The Association of Contraceptive Use, Non-Use, and Failure with Child Health

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Abstract: *Objective*: To examine the association of contraceptive use in the interpregnancy interval with subsequent child health outcomes in low- and middle-income countries.

Design: A cross-sectional analysis of nationally representative household samples was performed. A modified Poisson regression model was used to estimate unadjusted and adjusted relative risk ratios for high prevalence outcomes.

Setting: Low- and middle-income countries.

Population: Births to women aged 12-49 years for which this birth occurred 12-79 months prior to the interview were included. The sample for analysing infant mortality was comprised of 453,795 children from 35 low- and middle-income countries across 67 Demographic and Health Surveys conducted between 1990 and 2011.

Main Outcome Measures: Infant mortality, stunting, underweight, wasting, diarrhoea, and anaemia.

Results: Contraceptive use in the interpregnancy interval, even if contraceptive failure resulted in birth, had a positive effect on all child health outcomes compared to non-use of contraception in the interpregnancy interval. The positive effect of contraceptive use was the lengthening of the interpregnancy interval, but it also had a direct positive effect on child health, independent of birth interval.

Conclusions: Extending the interval between births had a positive effect on child health outcomes, and contraceptive use had a positive effect on child health independent of the birth spacing effect. Additionally, contraceptive failure did not adversely affect child health outcomes.

Keywords: Contraceptive use, birth interval, child health outcomes, Demographic and Health Surveys, infant mortality.

INTRODUCTION

A handful of dedicated authors have persisted in promoting the importance of family planning over the past 20 years [1-6]. However, a recent edition of the Lancet that addresses the health benefits of contraception [4, 7-16] brings new energy to a field that had remained in the background while the fight against human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) dominated the field on this vital issue central to child and maternal health. Proponents of family planning have worked to increase the prevalence contraception, particularly in high fertility countries. In the past 20 years, the driving force behind this policy to increase contraceptive prevalence has been to address unmet need [4].

The obvious benefit of contraceptive access and use is to aid women and couples in achieving their desired family size. However, contraceptive use is also associated with lower completed fertility [17, 18], which has many health and economic benefits at both the children of women with lower fertility rates enjoy household [6, 19] and aggregate levels [3, 20]. The greater health compared to those in large families [21-23]. The economic benefits of lower fertility lead to encouragement of female participation in the labour force, savings, and education attainment, which combine to promote economic growth [3, 23-27].

The side effects of the hormonal contraceptive pill have been well studied, as the pill is a central method of contraception in Western countries. In fact, many positive side effects have been documented [28-30]. However, the health benefits of contraception, particularly regarding the situation in developing countries, focus on maternal mortality reduction [7, 8, 22, 31-33], notably by providing a means to avoid unsafe abortions [34] and assist women in achieving adequate spacing between births [5, 35-41].

Contraceptive use can have positive effects on child health. Typically, these effects are thought of in the context of extending spacing between births, allowing the mother time to recover and restore nutritional balance. However, contraceptive use may lead to positive child health outcomes through other channels, over and above the effect it has on extending birth intervals. Contraceptive use may be indicative of contraceptive access and, more broadly, access to

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primary healthcare. Additionally, women may obtain contraception at a facility that also offers other maternal and child health facilities, provisions, and information. Thus, by attending a health care facility for the purpose of contraception, the mother-to-be is also indirectly gathering information on child health and gaining knowledge of the availability of programs to support her future child's health. Thus, these visits may also improve a woman's knowledge of her own health during a future pregnancy and the health of her future child. This argument works well for modern methods of contraception, but women also practice traditional methods of contraception, which may also have beneficial effects on child health. In this case, it may be that women who want to practice traditional methods of contraception discuss these methods with their female relatives and friends. As these women discuss contraception, they may also discuss general maternal and child health issues. Practicing any form of contraception, modern or traditional, may promote knowledge or at least mindfulness of the broader issues of maternal and child health, leading to significant improvements in child health outcomes.

A woman's contraceptive history, or lack thereof, rarely follows a "perfect" pattern. The data reveal that women seldom exist who space their children by two or more years using a modern contraception method between pregnancies, discontinue this contraception because they want to become pregnant and then become pregnant in the next three months. Women usually have a more chequered history with lactational amenorrhea, terminations, periods of attempting traditional methods of contraception, method switching, tightly spaced births, or long times to conception.

In contrast, some women do not use any form of contraception. The reason for non-use of contraception could be due to supply side (no access to contraception) or demand side (fear of side effects, lack of partner's support for use) issues. These women who do not use contraception may desire children, but they are not concerned with the timing or number of children. Thus, not all non-use translates to an unmet need for contraception. Unmet need is more precisely defined as "the proportion of fecund married women who wish to avoid further child bearing altogether or postpone their next child for at least two years, but who are using no method of contraception" [4]. While un-met need captures more the lack of contraceptive access, non-use of contraception also encompasses potential demand side influences. Thus, when non-use of contraception is discussed in this paper, it is not always due to unmet need and lack of access to contraception.

Here, I analysed the effect of contraceptive use (modern and traditional), contraceptive failure, and non-use of contraception on the health of subsequent children born. Child health is often proxied for by infant mortality; this outcome was studied here along with a range of nutritional outcomes. Anthropometric outcomes of stunting, wasting, and underweight were analysed as indicators of child health, as were diarrhoea and anaemia. The aim of this paper was to examine the effect of a woman's contraceptive history on subsequent child health. The effect of contraceptive use was isolated from birth spacing to identify the direct effects of contraception over and above the effect it had on spacing.

In this study, the definition of child health was not confined to infant mortality. Given the prevalence of poor child health outcomes in low- and middle-income countries, and only high infant mortality, studies that extend the monitoring of child health beyond infant mortality provide valuable information regarding health disparities and progress in achieving Millennium Development Goal 4, and its sub-goals relating to child health [42].

The purpose of the current study was to assess the association between contraceptive use and child health outcomes of infant mortality, stunting, underweight, wasting, diarrhoea, and anaemia. The direct effect of contraceptive use on child health can be parsed out from tempo and quantum trends across socio-economic status (SES) lines by controlling for birth spacing and socio-economic and demographic factors. Using secondary source data from 67 Demographic and Health Surveys conducted between 1990 and 2011, and utilizing data within the DHS from the reproductive calendar, 453,795 children aged between 0-59 months at the time of interview were in the study. The findings presented here on the additional beneficial effects of contraceptive use on child health could critically inform family planning policies. To my knowledge, such a systematic and comprehensive study of the effects of contraceptive use on subsequent child health has not been conducted.

METHODS

Data Source

Data from 67 Demographic and Health Surveys (DHS) conducted in 35 countries between 1990 and

2011 were analysed in this study [43]. The DHS are nationally representative household sample surveys that measure population, health, socio-economic, and anthropometric indicators, with an emphasis on maternal and child health [44]. The DHS are an important data source for studying population health across developing countries due to their extensive coverage, comparability, and data quality [45-47]. To ensure standardisation and comparability across diverse sites and time, Macro ICF employs intense interviewer training, standardised measurement tools and techniques, an identical core questionnaire, and instrument pretesting in conducting the DHS [48]. Each participating country reports detailed pretesting and quality assurance measures by survey [49]. In addition, the DHS is modular in structure, and for a selection of countries/surveys, the reproductive calendar and child height-weight modules were collected for analysis here. The DHS provides data with standardised variables across surveys [50].

Sampling Plan

The DHS involves stratified cluster randomised samples of households [51]. The sampling frame was stratified by urban and rural status, and then additionally by country-specific geographic or administrative regions. Within each stratified area, random clusters of households were drawn from a list of all enumeration areas taken from a population census. In the second stage of sampling, all private households within the cluster were listed (institutions excluded) and an average of 25 houses within a cluster was selected by equal probability systematic sampling to be surveyed. Detailed sampling plans are available from survey final reports [49].

Within each sampled household, a household questionnaire was administered and women eligible for a more detailed women's survey were identified. In most surveys, all women aged 15-49 years were interviewed. In a limited number of surveys, the target group was women aged 10-49 or 15-45 years, and never-married women. The child anthropometry module was conducted in a selection of the Standard DHS [52].

The reproductive calendar was conducted in a sub-set of the DHS [53]. The reproductive calendar has two forms: one for low-contraceptive prevalence (Model B) countries and one for high-contraceptive prevalence (Model A) countries. In the Model B countries, pregnancies, terminations, and births were recorded whereas no information on intervening contraceptive use was collected. In Model A countries, in addition to pregnancies, terminations, and births, contraceptive use (modern and traditional) was recorded on a month-by-month basis for up to 80 months. Countries that changed from low- to high- contraceptive prevalence switch models (e.g., Ghana). In this study, information from Model A countries was used; thus, Model B countries (or surveys) that lacked the full monthly contraceptive history were excluded from the sample. The calendars were traced back 59-79 months from the time of the interview. Data were initially taken from the women's recode file (IR); the data were reshaped to make the child the observation. Thus, the panel structure is country, year, mother, and child. The DHS provides weights for calculating nationally representative statistics.

Study Population and Sample Size

In this study, each child health outcome had its own unique sample that reflected the characteristics of the outcome variable and complementary availability of the reproductive calendar data.

The infant mortality sample consisted of children born to women during the 12-79 months covered by the reproductive calendar. The lower bound of 12 months was applied to ensure that each child had equal exposure to one year of life and so that infant mortality (children who die within the first year of life) could be accurately calculated. The diarrhoea sample included all children aged 0-79 months and was self-reported by the mother if the child had diarrhoea in the two weeks prior to interview. Detailed child health biomarkers were only measured for children up to 60 months of age, which established the upper bound for the anthropometry and anaemia samples; the lower bound was 0 months. All children born within the reference period were included in the sample. Additionally, the start of the pregnancy for the index child was included within the reference period to ensure that contraceptive use behaviour could be observed prior to the pregnancy. Only surveys with Model A DHS were included in the initial sample. The initial infant mortality sample was 762,389 children across 38 countries from 76 surveys. The sample was reduced by 126,952, as children born within the past 12 months were excluded from the sample. Those children who died 1-5 years after birth (child mortality) were also excluded from the sample, further reducing the samples size by 8,984 observations. Some mothers did not agree to complete the reproductive calendar even though it was part of

the survey; thus, a further 106,982 children were excluded from the sample. There is an extensive list of covariates, and in the multivariate analysis, 65,676 observations were lost due to these covariates. The final infant mortality sample for this study was 453,795 children across 35 countries and 67 surveys. Details of the samples for the child health outcomes are given (Table **A1** appendix). Anthropometric samples are smaller because the child anthropometric module was not conducted in a number of surveys, and only children aged up to 36 or 59 months were measured. The samples consisted of the following numbers of children: stunting (360,785), wasting (360,137), underweight (369,881), diarrhoea (508,647), and anaemia (123,337).

Outcome Measures

In this study, I focused on six outcomes: infant mortality, stunting, underweight, wasting, diarrhoea, and anaemia. The birth history in the DHS Individual Recode records the survival status of a woman's (respondent's) child. A child's death and age of death was reported by the mother. Infants who passed away within the first year of life (<12 months) were counted as an infant mortality.

Anthropometric failure was captured in three outcomes: stunting, underweight, and wasting. First, a z-score determined by the child's height minus the median height for that child's age and sex in a reference population was calculated. The resulting value was divided by the standard deviation of the same age and sex in the World Health Organization (WHO) reference population of healthy children in developing countries [54]. Stunting was defined as a height z-score of <-2. Similarly, underweight was defined as a z-score of <-2 for weight relative to children of the same sex and age in the reference population. Wasting was defined as a z-score of <-2 for weight-to-height relative to children of the same sex and age in the reference population. Biologically impossible values were defined by the WHO for height (stunting) as z-scores of <-6 or >6; for weight (underweight) as <-6 or >5; and for weight for height (wasting) as <-5 or >5, and those out of the feasible range were excluded from the sample.

The outcome of child diarrhoea was based on the mother's recall of whether their child had diarrhoea within the two weeks prior to interview. Anaemia was measured by a finger stick blood test from the child at the time of interview. The first two drops of blood were discarded, and the third drop was taken as a sample. The blood drop was analysed using the HemoCue system. Adjustments for altitude were taken into account, and children with a haemoglobin concentration less than 10 g/dL were considered as having moderate anaemia.

Exposure and Covariates

The explanatory variable of interest in this study was the woman's contraceptive history prior to the pregnancy and birth of the index child. Contraceptive use was monitored between the start of the pregnancy that resulted in the index birth and the preceding birth. For example, if two children were born within the reference period and both pregnancies also started within the reference period, the contraceptive behaviour of the mother between the two pregnancies could be observed. The history of contraceptive use prior to the pregnancy of the elder of the two children was observed from the start of the pregnancy of that child back to the start of the reproductive calendar. Contraceptive use before pregnancies categorised into eight groups: no contraceptive failure and used modern contraception (No failure/Modern use); no contraceptive failure and used traditional contraception (No failure/Traditional use); no contraceptive failure and had lactational amenorrhea (No failure/Lactational); no contraceptive failure and had a termination (No failure/Termination); no contraceptive failure and used no contraception between births (No failure/Non-use); modern contraceptive failure (Modern failure); and traditional contraceptive failure (Traditional failure). Failure was defined as using contraception for one month and then being pregnant with the index child the following month. These categories are mutually exclusive. Thus, the contraceptive history of the mother prior to the pregnancy of the index child was taken as the last reproductive event prior to the start of that pregnancy. Thus, women who had a termination prior to the pregnancy of the index child and then after that termination used no form of contraception (traditional or modern) before the pregnancy of the index child fell into the category of No failure/Termination. A woman who had a birth, had lactational amenorrhea, then used the rhythm method, and then went on a hormonal contraceptive pill before stopping all contraception prior to the start of the pregnancy of the index child was coded as No failure/Modern use.

In addition to the explanatory variables of interest, a number of other covariates were also controlled for that includes child, maternal, and paternal characteristics, as well as household and social factors. The child

characteristics were the child's sex, singleton or multiple births, the age of the child in months, and interpregnancy birth interval. The covariate for the age of the child was not included in the infant mortality model, but was included in all other models. Child age in months was categorised into five groups: 12-23, 24-35, 36-47, 48-59, and 60-79 (0-11 month olds were included in all samples other than infant mortality). The birth interval was the number of months between the index birth and the preceding birth. First births comprised their own category, and then birth intervals were grouped into 1-11, 12-24, and >24 months.

The maternal factors included in this study were the mother's age and education. The age of the mother at first birth was a variable reported in the DHS recode manual [50] and was calculated as from the century month code (CMC) of the date of the first birth and the CMC of the date of birth of the mother. Age was categorised into five-year intervals: ages 12-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49 years. Maternal education was classified into three categories: no education or less than completed primary, completed primary, and completed secondary or higher. Paternal covariates were captured by variables that indicated whether the woman had a partner, and if so, the partner's education level. The partner's education followed the same classifications as coded for the mother's education described above.

Household and social factors included the wealth quintile of the household and whether the household was in a rural or urban location. The wealth quintile is a within-country measure of the wealth of the household relative to other households in that survey based on its ownership of household assets. This measure of wealth, generated by Filmer and Pritchett [55], is a linear index of asset ownership indicators using principal component analysis to derive weights. This measure has been standardised by Measure DHS across most of the DHS and is widely used as a measure of relative wealth within a country. Given that country fixed effects are controlled for in the regression analyses, this wealth index is an indicator of how each household's wealth deviates from its own country's mean wealth. Indicators for piped water to the house were also included as covariates, as well as the presence of a flush toilet in the household. In addition to these household measures, a cluster level health measure was included: the percentage of living children aged 12-60 months who had received a measles vaccination in the cluster. There were no vaccination data for children who died, and the cluster level measles vaccination percentage enables neighbourhood health system inputs to be controlled for. The measles vaccine was administered between 9-12 months of age and was likely to have only a limited direct effect on infant mortality. The vaccine coverage may be thought of as a proxy for health care provision to assist in parsing out the direct effects of contraceptive use from the general health effects of health care provisions that may be correlated with contraceptive access.

Statistical Analysis

To measure the relative risk of a given outcome, a modified Poisson regression was applied following Zou's [56] methodology for the high prevalence child health outcomes, which are all but infant mortality, for which I used a logit regression. The unadjusted model was estimated controlling for country fixed effects and year of birth dummies to account for the uneven repeated cross section. The adjusted model was then estimated and included the covariates. While summary statistics were weighted to take into account the multistage sampling design, the regressions were not weighted [57].

RESULTS

Summary Statistics

Average No failure/Non-use of the 67 DHS was 20.41. This ranged from an average of 5.06 in Moldova in 2005, to an average of 37.17 in Guatemala in 1995 (Table **1**). Ethiopia in 2005 (36.36) and Colombia in 2000 (5.11) were near the extremes. Across the 67 surveys, infant mortality was highest in Sierra Leone in 2008, at 10.62%. In 28 of the 58 surveys, 30% or more of the children were stunted, and 43 of the 58 survey country/years had stunting rates of 20% or higher. Bangladesh in 1996 had the highest average stunting and underweight rates, 57.75% and 52.88%, respectively. An underweight prevalence of 25% or more was present in 9 of the 57 surveys. Wasting (weight-for-height) was not as prevalent as stunting; 12 of the 57 surveys recorded an average wasting prevalence of 10% or more. An average of 30.08% children in Turkey in 1998 suffered diarrhoea within the two weeks prior to the DHS interview, but across the 67 surveys, the average was 13.72%. Anaemia was recorded in 27 of the surveys that also had reproductive calendar. In those 27 surveys, average anaemia rates ranged from 6.21% children in Albania in 2008 to 55.85% in Ghana in 2008. The average was 32.63% across the 27 surveys (Table **1**).

Table 1: Weighted Mean Child Health Outcomes and Confidence Intervals by Survey

	Survey year	N	No failure/No contraception	95% CI	Infant mortality %	95% CI	Stunting %	95% CI	Underweight %	95% CI	Wasting %	95% CI	Diarrhoea %	95% CI	Anaemia %	95% CI
Albania	2008	1,468	8.69	[7.04,10.69]	1.94	[1.26,2.96]	20.94	[18.12,24.08]	6.02	[4.76,7.60]	9.39	[7.36,11.90]	5.28	[4.03,6.91]	6.21	[4.71,8.15]
Armenia	2000	1,392	10.4	[8.70,12.39]	4.14	[3.06,5.59]	18.16	[15.55,21.10]	2.52	[1.79,3.55]	2.61	[1.68,4.04]	7.98	[6.35,9.97]	10.12	[8.28,12.31]
Armenia	2005	1,134	11.78	[9.33,14.77]	3.07	[1.87,5.00]	17.69	[13.77,22.42]	4.59	[3.20,6.55]	5.5	[3.82,7.87]	17.11	[14.62,19.92]	20.38	[15.71,26.02]
Armenia	2010	1,188	13.07	[10.80,15.72]	1.65	[0.96,2.82]	19.77	[17.13,22.71]	5.22	[3.83,7.09]	4.09	[2.92,5.70]	8.83	[7.19,10.80]		
Azerbaijan	2006	1,777	18.09	[15.98,20.40]	5.3	[4.19,6.69]	25.93	[22.61,29.54]	8.67	[6.63,11.26]	7.04	[5.52,8.93]	10.46	[8.44,12.90]	18.18	[15.11,21.71]
Bangladesh	1993	5,759	25.96	[24.36,27.63]	10.3	[9.36,11.31]							12.29	[10.91,13.81]		
Bangladesh	1996	4,941	20.79	[19.35,22.32]	9.84	[9.01,10.74]	57.75	[55.92,59.56]	52.88	[50.93,54.82]	20.55	[19.09,22.09]	7.59	[6.67,8.63]		
Bangladesh	1999	5,388	17.57	[16.28,18.95]	7.75	[6.99,8.59]	49.32	[47.62,51.03]	41.27	[39.48,43.09]	12.62	[11.62,13.69]	6.2	[5.50,7.00]		
Bangladesh	2004	5,626	15.8	[14.45,17.25]	7.64	[6.83,8.54]	49.02	[47.02,51.03]	42.37	[40.34,44.42]	14.72	[13.60,15.92]	7.54	[6.78,8.37]		
Bangladesh	2007	4,637	11.35	[10.17,12.64]	6.2	[5.31,7.22]	43.12	[41.08,45.18]	41.55	[39.66,43.47]	17.66	[16.32,19.09]	9.92	[8.82,11.14]		
Bolivia	1993	4,100	25.16	[23.25,27.17]	8.47	[7.48,9.58]	32.24	[29.80,34.77]	12.49	[11.11,14.01]	5.33	[4.47,6.35]	29.78	[27.85,31.78]		
Brazil	1996	3,482	12.21	[10.84,13.73]	4.5	[3.78,5.36]	13.03	[11.64,14.55]	4.46	[3.73,5.33]	2.71	[2.13,3.45]	10.48	[9.38,11.70]		
Colombia	1990	2,750	14.35	[12.19,16.81]	1.91	[1.45,2.51]							8.63	[6.72,11.03]		
Colombia	1995	3,733	9.63	[8.55,10.83]	3.28	[2.72,3.95]	19.18	[17.74,20.70]	6.24	[5.43,7.16]	1.66	[1.27,2.16]	17.37	[16.10,18.71]		
Colombia	2000	3,295	5.11	[4.38,5.95]	2.54	[2.03,3.17]	18.36	[16.89,19.92]	5.04	[4.29,5.90]	1.15	[0.84,1.57]	14.59	[13.35,15.93]		
Colombia	2004	12,695	7.76	[7.12,8.46]	2.24	[1.92,2.61]	15.42	[14.46,16.43]	4.9	[4.39,5.46]	1.55	[1.30,1.84]	14.15	[13.31,15.03]		
Colombia	2009	13,813	6.88	[6.33,7.46]	1.84	[1.55,2.17]	12.57	[11.80,13.37]	3.33	[2.97,3.73]	0.94	[0.77,1.15]	12.93	[12.23,13.66]		
Dominican Rep.	1996	3,485	18.92	[17.32,20.63]	5.23	[4.38,6.23]	13.72	[12.18,15.42]	4.7	[3.87,5.70]	2.03	[1.51,2.72]	10.84	[9.62,12.18]		
Dominican Rep.	1999	439	12.17	[9.15,16.02]	2.84	[1.27,6.20]							15.8	[12.91,19.19]		
Dominican Rep.	2002	8,402	13.05	[12.01,14.17]	3.66	[3.06,4.38]	11.39	[10.26,12.62]	4.21	[3.59,4.93]	2.08	[1.66,2.62]	14.16	[13.16,15.21]		
Egypt	1995	10,065	23.21	[21.88,24.59]	7.25	[6.54,8.03]	33.24	[31.51,35.02]	10.73	[9.79,11.75]	5.62	[5.00,6.30]	15.89	[14.92,16.91]		
Egypt	2000	7,860	16.15	[15.16,17.19]	5.12	[4.58,5.71]	23.85	[22.49,25.26]	4.29	[3.81,4.84]	3.29	[2.87,3.76]	7.59	[6.96,8.28]	12.31	[11.21,13.51]
Egypt	2003	4,713	11.39	[10.27,12.62]	4.78	[4.10,5.57]	19.24	[17.83,20.74]	8.54	[7.62,9.55]	5.53	[4.73,6.46]	19.78	[18.52,21.10]		
Egypt	2005	9,937	11.22	[10.25,12.28]	4	[3.52,4.54]	22.65	[21.44,23.91]	5.73	[5.15,6.36]	5.42	[4.80,6.11]	19.3	[18.29,20.35]	21.59	[19.92,23.37]
Egypt	2008	7,351	8.01	[7.31,8.78]	3.05	[2.61,3.56]	28.97	[27.52,30.45]	6.52	[5.89,7.21]	8.09	[7.24,9.02]	8.95	[8.24,9.71]		
Ethiopia	2005	7,812	36.37	[34.84,37.92]	9.45	[8.59,10.39]	47.99	[45.41,50.58]	34.35	[32.25,36.52]	12.31	[10.89,13.89]	18.22	[16.81,19.71]	32.97	[30.72,35.29]
Ghana	2008	2,237	21.89	[19.77,24.18]	6.33	[5.27,7.58]	27.18	[24.85,29.63]	14.42	[12.77,16.24]	9.46	[8.26,10.82]	19.77	[17.73,22.00]	55.85	[52.74,58.92]
Guatemala	1995	7,697	37.17	[35.34,39.02]	6.06	[5.38,6.82]	53.95	[51.12,56.75]	21.98	[20.23,23.84]	3.85	[3.37,4.39]	20.91	[19.23,22.70]		
Honduras	2005	9,624	15.59	[14.69,16.53]	2.92	[2.56,3.33]	29.2	[27.66,30.78]	8.36	[7.62,9.17]	1.38	[1.13,1.69]	16.05	[15.15,16.99]	14.46	[13.44,15.54]
India	2005	41,664	27.51	[26.84,28.20]	6.75	[6.43,7.10]	46.5	[45.63,47.37]	43.18	[42.25,44.11]	20.06	[19.38,20.75]	9.14	[8.70,9.61]	43.8	[42.88,44.72]
Indonesia	2002	13,622	9.6	[8.64,10.65]	4.19	[3.66,4.80]							11.08	[9.93,12.35]		
Indonesia	2007	14,244	8.05	[7.31,8.87]	3.9	[3.42,4.44]							13.92	[12.97,14.93]		
Jordan	1990	7,019	33.11	[31.43,34.83]	4.02	[3.51,4.60]	20.29	[18.84,21.83]	5.06	[4.36,5.86]	3.98	[3.38,4.68]	8.46	[7.73,9.25]		

(Table 1). Continued

	Survey year	N	No failure/No contraception	95% CI	Infant mortality %	95% CI	Stunting %	95% CI	Underweight %	95% CI	Wasting %	95% CI	Diarrhoea %	95% CI	Anaemia %	95% CI
Jordan	1997	5,061	20.05	[18.76,21.40]	3.4	[2.85,4.05]	11	[9.88,12.23]	3.89	[3.30,4.58]	2.38	[1.97,2.88]	18.52	[17.40,19.70]		
Jordan	2007	7,990	14.96	[13.63,16.39]	2.43	[1.87,3.14]	14.92	[13.14,16.88]	5.71	[4.78,6.80]	7.4	[6.10,8.94]	16.13	[14.76,17.61]	16.09	[14.22,18.16]
Kenya	1998	3,951	25.16	[23.58,26.81]	8.88	[7.56,10.41]	37.04	[35.11,39.02]	18.04	[16.49,19.70]	7.6	[6.69,8.62]	17.51	[15.96,19.17]		
Kenya	2003	4,263	26.05	[24.35,27.83]	9.2	[7.95,10.63]	35.19	[33.27,37.16]	16.18	[14.68,17.80]	6.31	[5.31,7.49]	16.88	[15.32,18.56]		
Kenya	2008	5,015	26.29	[24.38,28.29]	6.23	[5.20,7.46]	34.5	[32.35,36.71]	16.28	[14.40,18.36]	6.98	[5.94,8.19]	16.85	[15.03,18.83]		
Madagascar	2008	10,073	30.72	[29.31,32.17]	5.42	[4.86,6.04]	46.14	[43.80,48.50]					8.32	[7.47,9.25]	20.62	[18.91,22.44]
Malawi	2004	8,603	24.75	[23.50,26.04]	9.08	[8.28,9.95]	51.46	[49.82,53.09]	18.38	[17.25,19.57]	6.44	[5.71,7.26]	22.59	[21.25,23.99]	48.08	[45.46,50.70]
Malawi	2010	15,094	20.45	[19.46,21.48]	8.06	[7.46,8.71]	46.98	[45.03,48.94]	13.88	[12.54,15.35]	4.32	[3.57,5.21]	17.94	[17.13,18.78]	40.52	[38.15,42.93]
Moldova	2005	1,148	5.06	[3.71,6.86]	1.55	[0.95,2.53]	11.57	[9.75,13.68]	3.42	[2.50,4.66]	6.01	[4.57,7.86]	7.52	[6.26,9.01]	10.44	[8.58,12.64]
Morocco	1992	4,642	28.61	[25.85,31.53]	6.76	[5.88,7.77]	28.22	[25.47,31.14]	7.92	[6.43,9.72]	2.65	[2.09,3.36]	7.09	[6.18,8.12]		
Morocco	2003	5,067	5.11	[4.24,6.15]	4.79	[4.18,5.50]	21.8	[20.16,23.54]	9.78	[8.71,10.96]	10.75	[9.60,12.02]	7.68	[6.80,8.65]		
Nepal	2006	5,052	25.58	[23.72,27.55]	5.72	[4.86,6.73]	48.98	[46.32,51.66]	38.68	[36.01,41.42]	12.73	[11.29,14.32]	11.88	[10.67,13.20]	22.73	[20.66,24.94]
Nepal	2011	4,550	22.94	[20.72,25.32]	5.42	[4.64,6.33]	39.21	[36.45,42.04]	28.94	[26.37,31.65]	11.2	[9.61,13.01]	13.9	[12.61,15.31]	18.94	[16.81,21.27]
Nigeria	2008	20,829	35.24	[34.24,36.24]	9.43	[8.93,9.96]	38.14	[36.89,39.41]	26.78	[25.36,28.26]	14.56	[13.61,15.57]	10.34	[9.55,11.19]		
Peru	1991	7,787	20.8	[19.53,22.13]	6.28	[5.68,6.94]	36.75	[34.73,38.81]	8.77	[7.87,9.76]	1.96	[1.64,2.35]	10.11	[9.27,11.02]		
Peru	1996	14,269	17.32	[16.35,18.32]	5.06	[4.60,5.57]	30.74	[29.19,32.33]	5.72	[5.19,6.29]	1.65	[1.40,1.95]	18.21	[17.36,19.09]		
Peru	2000	11,079	14.66	[13.71,15.67]	3.95	[3.50,4.46]	30.94	[29.27,32.66]	5.23	[4.68,5.85]	1.16	[0.95,1.41]	15.56	[14.67,16.49]	26.62	[24.29,29.08]
Peru	2003	11,027	7.24	[6.54,8.02]	2.3	[1.95,2.71]	28.05	[26.19,29.99]	4.57	[3.98,5.24]	0.86	[0.63,1.18]	14.32	[13.43,15.27]	20.89	[19.49,22.36]
Philippines	1998	5,575	21.03	[19.84,22.28]	4.02	[3.48,4.64]							7.87	[7.15,8.66]		
Philippines	2003	5,425	20.87	[19.66,22.14]	3.61	[3.07,4.25]							10.96	[10.06,11.93]		
Rwanda	2010	7,686	30.81	[29.78,31.85]	5.72	[5.17,6.33]	43.46	[41.46,45.47]	11.8	[10.77,12.93]	3.04	[2.52,3.66]	13.24	[12.30,14.25]	14.18	[12.96,15.49]
Senegal	2010	9,580	33.77	[32.32,35.26]	5.52	[4.95,6.16]	27.46	[25.28,29.75]	19.11	[17.35,21.00]	10.22	[9.09,11.47]	20.62	[19.06,22.29]	53.33	[50.28,56.36]
Sierra Leone	2008	3,901	28.22	[26.67,29.83]	10.62	[9.43,11.95]	35.42	[32.70,38.25]	21.26	[18.87,23.87]	11.01	[9.56,12.66]	13.91	[12.21,15.80]	49.19	[45.96,52.42]
Swaziland	2006	2,220	25.65	[24.06,27.31]	10.27	[8.92,11.81]	27.76	[25.44,30.21]	5.61	[4.60,6.82]	3.08	[2.40,3.94]	14.24	[12.51,16.16]	21.52	[19.45,23.74]
Tanzania	2004	6,936	28.31	[26.42,30.28]	8.14	[7.29,9.08]	43.07	[41.00,45.16]	16.35	[15.04,17.74]	3.68	[3.18,4.24]	13.09	[11.97,14.29]	47	[44.89,49.12]
Tanzania	2009	5,474	23.36	[21.48,25.35]	6.29	[5.46,7.23]	42.2	[40.36,44.05]	15.95	[14.61,17.38]	5.3	[4.63,6.06]	15.55	[14.15,17.07]	29.54	[27.74,31.41]
Turkey	1993	2,931	18.29	[15.85,21.02]	6.2	[5.23,7.35]	23.46	[21.02,26.09]	8.89	[7.24,10.86]	3.84	[3.07,4.79]	15.15	[13.73,16.69]		
Turkey	1998	2,745	13.96	[11.87,16.36]	5.15	[4.16,6.36]	18.66	[16.60,20.91]	6.77	[5.54,8.25]	3.08	[2.45,3.86]	30.08	[27.86,32.39]		
Uganda	2006	6,101	34.38	[33.06,35.72]	8.16	[7.34,9.06]	37.29	[35.02,39.61]	16.28	[14.45,18.28]	7.04	[5.89,8.38]	27.39	[25.80,29.04]	51.91	[48.84,54.96]
Vietnam	1997	2,539	18	[15.35,21.00]	3.35	[2.53,4.42]							11.29	[8.99,14.10]		
Vietnam	2002	1,883	10.58	[8.41,13.21]	2.09	[1.25,3.46]							16.28	[14.92,17.73]		
Zambia	2007	4,632	16.43	[14.98,17.99]	8.56	[7.71,9.51]	45.05	[43.01,47.10]	14.73	[13.60,15.94]	5.86	[5.12,6.70]				
Zimbabwe	1994	3,143	9.06	[7.81,10.49]	6.28	[5.36,7.34]	28.39	[25.97,30.94]	11.83	[10.33,13.52]	6.26	[5.13,7.62]	24.18	[22.11,26.38]		
Zimbabwe	2005	4,175	7.73	[6.00,9.89]	6.9	[5.99,7.94]	33.03	[30.56,35.60]	13.2	[11.74,14.82]	6.74	[5.77,7.85]	12.75	[11.49,14.14]	33.86	[29.84,38.13]
	2004	453,795	20.41	[20.19,20.63]	5.76	[5.66,5.86]	33.02	[32.71,33.33]	17.4	[17.09,17.72]	7.66	[7.49,7.83]	13.72	[13.56,13.88]	32.63	[32.11,33.16]

In the infant mortality model (n=453,795 children), contraceptive use prior to the pregnancy and birth of the index child was observed. I was unable to observe the full history prior to 46.46% of pregnancy/births, as the length of the calendar was truncated at 79 months and the previous birth occurred prior to the start date of the calendar. In 20.75% of the cases prior to pregnancy/birth of the index child, women did not use any form of contraception (traditional nor modern). Failure of modern and traditional contraception occurred in 6.16% and 5.81% of cases, respectively, while 14.22% of cases used modern contraception successfully. Terminations, lactational amenorrhea, and successful use of traditional methods of contraception were rare (Table **2**). First births comprised 28.55% of the sample, and most women practiced spacing, with 54.81% of children born >24 months after their previous sibling. Family sizes varied; 27.24% of children had five or more siblings at the time of the interview. Children of multiple births were rare (2.39%), most women (97.66%) had partners, 62.49% of children were born in rural areas, 44.22% had piped water to the house whereas the remainder left the house to collect water, and 37.13% of children had a flush toilet at the house. Distributions of covariates were similar across the different outcome models (Table **2**).

Two dominant groups emerged from the data collected: those cases where there was successful use of modern contraception between births (No fail/Modern use), and those cases where there was no use of contraception between births (No fail/Non-use) (Table **2**). The characteristics of women who fell into these two groups are presented in Table **3**. In cases where there was no use of contraception, birth intervals were shorter on average (20.31% with a 12-17-month interval and 50.76% with a >24-month interval) than in cases where there was successful use of modern contraception (1.8% with a 12-17-month interval and 78.13% with a >24-month interval) and failure of modern contraception (5.97% with a 12-17-month interval and 69.21% with a >24-month interval) (Table **3**). Of the non-use cases, 40.93% had >5 siblings to the index child, compared to 20.81% of the successful modern contraceptive use cases and 25% of the modern failure cases. Non-use of contraception was associated with low education; 64.91% of cases were women with no education or incomplete primary. Successful modern use (36.05%) and modern failure (33.35%) had a lower prevalence in women with no education or incomplete primary. Of the cases that present as non-use, 74.59% were rural households, and this percentage was lower for successful modern use (51.41%) and modern failure (44.71%) cases (Table **3**). Women who did not use any contraception between births stood apart from women who did use modern contraception (even if they experienced contraceptive failure); women who did not use contraception were socially disadvantaged, on average, compared to women who did use contraception. Thus, contraception use is what made women similar, whereas contraceptive failure can occur at random and thus affect any contraceptive user and not a particular sub-group of user.

Unadjusted and Adjusted Models

The absolute probability of poor child health outcomes by contraceptive history is presented in Table **4**. The cases of non-use resulted in the highest prevalence of poor child health outcomes, except for the case of diarrhoea where a prior termination led to the next child having an absolute probability of diarrhoea of 17.03% (95% CI [confidence interval]: 16.37, 17.70). If there was no use of contraception between the birth of the index child and the prior child, then the index child had a 41.97% (95% CI: 41.48, 42.46) probability of stunting. However, if modern contraception was used successfully in the interim, the index child had a lower probability of stunting (24.71%, 95% CI: 24.24, 25.18), and if modern contraception was used but failed, leading to the birth of the index child, then that child had a 22.77% (95% CI: 22.11, 23.45) probability of being stunted. Modern failure led to a child that had a statistically similar probability of infant mortality and anaemia to successful use of modern contraception prior to the index child's birth. In the cases of diarrhoea and anthropometric failure outcomes, births that resulted from contraceptive failure yielded better child health outcomes than if there was successful use of contraception in the interim between the index birth and previous child (Table **4**). The unexpected nature or the potential unwantedness of these children did not appear to affect their health outcomes.

The unadjusted relative risk of the six child health outcomes by contraceptive history are reported in Table **5**. Non-use of contraception prior to the birth of the index child had the highest relative risk of poor child health outcomes on all but diarrhoea (where it was second to a prior termination). The case of successful modern contraceptive use was the baseline case, with the default risk of 1.00; other contraceptive history

Table 2: Weighted Frequency and Distribution

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Anaemia	
Contraceptive history	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**
No failure/Modern	64,525	14.22	60,046	16.64	61,249	16.56	59,971	16.65	82,384	16.2	15,837	12.84
No failure/Traditional	13,361	2.94	12,896	3.57	13,044	3.53	12,766	3.54	16,931	3.33	4,573	3.71
No failure/Lactational	1,382	0.3	1,319	0.37	1,355	0.37	1,276	0.35	1,824	0.36	462	0.37
No failure/Termination	15,243	3.36	14,143	3.92	14,502	3.92	14,171	3.93	19,256	3.79	4,808	3.9
No failure/No contraception	94,140	20.75	83,326	23.1	86,612	23.42	83,457	23.17	118,985	23.39	31,195	25.29
No failure/End calendar	210,831	46.46	140,127	38.84	143,474	38.79	139,650	38.78	204,644	40.23	55,250	44.8
Modern failure	27,961	6.16	24,574	6.81	25,011	6.76	24,607	6.83	33,076	6.5	5,026	4.08
Traditional failure	26,352	5.81	24,354	6.75	24,634	6.66	24,239	6.73	31,547	6.2	6,186	5.02
Total	**453,795**	**100**	**360,785**	**100**	**369,881**	**100**	**360,137**	**100**	**508,647**	**100**	**123,337**	**100**
Birth interval group (months)												
First birth	129,550	28.55	101,965	28.26	104,247	28.18	101,583	28.21	144,634	28.44	34,554	28.02
1-11	3,531	0.78	2,274	0.63	2,381	0.64	2,334	0.65	3,266	0.64	736	0.6
12-17	27,558	6.07	20,564	5.7	21,210	5.73	20,737	5.76	28,384	5.58	6,312	5.12
18-23	44,444	9.79	34,740	9.63	35,698	9.65	34,761	9.65	47,653	9.37	11,623	9.42
24+	248,712	54.81	201,242	55.78	206,345	55.79	200,722	55.73	284,710	55.97	70,112	56.85
Child index												
Most recent born	295,511	65.12	266,325	73.82	273,748	74.01	265,908	73.84	378,249	74.36	88,993	72.15
2nd most recent	136,823	30.15	83,327	23.1	84,953	22.97	83,261	23.12	115,353	22.68	30,819	24.99
3rd most recent	19,933	4.39	10,485	2.91	10,526	2.85	10,323	2.87	14,156	2.78	3,352	2.72
4th most recent	1,419	0.31	610	0.17	618	0.17	609	0.17	843	0.17	159	0.13
5th most recent	98	0.02	34	0.01	32	0.01	32	0.01	42	0.01	11	0.01
6th most recent	11	0	4	0	4	0	4	0	4	0	3	0
Number of children ever born to index child's mother												
One child	72,659	16.01	67,521	18.72	69,151	18.7	67,231	18.67	97,090	19.09	21,641	17.55
Two children	114,366	25.2	90,692	25.14	92,788	25.09	90,445	25.11	127,329	25.03	32,533	26.38
Three children	85,567	18.86	66,437	18.41	68,010	18.39	66,347	18.42	92,804	18.25	22,753	18.45
Four children	57,600	12.69	44,077	12.22	45,273	12.24	44,062	12.23	62,123	12.21	15,392	12.48
>Five children	123,603	27.24	92,058	25.52	94,659	25.59	92,052	25.56	129,301	25.42	31,018	25.15
Mother's age (years) at interview												
12-14	369	0.08	711	0.2	727	0.2	689	0.19	956	0.19	95	0.08
15-19	37,633	8.29	38,173	10.58	39,099	10.57	37,852	10.51	52,850	10.39	10,863	8.81
20-24	125,662	27.69	104,352	28.92	107,243	28.99	104,453	29	144,296	28.37	37,017	30.01
25-29	128,437	28.3	99,854	27.68	102,385	27.68	99,737	27.69	140,692	27.66	35,596	28.86
30-34	84,826	18.69	63,578	17.62	65,179	17.62	63,536	17.64	91,487	17.99	21,641	17.55
35-39	51,079	11.26	36,810	10.2	37,649	10.18	36,691	10.19	53,549	10.53	12,221	9.91
40-44	20,925	4.61	14,314	3.97	14,541	3.93	14,205	3.94	20,454	4.02	4,858	3.94
45-49	4,864	1.07	2,993	0.83	3,058	0.83	2,974	0.83	4,363	0.86	1,046	0.85

(Table 2). Continued.

	Infant mortality		Stunting		Underweight		Wasting		Diarrhoea		Anaemia	
Contraceptive history	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**	**No.**	**Col %**
Child age (months)												
0-11			75,911	21.04	78,789	21.3	74,807	20.77	109,450	21.52	16,445	13.33
12-23			75,944	21.05	78,585	21.25	76,863	21.34	106,465	20.93	28,298	22.94
24-35			73,632	20.41	75,382	20.38	73,865	20.51	105,176	20.68	27,651	22.42
36-47			72,501	20.1	73,864	19.97	72,532	20.14	100,605	19.78	27,458	22.26
48-59			62,797	17.41	63,261	17.1	62,070	17.24	86,951	17.09	23,485	19.04
60-79			360,785	100	369,881	100	360,137	100	508,647	100	123,337	100
Child gender												
Male	232,347	51.2	182,986	50.72	188,194	50.88	182,854	50.77	259,117	50.94	63,200	51.24
Female	221,448	48.8	177,799	49.28	181,687	49.12	177,283	49.23	249,530	49.06	60,137	48.76
Multiple birth												
Singleton	442,966	97.61	353,609	98.01	362,415	97.98	352,890	97.99	498,566	98.02	120,881	98.01
Multiple birth	10,829	2.39	7,176	1.99	7,466	2.02	7,247	2.01	10,081	1.98	2,456	1.99
Mother's education												
No education or incomplete primary	219,673	48.41	169,014	46.85	173,950	47.03	168,727	46.85	237,251	46.64	61,845	50.14
Completed primary	146,765	32.34	117,577	32.59	119,778	32.38	117,041	32.5	166,432	32.72	42,990	34.86
Completed secondary	87,357	19.25	74,194	20.56	76,153	20.59	74,369	20.65	104,964	20.64	18,502	15
Mother's union status												
Partner	443,156	97.66	350,171	97.06	359,200	97.11	349,645	97.09	495,038	97.32	120,355	97.58
No partner	10,639	2.34	10,614	2.94	10,681	2.89	10,492	2.91	13,609	2.68	2,982	2.42
Mother's partner's education												
No education or incomplete primary	195,012	42.97	151,027	41.86	154,852	41.87	150,376	41.76	213,276	41.93	55,471	44.98
Completed primary	157,268	34.66	125,359	34.75	127,948	34.59	125,042	34.72	176,101	34.62	46,143	37.41
Completed secondary	101,515	22.37	84,399	23.39	87,081	23.54	84,719	23.52	119,270	23.45	21,723	17.61
Mother's household's wealth quintile												
Poorest	119,864	26.41	91,713	25.42	94,604	25.58	92,033	25.55	132,550	26.06	28,777	23.33
Poor	101,923	22.46	81,635	22.63	83,881	22.68	81,757	22.7	113,730	22.36	26,759	21.7
Middle	89,796	19.79	73,069	20.25	74,787	20.22	72,881	20.24	101,131	19.88	25,229	20.46
Rich	77,010	16.97	62,666	17.37	64,003	17.3	62,292	17.3	87,050	17.11	23,304	18.89
Richest	65,202	14.37	51,702	14.33	52,606	14.22	51,174	14.21	74,186	14.58	19,268	15.62
Urban/Rural living												
Urban	170,219	37.51	142,947	39.62	145,887	39.44	142,658	39.61	194,235	38.19	38,579	31.28
Rural	283,576	62.49	217,838	60.38	223,994	60.56	217,479	60.39	314,412	61.81	84,758	68.72
Piped water to house												
Water not piped to house	253,118	55.78	182,538	50.59	187,859	50.79	181,893	50.51	279,586	54.97	68,999	55.94
Water piped to house	200,677	44.22	178,247	49.41	182,022	49.21	178,244	49.49	229,061	45.03	54,338	44.06
Flush toilet at house												
No flush toilet at house	285,301	62.87	218,120	60.46	223,455	60.41	216,952	60.24	313,622	61.66	86,139	69.84
Flush toilet at house	168,494	37.13	142,665	39.54	146,426	39.59	143,185	39.76	195,025	38.34	37,198	30.16

Table 3: Weighted Frequency and Distribution of Covariates Across Contraceptive Behaviour

	No failure/ Modern		No failure/ Traditional		No failure/ Lactational		No failure/ Termination		No failure/ No contraception		No failure/ End calendar		Modern failure		Traditional failure	
	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %
Birth interval group (months)																
First birth	9,355	14.5	3,040	22.75	22	1.59	5,813	38.14	1,125	1.2	101,660	48.22	3,891	13.92	4,644	17.62
1-11	25	0.04	3	0.02	1	0.07	1	0.01	3,062	3.25	265	0.13	103	0.37	71	0.27
12-17	1,161	1.8	262	1.96	94	6.8	155	1.02	19,116	20.31	3,500	1.66	1,670	5.97	1,600	6.07
18-23	3,572	5.54	950	7.11	333	24.1	635	4.17	23,047	24.48	9,776	4.64	2,946	10.54	3,185	12.09
24+	50,412	78.13	9,106	68.15	932	67.44	8,639	56.68	47,790	50.76	95,630	45.36	19,351	69.21	16,852	63.95
Total	**64,525**	**100**	**13,361**	**100**	**1,382**	**100**	**15,243**	**100**	**94,140**	**100**	**210,831**	**100**	**27,961**	**100**	**26,352**	**100**
Child index																
Most recent born	52,465	81.31	10,108	75.65	956	69.18	10,524	69.04	66,508	70.65	113,380	53.78	22,086	78.99	19,484	73.94
2nd most recent	11,205	17.37	3,005	22.49	398	28.8	4,214	27.65	24,965	26.52	81,488	38.65	5,354	19.15	6,194	23.5
3rd most recent	823	1.28	236	1.77	27	1.95	475	3.12	2,456	2.61	14,784	7.01	491	1.76	641	2.43
4th most recent	32	0.05	12	0.09	1	0.07	29	0.19	192	0.2	1,091	0.52	30	0.11	32	0.12
5th most recent	-	0	-	0	-	0	1	0.01	17	0.02	79	0.04	-	0	1	0
6th most recent	-	0	-	0	-	0	-	0	2	0	9	0	-	0	-	0
Number of children ever born to index child's mother																
One	6,760	10.48	2,168	16.23	2	0.14	3,445	22.6	-	0	54,299	25.75	2,738	9.79	3,247	12.32
Two	19,288	29.89	3,772	28.23	239	17.29	4,434	29.09	18,962	20.14	54,996	26.09	6,948	24.85	5,727	21.73
Three	15,629	24.22	2,721	20.37	297	21.49	2,661	17.46	21,070	22.38	31,222	14.81	6,584	23.55	5,383	20.43
Four	9,420	14.6	1,711	12.81	236	17.08	1,519	9.97	15,579	16.55	20,925	9.93	4,446	15.9	3,764	14.28
>Five	13,428	20.81	2,989	22.37	608	43.99	3,184	20.89	38,529	40.93	49,389	23.43	7,245	25.91	8,231	31.23
Mother's age (years) at interview																
12-14	28	0.04	3	0.02	-	0	7	0.05	9	0.01	295	0.14	14	0.05	13	0.05
15-19	3,064	4.75	755	5.65	49	3.55	1,148	7.53	5,004	5.32	24,883	11.8	1,426	5.1	1,304	4.95
20-24	14,861	23.03	3,140	23.5	303	21.92	4,518	29.64	27,525	29.24	63,489	30.11	6,203	22.18	5,623	21.34
25-29	20,999	32.54	3,949	29.56	421	30.46	4,366	28.64	28,903	30.7	54,228	25.72	8,266	29.56	7,305	27.72
30-34	15,222	23.59	3,013	22.55	324	23.44	2,721	17.85	17,562	18.66	33,621	15.95	6,457	23.09	5,906	22.41
35-39	7,648	11.85	1,741	13.03	195	14.11	1,630	10.69	10,553	11.21	21,444	10.17	3,819	13.66	4,049	15.37
40-44	2,341	3.63	648	4.85	83	6.01	703	4.61	3,826	4.06	9,969	4.73	1,538	5.5	1,817	6.9
45-49	362	0.56	112	0.84	7	0.51	150	0.98	758	0.81	2,902	1.38	238	0.85	335	1.27
Child age (months)																
0-11	649	1.01	146	1.09	21	1.52	251	1.65	1,699	1.8	1,103	0.52	237	0.85	219	0.83
12-23	20,997	32.54	4,353	32.58	548	39.65	5,194	34.07	35,633	37.85	30,945	14.68	7,732	27.65	7,655	29.05
24-35	18,953	29.37	3,848	28.8	454	32.85	4,438	29.12	31,811	33.79	38,110	18.08	7,464	26.69	7,137	27.08
36-47	15,787	24.47	3,163	23.67	283	20.48	3,644	23.91	20,306	21.57	56,430	26.77	7,025	25.12	6,384	24.23
48-59	7,771	12.04	1,760	13.17	73	5.28	1,664	10.92	4,599	4.89	72,836	34.55	5,043	18.04	4,579	17.38
60-79	368	0.57	91	0.68	3	0.22	52	0.34	92	0.1	11,407	5.41	460	1.65	378	1.43
Child gender																
Male	32,988	51.12	6,905	51.68	696	50.36	7,827	51.35	48,147	51.14	108,037	51.24	14,264	51.01	13,483	51.16
Female	31,537	48.88	6,456	48.32	686	49.64	7,416	48.65	45,993	48.86	102,794	48.76	13,697	48.99	12,869	48.84

(Table 3). Continued.

	No failure/ Modern		No failure/ Traditional		No failure/ Lactational		No failure/ Termination		No failure/ No contraception		No failure/ End calendar		Modern failure		Traditional failure	
	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %	No.	Col %
Multiple birth																
Singleton	62,867	97.43	13,089	97.96	1,347	97.47	14,823	97.24	91,893	97.61	205,899	97.66	27,273	97.54	25,775	97.81
Multiple birth	1,658	2.57	272	2.04	35	2.53	420	2.76	2,247	2.39	4,932	2.34	688	2.46	577	2.19
Mother's education																
No education or incomplete primary	23,263	36.05	4,245	31.77	759	54.92	6,650	43.63	61,104	64.91	105,544	50.06	9,324	33.35	8,784	33.33
Completed primary	23,670	36.68	5,071	37.95	420	30.39	4,942	32.42	24,567	26.1	67,602	32.06	10,643	38.06	9,850	37.38
Completed secondary	17,592	27.26	4,045	30.27	203	14.69	3,651	23.95	8,469	9	37,685	17.87	7,994	28.59	7,718	29.29
Mother's union status																
Partner	63,465	98.36	13,121	98.2	1,375	99.49	15,133	99.28	93,371	99.18	203,922	96.72	27,288	97.59	25,481	96.69
No partner	1,060	1.64	240	1.8	7	0.51	110	0.72	769	0.82	6,909	3.28	673	2.41	871	3.31
Mother's partner's education																
No education or incomplete primary	21,508	33.33	4,016	30.06	636	46.02	5,646	37.04	51,435	54.64	94,542	44.84	8,933	31.95	8,296	31.48
Completed primary	23,891	37.03	5,080	38.02	489	35.38	5,485	35.98	29,728	31.58	71,810	34.06	10,694	38.25	10,091	38.29
Completed secondary	19,126	29.64	4,265	31.92	257	18.6	4,112	26.98	12,977	13.78	44,479	21.1	8,334	29.81	7,965	30.23
Mother's household's wealth quintile																
Poorest	12,269	19.01	2,893	21.65	551	39.87	3,702	24.29	32,759	34.8	56,421	26.76	4,937	17.66	6,332	24.03
Poor	13,458	20.86	2,757	20.63	323	23.37	3,293	21.6	23,006	24.44	47,038	22.31	5,901	21.1	6,147	23.33
Middle	13,440	20.83	2,747	20.56	236	17.08	3,109	20.4	17,549	18.64	41,361	19.62	6,022	21.54	5,332	20.23
Rich	12,716	19.71	2,523	18.88	147	10.64	2,641	17.33	12,945	13.75	35,940	17.05	5,546	19.83	4,552	17.27
Richest	12,642	19.59	2,441	18.27	125	9.04	2,498	16.39	7,881	8.37	30,071	14.26	5,555	19.87	3,989	15.14
Urban/Rural living																
Urban	31,351	48.59	6,296	47.12	460	33.29	6,493	42.6	23,924	25.41	73,114	34.68	15,462	55.3	13,119	49.78
Rural	33,174	51.41	7,065	52.88	922	66.71	8,750	57.4	70,216	74.59	137,717	65.32	12,499	44.7	13,233	50.22
Piped water to house																
Water not piped to house	30,230	46.85	6,606	49.44	874	63.24	7,575	49.69	60,476	64.24	124,106	58.87	11,547	41.3	11,704	44.41
Water piped to house	34,295	53.15	6,755	50.56	508	36.76	7,668	50.31	33,664	35.76	86,725	41.13	16,414	58.7	14,648	55.59
Flush toilet at house																
No flush toilet at house	30,527	47.31	7,537	56.41	988	71.49	8,459	55.49	72,927	77.47	138,693	65.78	11,572	41.39	14,598	55.4
Flush toilet at house	33,998	52.69	5,824	43.59	394	28.51	6,784	44.51	21,213	22.53	72,138	34.22	16,389	58.61	11,754	44.6

cases were measured relative to this case. In terms of infant mortality, non-use yielded a 1.825 times (95% CI: 1.737, 1.917) higher risk of infant mortality than successful modern contraceptive use. There was no significant difference in risk of infant mortality between successful modern contraceptive use and failed modern contraceptive use.

Table 4: Absolute Probability of Child Health Outcomes by Contraceptive History

	Infant mortality %	95% CI	Diarrhoea %	95% CI	Anaemia %	95% CI
No failure/Modern	4.08	[3.89,4.28]	14.55	[14.22,14.88]	27.87	[26.91,28.84]
No failure/Traditional	4.18	[3.79,4.62]	14.09	[13.45,14.75]	29.11	[27.33,30.95]
No failure/Lactational	5.92	[4.69,7.44]	14.39	[12.35,16.71]	22.81	[18.71,27.51]
No failure/Termination	5.69	[5.24,6.17]	17.03	[16.37,17.70]	33.76	[32.02,35.55]
No failure/No contraception	8.69	[8.45,8.93]	15.97	[15.65,16.28]	43.34	[42.47,44.23]
No failure/End calendar	5.51	[5.39,5.64]	11.59	[11.39,11.79]	29.05	[28.45,29.65]
Modern failure	4.03	[3.75,4.33]	13.61	[13.13,14.09]	27.51	[25.90,29.18]
Traditional failure	4.33	[4.03,4.65]	14.87	[14.38,15.38]	27.11	[25.58,28.69]
Total	**5.76**	**[5.66,5.86]**	**13.72**	**[13.56,13.88]**	**32.63**	**[32.11,33.16]**
	Stunting %	**95% CI**	**Underweight %**	**95% CI**	**Wasting %**	**95% CI**
No failure/Modern	24.71	[24.24,25.18]	10.73	[10.39,11.09]	5.78	[5.55,6.03]
No failure/Traditional	26.86	[25.87,27.87]	12.85	[12.08,13.66]	6.42	[5.88,7.01]
No failure/Lactational	33.59	[30.34,37.01]	11.75	[9.92,13.86]	6.34	[5.03,7.96]
No failure/Termination	28.62	[27.70,29.55]	15.65	[14.90,16.44]	7.91	[7.37,8.49]
No failure/No contraception	41.97	[41.48,42.46]	24.46	[23.93,25.00]	10.93	[10.59,11.29]
No failure/End calendar	35.24	[34.84,35.64]	19.25	[18.86,19.66]	7.68	[7.45,7.91]
Modern failure	22.77	[22.11,23.45]	9.77	[9.30,10.27]	4.93	[4.61,5.27]
Traditional failure	27.42	[26.64,28.20]	10.95	[10.35,11.58]	4.64	[4.27,5.05]
Total	**33.02**	**[32.71,33.33]**	**17.4**	**[17.09,17.72]**	**7.66**	**[7.49,7.83]**

Table 5: Unadjusted Relative Risk of Infant Mortality and Child Health Outcome by Contraceptive History

	(1)	(2)	(3)	(4)	(5)	(6)
	Infant mortality	**Stunting**	**Underweight**	**Wasting**	**Diarrhoea**	**Anaemia**
Contraceptive history						
No failure/modern (omitted)						
No failure/traditional	1.069	1.036	1.092	1.036	1.001	0.976
	(0.971 - 1.176)	(1.003 - 1.070)	(1.038 - 1.149)	(0.959 - 1.119)	(0.961 - 1.043)	(0.924 - 1.031)
No failure/Lactational	1.283	1.361	1.168	0.978	0.994	1.114
	(1.019 - 1.617)	(1.251 - 1.481)	(0.999 - 1.364)	(0.792 - 1.207)	(0.878 - 1.125)	(0.954 - 1.300)
No failure/Termination	1.357	1.118	1.205	1.075	1.228	1.084
	(1.250 - 1.474)	(1.086 - 1.151)	(1.153 - 1.258)	(1.008 - 1.148)	(1.186 - 1.272)	(1.035 - 1.136)
No failure/No contraception	1.825	1.433	1.555	1.295	1.109	1.215
	(1.737 - 1.917)	(1.408 - 1.458)	(1.514 - 1.598)	(1.243 - 1.349)	(1.084 - 1.135)	(1.180 - 1.252)
No failure/End calendar	1.219	1.218	1.261	1.055	0.859	0.957
	(1.164 - 1.276)	(1.198 - 1.238)	(1.229 - 1.294)	(1.014 - 1.097)	(0.841 - 0.878)	(0.929 - 0.985)
Modern failure	1.067	0.997	0.992	0.945	0.989	0.965
	(0.991 - 1.148)	(0.971 - 1.024)	(0.951 - 1.036)	(0.887 - 1.007)	(0.958 - 1.021)	(0.917 - 1.015)
Traditional failure	1.136	1.128	1.184	1.063	1.046	1.008
	(1.053 - 1.225)	(1.099 - 1.158)	(1.133 - 1.237)	(0.992 - 1.139)	(1.013 - 1.080)	(0.959 - 1.061)
Constant	1.79e-06	0.0813	0.0352	0.0911	0.0748	0.104
	(2.04e-10 - 0.0157)	(0.0637 - 0.104)	(0.0267 - 0.0466)	(0.0682 - 0.121)	(0.0570 - 0.0981)	(0.0774 - 0.141)
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	453,795	360,785	369,881	360,137	508,647	123,337

As shown in Table **3**, women who had a case of non-use prior to the birth of the index child were socially disadvantaged compared to women who used modern contraception, even when compared to contraceptive users who experienced a failure of that contraception. Thus, in the unadjusted model, it may be that the correlates of non-contraceptive use, which represent social disadvantage that drive the poor child health outcomes, and non-contraceptive use had no direct effect on poor child health outcomes. Moreover, as contraceptive use is correlated with wider birth intervals, it may be that contraceptive use proxies for the birth interval and that contraceptive use had no direct effect on child health. In Table **6**, demographic and social covariates were included in the multivariate model to identify the direct effects of contraceptive history on child health outcomes independent of social and demographic characteristics. In short, inclusion of demographic and social characteristics in the multivariate model did not alter the main conclusion from the unadjusted model that non-use of contraception prior to the birth of the index child led to the highest risk of poor child health outcomes across five of the six outcomes included in this study (Table **6**). Consider the stunting sample, column 2 of Table **6**: non-use of contraception prior to the pregnancy/birth of the index child yielded the highest relative risk (RR) of a stunted child (RR 1.120, 95% CI: 1.101, 1.140), and modern failure was not significantly different from successful use of modern contraception (RR 0.990, 95% CI: 0.965, 1.106). Moreover, successful traditional contraceptive use prior to the birth of the index child had no significantly different effect on child health than successful modern contraceptive use (RR 1.029, 95% CI: 0.998, 1.061). A child that was born following the failure of a traditional contraceptive method, however, was more likely to be stunted (RR 1.064, 95% CI: 1.039, 1.090) compared to the reference group. Regarding other child health outcomes, non-use ranged from a relative risk of anaemia of 1.045 RR (95% CI: 1.014, 1.077), 1.114 RR (95% CI: 1.068, 1.163) for wasting, 1.161 RR (95% CI: 1.130, 1.194) for underweight, and 1.244 RR (95% CI: 1.179, 1.312) for infant mortality. Modern failure was not significantly different from modern use in any of the child health outcomes. A prior termination led to poor child health outcomes in terms of the index child's stunting, underweight, and diarrhoea. Traditional contraceptive failure only resulted in a higher risk of stunting and underweight, but not of the other child health outcomes.

In the stunting sample, the risk of stunting declined with the mother's age through to age 40-44 years. Short birth intervals (12-17 months) increased the risk of stunting compared to intervals of >24 months (RR 1.125, 95% CI: 1.104, 1.147). Female children were less likely to be stunted (RR 0.911, 95% CI: 0.903, 0.919) than male children. There was a positive education gradient for child health; mothers who had no education or incomplete primary at the time of the interview Had a relative risk of having a stunted child of 1.394 (95% CI: 1.361, 1.428) compared to women with secondary education. The father's education also had a positive effect on child health, although to a lesser extent (0.906 RR of completed secondary compared to no education, 95% CI: 0.889, 0.923). The risk of stunting declined with wealth, and children in rural areas were more likely to be stunted (1.083 RR, 95% CI: 1.065, 1.101). A higher cluster level average vaccination rate also reduced the risk of stunting.

In Figure **1**, the adjusted relative risks of the key outcome of No failure/Non-use were compared to other key variables of education (age of the mother and birth interval). Each of these outcomes had a significant effect on child health. However, the independent effect of non-contraceptive use is not dwarfed by any of the other adjusted covariates. Thus, contraceptive use is just as important to child health outcomes as the well-known predictors of child health such as mother's age, education and birth interval.

DISCUSSION

Principal Findings

In this paper, I demonstrated that successful contraceptive use (modern use in particular, but also traditional use) had a positive effect on child health outcomes over and above the birth spacing effect compared to non-use of contraception in the intervening period between pregnancies. Contraceptive use increased birth spacing, and greater birth spacing has a positive effect on child health, but contraceptive use also had a direct positive effect on child health outcomes. This may be due to the greater access or knowledge of maternal and child health issues available to women who use contraception. Moreover, failure of modern contraception had no adverse effect on the health of the resultant child compared to successful use of modern contraception in the intervening period.

The results presented here indicate that contraceptive use, even if used unsuccessfully, provided positive health outcomes for subsequent

Table 6: Adjusted Relative Risk Ratios

	Infant mortality	Stunting	Underweight	Wasting	Diarrhoea	Anaemia
Contraceptive history						
No failure/Modern (omitted)						
No failure/Traditional	0.990	1.029	1.049	1.008	0.988	0.945
	(0.899 - 1.091)	(0.998 - 1.061)	(0.998 - 1.102)	(0.934 - 1.089)	(0.949 - 1.029)	(0.896 - 0.997)
No failure/Lactational	1.037	1.103	0.933	0.874	0.877	0.973
	(0.824 - 1.305)	(1.016 - 1.197)	(0.800 - 1.088)	(0.711 - 1.075)	(0.776 - 0.991)	(0.836 - 1.133)
No failure/Termination	1.072	1.063	1.104	1.021	1.172	1.042
	(0.985 - 1.167)	(1.033 - 1.094)	(1.058 - 1.153)	(0.957 - 1.090)	(1.131 - 1.213)	(0.995 - 1.092)
No failure/No contraception	1.244	1.120	1.161	1.114	0.941	1.045
	(1.179 - 1.312)	(1.101 - 1.140)	(1.130 - 1.194)	(1.068 - 1.163)	(0.918 - 0.963)	(1.014 - 1.077)
No failure/End calendar	0.773	1.113	1.131	1.103	0.979	1.011
	(0.735 - 0.812)	(1.094 - 1.132)	(1.101 - 1.162)	(1.055 - 1.152)	(0.955 - 1.003)	(0.979 - 1.044)
Modern failure	1.007	0.990	0.992	0.964	1.012	1.000
	(0.934 - 1.084)	(0.965 - 1.016)	(0.951 - 1.034)	(0.905 - 1.026)	(0.981 - 1.044)	(0.951 - 1.051)
Traditional failure	0.975	1.064	1.093	1.032	1.024	0.970
	(0.903 - 1.053)	(1.039 - 1.090)	(1.048 - 1.140)	(0.963 - 1.105)	(0.992 - 1.057)	(0.923 - 1.019)
Birth interval group (months)						
24+ (omitted)						
18-23	1.288	1.102	1.108	1.010	1.028	1.028
	(1.231 - 1.347)	(1.086 - 1.118)	(1.084 - 1.133)	(0.970 - 1.051)	(1.003 - 1.053)	(1.000 - 1.057)
12-17	1.760	1.125	1.181	0.962	1.059	1.043
	(1.671 - 1.853)	(1.104 - 1.147)	(1.147 - 1.215)	(0.911 - 1.015)	(1.026 - 1.092)	(1.004 - 1.083)
1-11	3.136	1.082	1.141	1.003	1.104	1.068
	(2.840 - 3.464)	(1.029 - 1.139)	(1.061 - 1.227)	(0.876 - 1.148)	(1.016 - 1.200)	(0.976 - 1.169)
First birth	1.838	0.969	1.007	1.026	0.956	0.949
	(1.754 - 1.926)	(0.951 - 0.987)	(0.979 - 1.036)	(0.972 - 1.084)	(0.923 - 0.991)	(0.914 - 0.986)
Child index						
Most recent born (omitted)						
2nd most recent	1.880	1.034	0.948	0.869	0.763	1.048
	(1.818 - 1.944)	(1.022 - 1.047)	(0.930 - 0.966)	(0.837 - 0.903)	(0.746 - 0.782)	(1.021 - 1.076)
3rd most recent	3.179	0.908	0.793	0.814	0.606	1.010
	(3.006 - 3.362)	(0.883 - 0.934)	(0.758 - 0.831)	(0.744 - 0.892)	(0.564 - 0.650)	(0.944 - 1.080)
4th most recent	4.549	0.763	0.681	0.861	0.713	1.156
	(3.942 - 5.250)	(0.679 - 0.858)	(0.567 - 0.819)	(0.624 - 1.187)	(0.551 - 0.921)	(0.908 - 1.470)
5th most recent	8.452	0.649	0.767	0.839	0.522	1.421
	(5.452 - 13.10)	(0.383 - 1.100)	(0.382 - 1.542)	(0.236 - 2.979)	(0.136 - 2.004)	(0.538 - 3.757)
6th most recent	8.949	0.843	1.596	3.35e-07	7.26e-06	5.68e-06
	(2.357 - 33.98)	(0.282 - 2.519)	(0.440 - 5.788)	(1.17e-07 - 9.53e-07)	(2.70e-06 - 1.95e-05)	(1.72e-06 - 1.87e-05)
Number of children ever born to index child's mother						
One (omitted)						
Two	1.204	1.046	1.034	1.066	0.931	0.960
	(1.135 - 1.276)	(1.024 - 1.069)	(1.001 - 1.069)	(1.005 - 1.131)	(0.897 - 0.967)	(0.921 - 1.000)
Three	1.570	1.110	1.091	1.081	0.939	1.000
	(1.460 - 1.688)	(1.081 - 1.140)	(1.048 - 1.136)	(1.007 - 1.160)	(0.899 - 0.981)	(0.952 - 1.051)
Four	1.718	1.171	1.127	1.073	0.989	1.023
	(1.582 - 1.865)	(1.138 - 1.205)	(1.079 - 1.177)	(0.995 - 1.157)	(0.943 - 1.036)	(0.970 - 1.079)
>Five	1.948	1.272	1.217	1.093	1.039	1.051
	(1.787 - 2.123)	(1.235 - 1.310)	(1.163 - 1.272)	(1.012 - 1.181)	(0.991 - 1.089)	(0.996 - 1.110)

(Table 6). Continued.

	Infant mortality	Stunting	Underweight	Wasting	Diarrhoea	Anaemia
Mother's age (years) at interview						
25-29 (omitted)						
12-14	6.059	1.333	1.398	1.092	1.234	1.262
	(4.577 - 8.020)	(1.204 - 1.476)	(1.251 - 1.563)	(0.900 - 1.326)	(1.086 - 1.404)	(1.025 - 1.554)
15-19	2.159	1.173	1.177	0.982	1.189	1.112
	(2.041 - 2.284)	(1.150 - 1.197)	(1.143 - 1.213)	(0.936 - 1.031)	(1.155 - 1.223)	(1.074 - 1.151)
20-24	1.237	1.082	1.050	0.964	1.096	1.071
	(1.188 - 1.288)	(1.067 - 1.097)	(1.029 - 1.073)	(0.932 - 0.997)	(1.073 - 1.119)	(1.046 - 1.097)
30-34	1.004	0.958	0.977	0.943	0.930	0.964
	(0.959 - 1.050)	(0.943 - 0.972)	(0.954 - 1.000)	(0.907 - 0.981)	(0.909 - 0.952)	(0.937 - 0.991)
35-39	1.102	0.941	0.972	0.949	0.860	0.940
	(1.044 - 1.164)	(0.924 - 0.958)	(0.944 - 1.001)	(0.902 - 0.997)	(0.835 - 0.885)	(0.907 - 0.974)
Age 40-44	1.359	0.924	0.932	0.936	0.846	0.902
	(1.264 - 1.461)	(0.902 - 0.947)	(0.894 - 0.971)	(0.869 - 1.007)	(0.810 - 0.883)	(0.857 - 0.949)
45-49	1.990	0.944	0.927	0.942	0.806	0.867
	(1.769 - 2.239)	(0.904 - 0.986)	(0.861 - 0.999)	(0.818 - 1.084)	(0.738 - 0.880)	(0.781 - 0.963)
Child age (months)						
0-11 (omitted)						
12-23		1.883	1.221	0.767	1.285	1.048
		(1.849 - 1.917)	(1.192 - 1.252)	(0.740 - 0.794)	(1.261 - 1.309)	(1.022 - 1.073)
24-35		1.933	1.226	0.636	0.874	0.728
		(1.896 - 1.971)	(1.193 - 1.260)	(0.610 - 0.664)	(0.854 - 0.894)	(0.705 - 0.751)
36-47		1.812	1.160	0.561	0.599	0.538
		(1.774 - 1.852)	(1.124 - 1.196)	(0.533 - 0.590)	(0.582 - 0.617)	(0.517 - 0.559)
48-59		1.622	1.197	0.598	0.493	0.439
		(1.583 - 1.662)	(1.155 - 1.241)	(0.563 - 0.634)	(0.476 - 0.511)	(0.417 - 0.461)
Child gender						
Male (omitted)						
Female	0.819	0.911	0.912	0.878	0.920	0.929
	(0.797 - 0.840)	(0.903 - 0.919)	(0.900 - 0.924)	(0.858 - 0.898)	(0.908 - 0.933)	(0.915 - 0.944)
Multiple birth						
Singleton (omitted)						
Multiple birth	3.467	1.369	1.781	1.301	1.112	1.179
	(3.256 - 3.691)	(1.324 - 1.415)	(1.697 - 1.869)	(1.189 - 1.424)	(1.043 - 1.185)	(1.113 - 1.248)
Mother's education						
Completed secondary (omitted)						
Completed primary	1.189	1.260	1.246	1.042	1.176	1.114
	(1.123 - 1.259)	(1.232 - 1.288)	(1.201 - 1.293)	(0.993 - 1.094)	(1.147 - 1.206)	(1.069 - 1.160)
No education or incomplete primary	1.293	1.394	1.498	1.186	1.230	1.191
	(1.214 - 1.376)	(1.361 - 1.428)	(1.440 - 1.559)	(1.125 - 1.251)	(1.195 - 1.267)	(1.139 - 1.244)
Mother's union status						
Partner (omitted)						
No partner	1.190	1.033	0.994	0.919	0.944	1.039
	(1.079 - 1.312)	(0.998 - 1.069)	(0.932 - 1.061)	(0.828 - 1.021)	(0.905 - 0.985)	(0.983 - 1.098)

(Table 6). Continued.

	Infant mortality	Stunting	Underweight	Wasting	Diarrhoea	Anaemia
Mother's partner's education						
No education or incomplete primary (omitted)						
Completed primary	0.976	0.963	0.912	0.895	0.987	0.955
	(0.942 - 1.011)	(0.952 - 0.975)	(0.896 - 0.929)	(0.867 - 0.923)	(0.969 - 1.007)	(0.935 - 0.976)
Completed secondary	0.888	0.906	0.822	0.857	0.940	0.920
	(0.843 - 0.936)	(0.889 - 0.923)	(0.797 - 0.848)	(0.818 - 0.897)	(0.916 - 0.965)	(0.887 - 0.954)
Mother's household's wealth quintile						
Poorest (omitted)						
Poor	1.007	0.916	0.871	0.890	0.933	0.959
	(0.969 - 1.047)	(0.904 - 0.928)	(0.854 - 0.889)	(0.858 - 0.923)	(0.913 - 0.953)	(0.935 - 0.983)
Middle	1.007	0.851	0.782	0.837	0.898	0.924
	(0.964 - 1.051)	(0.838 - 0.865)	(0.764 - 0.801)	(0.804 - 0.872)	(0.876 - 0.920)	(0.899 - 0.950)
Rich	1.018	0.790	0.731	0.820	0.832	0.886
	(0.968 - 1.070)	(0.775 - 0.805)	(0.711 - 0.753)	(0.782 - 0.859)	(0.809 - 0.857)	(0.858 - 0.915)
Richest	0.986	0.689	0.612	0.790	0.744	0.781
	(0.925 - 1.051)	(0.672 - 0.707)	(0.588 - 0.636)	(0.745 - 0.838)	(0.718 - 0.771)	(0.749 - 0.815)
Urban/Rural living						
Urban (omitted)						
Rural	0.959	1.083	1.013	0.933	0.912	1.004
	(0.923 - 0.997)	(1.065 - 1.101)	(0.988 - 1.039)	(0.898 - 0.970)	(0.891 - 0.933)	(0.975 - 1.034)
Piped water to house						
Water not piped to house (omitted)						
Water piped to house	0.946	1.056	0.988	0.992	0.998	1.009
	(0.912 - 0.982)	(1.042 - 1.071)	(0.966 - 1.011)	(0.955 - 1.031)	(0.978 - 1.019)	(0.985 - 1.033)
Flush toilet at house						
No flush toilet at house (omitted)						
Flush toilet at house	0.881	0.826	0.861	0.883	0.942	0.976
	(0.841 - 0.923)	(0.811 - 0.842)	(0.837 - 0.886)	(0.847 - 0.920)	(0.919 - 0.965)	(0.946 - 1.007)
Cluster average measles vaccination rate (continuous variable)						
Measles vaccination rate	0.551	0.914	0.784	0.743	0.880	0.856
	(0.510 - 0.596)	(0.886 - 0.943)	(0.749 - 0.820)	(0.689 - 0.802)	(0.838 - 0.923)	(0.811 - 0.903)
Constant	6.58e-06	0.160	0.130	0.319	0.172	0.244
	(-)	(0.124 - 0.207)	(0.0974 - 0.175)	(0.223 - 0.456)	(0.127 - 0.233)	(0.169 - 0.351)
Year of birth FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	453,795	360,785	369,881	360,137	508,647	123,337

children. Non-use of contraception in the intervening period led to poor child health outcomes, and this was not exclusively due to shorter inter-pregnancy periods. In contrast, the negative effect of non-use of contraception on child health was evident across all outcomes analysed in this study: infant mortality, stunting, wasting, underweight, diarrhoea, and anaemia.

Non-use of contraception was associated with low SES. Cross-tabulation in Table **3** demonstrated that of women who were non-users of contraception, more were in the poorest wealth quintile (24.29%) compared to those women who were successful users of modern contraception (19.01%). The same disparity existed for education level (non-users had lower education levels), rural living, and the presence of water and sanitation facilities at the house. Partners of non-users also had

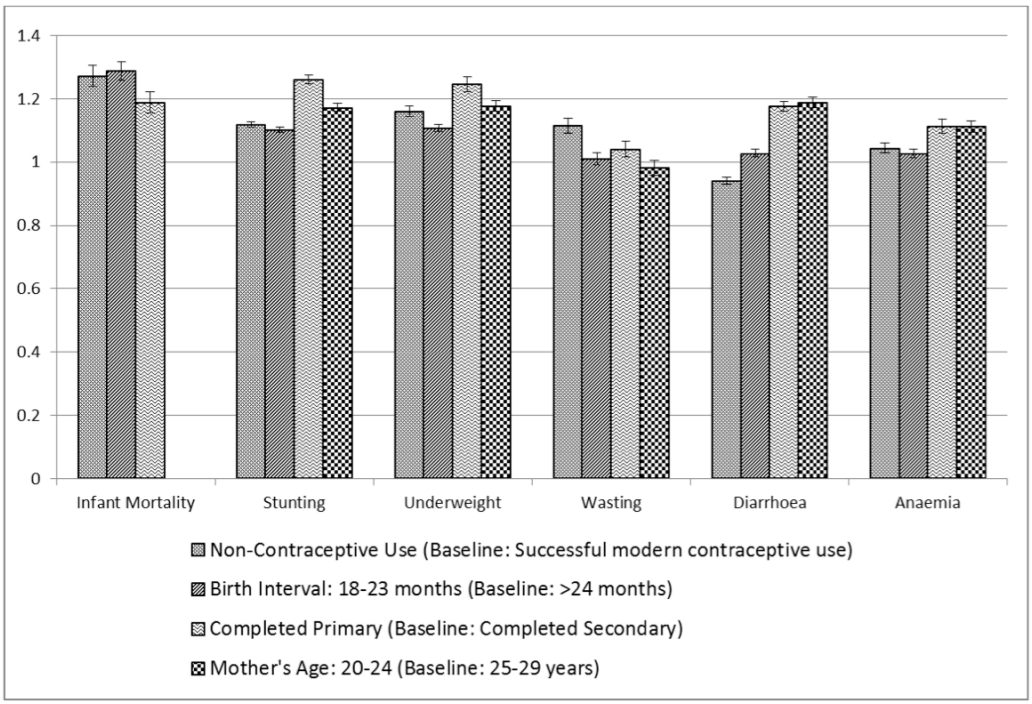

Figure 1: Magnitude of the adjusted relative risk of non-use of contraception compared to other key predictors of child health.

lower education levels. Contraceptive failure was not marked by women who were disadvantaged.

Women who used contraception, whether the contraception failed or not, were more advantaged than those women who did not use any contraception. Women who did not use contraception also had shorter birth intervals between births compared to users of modern (and traditional) contraception. These differences were large. Of the women who did not use contraception, 24.48% of them had children spaced 18-23 months apart; of those who used modern contraception successfully, 5.54% had children spaced 18-23 months apart; and for those who used modern contraception that failed, 10.54% had children spaced 18-23 months apart. Thus, non-contraceptive use was clearly associated with shorter birth intervals, but the multivariate analysis highlights that contraceptive use had a positive effect on child health in addition to the effect it had on widening birth intervals.

Comparisons to other Studies

Consistent with other studies, I found beneficial effects of contraceptive use on child health outcomes [4, 7]. Cleland *et al*. [7] focus on the effect of extended birth interval on child health outcomes; however, these authors did not analyse the direct effect of contraception on child health outcomes. In this paper, it was shown that contraceptive use was associated with longer interpregnancy intervals, thus supporting Cleland *et al*.'s [7] analysis. Cleland *et al*. [7] also analysed the effect of birth interval on infant mortality, child mortality, and stunting. They found that the risk of these poor child health outcomes decreases as the birth interval increases (although for infant mortality, intervals longer than four years result in a slightly increased risk). In the current study, the analysis was taken to a deeper level, examining the contraceptive practices of individual women and the effect of those practices on subsequent children. The ranges of health outcomes examined in this paper were also more comprehensive than any other study conducted to date to my knowledge.

Limitations of the Study

Although this study provided important insights into the benefits of contraceptive use, there are certain limitations that should be considered when interpreting the results. The primary variable of interest, contraceptive history, is subject to measurement error as data collection of this variable relies on recall by the respondent on a month-by-month basis for up to 80 months prior to the interview. As the contraceptive history data are drawn from a different variable than the child health outcomes and birth (and death) history, there is a possibility that the three histories do not agree. This was easily confirmed with the variable of the age of the child that can be calculated using all three histories. For the sample used in this study, I

found near perfect agreement across the three histories.

A further limitation of the model is that the socio-economic measures of male and female education, together with the wealth index, may not fully capture the SES of the woman and her child. While I included information regarding location of residence, piped water to the house, and flush toilets, these all served as proxies for actual SES. Any unobserved wealth captured in the residual will confound the current results. Factors such as actual household income and education quality are such variables that we are unable to control for in the regression and may significantly influence child health outcomes and shape our understanding of the role of SES factors.

In general, observational studies are subject to the limitation of omitted variables. In this case, there may have been variables that were spuriously correlated with contraceptive use, but for which I did not control. This would mean that the significance attributed to contraceptive use behavior as a significant spurious correlate of child health outcomes may in fact be a proxy for other omitted factors. Fixed effects on year of birth are included in both the unadjusted and adjusted regressions to control for common factors in a given year, and secular changes over time. Country fixed effects were also included in the unadjusted and adjusted regressions to control for factors that may have been common to women within the same country and were unchanging over time. The covariates controlled for deviations from the country average and the global time trends in the variables included in the adjusted regressions. However, there may be some factors that were correlated to the explanatory variable of interest that were omitted from the regression, in which case the regression coefficients suffered from omitted variable bias.

One of the key outcomes of interest in this study was infant mortality. Infant mortality was aggregated across all causes of death. However, it could be reasonably expected that the contraceptive history of the mother affected infant mortality outcomes that were attributed to a specific cause of death. Using a range of child health outcomes in this study, I illustrated how the age of the mother was differentially (or similarly) related to various outcomes. However, an investigation of the vulnerability of death by pneumonia, diarrhoea, malaria, or AIDS, for example, by the age of the mother is beyond the scope of this study as cause of death for children is not recorded in most DHS.

CONCLUSIONS AND IMPLICATIONS

The results of this study provide an additional force in the setting of the family planning agenda. In this study, it was clear that contraceptive use (particularly the use of modern contraception) had a positive effect on child health. This is in part due to an indirect effect of long inter-pregnancy intervals, but contraception also has an additional direct effect on child health over and above the positive influence of spacing. The use of family planning has an equal, and independent, effect on child health as female education and the age of the mother at birth. While family planning is known to have indirect effects on health through assisting with birth spacing, empowering women to stay in school, and delay of first birth, the findings in this paper highlight the large direct benefits contraceptive use has on child health.

The findings in this paper bring family planning to the centre stage as an effective mechanism to help achieve the Millennium Development Goals, namely MGD4 of Child Health.

CONTRIBUTORS

JEF led the conception, preparation of the secondary source data, empirical analysis, interpretation of the results, and drafting of the manuscript. The author has seen and approved this final submitted version of the manuscript. The author will provide final approval of the version to be published.

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COMPETING INTERESTS

None declared.

ETHICAL REVIEW

The DHS data collection procedures were approved by the ICF Macro International (Calverton, Maryland)

Institutional Review Board, as well as by the relevant body in each country that approves research studies on human subjects. Oral informed consent for the interview/survey was obtained from respondents by the interviewers. The current study was reviewed by the Harvard School of Public Health Institutional Review Board (Protocol #21213-101) and was ruled exempt from full review because the study was based on an anonymous public use data set with no identifiable information on the survey participants.

APPENDIX

Table A1: Sample Deduction

	Infant mortality		Stunting		Wasting		Underweight		Diarrhoea		Anaemia	
	Sample	**lost**	**Sample**	**lost**	**Sample**	**lost**	**Sample**	**lost**	**Sample**	**lost**	**Sample**	**lost**
Start with												
N countries	38		34		34		34		37		24	
N surveys	76		64		64		64		75		31	
N observations	762,389		642,876		642,876		642,876		760,963		333,909	
N lost if child height missing				214,205		214,205		214,205				
N lost if child height mis-coded				6,659		6,659		6,659				
N lost if child weight mis-coded				567		567		567				
N lost if too low				13,770		3,948		778				
N lost if too high				3,939		14,275		6,789				
			403,736		403,222		413,878					
N lost if diarrhoea data missing										162,562		
N lost if anaemia data missing												197,480
N lost if mother's info is missing												
N lost if child is aged 0-11 months		126,952										
N lost if child mortality		8,984										
N lost if contraceptive history missing		106,982		12,829		12,780		13,088		17,097		4,557
	519,471		390,907		390,442		400,790		581,304		131,872	
N lost to covariates	453,795	65,676	360,785	30,122	360,137	30,305	369,881	30,909	508,647	72,657	123,337	8,535
End with												
N countries	35		32		31		31		35		21	
N surveys	67		58		57		57		67		27	
N observations	**453,795**		**360,785**		**360,137**		**369,881**		**508,647**		**123,337**	

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