04).

## Conclusions

To achieve significant reduction in under-five mortality rate, Intervention programs that encourages antenatal care visits should be considered. This will improve child survival and help in attaining sustainable Development Goal target.

## Background

The world has made significant progress in improving child health. Child mortality is one of the key indicators of health status in a country [1]. The international community has come up with several plans to improve child health outcomes and countries have key into these plans with the aim of achieving necessary improvements in health and general well-being of their communities.

Through implementation of comprehensive health development strategies, Ethiopia was able to meet the target of the Millennium Development Goal 4, with under-five mortality rate per 1000 live births decreasing from 205 in 1990 to 67 in 2015 [2, 3]. Despite this remarkable progress, the rate of under-five mortality in the country still ranks among the highest in the world. It is estimated that one in every 15 children still die before reaching their fifth birthday in Ethiopia [4]. This present a challenge to the government in achieving the Sustainable Development Goal which aim at reducing neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births in all countries by 2030 [5].

Antenatal care (ANC) is a maternal health program provided by trained health workers to women who are pregnant. The primary objective of ANC is to identify and monitor pregnant women at high risk early [6]. To promote health outcome for mother and child, ANC offer services such as risk recognition, prevention and control of pregnancy-related diseases and health education [7].

The period of antenatal also afford avenues for providing pregnant women with a variety of interventions that may be critical to their health. Evidence indicates that no nation has succeeded in bringing the maternal mortality ratio below 100 per 100 000 live births without ensuring that all women are attended by an adequately trained health professional during delivery and soon after birth [8].

In Ethiopia, ANC service utilization has improved but large number of women still give birth at home without taking advantage of such services [9–11]. The Ethiopian government has introduced a set of result-oriented measures with the goal of reducing maternal mortality and improving the outcome of child health [12]. Such interventions include Community-based health extension workers and maternity waiting homes where women are temporarily accommodated who are nearing their delivery date and will have difficulty getting to a health facility on time [13].

The importance of ANC for the well-being of the mother and the child after delivery cannot be overemphasized. Several studies have shown ANC to have a positive effect on child mortality reduction [14–18]. However, most of these studies only shows the association between ANC and child mortality. Also, ANC as a determinant of child mortality is strongly related with other socioeconomic and environmental characteristics [19–21], this raises the question about it causal effect of on child mortality. Therefore, this paper contributes to the literature by estimating the impact of ANC on health outcome in Ethiopia between 2011 and 2016. Specifically, we estimated the causal effect of ANC on under-five mortality. We used matching approach in combination with a Difference-in-Difference research design to tackle confounding variables that are linked to both child mortality and ANC.

## Methods

### Data and sample

This study is based on data from the 2011 and 2016 Ethiopian Demographic and Health Survey (EDHS). The EDHS are five-year periodic national representative household surveys that collects retrospective information on a wide variety of health, socio-economic and demographic factors for the population across all region with the aim of improving maternal and child health in Ethiopia. The 2011 and 2016 EDHS used stratified two-stage cluster sampling design to select respondents for the study. Elaborate details of the survey protocols and their deigns have been reported elsewhere [22, 23]. Data were obtained through personal interviews with women in the child-bearing age 15–49 years. The EDHS consist of three components: the household questionnaire, the woman's questionnaire and the man's questionnaire. From the woman's questionnaire, data for child mortality along with related variables were extracted. A total

sample 11 654 children from 2011 survey and 10 641 from 2016 were examined. Information on children were taken from birth history supplied by mothers.

## **Treatment and Outcome**

The health outcomes in our study is under-five child mortality which refers to death of children before reaching the age of five. The information is captured through the full birth's history recalled by the interviewed women and recorded in the surveys. We define treatment as utilisation of antenatal care. Therefore, we have two groups. One group is composed of women who attended at least one ANC, considered as the treatment group. The other group includes women who never attended ANC throughout their pregnancy, known as the control group. The rate of under-five mortality from 2011 to 2016 for the control group will vary due to several possible unknown factors. The variation of this rate at the treatment group will be due to the same factors plus the variation in the utilisation of ANC.

## **Statistical Analysis**

We adapted a two-stage research design to improve comparison between the treated and control groups. First, using propensity score matching, we matched mothers on a number of individual and household characteristics that would affect their likelihood of utilising ANC. Second, we assess the impact of ANC on under-five mortality among those coming from similar households. This minimizes the effects from uncontrolled factors that affect both utilisation of ANC and child health.

Our analyses begin by matching individuals with household characteristics that provide equal probability of utilising ANCs across groups. To this end, we used propensity score matching. Propensity score matching is a statistical technique that seeks to address the primary drawback of causal inferences from observational research designs where no standardized methods have been used to establish control groups [24]. This technique involves forming matched sets of control and treatment individuals who's propensity score are similar [25]. If a matched sample has been established, the treatment effect can be assessed by comparing the outcomes directly between treated and control subjects in the matched sample [26].

The demographic and socio-economic covariates entered into the propensity score includes maternal age, age at first birth, child sex, birth order, birth size, birth interval, family size, residence status, region, wealth index and religion. Women that utilised ANC were matched to women that did not utilised ANC based on a logit regression performed using calipers of width equal to 0.2 and a nearest neighbourhood matching method with ratio of 1:1. We used a Chi-Square test to access the balance for all covariates before and after matching, with a 5% level of significance or more considered indicative of imbalance.

The Difference-in-Differences (DID) method was used to analyse the effect of ANC on under-five mortality. The DID is a quasi-experimental approach that compares outcome changes over time between a group involved in intervention (treatment group) and a group that is not (control group) [27]. While the DID method typically uses panel data to estimate the causal impact of policies or programmes, repeated cross-sectional data from the same areas has also been used in the literature [28–30].

We apply the DID method using the linear probability model:

$$Y_{it} = \beta_0 + \beta_1 Treatment_i + \beta_2 Time_t + \beta_3 (Treatment_i * Time_t) + \beta_4 X_i + \beta_5 Z_i + \varepsilon_{it}$$

To enable us to estimate the differences in under-five mortality for treatment and control groups. Where,  $Y_{it}$  refers to the binary indicator whether child  $i$  born in year  $t$  died or not prior to reaching the age of five (under-five mortality). The variable  $Treatment_i$  is a dummy with 1 indicating mother had ANC and 0 otherwise. The variable  $Time_t$  is also a dummy variable coded 0 for 2011 and 1 for 2016. The DID estimate  $\beta_3$  of effect of ANC, is an interaction between Treatment and Time. The vector  $X_i$  is a vector of variables controlled by propensity score matching and  $Z_i$  is a vector of additional covariates to adjust for the remaining imbalance from our matching procedure. To account for the complexity of the survey design, the primary sampling unit, strata and person weight were incorporated in the regression models to adjust for the standard error. All statistical analysis were carried out using SAS version 9.4.

## Results

### Descriptive of the study data

The crude rates of under-five mortality in 2011 and 2016 are shown in Table 1. Women in the control group who did not use ANC services in 2011 showed relatively little difference in the rates of under-five mortality when compared with 2016. In 2011 the control group's under-five mortality rate was 8.2 (CI = 7.6–8.8%), compared with 7.9% (CI = 7.9–9.3%) in 2016. However, there has been a substantial rise in the under-five mortality rate within the treatment group. In 2011 the treatment group's under-five mortality rate was 4.6 (CI = 3.8–5.4%) compared with the 2.7% (CI = 2.3–3.4%) in 2016.

Table 1  
Under-five mortality rates by treatment and control groups in 2011 and 2016

	2011			2016		
	Number of non-ufm	Number of ufm	% Ufm (95% CI)	Number of non-ufm	Number of ufm	% Ufm (95% CI)
Treatment	2782	133	4.6% (3.8–5.4%)	3857	109	2.7% (2.3–3.4%)
Control	8026	713	8.2% (7.6–8.8%)	6149	526	7.9% (7.9–9.3%)

### Propensity score matching result

The propensity score matching produced a matched sample of 10 992 births. Table 2 contrasts the demographic characteristics of women that with ANC visits and women that did not, before and after

propensity score matching. Prior to matching, all the baseline characteristics showed no significant difference (p-value < 0.05) in under-five mortality between the treatment and control group, with the exception of sex of child which already had a significant difference (p = 0.234) in under-five mortality between the two group prior to matching.

Table 2

Descriptive characteristics of women before and after propensity score matching

Characteristic	% Before matching		P-value	% After matching		P-value
	No n = 14980	Yes n = 7315		No n = 5496	Yes n = 5496	
<b>Health professional gave prenatal care</b>						
<b>Maternal age</b>			< 0.001			0.986
15–24 Years	22.8	27.8		27.0	27.3	
25–29 Years	30.4	30.7		29.7	29.7	
30–34 Years	21.7	20.2		20.3	20.2	
35–39 Years	16.3	14.3		15.4	15.0	
40 + Years	8.9	7.0		7.7	7.8	
<b>Age of respondent at time of first birth</b>			< 0.001			0.074
17 years or less	40.5	34.1		38.6	37.5	
18–24 Years	52.8	55.2		54.1	54.0	
25 years or more	6.8	10.7		7.3	8.4	
<b>Sex of child</b>			0.234			0.462
Male	51.7	50.9		51.2	51.1	
Female	48.3	49.1		48.8	48.9	
<b>Birth order</b>			< 0.001			0.215
First birth	17.3	26.3		22.0	22.3	
2, 3 or 4	43.4	45.7		43.5	44.8	
5 and more	39.3	28.0		34.4	32.9	
<b>Birth size</b>			< 0.001			0.417
Larger than average	29.4	30.5		31.0	30.7	
Average	40.2	43.3		42.0	41.3	

	% Before matching		% After matching		
Smaller than average	30.4	26.2	26.9	28.0	
<b>Birth interval</b>					0.872
					< 0.001
First birth	17.3	26.6	22.2	22.4	
7–18 Months	10.8	5.7	6.7	6.7	
19–36 Months	42.1	28.7	33.0	33.5	
36 Months or more	29.7	38.9	38.1	37.4	
<b>Family size</b>					0.311
					< 0.001
At most 4	22.3	37.8	30.1	31.5	
4–7	50.4	43.6	47.7	47.0	
8 or more	27.3	18.6	22.1	21.5	
<b>Residence status</b>					0.092
					< 0.001
Urban	9.1	37.2	21.9	23.3	
Rural	90.9	62.8	78.1	76.7	
<b>Region</b>					0.270
					< 0.001
Tigray	7.8	15.1	14.3	14.6	
Affar	11.2	6.8	8.3	7.7	
Amhara	10.2	10.3	11.7	11.6	
Oromia	17.1	10.3	12.7	12.4	
Somali	13.5	6.5	9.0	7.9	
Benishangul-Gumuz	9.2	7.1	8.1	8.3	
Southern Nations, Nationalities and Peoples	14.3	10.1	11.7	12.1	
Gambela	6.6	8.0	8.1	8.2	
Harari	4.7	7.9	6.8	6.6	
Addis Ababa	1.2	9.9	3.2	3.9	
Dire Dawa	4.5	8.0	6.1	6.8	

	% Before matching		% After matching		
<b>Wealth index</b>					
					< 0.001
Poor	60.1	32.7	42.4	40.6	0.168
Middle	15.9	13.0	15.6	15.9	
Rich	24.0	54.3	42.1	43.5	
<b>Religion</b>					
					< 0.001
Muslim	52.9	39.8	44.5	43.3	0.632
Orthodox	24.6	42.3	35.9	36.7	
Protestant	19.3	16.4	18.0	18.3	
Others	3.3	1.5	1.6	1.7	

After the propensity score matching, all characteristics showed a significant ( $P > 0.05$ ) difference in under-five mortality between the treatment and control group, suggesting that the between-group differences in the observed characteristics were significantly reduced by propensity score matching approach.

## DID estimation results

Table 3 summarizes the main outcome of the DID analysis. We considered three variation of the regression model stated in the method section to test the robustness of our result. For the first model in Table 3, no covariate was added. In the second model we added the covariates that were used in the propensity score matching. As expected, estimates in the first and second model were very similar, it shows that the effect of the covariates used in the matching were substantially removed. For the third model we added other birth-related covariates such as; post-delivery care, single or multiple birth, place of delivery and breastfeeding status. The third model is our choice model because it adjusts for the imbalance between the treatment and control group that may remain after propensity score matching. The estimates in the model suggest that being a mother using ANC services reduces the likelihood of the incidence of under-five mortality by 28.7% (CI = 1.3–56%,  $P = 0.04$ ).

Table 3  
Difference-in-differences regression results for the impact of antenatal care visits on under-five mortality

Model	Estimate	95% CI		t	P-value
		Lower	Upper		
With no covariate	-0.136	-0.261	-0.011	-2.14	0.033
With matched covariates	-0.141	-0.271	-0.011	-2.13	0.034
With additional covariates	-0.287	-0.560	-0.013	-2.05	0.040

## Discussion

Using data from large nationally representative demographic and health surveys, we investigated the impact of ANC visits on child health outcome, specifically under-five mortality. The rate of under-five mortality in the study dropped from 7.3% in 2011 to 6.0% in 2016. In the same period, the rate of women who had at least one ANC visit during their pregnancy increased from 25.0–37.3%. Based on a DID model, we present evidence that 28.7% of the decrease in under-five mortality was as a result of ANC visits.

This is, to the best of our knowledge, one of the first studies investigating the causal impact of ANC visits on under-five mortality. However, several cross-sectional studies have associated increased number of ANC visits to significant decrease in child mortality [31–33]. In particular, Jana Kuhnt and Sebastian Vollmer [34], used national representative health and welfare data from 193 Demographic and Health Surveys conducted between 1990 and 2013 to investigate the implication of antenatal care on health outcome of children. They found using linear probability regression that at least one ANC visit was associated with 1.04% decrease in risk of neonatal mortality and a 1.07% decrease in risk of infant mortality. Another cross-sectional study in Bangladesh by Tanvir et al [35] used multivariate logistic regression to analysis three demographic health surveys, also found odds of under-five mortality to be lower for women with ANC visits. Malachi et al. [36], investigated the effectiveness of antenatal care services in reducing neonatal mortality in Kenya. Their findings using a binary logistic regression shows the lowest odds of neonatal mortality to belong to mothers who attended ANC visits.

The Ethiopian government has been putting up measures to improve maternal and child health outcome such as providing free health care service for the poor, creating ANC centres across the country and making primary health care accessible for all [12, 37]. Past studies in Ethiopia has identified factors such as urban residence, higher educational attainment, wealth, perceived good quality of maternal health services and exposure to mass media to be significantly associated with increased ANC visit [38–40].

## Strengths and limitations

One major strength of this study is the use of national representative data. Although this was not a randomized control trial, the use of repeated cross-sectional survey from the same sample frame can be used to obtain causal inference [41]. The double approach we employed ensures that bias is reduced to the minimum by matching the treatment to the control to be similar before applying the quasi-experimental study design for causal inference. The finding of this study will assist policy makers to see the true impact of ANC visits on under-five mortality. That will guide in intensifying the advocacy of ANC.

The DID approach relies on the assumption that there were no important unmeasured characteristics of individuals that could affect the outcome based on differences between the treatment and control group [42]. As mentioned above we reduced possible bias to the minimum by using a double approach, but we cannot completely rule out unmeasured characteristics. Although our selection of characteristics was informed through careful study of literatures. Another limitation is the quality of data. As peculiar with must national surveys there will be the presence of missingness in the data. This problem was addressed using multiple imputation. This technique is efficient where data are missing at random, and we ensured that the imputed values were predictive of the missing values. There was no significant difference in our results before and after the imputation.

## **Conclusion**

In this paper, we examined the effects of antenatal care on under-five mortality using propensity score matching and difference-in-difference logistic regression analysis. We found evidence to suggest that ANC visits have causal impact on under-five mortality and are highly effective in decreasing it rate. Intervention programs that encourages ANC visits should be considered if meaningful progress is to be achieved in the reduction of under-five mortality and realization of the sustainable Development Goal by 2030.

## **Declarations**

### **Ethical consideration**

The original EDHS data were collected in conformity with international and national ethical guidelines. Ethical clearance for the original survey was provided by the Ethiopian Public Health Institute Review Board, the National Research Ethics Review Committee (NRERC) at the Ministry of Science and Technology, the Institutional Review Board of ICF International and the Centers for Disease Control and Prevention (CDC). The data for this study were downloaded and used after the purpose of the analysis was communicated and approved by the Measure DHS.

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**Availability of data and materials**

The dataset supporting the conclusions of this article is available in the IDHS repository

<https://www.idhsdata.org/idhs-action/menu>

### Authors' contributions

OS acquired the data, performed the analysis, and drafted the manuscript. OS, TZ, and DN designed the research problem. All authors worked together in discussing the results and appropriate implications of the result. All authors contributed in design of the manuscript. All authors contributed extensively to the work presented in this paper, read and approved the final manuscript.

**Consent for publication:** Not applicable

**Competing interests:** The authors declare that they have no competing interests.

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