

Determinants of Suboptimal Birth Interval in Ugandan Women of Reproductive Age: A Generalized Linear Model Approach Using Modified Poisson Regression Analysis

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Abstract

Background

Optimal birth spacing is critical for maternal and child health, with the World Health Organization recommending pregnancy intervals of at least 24 months to minimize adverse health outcomes. Despite global progress in family planning, suboptimal birth intervals remain persistently high in sub-Saharan Africa, particularly in Uganda, where high fertility rates and unmet contraceptive needs continue to compromise maternal and child wellbeing. This study estimated the prevalence and determinants of suboptimal birth intervals among Ugandan women over a two-decade period.

Methods

This study utilized data from five consecutive Uganda Demographic and Health Surveys conducted in 2000/2001, 2006, 2011, 2016, and 2022. The analytical sample comprised 28,319 women of reproductive age with at least two live births. Suboptimal birth interval was defined as spacing less than 33 months between consecutive births, following WHO recommendations. Modified Poisson regression with robust variance estimation was employed to estimate prevalence ratios and 95% confidence intervals for socio demographic, economic, reproductive health, and temporal factors associated with suboptimal birth spacing, accounting for the complex survey design.

Results

Overall, 84% of Ugandan women experienced at least one suboptimal birth interval, with prevalence declining from 88.3% in 2000 to 79.2% in 2022. High parity (≥ 4 children) emerged as the strongest predictor, with women experiencing 47% higher prevalence of suboptimal intervals compared to those with fewer children. Women with secondary and higher education had 5% and 11% lower prevalence respectively compared to uneducated women, while those in the highest wealth quintile experienced 5% lower prevalence than the poorest. Rural residence conferred 4% higher prevalence compared to urban areas, and women aged 15–24 years had 12% higher prevalence than older age groups. Desire for more than five children and use of traditional contraceptive methods were associated with increased prevalence, while temporal trends showed consistent improvements, with 9% lower prevalence in 2022 compared to 2000, coinciding with increased modern contraceptive use from 22.4% to 37.1%.

Conclusion

Suboptimal birth intervals remained persistently high among Ugandan women throughout the two-decade study period, though modest declining trends were observed. Key determinants included high parity, lower socioeconomic status, rural residence, younger maternal age, and desire for large families.

Multi-level interventions are urgently needed to address both supply-side barriers through expanded access to modern contraceptives and demand-side factors through culturally sensitive family planning counseling, male partner engagement, and community education.

Background

World Health Organization (WHO) defines a suboptimal birth interval as a duration of less than 33 months between two consecutive live births (1). Birth intervals shorter than 33 months (equivalent to 24-month pregnancy intervals plus 9 months of gestation) have been consistently associated with elevated risks of maternal mortality, neonatal mortality, stillbirth, preterm birth, low birth weight, and small-for-gestational-age infants, with these associations particularly pronounced in low- and middle-income countries where resource constraints amplify the consequences of suboptimal spacing (2–4). Recent systematic reviews and dose-response meta-analyses have documented that both short pregnancy intervals (less than 18 months) and excessively long intervals (greater than 60 months) demonstrate non-linear relationships with adverse pregnancy outcomes, though the mechanisms differ, with short intervals linked to maternal depletion syndrome and long intervals associated with physiological regression of beneficial pregnancy adaptations (5). Despite global progress in family planning programs and contraceptive prevalence, sub-Saharan Africa continues to experience persistently high rates of suboptimal birth spacing, with approximately 20% of births occurring less than 24 months apart, reflecting the region's distinctive fertility transition characterized by lengthening birth intervals across all parities rather than concentrated parity-specific stopping behavior observed in Asia and Latin America (6–8).

The public health burden of inadequate birth spacing extends beyond immediate perinatal outcomes to encompass long-term child developmental consequences, with evidence from high-income nations documenting associations between suboptimal intervals and deficits in school readiness, cognitive development, and early childhood educational achievement (7). The determinants of suboptimal birth spacing in sub-Saharan Africa operate through complex, interrelated pathways encompassing socio-demographic inequalities, reproductive health service access, fertility preferences, and gender dynamics within couples. Socioeconomic gradients in birth spacing are well-established, with women's educational attainment demonstrating consistent protective associations through enhanced health literacy, improved contraceptive knowledge and self-efficacy, greater reproductive autonomy, and increased economic opportunities that incentivize smaller, better-spaced families (9, 10).

Uganda exemplifies the persistent challenges of achieving optimal birth spacing in sub-Saharan Africa, maintaining one of the world's highest total fertility rates at 5.4 births per woman and elevated levels of unmet need for family planning at 28.4% among married women of reproductive age despite substantial investments in reproductive health programming over recent decades (11, 12). Contraceptive prevalence in Uganda has increased gradually, with modern method use rising from approximately 18% in the early 2000s to 37% by 2022, yet these gains remain insufficient to substantially alter birth spacing patterns, with 56% of all pregnancies classified as unintended and rapid repeat pregnancies continuing to drive

poor maternal and child health outcomes (13–15). Context-specific barriers to optimal birth spacing in Uganda include multi-level constraints operating at individual, interpersonal, community, and health system levels, with qualitative research documenting persistent sociocultural inhibitors such as pro naturist norms valuing large families, misconceptions and fears about contraceptive side effects, male partner opposition to family planning, religious proscriptions against contraception, and provider-level barriers including imposing non-evidence-based restrictions on young and nulliparous women's contraceptive access (16).

Regional variations within Uganda reflect heterogeneous fertility regimes shaped by differential exposure to family planning programs, varying ethnic and cultural compositions, uneven health system capacity, and socioeconomic development trajectories, with recent program evaluations documenting modest but significant reductions in education-related and socioeconomic inequities in modern contraceptive use following targeted interventions (17, 18). The Ugandan government has committed to reducing unmet need for family planning and improving birth spacing through policies including integration of family planning into maternal health services, youth-friendly sexual and reproductive health services, and community-based distribution of contraceptives, though implementation challenges and resource constraints limit program reach and quality (13, 19, 20). Recent demographic transitions across sub-Saharan Africa, including Uganda, have been characterized by stalled or slow fertility decline in many settings, raising questions about whether traditional demographic transition theories developed in other regions adequately capture African fertility dynamics, with evidence suggesting that institutional, economic, and cultural factors unique to the region may necessitate context-specific theoretical frameworks and programmatic approaches (21, 22). Thus, this analysis aimed to estimate the prevalence and determinants of suboptimal birth intervals among Ugandan women using five waves of nationally representative Demographic and Health Survey data spanning two decades (2000–2022), employing modified Poisson regression to identify socio demographic, economic, reproductive health, and temporal factors associated with suboptimal birth spacing while accounting for complex survey design and controlling for potential confounders.

Methods

Data Source and Study Population

This study utilized data from five consecutive Uganda Demographic and Health Surveys (UDHS) conducted in 2000/2001, 2006, 2011, 2016, and 2022. The UDHS are nationally representative cross-sectional surveys that employ a two-stage stratified sampling design to collect comprehensive data on demographic and health indicators from women of reproductive age (15–49 years). The surveys are conducted under the global Demographic and Health Surveys (DHS) Program, which maintains standardized data collection methodologies across countries and time periods, ensuring comparability of findings.

Data Management

To create a comprehensive dataset spanning two decades, we systematically harmonized and merged the five UDHS datasets. Data management was conducted using Stata version 15 statistical software. The harmonization process involved several critical steps to ensure consistency across survey years, given variations in variable coding and categorization across different UDHS waves. First, we extracted relevant variables from each individual survey dataset, focusing on variables pertaining to birth intervals, socio demographic characteristics, reproductive health behaviors, and fertility preferences. For each survey year, we implemented standardized data cleaning procedures to recode variables into consistent categories across all datasets. Key harmonization steps included: regional classification, where survey regions were categorized into four consistent geographical zones (Central, Eastern, Western, and Northern) across all survey years; marital status standardization by combining "married" and "living together" categories into a single "married" category, and "divorced" and "separated" into a "separated" category; education variables harmonization for both respondent and partner into consistent categories (no education, primary, secondary, and higher education); wealth index standardization across all surveys using consistent labels (lowest, second, middle, fourth, highest); media exposure recoding to create binary indicators that were summed and dichotomized at the median; contraceptive use categorization into no contraceptive use, modern methods, and traditional methods; fertility preferences recoding into three categories (both partners want the same, husband wants more, husband wants fewer); and perception of distance to health facility harmonization to indicate whether distance was perceived as a "big problem" or "not a big problem." Following individual dataset cleaning, all five datasets were appended sequentially to create a pooled cross-sectional dataset, with a time variable created to identify the survey year for each observation, coded as: 1 = 2000/2001, 2 = 2006, 3 = 2011, 4 = 2016, and 5 = 2022.

To ensure analytical validity and focus on the study population of interest, we applied the following exclusion criteria: women with no live births (parity = 0) or only one live birth (parity = 1) were excluded, as birth intervals can only be calculated for women with at least two live births; women who reported a terminated pregnancy between their last two births were excluded to eliminate potential confounding effects on birth interval duration; and women with missing data on birth interval variables were excluded from the analysis. After applying these exclusion criteria, the final analytical sample comprised 28319 women with complete data on birth intervals and relevant covariates.

Variable Definition and Measurement

Outcome Variable

The primary outcome variable was suboptimal birth interval, defined according to World Health Organization (WHO) recommendations. Birth intervals were calculated as the duration in months between consecutive live births, derived from the birth history data collected in the UDHS. Specifically,

birth intervals were computed as the difference between the date of a subsequent birth and the date of the preceding birth. Birth intervals were initially extracted for up to 18 consecutive births per woman (variables b11_01 through b11_18 in the DHS datasets). For each birth interval, we created a binary indicator classifying the interval as suboptimal (coded as 1) if it was less than 33 months, or optimal (coded as 0) if it was 33 months or longer. This threshold is based on WHO recommendations that births should be spaced at least 33 months apart (equivalent to 24 months inter-pregnancy interval plus 9 months of pregnancy) to minimize adverse maternal and child health outcomes. A dichotomous variable indicating whether a woman had experienced at least one suboptimal birth interval (coded as 1) or had experienced only optimal birth intervals (coded as 0). This binary variable served as the primary outcome for the modified Poisson regression analysis.

Independent Variables

Independent variables were selected based on theoretical frameworks of fertility behavior and prior empirical evidence on determinants of birth spacing, encompassing socio demographic, economic, reproductive health, and temporal factors. Socio demographic characteristics included: maternal age at the time of survey, categorized into three groups (15–24 years, 25–34 years, and 35–49 years); place of residence as a binary variable indicating urban or rural location; region of residence categorized as Central, Eastern, Western, or Northern; marital status categorized as single, married, widowed, or separated; woman's education level categorized as no education, primary, secondary, or higher education; and partner's education level categorized as primary, secondary, or higher education. Economic factors comprised the household wealth index quintile based on ownership of assets and household amenities, categorized as lowest, second, middle, fourth, or highest. Reproductive health and fertility factors included: parity (birth order) as a binary variable indicating whether the woman had fewer than four children or four or more children; contraceptive use categorized as no contraceptive use, modern contraceptive methods, or traditional contraceptive methods; ideal number of children representing the woman's stated ideal family size, categorized as less than five children, five or more children, or "fatalistic" (up to God/doesn't know); and couple's fertility preferences indicating the concordance between partners regarding desired family size, categorized as both partners want the same number of children, husband wants more children, or husband wants fewer children. Health access and information factors comprised: perception of distance to health facility as a binary variable indicating whether distance to the nearest health facility was perceived as a big problem for accessing healthcare; and mass media exposure as a binary variable derived from frequency of exposure to radio, television, and newspapers, categorized as low exposure or high exposure. A temporal variable representing survey year was included as a categorical variable indicating the UDHS wave (2000/2001, 2006, 2011, 2016, or 2022) to account for temporal trends in birth spacing practices. All variables were checked for completeness, and descriptive statistics were computed to characterize the study population, with survey weights (v005) and cluster identifiers (v021 and v023) retained in the dataset to account for the complex survey design in subsequent analyses.

Statistical Analysis.

All statistical analyses were conducted using Stata version 15 statistical software, accounting for the complex survey design of the UDHS. Survey weights were applied to ensure nationally representative estimates, with the sampling weight variable (v005) divided by 1,000,000 to create normalized weights. The primary sampling unit (v021) was specified as the cluster identifier, and the survey design was declared using the svyset command to account for clustering and stratification in variance estimation. Descriptive statistics were computed to characterize the study population, with frequencies and proportions presented for categorical variables. Bivariate associations between independent variables and suboptimal birth interval were assessed using chi-square tests. The prevalence of suboptimal birth intervals was calculated with 95% confidence intervals for the overall sample and stratified by survey year to examine temporal trends. Given that the prevalence of suboptimal birth intervals exceeded 10%, modified Poisson regression with robust variance estimation was employed to estimate prevalence ratios (PRs) and their 95% confidence intervals, as odds ratios from logistic regression would overestimate the strength of associations when outcomes are common (23–25). The modified Poisson regression was implemented using a generalized linear model (GLM) framework with a Poisson family distribution and log link function. Initially, unadjusted modified Poisson regression models were fitted separately for each independent variable to examine crude associations with suboptimal birth intervals. Subsequently, a multivariable adjusted modified Poisson regression model was constructed including all independent variables simultaneously to estimate adjusted prevalence ratios (aPRs) while controlling for potential confounders. The overall significance of categorical variables with more than two levels was assessed using Wald tests. Statistical significance was set at $p < 0.05$ for all analyses. All analyses incorporated survey weights and accounted for the complex survey design to produce valid standard errors and confidence intervals.

Results

Table 1
Shows the study characteristics of Study Participants by Suboptimal
inter birth interval

Variable	Optimal n (%)	Suboptimal n (%)	P-value
	<i>4,536 (16.0)</i>	<i>23,783 (84.0)</i>	
Place of residence			
urban	<i>1,698 (37.4)</i>	<i>5,022 (21.1)</i>	<i>< 0.001</i>
rural	<i>2,838 (62.6)</i>	<i>18,761 (78.9)</i>	
Women`s education level			
No Education	<i>452 (10.0)</i>	<i>4,717 (19.8)</i>	<i>< 0.001</i>
Primary	<i>2,347 (51.8)</i>	<i>14,668 (61.7)</i>	
Secondary	<i>1,328 (29.3)</i>	<i>3,624 (15.2)</i>	
Higher	<i>408 (9.0)</i>	<i>774 (3.3)</i>	
Wealth index			
lowest	<i>770 (17.0)</i>	<i>5,678 (23.9)</i>	<i>< 0.001</i>
second	<i>768 (16.9)</i>	<i>4,921 (20.7)</i>	
middle	<i>731 (16.1)</i>	<i>4,502 (18.9)</i>	
fourth	<i>837 (18.5)</i>	<i>4,246 (17.9)</i>	
highest	<i>1,430 (31.5)</i>	<i>4,436 (18.7)</i>	
Distance to health facility			
big problem	<i>1,613 (35.6)</i>	<i>10,555 (44.4)</i>	<i>< 0.001</i>
Not a big problem	<i>2,922 (64.4)</i>	<i>13,217 (55.6)</i>	
Husband's desire for children			
both want same	<i>1,171 (47.5)</i>	<i>5,966 (42.9)</i>	<i>< 0.001</i>
husband wants more	<i>952 (38.6)</i>	<i>6,308 (45.3)</i>	
husband wants fewer	<i>344 (13.9)</i>	<i>1,641 (11.8)</i>	
Partner's education level			
no education	<i>175 (5.1)</i>	<i>1,707 (8.6)</i>	<i>< 0.001</i>
primary	<i>1,496 (43.4)</i>	<i>11,483 (57.6)</i>	
secondary	<i>1,253 (36.3)</i>	<i>5,025 (25.2)</i>	

Variable	Optimal n (%)	Suboptimal n (%)	P-value
higher	525 (15.2)	1,710 (8.6)	
Marital status			
Single	229 (5.0)	308 (1.3)	< 0.001
married	3,347 (73.8)	19,439 (81.7)	
widowed	146 (3.2)	1,164 (4.9)	
separated	813 (17.9)	2,869 (12.1)	
Contraceptive use			
No contraceptive use	2,852 (62.9)	15,667 (65.9)	< 0.001
Modern methods	1,528 (33.7)	7,199 (30.3)	
Traditional methods	156 (3.4)	917 (3.9)	
Birth order			
< 4	3,913 (86.3)	6,958 (29.3)	< 0.001
>= 4	623 (13.7)	16,825 (70.7)	
Ideal number of children			
Less than five	2,965 (65.8)	9,388 (40.0)	< 0.001
Greater than five	1,513 (33.6)	13,584 (57.9)	
fatalistic	29 (0.6)	507 (2.2)	
Region			
Central	1,379 (30.4)	6,090 (25.6)	< 0.001
Eastern	830 (18.3)	5,618 (23.6)	
Western	1,158 (25.5)	5,765 (24.2)	
Northern	1,169 (25.8)	6,310 (26.5)	
Media Exposure			
low exposure	2,713 (59.8)	16,776 (70.5)	< 0.001
high exposure	1,823 (40.2)	7,007 (29.5)	
Age group			
15–24	1,292 (28.5)	3,981 (16.7)	< 0.001
25–34	2,276 (50.2)	10,208 (42.9)	

Variable	Optimal n (%)	Suboptimal n (%)	P-value
35–49	968 (21.3)	9,594 (40.3)	
UDHS year			
2000	400 (8.8)	3,010 (12.7)	< 0.001
2006	434 (9.6)	3,440 (14.5)	
2011	547 (12.1)	3,451 (14.5)	
2016	1,377 (30.4)	7,126 (30.0)	
2022	1,778 (39.2)	6,756 (28.4)	

Table 1 presents the distribution of socio demographic, economic, and reproductive health characteristics stratified by birth interval status among 28,319 Ugandan women of reproductive age. Overall, 84.0% (n = 23,783) of women experienced at least one suboptimal birth interval, while 16.0% (n = 4,536) had exclusively optimal birth intervals. All predictor variables showed statistically significant associations with birth interval status ($p < 0.001$). Women with suboptimal birth intervals were more likely to reside in rural areas (78.9% vs. 62.6%), have lower educational attainment (19.8% with no education vs. 10.0%), belong to lower wealth quintiles (23.9% in the lowest quintile vs. 17.0%), and perceive distance to health facilities as a major barrier (44.4% vs. 35.6%). Reproductive characteristics revealed that women with suboptimal intervals had higher parity (70.7% with ≥ 4 children vs. 13.7%), desired larger families (57.9% wanting > 5 children vs. 33.6%), and more frequently reported discordant fertility preferences with their partners, particularly husbands wanting more children (45.3% vs. 38.6%). Additionally, women experiencing suboptimal intervals were more likely to have partners with lower education, have lower mass media exposure (70.5% vs. 59.8%), and be in older age groups (40.3% aged 35–49 years vs. 21.3%). Temporal analysis showed a declining trend in suboptimal birth intervals from 88.3% in 2000 to 79.2% in 2022, with the proportion of women maintaining optimal intervals increasing from 8.8% in 2000 to 39.2% in 2022.

Table 2
Shows the distribution of the study variables by UDHS years

UDHS YEAR						
Variable	2000	2006	2011	2016	2022	P - Value
	n (%)	n (%)	n (%)	n (%)	n (%)	
N	3,410 (12.0)	3,874 (13.7)	3,998 (14.1)	8,503 (30.0)	8,534 (30.1)	
Place of residence						
urban	926 (27.2)	503 (13.0)	966 (24.2)	1,697 (20.0)	2,628 (30.8)	< 0.001
rural	2,484 (72.8)	3,371 (87.0)	3,032 (75.8)	6,806 (80.0)	5,906 (69.2)	
Women`s education level						
No Education	894 (26.2)	1,025 (26.5)	829 (20.7)	1,327 (15.6)	1,094 (12.8)	< 0.001
Primary	1,974 (57.9)	2,291 (59.1)	2,313 (57.9)	5,270 (62.0)	5,167 (60.5)	
Secondary	429 (12.6)	458 (11.8)	698 (17.5)	1,479 (17.4)	1,888 (22.1)	
Higher	112 (3.3)	100 (2.6)	158 (4.0)	427 (5.0)	385 (4.5)	
wealth index						
lowest	639 (18.7)	913 (23.6)	960 (24.0)	2,009 (23.6)	1,927 (22.6)	< 0.001
second	524 (15.4)	794 (20.5)	768 (19.2)	1,797 (21.1)	1,806 (21.2)	
middle	604 (17.7)	725 (18.7)	649 (16.2)	1,716 (20.2)	1,539 (18.0)	
fourth	629 (18.4)	700 (18.1)	669 (16.7)	1,539 (18.1)	1,546 (18.1)	
highest	1,014 (29.7)	742 (19.2)	952 (23.8)	1,442 (17.0)	1,716 (20.1)	
Distance to health facility						
big problem	1,403 (41.2)	2,229 (57.6)	1,725 (43.2)	3,562 (41.9)	3,249 (38.1)	< 0.001
Not a big problem	2,003 (58.8)	1,642 (42.4)	2,268 (56.8)	4,941 (58.1)	5,285 (61.9)	

UDHS YEAR						
Variable	2000 n (%)	2006 n (%)	2011 n (%)	2016 n (%)	2022 n (%)	P - Value
husband's desire for children						
both want same	714 (41.9)	855 (41.5)	873 (42.3)	2,358 (44.3)	2,337 (44.7)	0.021
husband wants more	800 (46.9)	964 (46.8)	915 (44.3)	2,305 (43.3)	2,276 (43.5)	
husband wants fewer	191 (11.2)	243 (11.8)	276 (13.4)	656 (12.3)	619 (11.8)	
Partner's education level						
no education	364 (11.4)	452 (12.4)	485 (12.7)	581 (8.7)	0 (0.0)	< 0.001
primary	1,795 (56.2)	2,138 (58.5)	1,955 (51.0)	3,756 (56.0)	3,335 (55.7)	
secondary	747 (23.4)	798 (21.8)	1,025 (26.7)	1,672 (24.9)	2,036 (34.0)	
higher	290 (9.1)	268 (7.3)	368 (9.6)	696 (10.4)	613 (10.2)	
Marital status						
Single	63 (1.8)	69 (1.8)	56 (1.4)	174 (2.0)	175 (2.1)	< 0.001
married	2,761 (81.0)	3,159 (81.5)	3,248 (81.3)	6,875 (80.9)	6,743 (79.0)	
widowed	181 (5.3)	210 (5.4)	227 (5.7)	357 (4.2)	335 (3.9)	
separated	405 (11.9)	436 (11.3)	463 (11.6)	1,097 (12.9)	1,281 (15.0)	
Contraceptive use						
No contraceptive use	2,505 (73.5)	2,977 (76.8)	2,799 (70.0)	5,199 (61.1)	5,039 (59.0)	< 0.001
Modern methods	765 (22.4)	718 (18.5)	1,061 (26.5)	3,016 (35.5)	3,167 (37.1)	
Traditional methods	140 (4.1)	179 (4.6)	138 (3.5)	288 (3.4)	328 (3.8)	
Birth Order						
< 4	1,334 (39.1)	1,305 (33.7)	1,442 (36.1)	3,351 (39.4)	3,439 (40.3)	< 0.001

UDHS YEAR						
Variable	2000 n (%)	2006 n (%)	2011 n (%)	2016 n (%)	2022 n (%)	P - Value
>= 4	2,076 (60.9)	2,569 (66.3)	2,556 (63.9)	5,152 (60.6)	5,095 (59.7)	
Ideal number of children						
Less than five	1,672 (51.7)	1,598 (41.6)	1,781 (45.0)	3,919 (46.1)	3,383 (40.0)	< 0.001
Greater than five	1,563 (48.3)	2,127 (55.3)	2,099 (53.0)	4,347 (51.1)	4,961 (58.7)	
fatalistic	0 (0.0)	119 (3.1)	80 (2.0)	234 (2.8)	103 (1.2)	
Region						
Central	1,084 (31.8)	1,363 (35.2)	1,500 (37.5)	1,724 (20.3)	1,798 (21.1)	< 0.001
Eastern	840 (24.6)	450 (11.6)	460 (11.5)	2,333 (27.4)	2,365 (27.7)	
Western	513 (15.0)	908 (23.4)	838 (21.0)	2,430 (28.6)	2,234 (26.2)	
Northern	973 (28.5)	1,153 (29.8)	1,200 (30.0)	2,016 (23.7)	2,137 (25.0)	
Media Exposure						
low exposure	2,845 (83.4)	3,354 (86.6)	3,163 (79.1)	7,165 (84.3)	2,962 (34.7)	< 0.001
high exposure	565 (16.6)	520 (13.4)	835 (20.9)	1,338 (15.7)	5,572 (65.3)	
Age group						
15–24	825 (24.2)	784 (20.2)	756 (18.9)	1,598 (18.8)	1,310 (15.4)	< 0.001
25–34	1,542 (45.2)	1,784 (46.1)	1,832 (45.8)	3,766 (44.3)	3,560 (41.7)	
35–49	1,043 (30.6)	1,306 (33.7)	1,410 (35.3)	3,139 (36.9)	3,664 (42.9)	
Suboptimal inter birth interval (SBI)						
Optimal	400 (11.7)	434 (11.2)	547 (13.7)	1,377 (16.2)	1,778 (20.8)	< 0.001

UDHS YEAR						P - Value
Variable	2000 n (%)	2006 n (%)	2011 n (%)	2016 n (%)	2022 n (%)	
Suboptimal	3,010 (88.3)	3,440 (88.8)	3,451 (86.3)	7,126 (83.8)	6,756 (79.2)	

Table 2 presents the temporal distribution of socio demographic, economic, and reproductive health characteristics across the five UDHS waves (2000, 2006, 2011, 2016, and 2022) among 28,319 Ugandan women. The sample was fairly distributed across survey years, with 12.0% from 2000, 13.7% from 2006, 14.1% from 2011, and 30.0% each from 2016 and 2022. All study variables showed statistically significant variation across survey years ($p < 0.05$). Notable temporal trends included increasing urbanization, with urban residence rising from 27.2% in 2000 to 30.8% in 2022, despite a dip to 13.0% in 2006, while rural residence correspondingly declined from 72.8% to 69.2%. Educational attainment improved substantially over time, with the proportion of women with no education declining from 26.2% in 2000 to 12.8% in 2022, while secondary education increased from 12.6% to 22.1%. Wealth distribution remained relatively stable, though the highest wealth quintile showed fluctuation across surveys. Perceived barriers to healthcare access varied, with distance to health facilities being most problematic in 2006 (57.6%) and least problematic in 2022 (38.1%). Contraceptive use patterns demonstrated marked improvement, with modern method adoption increasing from 22.4% in 2000 to 37.1% in 2022, while non-use declined from 73.5% to 59.0%. Fertility preferences shifted toward smaller families, with the proportion desiring five or more children increasing from 48.3% in 2000 to 58.7% in 2022, though this appears counterintuitive and may reflect changing demographic profiles. Media exposure showed dramatic improvement in recent years, particularly in 2022 when 65.3% had high exposure compared to just 15.7% in 2016. Partner education improved over time, with the proportion having secondary education rising from 23.4% in 2000 to 34.0% in 2022, though the "no education" category was not captured in 2022. Finally, the prevalence of suboptimal birth intervals declined consistently from 88.3% in 2000 to 79.2% in 2022, reflecting positive trends in birth spacing practices over the two-decade period.

Table 3

Shows the factors associated with suboptimal inter-birth interval among women of reproductive age in Uganda.

Category	Unadjusted PR (95%CI)	P-value	Adjusted PR (95%CI)	P-value
Place of residence (Ref: Urban)				
Rural	1.17 (1.15–1.19)	< 0.001*	1.04 (1.02–1.06)	0.001*
Woman's education (Ref: No education)				
Primary	0.95 (0.94–0.96)	< 0.001*	1.00 (0.99–1.02)	< 0.001*
Secondary	0.81 (0.79–0.82)		0.95 (0.93–0.98)	
Higher	0.70 (0.67–0.74)		0.89 (0.84–0.95)	
Wealth index (Ref: Lower)				
Second	0.99 (0.97–1.00)	< 0.001*	1.00 (0.98–1.02)	< 0.001*
Middle	0.97 (0.96–0.99)		0.97 (0.95–0.98)	
Fourth	0.95 (0.94–0.97)		0.97 (0.95–0.99)	
Highest	0.87 (0.85–0.88)		0.95 (0.92–0.98)	
Problem accessing health care (Ref: Big problem)				
Not a big problem	0.94 (0.93–0.95)	< 0.001*	0.99 (0.97–1.00)	0.039*
Husband's fertility preference (Ref: Both want same)				
Husband wants more	1.04 (1.02–1.05)	< 0.001*	0.99 (0.98–1.01)	0.423
Husband wants fewer	1.00 (0.97–1.02)		0.99 (0.96–1.01)	
Partner's education (Ref: No education)				
Primary	0.97 (0.95–0.99)	< 0.001*	1.01 (0.99–1.04)	0.060

Category	Unadjusted PR (95%CI)	P-value	Adjusted PR (95%CI)	P-value
Place of residence (Ref: Urban)				
Secondary	0.88 (0.86–0.90)		1.00 (0.97–1.02)	
Higher	0.84 (0.82–0.87)		1.03 (1.00–1.07)	
Marital status (Ref: Single)				
Married	1.45 (1.34–1.57)	< 0.001*		
Widowed	1.53 (1.41–1.67)			
Separated	1.33 (1.22–1.45)			
Contraceptive use (Ref: No contraceptive)				
Modern methods	0.97 (0.96–0.99)	< 0.001*	1.00 (0.99–1.02)	0.022*
Traditional methods	1.01 (0.98–1.04)		1.04 (1.01–1.08)	
Birth order (Ref: < 4)				
≥ 4	1.50 (1.48–1.53)	< 0.001*	1.47 (1.43–1.51)	< 0.001*
Ideal number of children (Ref: less or equal to five)				
Greater than five	1.19 (1.17–1.20)	< 0.001*	1.06 (1.04–1.07)	< 0.001*
Fatalistic	1.24 (1.21–1.27)		1.08 (1.04–1.12)	
Region (Ref: Central)				
Eastern	1.07 (1.05–1.09)	< 0.001*	1.00 (0.98–1.02)	< 0.001*
Western	1.03 (1.01–1.05)		0.99 (0.97–1.01)	
Northern	1.04 (1.02–1.06)		0.95 (0.93–0.97)	
Survey year (Ref: 2001)				

Category	Unadjusted PR (95%CI)	P-value	Adjusted PR (95%CI)	P-value
Place of residence (Ref: Urban)				
2006	<i>0.99 (0.97–1.01)</i>	<i>< 0.001*</i>	<i>0.97 (0.95–0.99)</i>	<i>< 0.001*</i>
2011	<i>0.97 (0.95–1.00)</i>		<i>0.97 (0.95–1.00)</i>	
2016	<i>0.93 (0.91–0.95)</i>		<i>0.95 (0.93–0.97)</i>	
2022	<i>0.89 (0.88–0.91)</i>		<i>0.91 (0.89–0.93)</i>	
Media exposure (Ref: Low exposure)				
High exposure	<i>0.92 (0.91–0.93)</i>	<i>< 0.001*</i>	<i>0.99 (0.97–1.01)</i>	<i>0.450</i>
Age group (Ref: 15–24)				
25–34	<i>1.07 (1.05–1.10)</i>	<i>< 0.001*</i>	<i>0.88 (0.85–0.91)</i>	<i>< 0.001*</i>
35–49	<i>1.20 (1.18–1.22)</i>		<i>0.88 (0.86–0.91)</i>	

PR; Prevalence ratio, CI: Confidence Intervals, Ref; Reference category

Table 3 presents women residing in rural areas had a 4% higher prevalence of suboptimal birth intervals compared to their urban counterparts (aPR = 1.04, 95% CI: 1.02–1.06, $p = 0.001$). Educational attainment showed a protective dose-response relationship, with women having secondary education experiencing 5% lower prevalence (aPR = 0.95, 95% CI: 0.93–0.98, $p < 0.001$) and those with higher education having 11% lower prevalence (aPR = 0.89, 95% CI: 0.84–0.95, $p < 0.001$) compared to women with no education, while primary education showed no significant difference. Similarly, household wealth demonstrated a gradient effect, with women in the middle, fourth, and highest wealth quintiles experiencing 3% (aPR = 0.97, 95% CI: 0.95–0.98), 3% (aPR = 0.97, 95% CI: 0.95–0.99), and 5% (aPR = 0.95, 95% CI: 0.92–0.98) lower prevalence respectively compared to the lowest quintile (overall $p < 0.001$). Women who did not perceive distance to health facilities as a major problem had marginally lower prevalence of suboptimal intervals (aPR = 0.99, 95% CI: 0.97–1.00, $p = 0.039$), suggesting a 1% reduction. Contraceptive use showed minimal effects, with traditional methods associated with 4% higher prevalence (aPR = 1.04, 95% CI: 1.01–1.08, $p = 0.022$) compared to non-users, while modern methods showed no significant difference. Partner's education and couple's fertility preferences were not significantly associated with suboptimal intervals in the adjusted model. The strongest predictor of suboptimal birth intervals was

high parity, with women having four or more children experiencing 47% higher prevalence compared to those with fewer than four children (aPR = 1.47, 95% CI: 1.43–1.51, $p < 0.001$). Fertility preferences also remained significant, with women desiring more than five children having 6% higher prevalence (aPR = 1.06, 95% CI: 1.04–1.07, $p < 0.001$) and those with fatalistic attitudes having 8% higher prevalence (aPR = 1.08, 95% CI: 1.04–1.12, $p < 0.001$) compared to women desiring five or fewer children. Regional variations persisted after adjustment, with women in the Northern region showing 5% lower prevalence (aPR = 0.95, 95% CI: 0.93–0.97, $p < 0.001$) compared to the Central region, while Eastern and Western regions showed no significant differences. Temporal trends revealed significant improvements in birth spacing practices over time, with prevalence declining by 3% in 2006 (aPR = 0.97, 95% CI: 0.95–0.99), 3% in 2011 (aPR = 0.97, 95% CI: 0.95–1.00), 5% in 2016 (aPR = 0.95, 95% CI: 0.93–0.97), and 9% in 2022 (aPR = 0.91, 95% CI: 0.89–0.93) compared to 2000/2001 (overall $p < 0.001$). Finally, after controlling for other factors, older women had significantly lower prevalence of suboptimal intervals, with those aged 25–34 years showing 12% lower prevalence (aPR = 0.88, 95% CI: 0.85–0.91) and those aged 35–49 years also showing 12% lower prevalence (aPR = 0.88, 95% CI: 0.86–0.91) compared to younger women aged 15–24 years (overall $p < 0.001$), suggesting that younger women may be at higher risk of inadequate birth spacing. Media exposure showed no significant independent association with suboptimal intervals in the adjusted analysis ($p = 0.450$).

Figure 1 shows a consistent downward trend in the prevalence of suboptimal inter-birth intervals across five Uganda Demographic and Health Survey (UDHS) years from 2001 to 2022. The prevalence decreased from 88.3% in 2001 to 79.2% in 2022, representing an approximate 9 percentage point reduction over the two-decade period. While the decline shows a relatively steady trajectory, the rate of decrease appears modest, with the most notable drop occurring between 2016 (83.8%) and 2022 (79.2%). The shaded area representing the 95% confidence interval remains relatively narrow throughout, suggesting stable estimates across all survey years.

Discussion

The present study reveals that 84% of Ugandan women experienced suboptimal birth intervals over a 22-year period from 2000 to 2022, though this prevalence declined modestly from 88.3% to 79.2% over this timeframe. This persistently high prevalence aligns with broader regional patterns documented across sub-Saharan Africa, where birth spacing practices remain a critical public health concern despite ongoing fertility transitions. Research demonstrates that intervals shorter than 36 months substantially increase infant mortality risk, particularly in high-mortality settings like Uganda, and this relationship persists even after controlling for maternal heterogeneity (2, 26–28). The protective effects of optimal birth spacing are especially pronounced in low-resource contexts where maternal depletion, inadequate breastfeeding duration, and resource competition between closely-spaced siblings create compounding vulnerabilities for child survival (29–32). Our finding that high parity (≥ 4 children) emerged as the strongest predictor of suboptimal intervals (aPR = 1.47) reflects the cumulative reproductive burden faced by multiparous women, corroborating evidence that fertility decline in sub-Saharan Africa follows a distinctive pattern characterized by longer birth intervals across all parities rather than concentrated

family size limitation at higher parities (33–35). The observation that women desiring more than five children had 6% higher prevalence of suboptimal intervals underscores the persistent high fertility preferences in the region, where desired family sizes remain substantially elevated compared to other global regions, reflecting complex cultural, economic, and social factors that sustain pronatalist norms (36–39). Furthermore, the temporal trend showing declining suboptimal intervals by 9% in 2022 compared to 2000 (aPR = 0.91) suggests gradual improvements in reproductive behaviors, potentially reflecting increased contraceptive prevalence which rose from 22.4% to 37.1% for modern methods during the study period, consistent with documented contraceptive transitions in East Africa (40–42).

The socioeconomic gradients observed in this study—whereby educational attainment and household wealth demonstrated protective dose-response relationships with optimal birth spacing—illuminate the structural determinants underlying reproductive health disparities in Uganda. Women with secondary education experienced 5% lower prevalence of suboptimal intervals while those with higher education had 11% lower prevalence compared to uneducated women, findings consistent with extensive evidence that maternal education operates through multiple pathways including enhanced cognitive skills, improved economic opportunities, greater autonomy in fertility decision-making, and increased healthcare utilization (43–45). Education's impact on birth spacing extends beyond knowledge acquisition to encompass fundamental changes in women's bargaining power within households and their capacity to negotiate reproductive preferences with partners, particularly relevant in patriarchal contexts where husbands' fertility desires may diverge from women's optimal spacing intentions (10, 19, 46). The wealth gradient, with women in the highest quintile experiencing 5% lower prevalence compared to the poorest, reflects both direct economic barriers to contraceptive access and indirect pathways through which poverty constrains reproductive autonomy, consistent with documented wealth-related inequalities in maternal healthcare utilization across sub-Saharan Africa (10, 15, 47, 48). The finding that rural residence conferred 4% higher prevalence of suboptimal intervals compared to urban areas mirrors persistent urban-rural disparities in contraceptive access, health facility proximity, media exposure to family planning messages, and overall reproductive healthcare quality documented across the region (32, 49, 50). Notably, our results showed that perceiving distance to health facilities as a major problem was associated with only marginal increases in suboptimal intervals (aPR = 0.99), suggesting that geographic barriers may operate more indirectly through limiting women's exposure to family planning counseling and sustained contraceptive use rather than through absolute access constraints. The age-related protective effects whereby women aged 25–34 and 35–49 years had 12% lower prevalence of suboptimal intervals compared to adolescents (15–24 years) reflects developmental differences in reproductive maturity, contraceptive knowledge, and negotiating capacity, highlighting adolescent mothers as a particularly vulnerable population requiring targeted birth spacing (47).

The modest decline in suboptimal birth interval prevalence observed over the 22-year study period from 88.3% in 2000 to 79.2% in 2022 reflects the complex, often non-linear trajectory of fertility transitions in sub-Saharan Africa, which differs markedly from the rapid transitions experienced in Asia and Latin America during comparable developmental stages. This slower pace aligns with evidence that sub-Saharan African fertility transitions have been characterized by later onset and slower progression, with

distinctively longer birth intervals that emerge early in the transition process rather than exclusively through parity-specific stopping behaviors (6, 9). The finding that contraceptive use showed minimal independent effects in the adjusted model with traditional methods paradoxically associated with 4% higher prevalence of suboptimal intervals suggests potential issues with method effectiveness, discontinuation, or inconsistent use that merit further investigation, as contraceptive failure and method-switching remain substantial barriers to optimal birth spacing in the region (37, 51). Regional variations, with Northern Uganda showing 5% lower prevalence compared to Central region, may reflect differential exposure to humanitarian interventions, varying cultural norms around birth spacing, and heterogeneous health system capacity across the country's geopolitical zones. The observation that media exposure lost statistical significance in adjusted models ($p = 0.450$) despite bivariate associations suggests that media's influence on birth spacing operates largely through its correlation with education and urban residence rather than as an independent pathway, though high-quality family planning messaging remains an important component of comprehensive reproductive health strategies (47, 52). The interspousal fertility discordance observed in this study, where 45.3% of women with suboptimal intervals reported husbands wanting more children compared to 38.6% with optimal intervals, underscores the critical importance of couple-level interventions and male partner engagement in family planning programs, as spousal communication and shared decision-making are consistently associated with improved contraceptive uptake and optimal birth spacing outcomes (53). Looking forward, accelerating improvements in birth spacing practices will require multi-pronged interventions that simultaneously address supply-side constraints such as expanded access to long-acting reversible contraceptives (LARCs) through diversified service delivery channels including mobile outreach and task-sharing models (54, 55), demand-side factors including fertility preferences and gender norms and structural determinants particularly poverty, education, and women's empowerment. The persistently high prevalence of suboptimal intervals even in 2022 confirm that Uganda like many sub-Saharan African countries remains in the midst of a protracted demographic transition that will require sustained policy commitment and investment to achieve the reproductive health outcomes necessary for advancing maternal and child wellbeing and realizing the demographic dividend potential that optimal fertility behaviors can generate.

This analysis estimated the prevalence and determinants of suboptimal birth intervals among Ugandan women using five waves of nationally representative Demographic and Health Survey data spanning two decades (2000–2022), employing modified Poisson regression to identify sociodemographic, economic, reproductive health, and temporal factors associated with suboptimal birth spacing. The study revealed that suboptimal birth intervals remained persistently high throughout the study period, though a modest declining trend was observed from the earliest to the most recent survey year. Despite these improvements, the prevalence of inadequate birth spacing continued to represent a substantial public health burden, indicating that progress toward optimal reproductive health outcomes remained slow and insufficient. Key determinants of suboptimal birth intervals included high parity, lower educational attainment, household poverty, rural residence, younger maternal age, desire for large families, and use of traditional contraceptive methods, while temporal improvements were associated with increased

modern contraceptive uptake over the two-decade period. These findings highlighted the need for comprehensive, multi-level interventions that simultaneously address supply-side constraints such as expanded access to modern contraceptives through diversified service delivery channels, and demand-side factors including culturally sensitive family planning counseling, male partner engagement programs, and community-based education on the health benefits of optimal birth spacing. Additionally, policy efforts should prioritize addressing structural determinants through investments in girls' education, poverty reduction initiatives, women's economic empowerment programs, and integration of birth spacing counseling into routine maternal and child health services to accelerate progress toward achieving optimal reproductive health outcomes in Uganda.

Strengths and Limitations

This study's principal strengths included the utilization of extensive sample sizes, nationally representative survey data spanning a twenty-year period, and the application of sophisticated statistical analytical techniques. Nevertheless, the cross-sectional design of the surveys precluded the establishment of causal inferences between predictor and outcome variables. Additionally, the potential for recall bias existed, as participants were required to report on events that had occurred five or more years before the survey administration.

Abbreviations

- aPR
Adjusted Prevalence Ratio
- CI
Confidence Interval
- DHS
Demographic and Health Surveys
- GLM
Generalized Linear Model
- LARC
Long-Acting Reversible Contraceptive
- PR
Prevalence Ratio
- UDHS
Uganda Demographic and Health Surveys
- WHO
World Health Organization

Declarations

Conflict of interest

The authors declare no competing interests.

Ethical statement

Not applicable.

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Consent for publications

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are publicly available in the DHS repository, <https://dhsprogram.com/methodology/survey/survey-display-549.cfm>.

Author contributions

All authors contributed to the conceptualization, methodology, extensive search of articles, critical review of articles and results synthesis. T.K did the manuscript preparation, original draft writing and statistical data analysis. All authors have read and agreed to the final draft of the manuscript.

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Figures

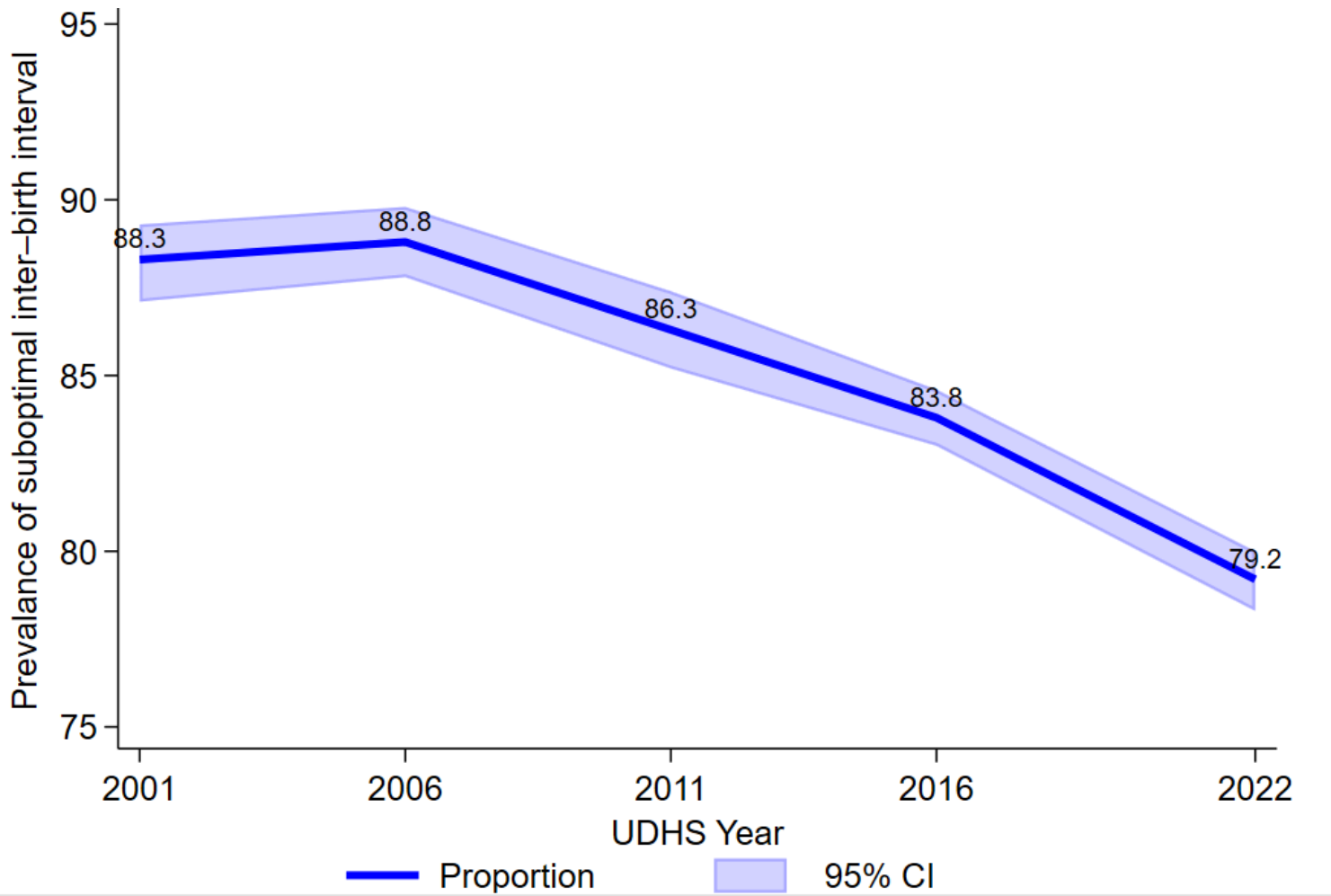


Figure 1

Shows the trend of prevalence of Suboptimal inter-birth interval over the five UDHS years