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Effects of short birth interval on neonatal, infant and under-five child mortality in Ethiopia: a nationally representative observational study using inverse probability of treatment weighting

Desalegn Markos Shifti ,[1,2] Catherine Chojenta,[2] Elizabeth Holliday ,[3] Deborah Loxton[2]

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For numbered affiliations see end of article.

Correspondence to
Desalegn Markos Shifti;
desalegnmarkos@gmail.com

ABSTRACT

Objective To assess the effect of short birth interval (SBI) on neonatal, infant, and under-five mortality in Ethiopia.

Design A nationally representative cross-sectional survey.

Setting This study used data from the Ethiopia Demographic and Health Survey 2016.

Participants A total of 8448 women who had at least two live births during the 5 years preceding the survey were included in the analysis.

Outcome measures Neonatal mortality (death of the child within 28 days of birth), infant mortality (death between birth and 11 months) and under-five mortality (death between birth and 59 months) were the outcome variables.

Methods Weighted logistic regression analysis based on inverse probability of treatment weights was used to estimate exposure effects adjusted for potential confounders.

Results The adjusted ORs (AORs) of neonatal mortality were about 85% higher among women with SBI (AOR=1.85, 95% CI=1.19 to 2.89) than those without. The odds of infant mortality were twofold higher (AOR=2.16, 95% CI=1.49 to 3.11) among women with SBI. The odds of under-five child mortality were also about two times (AOR=2.26, 95% CI=1.60 to 3.17) higher among women with SBI.

Conclusion SBI has a significant effect on neonatal, infant and under-five mortality in Ethiopia. Interventions targeting SBI are warranted to reduce neonatal, infant and under-five mortality.

Strengths and limitations of this study

- The application of inverse probability of treatment weighting (IPTW) mimics a randomised controlled trial by matching two comparison groups using a conditional probability of receiving exposure (short birth interval in this case) given a set of covariates.
- The study has also additional strengths, such as using data from a nationally representative survey with a large sample size.
- The application of direct acyclic graphs, a graphical tool used to identify minimum adjustment sets, which defined the set of explanatory variables for the propensity scores model was another strength of this study.
- Due to the cross-sectional nature of the study, temporal associations between short birth interval and neonatal, infant and under-five mortality may not be established.
- Another limitation of our study could be associated with the non-randomised design of the study. Although a propensity score-based analysis, IPTW, was used in our study, it may not account for unknown confounders in the same way that a randomised trial can, so the effect of residual confounders may not be avoided.

INTRODUCTION

Short birth interval (SBI), defined as a birth-to-birth interval of less than 33 months,[1] is a key public health problem with an estimated prevalence of 45.8% in Ethiopia.[2] Previous studies[2–4] have revealed the multifactorial nature of SBI, its spatial variation and socioeconomic inequality in Ethiopia. Only about one-third of women in Ethiopia use modern contraceptives, which can prevent SBI.[5] Literature has also shown the effects of SBI may include, but are not limited to, preterm birth,[6 7] low birth weight,[6 7] small sizes for gestational age,[6] congenital anomalies,[8 9] autism,[10] miscarriage, pre-eclampsia and premature rupture of membranes.[11 12]

Neonatal, infant and under-five mortality are defined as the death of a child within 28 days of birth, before the age of 1 year, and before 5 years, respectively.[5] These mortality outcomes are regarded as a highly sensitive (proxy) measure of population health, a

country's poverty and socioeconomic development status, and the availability and quality of health services and medical technology.[13 14]

The Sustainable Development Goal (SDG) 3.2 states that all countries should aim to reduce the neonatal mortality rate to 12 deaths per 1000 live births or fewer, and reduce under-five mortality to 25 deaths per 1000 live births or fewer, by 2030.[15] The Growth and Transformation Plan of Ethiopia (GTPE) II also targets reductions in neonatal, infant and under-five mortality rates, from 28 per 1000 live births, 44 per 1000 live births and 64 per 1000 live births in 2014/2015 to 10, 20 and 30 per 1000 live births by 2019/2020, respectively.[16] However, the 2019 Ethiopia Mini Demographic and Health Survey report revealed that the neonatal, infant and under-five mortality rates in Ethiopia were 30, 43 and 55 deaths per 1000 live births, respectively: still much higher than GTPE targets.[16 17]

Literature from Ethiopia has shown that neonatal, infant and under-five mortality are associated with maternal education,[18 19] lack of antenatal care,[20] home delivery,[21] preterm birth,[20 22] low birth weight,[21 22] multiple births,[18 20 23 24] sex of the child,[18 20 23–26] wealth status,[27 28] place of residence,[21 24 25] sources of drinking water,[28] and lack of access to an improved toilet facility.[29]

Although previous studies[18–20 24 25 28–32] have suggested birth interval as one factor influencing neonatal, infant, under-five mortality, these studies have several limitations. Of the key limitations is that these studies[18–20 24 25 28–32] did not use the WHO recommended[1] definition of SBI. Understanding the impact of SBI on neonatal, infant and under-five mortality, using the WHO definition,[1] is necessary for the formulation of valid, consistent policies and health planning strategies and interventions to improve child health outcomes. Second, women who were not eligible to provide birth interval information (ie, those who had given birth only once) were included in the analysis of some studies.[20 25 29] This may result in underestimation or obscuration of the true effect of birth interval on child mortality. Third, even among studies using the same definition of SBI, findings have been inconsistent.[20 25] One of the studies using national data[20] did not control for a range of potential confounders including maternal education, wealth status, number of children and region of residence, even though these data were available in the datasets used for analysis. Similarly, another previous study[30] that used national data did not condition on maternal occupation, husband education, husband occupation, the total number of preceding children, regions, access to mass media and women's decision-making autonomy. In addition, various studies did not consider SBI as a potential predictor of neonatal,[22 26 27 33–36] infant,[19 37 38] and under-five mortality[39–42] in their analysis.

Generally, the effect of SBI, as per the most recent WHO recommendation,[1] on neonatal, infant and under-five mortality has not been investigated in Ethiopia. Evidence regarding the effect of SBI is required for informed decision-making by policymakers and health programme planners. This paper aimed to assess the effect of SBI on neonatal, infant and under-five mortality using the most recent WHO definition and adjusting for a comprehensive set of potential confounders.

METHODS

Study design and study area

This analysis used data from the Ethiopia Demographic and Health Survey (EDHS) 2016. The EDHS is a nationally representative cross-sectional study conducted in nine geographical regions (Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples' region, Gambela and Harari) and two administrative cities (Addis Ababa and Dire Dawa). A two-stage, stratified, clustered random sampling design was employed to collect data from women who gave birth within the 5 years preceding the survey. Further descriptions of the sampling procedure for the EDHS are presented elsewhere.[5] A total of 8448 women who had at least two live births during the 5 years preceding the 2016 survey were included in the analysis. When women had more than two births in the 5 years preceding the survey, the birth interval between the most recent index child and the immediately preceding child was considered for all the study participants.

Variables

Outcome variables

The outcome variables in the current study were neonatal mortality (death of the child within 28 days of birth), infant mortality (death between birth and 11 months) and under-five mortality (death between birth and 59 months).[5 43] These outcomes were coded as binary variables (1/0).

Treatment/exposure variable

SBI was the treatment variable and was defined as a birth-to-birth interval of less than 33 months as per the WHO definition.[1] A preceding birth interval, the amount of time between the birth of the child under study (index child) and the immediately preceding birth, was considered in this study. Women's birth interval data were collected by extracting the date of birth of their biological children data from the children's birth/immunisation certificate, and/or asking for information regarding their children's date of birth from the women. Mothers were asked to confirm the accuracy of the information before documenting children's date of birth from children's birth/immunisation certificates. This crosschecking was performed to avoid errors, since in some cases the documented birth date may represent the date when the birth was recorded, rather than the actual birth date. In the absence of children's birth certificates, information regarding children's date of birth was obtained from their mothers. Further information regarding birth interval data collection is provided elsewhere.[2 3 44]

Control variables

After reviewing relevant literature,[2 18–21 23–25 28 29 39 45 46] direct acyclic graphs (DAGs) were constructed using DAGitty V.3.0[47] to identify confounders for the association between SBI and neonatal, infant and under-five child mortality. Adjustment for such confounders is necessary to estimate the unbiased effect of SBI on neonatal, infant and under-five mortality (figure 1). DAG is a formal system of mapping variables and the direction of causal relationships among them.[48 49] This graphical representation of causal effects among variables helps understand whether bias is potentially reduced or increased when conditioning on covariates. Moreover, it illustrates covariates that lie in the causal pathway between the treatment and outcomes, which should not be included in the analysis as a confounder. These variables are indicated by green lines in figure 1. This is because a propensity score (PS) that includes covariates affected by the treatment (ie, variables on the causal pathway between treatment and outcome) obscures part of the treatment effect that one is trying to estimate.[50] Identified confounders were maternal age at the birth of the index child, maternal education, maternal occupation, husband's education, husband's occupation, household wealth status, survival status of the preceding child, the total number of the preceding child, place of residence (urban/rural), regions, access to media and decision-making autonomy. A list of all variables considered in the DAG is provided in online supplemental material I.

A yellowish-green circle with a triangle at its centre indicates the main treatment/exposure variable, a blue circle with a vertical bar at its centre indicates the outcome variable, light red circles indicate ancestors of exposure and outcome (ie, confounders). Blue circles indicate the ancestors of the outcome variable. Green lines indicate a causal pathway. Red lines indicate open paths by which confounding may occur; this confounding can be removed by adjusting for one or several variables on the pathway.

Data analyses

Participants' characteristics were described using frequency with per cent. P values were calculated using Pearson's $\chi 2$ test. Given that the outcomes (ie, neonatal, infant and under-five mortality) were relatively infrequent, the unbiased effect of SBI on each outcome was estimated using PSs with a stabilised method of inverse probability of treatment weighting (IPTW). A previous study[51] has shown that IPTW with stabilised weights preserves the sample size of the original data, provides an appropriate estimation of the variance of the main effect and maintains an appropriate type I error rate. The other methods, such as IPTW with normalised weight and greedy algorithm with 1:1 matching methods, are discussed elsewhere.[52–54] A PS is defined as the probability of treatment assignment given observed baseline covariates (described in online supplemental material II).[54] PSs are used to estimate treatment effects on outcomes using observational

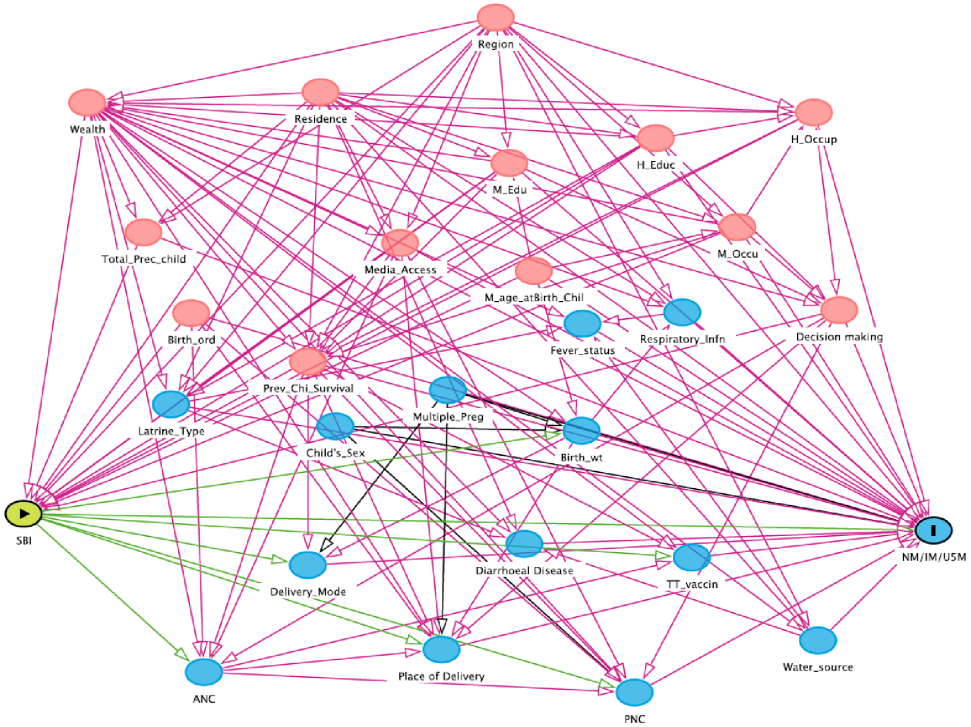

Figure 1 Direct acyclic graph used to select controlling variables. ANC, antenatal care; Birth_ord, birth order; Birth_wt, birth weight; H_Educ, husband education; H_Occup, husband occupation; IM, infant mortality; M_age_atBirth_chil, maternal age at birth of the index child; M_Edu, maternal education; M_Occu, maternal occupation; Multiple_preg, multiple pregnancy; NM, neonatal mortality; PNC, postnatal care; Prev_Chi_Survival, previous child survival; Respiratory_infn, respiratory infection; SBI, short birth interval; Total_Prec_child, total number of preceding child; TT_vaccin, tetanus toxoid vaccination status; U5M, under-five mortal.

data when confounding bias due to non-random treatment assignment is likely.[50] IPTW weights the entire study sample by the inverse of the PS[55]; a differential amount of information is used from each participant, depending on their conditional probability of receiving treatment. This means observations are less likely to be lost than when using matching for confounder adjustment.[56 57] PSs are a robust alternative to covariate adjustment when the outcome variable is rare, resulting in data sparsity and estimation issues in multivariable models.[57] In this study, the weighted prevalence of the outcome variables of neonatal, infant and under-five mortality were 2.9% (95% CI=2.39% to 3.61%), 4.8% (95% CI=4.11% to 5.58%) and 5.5% (95% CI=4.73% to 6.44%), respectively.

The analysis procedure was as follows. First, the PS was estimated using a logistic regression model in which treatment assignment (SBI vs non-SBI) was regressed on the 11 covariates identified using the DAG. The balance of measured covariates/confounders was then assessed across treatment groups (ie, women with SBI) and comparison groups (ie, women with non-SBI) before and after weighting, by computing standardised differences (online supplemental material II).[57 58] For a continuous covariate, the standardised difference[58 59] is defined as:

$$d = \frac{(\bar{x}_{\text{treatment}} - \bar{x}_{\text{control}})}{\sqrt{\frac{s^2_{\text{treatment}} + s^2_{\text{control}}}{2}}}$$

where $\bar{x}_{\text{treatment}}$ and $\bar{x}_{\text{control}}$ denote the sample mean of the covariate in treated and untreated subjects, respectively and $s^2_{\text{treatment}}$ and $s^2_{\text{treatment}}$ denote the corresponding sample variances of the covariate. The standardised difference[58 59] for a dichotomous variable is given as:

$$d = \frac{(\hat{p}_{\text{treatment}} - \hat{p}_{\text{control}})}{\sqrt{\frac{\hat{p}_{\text{treatment}}\,(1 - \hat{P}_{\text{treatment}}) + \hat{p}_{\text{control}}\,(1 - \hat{p}_{\text{control}})}{2}}}$$

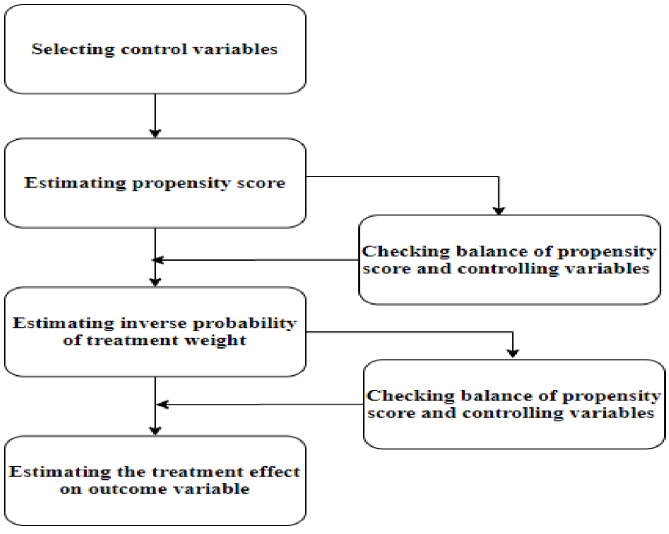

Figure 2 Schematic presentation of the overall steps followed in the analysis.

where $\hat{p}_{\text{treatment}}$ and $\hat{p}_{\text{control}}$ denote the prevalence of the dichotomous variable in treated and untreated subjects, respectively.

A standard difference <0.1 has been suggested as indicating a negligible difference in the mean or prevalence of a covariate between treatment and control groups and was used here.[58] In addition, kernel densities were plotted to graphically demonstrate the PS balance in the treatment group (ie, women with SBI) and control groups (women with non-SBI). Balance in PSs was considered to be achieved when the kernel density line for the treatment group and control group lay closer together.[60] The IPTWs was then calculated as 1/PS for those exposed to SBI and 1/(1–PS) for those who were not. The sample was then reweighted by the IPTW and the balance of the covariates checked in the reweighted sample.[50 61] Stabilisation of weights was made to preserve the sample size of the original data, reduce the effect of weights of either treated subjects with low PSs or untreated subjects with high PSs, and improve the estimation of variance estimates and CIs for the treatment effect.[51] Since the EDHS employed a two-stage, stratified, clustered random sampling, which is a complex sampling procedure, sampling weights were also used to adjust for the non-proportional allocation of sample participants to different regions, including urban and rural areas, and consider the possible differences in response rates.[5] Finally, a weighted logistic regression was fit to estimate the effect of the treatment (SBI) on each outcome variable (neonatal, infant and under-five mortality). Estimation of the treatment effect on outcome variables in the final model used the grand weight, which was formed as the product of the survey weight and the stabilised weight. Literature has shown that combining a PS method and survey weighting is necessary to estimate unbiased treatment effects which are generalisable to the original survey target population.[62] The treatment effect on the outcome variables was expressed as adjusted ORs (AORs) with a 95% CI. Statistical analysis was performed using Stata V.14 statistical software (StataCorp Stata Statistical Software: Release V.14. College Station, Texas: StataCorp LP 2015). Figure 2 presents a schematic summary of the overall analysis procedure.

Patient and public involvement

Patients and/or the general public were not involved in the design, or conduct or drafting of this secondary analysis.

RESULTS

Respondents' characteristics

Table 1 illustrates the baseline characteristics of the study participants. The occurrence of neonatal mortality differed with maternal age at birth, with mortality rates being higher among mothers aged ≥35 (p=0.021). Neonatal mortality was also higher in rural than in urban areas (p=0.004). Similarly, infant mortality and under-five mortality were somewhat higher in rural areas (p<0.001). Under-five mortality was higher among uneducated mothers (p=0.027) and in mothers without access to mass

Table 1 The weighted distribution of neonatal, infant and under-five child mortality by background characteristics, EDHS 2016

Variable	Neonatal mortality			Infant mortality			Under-five Mortality		
	No (%)	Yes (%)	P value	No (%)	Yes (%)	P value	No (%)	Yes (%)	P value
Maternal age at the birth of the index child (in years)									
≤19	291 (3.2)	17 (5.8)	0.021	283 (3.1)	25 (6.5)	0.065	280 (3.1)	28 (6.0)	0.068
20–24	1950 (23.4)	52 (18.8)		1896 (23.2)	106 (23.7)		1877 (23.3)	125 (23.0)	
25–29	2587 (30.8)	67 (26.0)		2536 (30.8)	118 (27.6)		2516 (30.8)	138 (27.4)	
30–34	1836 (22.7)	59 (22.6)		1802 (22.9)	93 (21.0)		1781 (22.7)	114 (22.9)	
≥35	1533 (19.9)	56 (26.8)		1515 (20.0)	74 (21.2)		1500 (20.1)	89 (20.7)	
Maternal education									
Uneducated	5890 (73.9)	182 (75.0)	0.859	5759 (73.8)	313 (75.9)	0.157	5694 (73.9)	378 (75.5)	0.027
Primary	1744 (22.0)	54 (19.7)		1715 (22.0)	83 (20.8)		1704 (22.0)	94 (21.1)	
Secondary+	563 (4.1)	15 (5.3)		558 (4.2)	20 (3.3)		556 (4.1)	22 (3.4)	
Maternal occupation									
Not employed	5935 (72.9)	178 (74.6)	0.604	5807 (72.9)	306 (73.2)	0.575	5747 (72.9)	366 (73.6)	0.376
Employed	2267 (27.1)	73 (25.4)		2225 (27.1)	110 (26.8)		2207 (27.1)	128 (26.4)	
Husband education									
Uneducated	4186 (49.9)	145 (53.2)	0.092	4104 (50.0)	227 (50.1)	0.346	4057 (50.0)	274 (49.0)	0.154
Primary	2482 (37.3)	69 (34.6)		2437 (37.3)	114 (36.2)		2416 (37.3)	135 (37.1)	
Secondary+	1529 (12.8)	37 (12.2)		1491 (12.7)	75 (13.7)		1481 (12.7)	85 (13.9)	
Husband occupation									
Not employed	873 (7.7)	22 (6.6)	0.339	846 (7.6)	49 (7.7)	0.421	838 (7.6)	57 (7.4)	0.482
Employed	7324 (92.3)	229 (93.4)		7186 (92.4)	367 (92.3)		7116 (92.4)	437 (92.6)	
Wealth									
Poorest	3238 (25.4)	109 (15.6)	0.248	3163 (25.3)	184 (21.5)	0.015	3118 (25.3)	229 (22.2)	<0.001
Poorer	1430 (23.4)	48 (22.5)		1400 (23.4)	78 (22.2)		1390 (23.5)	88 (21.3)	
Middle	1167 (21.1)	36 (22.8)		1147 (21.3)	56 (20.0)		1136 (21.2)	67 (20.7)	
Richer	1025 (17.8)	30 (24.8)		1000 (17.7)	55 (23.3)		993 (17.6)	62 (23.7)	
Richest	1337 (12.3)	28 (14.3)		1322 (12.3)	43 (13.0)		1317 (12.3)	48 (12.1)	
Total number of preceding child									
≤2	2627 (31.0)	57 (27.0)	<0.001	2591 (31.0)	93 (27.1)	<0.001	2575 (31.1)	109 (26.4)	<0.001
3–4	2561 (30.6)	77 (22.0)		2505 (30.7)	133 (23.6)		2482 (30.7)	156 (24.6)	
≥5	3009 (38.4)	117 (50.9)		2936 (38.2)	190 (49.3)		2897 (38.2)	229 (49.0)	
Residence									
Urban	1264 (8.8)	22 (12.0)	0.004	1251 (8.9)	35 (8.7)	<0.001	1248 (9.0)	38 (7.7)	<0.001
Rural	6933 (91.2)	229 (88.0)		6781 (91.1)	381 (91.3)		6706 (91.0)	456 (92.3)	
Region									
Tigray	765 (6.0)	23 (6.1)	0.516	762 (6.1)	26 (4.1)	0.145	752 (6.1)	36 (5.3)	0.039
Afar	808 (1.0)	20 (0.7)		779 (1.0)	49 (1.2)		762 (1.0)	66 (1.4)	
Amhara	774 (18.7)	26 (22.2)		765 (18.8)	35 (17.9)		761 (18.9)	39 (17.2)	
Oromia	1270 (44.7)	37 (45.5)		1245 (44.6)	62 (47.9)		1235 (44.6)	72 (47.1)	
Somali	1231 (5.0)	52 (6.3)		1210 (4.9)	73 (5.4)		1203 (4.9)	80 (5.1)	
Benishangul-Gumuz	711 (1.1)	24 (1.0)		690 (1.1)	45 (1.3)		682 (1.1)	53 (1.4)	
SNNPR	1021 (21.2)	23 (16.0)		995 (21.1)	49 (20.4)		987 (21.1)	57 (20.9)	
Gambella	541 (0.2)	16 (0.2)		531 (0.2)	26 (0.2)		522 (0.2)	35 (0.2)	
Harari	443 (0.2)	13 (0.2)		429 (0.2)	27 (0.2)		427 (0.2)	29 (0.2)	
Addis Ababa	246 (1.5)	6 (1.2)		245 (1.5)	7 (1.0)		245 (1.5)	7 (0.8)	
Dire Dawa	387 (0.4)	11 (0.4)		381 (0.4)	17 (0.4)		378 (0.4)	20 (0.4)	

Continued

Table 1 Continued

Variable	Neonatal mortality No (%)	Neonatal mortality Yes (%)	P value	Infant mortality No (%)	Infant mortality Yes (%)	P value	Under-five Mortality No (%)	Under-five Mortality Yes (%)	P value
Access to mass media									
Yes	1408 (15.8)	36 (23.2)	0.240	1383 (15.9)	61 (20.2)	0.177	1376 (15.9)	68 (19.0)	0.043
No	6789 (84.2)	215 (76.8)		6649 (84.1)	355 (79.8)		6578 (84.1)	426 (81.0)	
Decision-making autonomy									
Yes	6014 (77.7)	179 (74.9)	0.469	5898 (77.8)	295 (73.8)	0.258	5848	345	0.072
No	2183 (22.3)	72 (25.1)		2134 (22.2)	121 (26.2)		2106	149	

EDHS, Ethiopia Demographic and Health Survey; SNNPR, Southern Nations, Nationalities, and Peoples' Region.

media (p=0.043). Mortality at all ages was higher among infants with at least five siblings (p<0.0001). Both infant and under-five mortality were slightly higher among women from the richer household

Balance diagnostics

PS balance

Figure 3 presents the density plot of women in the treatment group (dashed lines) and the control group (solid lines) before and after weighting. It reveals that an adequate balance of the PS distribution between the treatment groups after weighting (figure 3).

Covariate balance

After weighting adjustment, standardised differences of covariates were all <0.1 (10%), showing comparability between women with and without SBI (online supplemental material II).

Treatment effect estimation

The prevalence of SBI in Ethiopia was 45.8% (95% CI=42.91% to 48.62%). Table 2 presents the estimated effects of SBI on neonatal, infant and under-five mortality. The adjusted estimated odds of neonatal mortality were 85% higher among women who experienced SBI (AOR=1.85, 95% CI=1.19 to 2.89) than those who did not. Similarly, the odds of infant mortality were two times higher (AOR=2.16, 95% CI=1.49 to 3.11) among women who experienced SBI compared with women who did not. The odds of under-five child mortality were two times (AOR=2.26, 95% CI=1.60 to 3.17) higher among women who were exposed to SBI compared with women who were not.

DISCUSSION

To our knowledge, this study provides the first comprehensive evidence regarding the effect of SBI on neonatal,

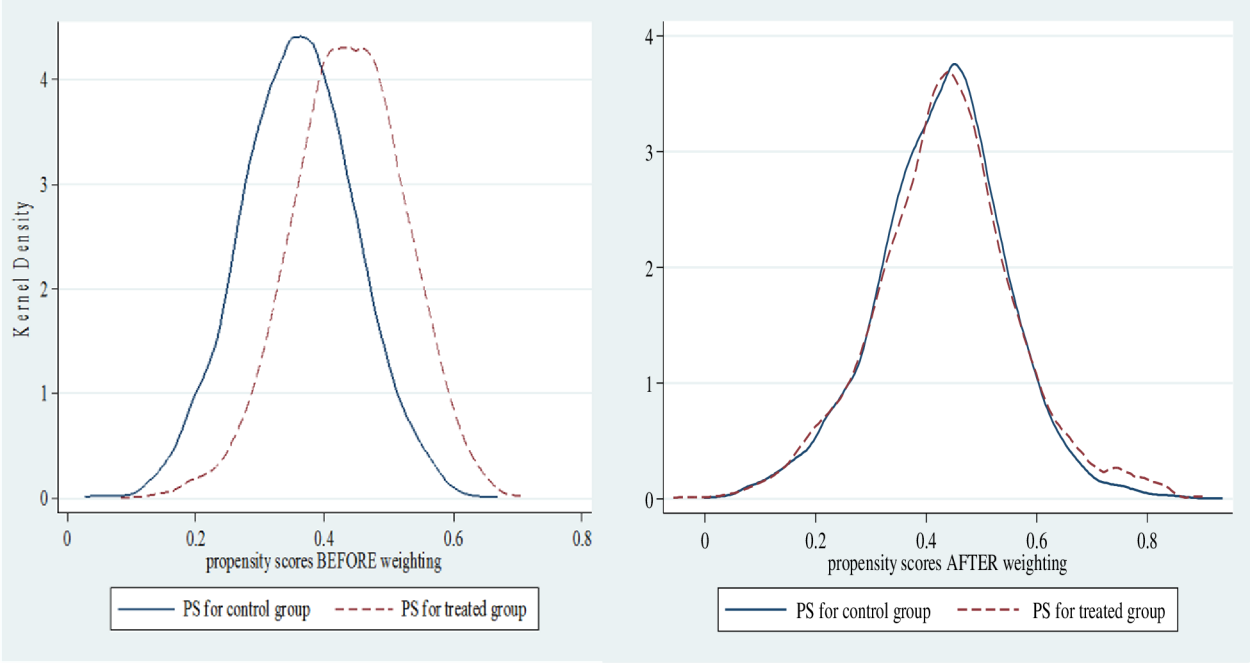

Figure 3 Balance of propensity scores (PS) before and after weighting across treatment and comparison groups.

Table 2 The effect of short birth interval on neonatal, infant and under-five mortality in Ethiopia, EDHS 2016

Treatment variable	Neonatal mortality		
	No (%)*	Yes (%)*	AOR (95% CI)
Short birth interval			
No	4166 (54.5)	95 (46.1)	Ref
Yes	4031 (45.5)	156 (53.9)	1.85 (1.19 to 2.89)
Short birth interval	**Infant mortality**		
	No (%)	Yes (%)	
No	4126 (54.9)	135 (40.5)	Ref
Yes	3906 (45.1)	281 (59.5)	2.16 (1.49 to 3.11)
Short birth interval	**Under-five mortality**		
	No (%)	Yes (%)	
No	4099 (55.1)	162 (39.3)	Ref
Yes	3855 (44.9)	332 (60.7)	2.26 (1.60 to 3.17)

*percentage are weighted.
AOR, adjusted OR; EDHS, Ethiopia Demographic and Health Survey; Ref, reference group.

infant and under-five mortality using the WHO recommendation to define SBI and applying rigorous analytical techniques to adjust for potential confounders. This study provides evidence that SBI is associated with neonatal, infant and under-five mortality in Ethiopia. These findings will help policymakers and programme planners formulate targeted interventions to increase birth intervals and contribute to achieving the GTPE and SDGs target of reducing neonatal, infant and under-five mortality.[15 16]

In this current study, SBI was found to be associated with higher odds of neonatal mortality. This finding is consistent with evidence from the previous studies[23 25 63–66] which have shown a higher risk of neonatal mortality among women with a SBI. However, the definition of SBI (ie, <33 months) used in the current study was in line with the WHO definition and longer than those used in previous studies (ie, ranges from <18 to 24 months). SBI could result in adverse neonatal child health outcomes, such as death, by causing maternal nutritional depletion, specifically folate depletion.[67 68] The maternal nutritional depletion hypothesis states that a short birth-to-pregnancy/birth interval worsens the mother's nutritional status because of inadequate time to recover from the physiological stresses of the subsequent pregnancy.[69] This may compromise maternal nutritional status and ability to support fetal growth, which could result in fetal malnutrition and increased risk of infection and death during childhood.[67] Women with SBI may also be less likely to attend postnatal care, which is vital for early detection and treatment of neonatal and maternal health problems. Evidence has shown that the majority of mothers and newborns in low-income and middle-income countries do not receive optimal postnatal care,[70] yet close to half of the newborn deaths occurred within the first 24 hours after birth, a critical time where mothers and their babies should get their first postnatal care.[71]

Our study found that infant mortality was two times higher among women who experienced SBI compared with women who did not. Our finding was consistent with evidence from Ethiopia,[18 32] Kenya,[72 73] Nepal[74] and Iran,[75] although the cut-off point for SBI in the current study was longer than the previous studies. The abovementioned previous studies also documented that the risk of infant mortality was higher among women who experienced SBI compared with women who did not. One of the possible reasons for the effect of SBI on infant mortality could be low maternal motivation to breast feed (eg, if the pregnancy was unintended).[76] Maternal perception of being undernourished due to a SBI may also influence her infant feeding choices, such as the duration and intensity of breast feeding and supplemental feeding of the infant. This could in turn affect infants' nutritional status, their resistance to infection and may expose them to death.[76–79] The abovementioned links between SBI and neonatal mortality also apply to infant mortality.

SBI doubled the odds of under-five mortality compared with non-SBI. Despite not using the WHO recommendation[1] of less than 33 months to define SBI, the existing literature[24 30 63 64 80] also supported our finding. The likely mechanism through which SBI affects under-five mortality could be competition between closely spaced siblings for limited household resources, maternal attention and cross-infection.[76] Moreover, children born within a SBI may not receive their vaccination at all or complete their booster series, which is one of the risk factors that exposed children to the infectious disease and its associated death.[81–83] Women with SBI could be burdened with caring for highly dependent children[77] and other domestic activities. As a result, they may lack the time and motivation to take children to the health facility for vaccination and other services.

The results of this study need to be interpreted within the limitations of the observational study design. Due to the cross-sectional nature of the study, temporal associations between SBI and neonatal, infant and under-five mortality may not be established. The second limitation of our study could be associated with the non-randomised design of the study. PS-based analysis, IPTW, cannot account for unknown confounders in the same way that a randomised trial can. As a result, the effect of residual confounders may not be avoided. However, the application of IPTW mimics a randomised controlled trial by matching two comparison groups using a conditional probability of receiving exposure (SBI in this case) given a set of covariates. The study has also additional strengths, such as using data from a nationally representative survey with large sample size. The application of DAGs,[48 49 84] a graphical tool used to identify minimum adjustment sets, which defined the set of explanatory variables for the PSs model was another strength of this study.

CONCLUSION

This study provides evidence that SBI has a significant effect on neonatal, infant and under-five mortality in Ethiopia. Interventions aiming to reduce neonatal, infant and under-five mortality in Ethiopia should target the prevention of SBI. These could be achieved through creating awareness of the optimum birth interval and the negative impacts of shorter birth intervals on the health of children. Further expanding the availability and accessibility of family planning services also help women achieve optimum birth interval. Birth interval counselling as per the WHO recommendation should be integrated into the maternal and child health services as part of the child survival intervention.

Author affiliations
[1]St Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia
[2]Centre for Women's Health Research, School of Medicine and Public Health, The University of Newcastle, Callaghan, New South Wales, Australia
[3]Centre for Clinical Epidemiology and Biostatistics, School of Medicine and Public Health, The University of Newcastle, Callaghan, New South Wales, Australia

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ORCID iDs
Desalegn Markos Shifti http://orcid.org/0000-0001-6638-6194
Elizabeth Holliday http://orcid.org/0000-0002-4066-6224

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