Original Article

Mapping Inequality: Spatial Patterns and Socio-Demographic Determinants of Unintended Pregnancy in Benin Republic

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Cite as: Dansou J. Mapping Inequality: Spatial Patterns and Socio-Demographic Determinants of Unintended Pregnancy in Benin Republic. Rwanda J Med Health Sci. 2026;9(3): 626-642. https://dx.doi.org/10.4314/rjmhs.v9i3.12.

Abstract

Background

Unintended pregnancy remains a major public health concern, with persistent disparities across low- and middle-income countries. In Benin, limited contraceptive access, socioeconomic vulnerability, and regional inequalities contribute to elevated rates, particularly among adolescents. This study estimated the prevalence of unintended pregnancy in Benin, identified its socio-demographic determinants, and mapped spatial disparities to inform equity-focused reproductive health interventions.

Methods

This cross-sectional study analyzed 8,993 women aged 15–49 from the 2017–2018 Benin Demographic and Health Survey (DHS). Unintended pregnancy was defined as mistimed or unwanted at conception. Survey-weighted logistic regression, accounting for DHS cluster sampling and stratification, identified predictors; spatial analysis used Local Indicators of Spatial Association (LISA) and Getis-Ord Gi* to detect geographic clusters.

Results

National prevalence was 26.0%. Higher odds were observed among adolescents, single women, those with higher parity, and women with primary or secondary education (e.g., single women: aOR = 2.20, 95% CI: 1.73–2.80). Atlantique emerged as a significant hotspot, while Atacora and Borgou were coldspots, with significant positive spatial autocorrelation (Global Moran's I = 0.546).

Conclusions

Unintended pregnancy in Benin shows marked geographic and socio-demographic disparities. Integrating spatial evidence into reproductive health planning is essential for equitable access and advancing Sustainable Development Goal 3.7.

Rwanda J Med Health Sci 2026;9(3):626-642

Keywords: Unintended pregnancy, spatial analysis, geographic disparities, determinants, Benin, LISA, Getis-Ord Gi, DHS

Introduction

Unintended pregnancy remains a significant global health challenge, particularly in low- and middle-income countries (LMICs).[1,2] Annually, between 2015 and 2019, an estimated 121 million unintended pregnancies occurred, with serious consequences: over 60% ended in abortion, and nearly half of those were performed under unsafe conditions.[3,4] Sub-Saharan Africa faces unique structural barriers—including limited access to modern contraceptives, restrictive sociocultural norms, and pervasive gender inequality—that undermine women's reproductive autonomy.[5] These pregnancies are linked to adverse maternal and child health outcomes, such as delayed antenatal care, low birth weight, and increased maternal morbidity and mortality.[6] The socioeconomic impacts are also substantial, contributing to school dropout rates, reduced labor force participation, and the perpetuation of intergenerational poverty, especially among adolescent girls.[7] Addressing unintended pregnancy is therefore crucial for achieving Sustainable Development Goals 3 and 5, which advocate for universal access to reproductive health and gender equality.[8,9]

Within sub-Saharan Africa, unintended pregnancy remains a pressing reproductive health concern, with significant regional disparities in both prevalence and outcomes. In Western Africa, approximately 6.5 million unintended pregnancies occurred each year between 2015 and 2019; alarmingly, 42% ended in abortion, an increase from 30% in the 1990s.[1,10] These statistics highlight persistent gaps in access to contraception, reproductive health education, and gender-responsive services.[5] In Benin, these challenges are particularly acute. The total fertility rate remains high at 5.7 births per woman, and the adolescent birth rate is among the highest in the region at 108 births per 1,000 girls aged 15–19.[11,12,16] Despite national efforts, only 12% of women use modern contraceptives, and 36% report unmet need – numbers that vary significantly by region and socioeconomic status.[11] Studies indicate that 80.1% of first pregnancies among adolescents in Benin are unplanned, with even higher rates in urban areas and among girls facing financial hardship.[24]

Despite a growing body of literature on unintended pregnancy in sub-Saharan Africa, research has often focused on prevalence and sociodemographic determinants, with limited attention to spatial variations.[5,13] Geospatial analyses are essential for identifying regional disparities and designing targeted interventions, yet they remain underutilized in reproductive health planning. While countries like Ethiopia and India have begun mapping unintended pregnancy hotspots using spatial autocorrelation and cluster analysis,[14,15] similar approaches are notably absent in West Africa. This represents a critical gap, as the absence of spatially explicit data hinders the design of localized strategies to reduce unintended pregnancies and improve contraceptive access, particularly in countries like Benin where reproductive outcomes vary widely by region.[24] Addressing this gap is essential for advancing equity, optimizing service delivery, and achieving Sustainable Development Goal 3.7 on universal access to sexual and reproductive healthcare.

Geographic disparities in unintended pregnancy remain a barrier to equitable reproductive health outcomes,[13] yet spatial analyses of this outcome are scarce in Benin. This study is among the first to apply spatial cluster analysis (LISA and Getis-Ord Gi*) to unintended pregnancy in Benin, with the objective of mapping geographic disparities and identifying the socio-demographic determinants that underlie them, to provide evidence for equity-focused reproductive health interventions.

Methods

Study design

This is a cross-sectional analytical study based on secondary data from the 2017–2018 Benin Demographic and Health

Survey (DHS), a nationally representative household survey implemented through a two-stage stratified cluster sampling design.

Data sources

The study draws on data from the 2017–2018 Benin Demographic and Health Survey (DHS), focusing on women aged 15 to 49 whose most recent pregnancy culminated in a live birth within the five years preceding the survey. This selection criterion was applied to enhance temporal relevance and reduce potential recall bias in self-reported pregnancy intentions. The analysis is based on the Individual Recode (IR) dataset, which provides comprehensive information on contraceptive practices, fertility preferences, and pregnancy outcomes at the individual level. The dataset is publicly available through the DHS Program repository. From the total sample of 15,928 women, 8,993 met the inclusion criteria and were retained for analysis.

Variables and measurement

Outcome variable

The primary outcome of interest is unintended pregnancy, determined based on retrospective self-reports regarding the intention status of the respondent's most recent live birth. A pregnancy was categorized as unintended if the woman indicated it was either mistimed or not desired at the time of conception. This variable was coded as a binary indicator, where 1 denotes an unintended pregnancy and 0 indicates an intended one, thereby capturing discrepancies between reproductive intentions and actual pregnancy experiences.

Independent variables

The independent variables in this study were selected based on both empirical significance in bivariate analysis and their established relevance in the literature on unintended pregnancy across sub-Saharan Africa. Demographic factors included age at the time of survey (categorized into seven age groups) and marital status (married/cohabiting vs. single/not cohabiting). Reproductive history was captured through the number of living children, ranging from none to seven or more. Socioeconomic indicators comprised highest level of education (none, primary, secondary or higher) and household wealth index (poorest to richest). Religious affiliation was categorized as traditional, Muslim, Christian, or other. Behavioral and informational variables included frequency of listening to radio and watching television, as well as perceived difficulty in accessing health facilities (big problem vs. not a big problem). Contextual factors such as place of residence (urban vs. rural) and region of residence (covering all twelve departments of Benin) were also included to account for geographic and cultural variation. These variables have consistently emerged as significant predictors of unintended pregnancy in prior studies.[17–27,30,31]

Spatial boundaries and analysis

Spatial weights were defined using queen contiguity (departments sharing a border or vertex) with row-standardization; LISA and Getis-Ord Gi* significance was assessed analytically (not via Monte Carlo permutation), consistent with the small number of areal units (12 departments). This study employed spatial analysis to examine geographic disparities in unintended pregnancy across Benin's twelve administrative departments; Alibori, Atacora, Atlantique, Borgou, Collines, Couffo, Donga, Littoral, Mono, Ouémé, Plateau, and Zou—as defined in the Demographic and Health Survey (DHS) dataset. These departments represent distinct geographic, cultural, and socioeconomic zones, enabling contextual interpretation of reproductive health outcomes. Spatial boundaries were defined using a shapefile of Benin's administrative divisions, imported into R using the {sf} package.[32] This ensured compatibility with geospatial workflows and allowed for seamless integration with department-level DHS data. The resulting spatial objects were used to generate thematic maps and conduct spatial statistical procedures, including hotspot analysis and Local Indicators of Spatial Association (LISA), to detect clusters of high and low prevalence.

This approach revealed significant spatial heterogeneity and aligns with best practices in spatial epidemiology, supporting targeted interventions in regions with elevated risk. [22,30,31,33]

Statistical modeling

To identify determinants of unintended pregnancy and account for spatial dependencies, we employed a combination of classical and spatially informed statistical models. Initial exploratory analysis included descriptive statistics and bivariate associations between unintended pregnancy and each independent variables. We then fitted survey-weighted logistic regression (accounting for the DHS cluster sampling and stratification) to estimate adjusted odds ratios while controlling for potential confounders; model fit was assessed with the C-statistic (AUC = 0.732) and the Hosmer-Lemeshow test (p = 0.082, indicating no evidence of lack of fit). To assess spatial autocorrelation in model residuals, we computed Moran's I and applied Local Indicators of Spatial Association (LISA), revealing significant clustering patterns. To assess whether this residual spatial dependence required a spatially explicit specification at the department level, we fitted an ordinary least-squares (OLS) model of department-level prevalence on aggregated socio-demographic covariates, tested it with Lagrange Multiplier diagnostics (robust LMerror and LMlag tests), and then fitted spatial lag and spatial error models by maximum likelihood using the same queen-contiguity, row-standardized spatial weights as the Moran's I and LISA analyses. The robust LM diagnostics favored the error specification (robust LMerror = 11.48, $p < 0.001$, versus robust LMlag = 10.64, p = 0.001), and the spatial error model achieved the best fit (AIC = 72.3, versus 76.6 for OLS and 77.5 for the lag model; spatial error term lambda significant at p = 0.012) and was retained.Given Benin's 12 departments, this ecological analysis has limited statistical power and is reported as a descriptive, exploratory complement to the individual-level logistic regression, not as a replacement for it. This integrative approach allowed for robust identification of high-risk regions and population subgroups, supporting geographically targeted public health interventions.[30,34,35]

All analyses were conducted using the R statistical software (version 4.5) [36] and its associated data-management, analysis and reporting packages.[37–42]

Ethical considerations

This study used anonymized data from the 2017–2018 Benin DHS, collected with informed consent and ethical approval. Access was granted by ICF Macro through formal request procedures. All analyses respected confidentiality and ethical standards for secondary data use, ensuring no personal identifiers were accessed or disclosed in the research.

Results

Sample characteristics

Table 1 provides a comprehensive overview of the study population. It analyzed data from 8,993 women aged 15–49 years in the 2017–2018 Benin DHS. The most represented age group was 25–29 years (28.1%), followed by 20–24 years (21.4%) and 30–34 years (20.6%), indicating a concentration of respondents in their prime reproductive years. A majority lived in rural areas (61.4%), suggesting potential geographic disparities in access to reproductive health services. Educational attainment was low overall: 64.3% had no formal education, 20.5% had primary education, and only 15.2% had secondary or higher education, reflecting persistent barriers to female education. Marital status was predominantly married or cohabiting (92.3%), with only 7.7% single, which may influence fertility intentions and contraceptive use. Religious affiliation was diverse, with 50.3% identifying as Christian, 33.4% as Muslim, and 16.3% adhering to traditional or other beliefs. Parity was high, only 3.6% of women had no children, while 96.4% had at least one, and 45.6% had three or more children.

Wealth distribution was relatively balanced, though 22.4% belonged to the poorest quintile and 20.6% to the second poorest, indicating socioeconomic vulnerability. Notably, 67.2% of women reported difficulty accessing health centers due to distance, highlighting infrastructural challenges that may hinder timely care. These demographic and contextual factors are essential for understanding reproductive health dynamics and guiding equitable policy responses.

Table 1. Characteristics of study participants

Variable	Weighted Frequency (n=8993)	Percent (%)
Unintended pregnancy (last child)		
No	6,653	74.0
Yes	2,340	26.0
Age at the survey - (Mean : 29.28 years)		
15-19 years	504	5.6
20-24 years	1,923	21.4
25-29 years	2,531	28.1
30-34 years	1,855	20.6
35-39 years	1,323	14.7
40-44 years	602	6.7
45-49 years	256	2.8
Highest level of education		
None	5,783	64.3
Primary	1,644	18.3
Secondary or higher	1,566	17.4
Number of living children		
Five children	925	10.3
Four children	1,361	15.1
No child	77	0.9
One child	1,919	21.3
Seven children or more	668	7.4
Six children	652	7.3
Three children	1,597	17.8
Two children	1,794	19.9
Household wealth index		
Middle	1,830	20.3
Poor	1,819	20.2
Poorest	1,819	20.2
Richer	1,849	20.6
The richest	1,676	18.6
Religious membership		
Christian	4,525	50.3
Muslim	3,002	33.4
Other	613	6.8
Traditional	852	9.5
Listen to radio		
No	3,987	44.3
Yes	5,006	55.7
Watch TV		
No	5,875	65.3
Yes	3,118	34.7
Perception of the distance to get to health Center		
Big problem	5,981	66.5
Not a big problem	3,012	33.5
Marital status		
Married/Cohabiting	8,314	92.4
Single/not cohabiting	679	7.6
Place of residence		
Rural	5,485	61.0
Urban	3,508	39.0
Region/Department of residence		
Alibori	1,221	13.6
Atacora	797	8.9
Atlantique	1,038	11.5
Borgou	1,159	12.9
Collines	602	6.7
Couffo	580	6.5
Donga	597	6.6
Littoral	406	4.5
Mono	391	4.3
Ouémé	795	8.8
Plateau	548	6.1
Zou	859	9.6
Total	**8,993**	**100.0**

Prevalence of unintended pregnancy in Benin

Figure 1 illustrates the distribution of unintended pregnancy among women in Benin. Among the 8,993 women included in the study, 26.0% reported that their most recent completed pregnancy was unintended, while 74.0% indicated it was intended. The data were weighted to ensure national representativeness.

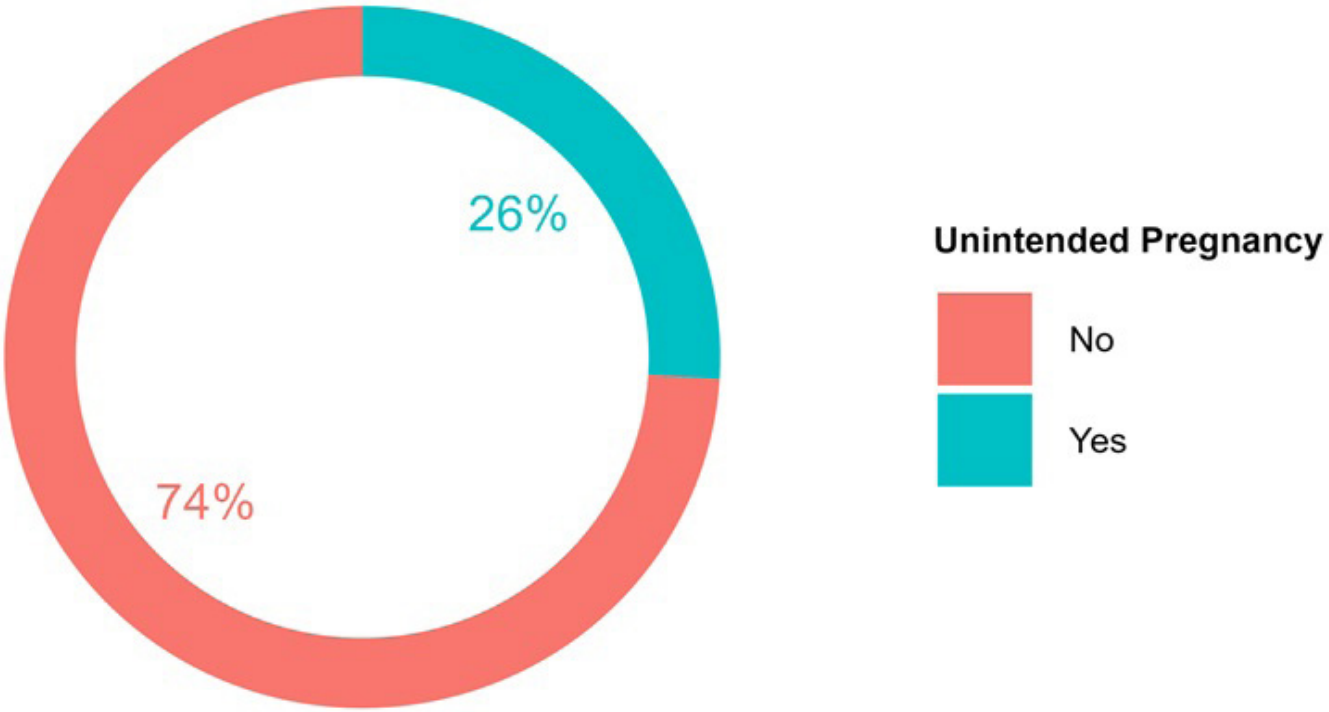

Figure 1. Unintended pregnancy rate in Benin

Table 2. Bivariate analysis of factors associated with unintended pregnancy in Benin

Variable	Unintended pregnancy (last child)		Chi-square	P value
	Yes	No		
Age at the survey - (Mean : 29.28 years)				
15-19 years	162 (32.0)	344 (68.0)		
20-24 years	571 (29.6)	1360 (70.4)		
25-29 years	613 (24.1)	1928 (75.9)		
30-34 years	453 (24.3)	1409 (75.7)	4.5	<0.001
35-39 years	323 (24.3)	1005 (75.7)		
40-44 years	153 (25.3)	451 (74.7)		
45-49 years	75 (29.1)	182 (70.9)		
Highest level of education				
None	1278 (22.0)	4528 (78.0)		
Primary	547 (33.1)	1103 (66.9)	46.9	<0.001
Secondary or higher	525 (33.4)	1048 (66.6)		
Number of living children				
No child	24 (30.7)	53 (69.3)		
One child	499 (25.9)	1428 (74.1)		
Two children	427 (23.7)	1374 (76.3)		
Three children	367 (22.9)	1236 (77.1)	5.3	<0.001
Four children	352 (25.8)	1014 (74.2)		
Five children	258 (27.7)	671 (72.3)		
Six children	187 (28.6)	468 (71.4)		
Seven children or more	236 (35.2)	435 (64.8)		
Household wealth index				
The richest	531 (31.6)	1152 (68.4)		
Poorest	349 (19.1)	1477 (80.9)		
Poor	438 (24.0)	1389 (76.0)	13.6	<0.001
Middle	479 (26.1)	1359 (73.9)		
Richer	554 (29.8)	1303 (70.2)		
Religious membership				
Traditional	247 (28.9)	609 (71.1)		
Muslim	421 (14.0)	2593 (86.0)	76.8	<0.001
Christian	1540 (33.9)	3003 (66.1)		
Other	142 (23.0)	474 (77.0)		

Table 2. Continued

Variable	Unintended pregnancy (last child)		Chi-square	P value
	Yes	No		
Religious membership				
Traditional	247 (28.9)	609 (71.1)	76.8	<0.001
Muslim	421 (14.0)	2593 (86.0)		
Christian	1540 (33.9)	3003 (66.1)		
Other	142 (23.0)	474 (77.0)		
Listen to radio				
Yes	1370 (27.3)	3657 (72.7)	5.5	0.019
No	980 (24.5)	3023 (75.5)		
Watch TV				
No	1485 (25.2)	4414 (74.8)	3.8	0.051
Yes	865 (27.6)	2265 (72.4)		
Perception of the distance to get to health Center				
Big problem	1619 (27.0)	4387 (73.0)	3.5	0.062
Not a big problem	731 (24.2)	2293 (75.8)		
Marital status				
Married/Cohabiting	2055 (24.6)	6292 (75.4)	60.6	<0.001
Single/not cohabiting	295 (43.2)	387 (56.8)		
Place of residence				
Rural	1355 (24.6)	4152 (75.4)	5.3	0.021
Urban	995 (28.3)	2527 (71.7)		
Region/Department of residence				
Littoral	153 (37.5)	255 (62.5)	29.5	<0.001
Alibori	72 (5.8)	1154 (94.2)		
Atacora	149 (18.6)	651 (81.4)		
Atlantique	494 (47.3)	549 (52.7)		
Borgou	200 (17.2)	964 (82.8)		
Collines	213 (35.3)	391 (64.7)		
Couffo	162 (27.8)	421 (72.2)		
Donga	98 (16.3)	501 (83.7)		
Mono	147 (37.6)	245 (62.4)		
Ouémé	262 (32.9)	536 (67.1)		
Plateau	134 (24.3)	416 (75.7)		
Zou	266 (30.8)	597 (69.2)		
Total	**2338 (26.0)**	**6655 (74.0)**		

At the bivariate level (Table 2), most variables showed significant associations with unintended pregnancy. Prevalence was highest among women aged 15–19 and lowest among those aged 25–39, rising again slightly among women aged 40 and above. Women with primary or secondary/higher education had higher prevalence than those with no education. Prevalence followed a U-shaped pattern with parity, lowest among women with two to three children and higher among those with no children or seven or more children. Single women had markedly higher prevalence than married/cohabiting women, and urban residents had higher prevalence than rural residents. Prevalence also varied by wealth, being highest among the richest and lowest among the poorest. Christians and traditionalists had higher prevalence than Muslims, and women reporting difficulty accessing health centers had slightly higher prevalence than those without difficulty.

Geographic variation in unintended pregnancy in Benin

Unintended pregnancy rates varied widely across Benin's twelve departments. The highest prevalences were observed in Atlantique (47.3%), Mono (37.6%), Littoral (37.5%), and Collines (35.3%), indicating concentrated reproductive health challenges in southern and central regions. Zou (30.8%), Ouémé (32.9%), and Couffo (27.8%) also showed elevated rates. In contrast, northern departments reported much lower prevalences: Alibori (5.8%), Donga (16.3%), Borgou (17.2%), and Atacora (18.6%). These disparities reflect underlying differences in education, access to services, and socioeconomic conditions, and highlight priority zones for targeted family planning interventions and spatially responsive health policies.

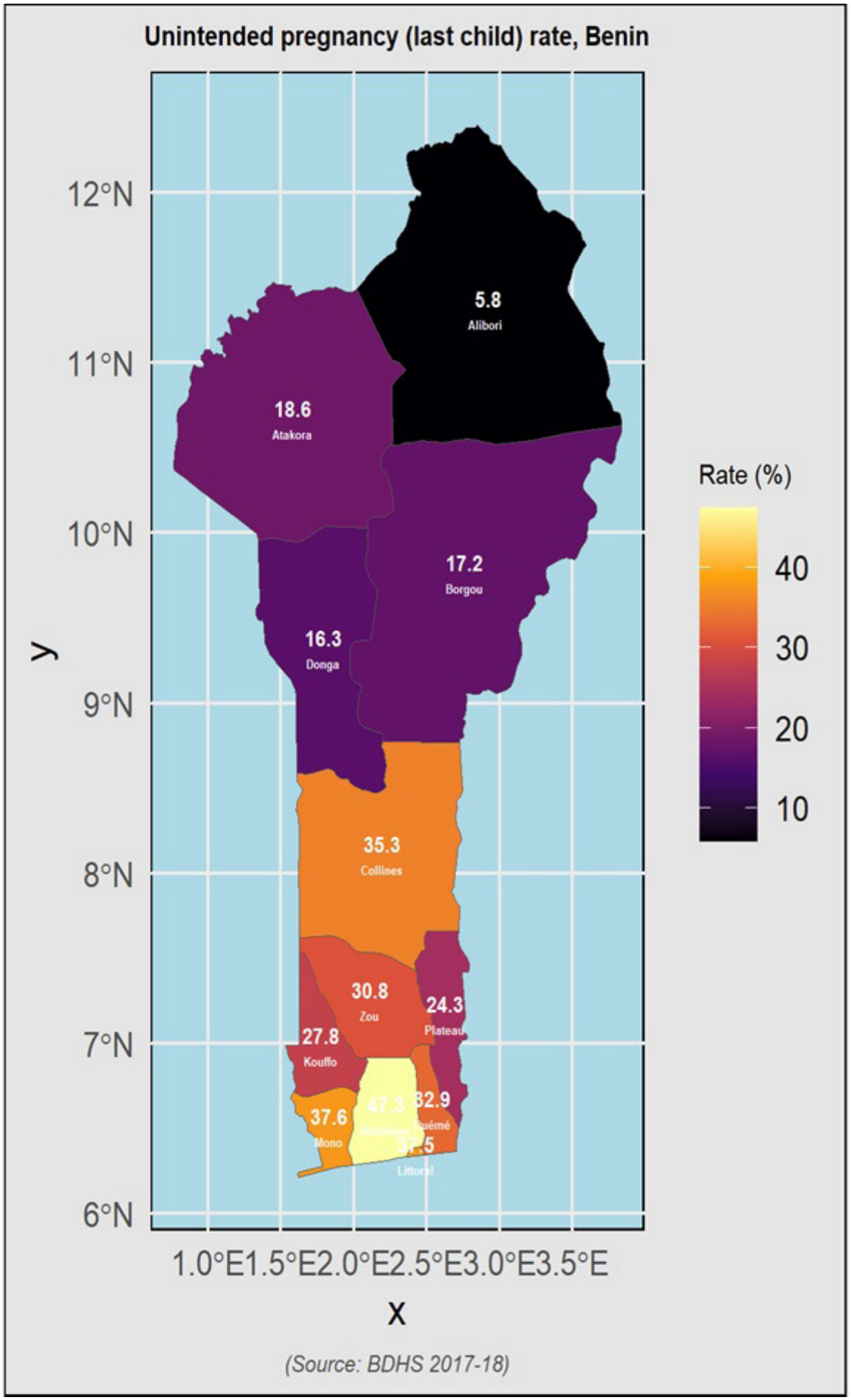

Figure 2. Spatial variations in unintended pregnancy across departments in Benin

Bivariate and multivariate analysis of factors associated with unintended pregnancy in Benin

Table 3 presents the findings from both bivariate and multivariate logistic regression analyses of unintended pregnancy among women of reproductive age in Benin, including adjusted odds ratios and their 95% confidence intervals. Multivariate logistic regression identified several significant predictors of unintended pregnancy. Compared with the youngest age group, odds of unintended pregnancy declined progressively with increasing age. Women with primary or secondary/higher education had significantly higher odds than those with no education. Parity showed a strong dose-response relationship among women with four or more children, with odds rising steadily as parity increased further. Single women had substantially higher odds than married or cohabiting women, while Muslim women had lower odds than traditionalists. Relative to residents of Littoral, women living in Alibori, Atacora, Borgou, Couffo, Donga, Ouémé, Plateau, and Zou had significantly lower odds of unintended pregnancy.

Table 3. Bivariate and multivariable analysis of factors associated with unintended pregnancy in Benin

Variable	Unintended pregnancy (last child)		unadjusted OR ~ 95 CI%	adjusted OR ~ 95% CI
	Yes	No		
Age at the survey - (Mean : 29.28 years)				
15-19 years	162 (32.0)	344 (68.0)	1.00	1.00
20-24 years	571 (29.6)	1360 (70.4)	0.89 [0.71-1.12]	0.67 [0.52-0.87]**
25-29 years	613 (24.1)	1928 (75.9)	0.68 [0.54-0.85]***	0.33 [0.25-0.44]***
30-34 years	453 (24.3)	1409 (75.7)	0.68 [0.54-0.87]**	0.22 [0.16-0.30]***
35-39 years	323 (24.3)	1005 (75.7)	0.68 [0.53-0.88]**	0.15 [0.11-0.21]***
40-44 years	153 (25.3)	451 (74.7)	0.72 [0.54-0.97]*	0.14 [0.09-0.20]***
45-49 years	75 (29.1)	182 (70.9)	0.88 [0.62-1.23]	0.14 [0.09-0.21]***
Highest level of education				
None	1278 (22.0)	4528 (78.0)	1.00	1.00
Primary	547 (33.1)	1103 (66.9)	1.76 [1.54-2.01]***	1.27 [1.10-1.47]**
Secondary or higher	525 (33.4)	1048 (66.6)	1.77 [1.52-2.08]***	1.46 [1.21-1.77]***
Number of living children				
No child	24 (30.7)	53 (69.3)	1.00	1.00
One child	499 (25.9)	1428 (74.1)	0.79 [0.45-1.38]	0.85 [0.46-1.58]
Two children	427 (23.7)	1374 (76.3)	0.70 [0.40-1.24]	1.24 [0.66-2.36]
Three children	367 (22.9)	1236 (77.1)	0.67 [0.38-1.17]	1.64 [0.87-3.13]
Four children	352 (25.8)	1014 (74.2)	0.78 [0.45-1.37]	2.62 [1.36-5.03]**
Five children	258 (27.7)	671 (72.3)	0.87 [0.49-1.53]	3.73 [1.92-7.25]***
Six children	187 (28.6)	468 (71.4)	0.90 [0.51-1.61]	4.82 [2.43-9.54]***
Seven children or more	236 (35.2)	435 (64.8)	1.23 [0.70-2.16]	8.73 [4.43-17.18]***
Household wealth index				
The richest	531 (31.6)	1152 (68.4)	1.00	1.00
Poorest	349 (19.1)	1477 (80.9)	0.51 [0.41-0.64]***	0.81 [0.62-1.05]
Poor	438 (24.0)	1389 (76.0)	0.68 [0.56-0.83]***	0.88 [0.70-1.12]
Middle	479 (26.1)	1359 (73.9)	0.76 [0.63-0.92]**	0.91 [0.73-1.14]
Richer	554 (29.8)	1303 (70.2)	0.92 [0.78-1.09]	1.02 [0.84-1.23]
Religious membership				
Traditional	247 (28.9)	609 (71.1)	1.00	1.00
Muslim	421 (14.0)	2593 (86.0)	0.40 [0.32-0.51]***	0.75 [0.58-0.98]*
Christian	1540 (33.9)	3003 (66.1)	1.26 [1.04-1.54]*	1.16 [0.93-1.44]
Other	142 (23.0)	474 (77.0)	0.74 [0.56-0.97]*	0.89 [0.67-1.17]
Listen to radio				
Yes	1370 (27.3)	3657 (72.7)	1.00	1.00
No	980 (24.5)	3023 (75.5)	0.87 [0.77-0.98]*	1.15 [1.01-1.32]*
Watch TV				
No	1485 (25.2)	4414 (74.8)	1.00	1.00
Yes	865 (27.6)	2265 (72.4)	1.14 [1.00-1.29]	0.92 [0.78-1.08]

Table 3. Continued

Variable	Unintended pregnancy (last child)		unadjusted OR ~ 95 CI%	adjusted OR ~ 95% CI
	Yes	No		
Perception of the distance to get to health Center				
Big problem	1619 (27.0)	4387 (73.0)	1.00	1.00
Not a big problem	731 (24.2)	2293 (75.8)	0.86 [0.74-1.01]	1.08 [0.93-1.26]
Marital status				
Married/Cohabiting	2055 (24.6)	6292 (75.4)	1.00	1.00
Single/not cohabiting	295 (43.2)	387 (56.8)	2.33 [1.87-2.90]***	2.20 [1.73-2.80]***
Place of residence				
Rural	1355 (24.6)	4152 (75.4)	1.00	1.00
Urban	995 (28.3)	2527 (71.7)	1.21 [1.03-1.42]*	1.04 [0.87-1.25]
Region/Department of residence				
Littoral	153 (37.5)	255 (62.5)	1.00	1.00
Alibori	72 (5.8)	1154 (94.2)	0.10 [0.07-0.15]***	0.11 [0.07-0.18]***
Atacora	149 (18.6)	651 (81.4)	0.38 [0.27-0.55]***	0.30 [0.20-0.46]***
Atlantique	494 (47.3)	549 (52.7)	1.50 [1.13-1.99]**	1.27 [0.93-1.74]
Borgou	200 (17.2)	964 (82.8)	0.35 [0.24-0.49]***	0.33 [0.22-0.49]***
Collines	213 (35.3)	391 (64.7)	0.91 [0.66-1.26]	0.76 [0.53-1.10]
Couffo	162 (27.8)	421 (72.2)	0.64 [0.46-0.90]*	0.58 [0.40-0.83]**
Donga	98 (16.3)	501 (83.7)	0.33 [0.22-0.47]***	0.35 [0.23-0.52]***
Mono	147 (37.6)	245 (62.4)	1.01 [0.67-1.50]	0.88 [0.58-1.34]
Ouémé	262 (32.9)	536 (67.1)	0.82 [0.60-1.12]	0.71 [0.51-0.99]*
Plateau	134 (24.3)	416 (75.7)	0.54 [0.38-0.75]***	0.51 [0.36-0.74]***
Zou	266 (30.8)	597 (69.2)	0.74 [0.57-0.97]*	0.62 [0.46-0.83]**

Number in data frame = 8993, Number in model = 8993, Missing = 0, AIC = 9429.4, C-statistic = 0.732, H&L = Chi-sq(8) 13.98 (p=0.082). Survey-weighted logistic regression accounting for DHS cluster sampling and stratification. * p<0.05, ** p<0.01, *** p<0.001.

Spatial autocorrelation in the distribution of unintended pregnancy rate: Global Moran's I

The Global Moran's I test was conducted to assess the presence of spatial autocorrelation in the distribution of unintended pregnancy rates. The analysis yielded a Moran's I value of 0.546, indicating a moderate positive spatial autocorrelation. The expected value under the null hypothesis of spatial randomness was –0.091, with a variance of 0.037. The standard deviate was 3.31, and the associated p-value was 0.0005, suggesting that the observed spatial clustering is statistically significant. These results support the alternative hypothesis that the spatial pattern is more clustered than would be expected by chance.

Geospatial clustering and hotspot analysis of unintended pregnancy

The three-panel spatial analysis of unintended pregnancy rates in Benin reveals distinct regional patterns and methodological convergence. The LISA cluster map identifies Atlantique as a statistically significant high-high cluster, indicating both a high unintended pregnancy rate (47.3%) and strong spatial autocorrelation with neighboring regions. Conversely, Atacora and Borgou emerge as low-low clusters, suggesting consistently low rates (18.6% and 17.2%, respectively) within a spatially coherent zone. The hotspot analysis corroborates these findings, classifying Atlantique as a significant hotspot and Atacora and Borgou as coldspots, based on z-score thresholds. Notably, several regions with moderately high rates, such as Littoral (37.5%), Mono (37.6%), and Ouémé (32.9%)—are not flagged by either method, suggesting that their spatial context may dilute statistical significance. The agreement map reinforces the robustness of the analysis, showing full concordance between LISA and hotspot methods in Atlantique (high) and Atacora/ Borgou (low), while the remaining

regions fall into a neutral category. This convergence strengthens confidence in the identified priority zones and highlights the utility of combining spatial autocorrelation and hotspot detection for public health surveillance.

Overall, the maps provide actionable insights for targeting interventions, allocating resources, and understanding the spatial dynamics of reproductive health disparities in Benin.

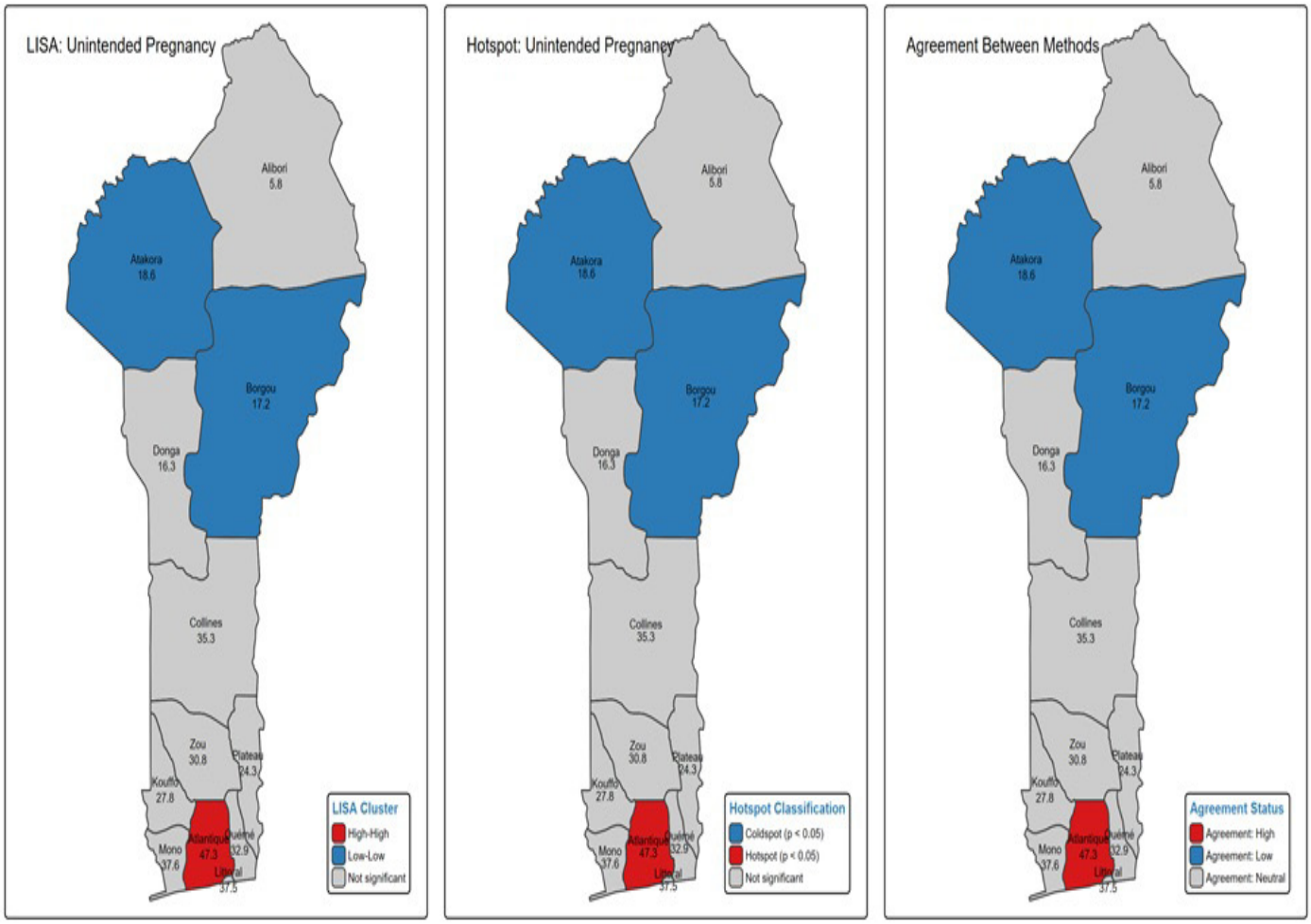

Figure 3. Comparative spatial clustering of unintended pregnancy rates in Benin: Lisa, Hotspot, and Method Agreement

Discussion

This study provides nationally representative and spatially disaggregated evidence on unintended pregnancy in Benin, identifying significant geographic clusters and socio-demographic correlates to inform equity-focused reproductive health interventions. This study found that 26.0% of women in Benin reported their last pregnancy as unintended. While lower than the global estimate of 48%,[1] it aligns with LMIC averages of 26.5%.[25] The figure reflects only live births, excluding abortions and miscarriages, which may underestimate the true burden. Regionally, Benin's rate is consistent with West Africa's slow progress: unintended pregnancy declined by just 8% between 1990–1994 and 2015–2019, while abortion rates among unintended pregnancies rose from 30% to 42%.[10] However, national averages mask disparities. A recent study found 80.1% of first pregnancies among Beninese adolescents were unplanned, especially among those with secondary education and unmet financial needs.[24] These findings highlight persistent gaps in contraceptive access and reproductive autonomy. Despite policy efforts, Benin's modern contraceptive prevalence remains low, and unmet need is high particularly among youth and rural women.[11]

In summary, before turning to interpretation: national prevalence of unintended pregnancy was 26.0%; the principal determinants were younger age, single marital status, higher parity, primary or secondary education and Muslim religious affiliation; and spatial analysis confirmed significant clustering, with Atlantique as a high-prevalence hotspot and Atacora and Borgou as coldspots, corroborated by a significant positive global spatial autocorrelation (Moran's I = 0.546) and concordant LISA and Getis-Ord Gi* results.

The study identified significant spatial heterogeneity in unintended pregnancy across Benin's departments. The Atlantique region emerged as a high-prevalence cluster, while Atacora and Borgou consistently showed low rates. These patterns were confirmed through both Local Indicators of Spatial Association (LISA) and Getis-Ord Gi* hotspot analysis, with strong agreement between methods. Several departments exhibited moderate prevalence but lacked statistically significant spatial clustering, suggesting neutral zones with diffuse or context-specific dynamics. These findings underscore the importance of spatially disaggregated data in reproductive health surveillance and policy design. The high concentration of unintended pregnancies in Atlantique, with Abomey-Calavi emerging as a key concentration zone, may reflect rapid urbanization, population density, and socioeconomic disparities. Abomey-Calavi commune functions as a dormitory city for many workers commuting to Cotonou, Benin's economic capital, reflecting rapid urbanization, and shifting socio-demographic dynamics. Urban areas often present paradoxes of access where services are available but underutilized due to cost, stigma, or misinformation.[24,33] In contrast, Atacora and Borgou's low rates may be shaped by rural norms, stronger community networks, or underreporting due to stigma or limited survey reach.[14,43] The presence of neutral zones regions with moderate rates but no spatial significance suggests local variability that may be masked by department-level aggregation. These areas warrant finer-scale analysis to uncover micro-level determinants and service gaps.

The multivariate analysis revealed that younger age, higher parity, primary or secondary education, being single, Muslim religious affiliation, and lack of radio exposure were significantly associated with unintended pregnancy in Benin. Adolescents aged 15–19 had the highest odds, consistent with findings from Mintogbe et al.,[24] who similarly reported elevated risk among young women in Benin. Women with four or more children showed sharply increasing odds, aligning with studies in Burundi and Ethiopia that link high parity and number of living children to unintended pregnancy.[17,23] Consistent with [33], women with primary or secondary education had higher odds than those with no education, suggesting that education alone may not reduce risk without empowerment or access to services. Being single more than doubled the odds, a pattern widely reported across LMICs.[19,25] Muslim women had lower odds, a pattern that may reflect cultural or normative factors not captured in this analysis and that warrants further qualitative investigation, while lack of radio exposure increased risk, underscoring the role of media in reproductive awareness. These findings reinforce the intersection of geographic, socioeconomic, and informational inequalities in shaping reproductive outcomes. Also, the importance of marital status and large family sizes as determinants of unintended pregnancies in these regions have been documented in some studies.[17]

Taken together, these socio-demographic and spatial findings directly address this study's objectives: they identify who is most affected (younger, single, higher-parity and Muslim women) and where (Atlantique and other high-prevalence departments), providing the evidence base called for in the introduction to inform equity-focused reproductive health interventions, with concrete program implications detailed below.

From a methodological standpoint, the use of LISA and Getis-Ord Gi* hotspot analysis is supported by spatial epidemiology literature, including foundational work by [34] and more recent applications in reproductive health.[35] These techniques allow for the detection of localized clusters and spatial autocorrelation, offering a nuanced view beyond national averages.[28,29] Importantly, few studies have applied spatial methods to unintended pregnancy in Benin, making this analysis a novel contribution. While previous research has highlighted socio-demographic determinants, the integration of geospatial techniques provides a new lens to understand how place-based factors interact with individual-level vulnerabilities.

The spatial convergence of unintended pregnancy in Atlantique identified as both a LISA high-high cluster and a statistically significant hotspot signals a critical zone for targeted reproductive health interventions. This dual-method agreement strengthens the case for prioritizing Atlantique in national and regional health planning. Policymakers should consider deploying intensified outreach programs, expanding contraceptive access, and strengthening youth-friendly services in this department, where the unintended pregnancy rate (47.3%) far exceeds the national average. Conversely, the consistent classification of Atacora and Borgou as low-low clusters and coldspots suggests relative resilience or effective coverage in these northern departments. The spatial neutrality of Ouémé (32.9%) and Littoral (37.5%) despite their relatively high prevalence raises concerns about potential under-recognition in policy prioritization. These departments may be overlooked in hotspot-driven strategies, yet their burden remains substantial. Integrating spatial analytics with epidemiological thresholds can help ensure that such regions receive appropriate attention. For example, deploying sentinel surveillance systems and community-based participatory mapping could uncover micro-level disparities and inform more granular interventions.

At the national level, the study advocates for embedding geospatial intelligence into reproductive health governance. Ministries should invest in interoperable data systems that link geocoded survey data with service delivery maps, enabling dynamic monitoring and responsive programming. Furthermore, the observed spatial patterns underscore the need for equity-focused budgeting, where resource allocation reflects both statistical significance and epidemiological burden. In summary, the mapped insights call for a shift from uniform reproductive health strategies to precision public health approaches. By aligning interventions with spatial evidence, Benin can enhance the efficiency, equity, and impact of its reproductive health programs—especially in underserved and emerging risk zones.

This study highlights the value of spatial analysis in understanding unintended pregnancy, but it also reveals several avenues for deeper inquiry. First, future research should incorporate temporal dimensions to examine trends over time and assess the impact of policy shifts, service expansions, or sociocultural changes. Longitudinal geospatial models could help identify emerging hotspots or declining clusters, offering predictive insights for proactive intervention. Second, integrating multilevel modeling would allow researchers to disentangle individual, household, and community-level effects. This approach could clarify how structural factors such as health facility density, education systems, or local governance interact with personal attributes to shape reproductive outcomes. It would also help address the limitations of department-level aggregation by capturing intra-regional variability. Third, future studies should explore the determinants of unintended pregnancy spatially, using geocoded survey data to map variables such as contraceptive access, education, media exposure, and financial autonomy. This would enable the identification of spatial correlates and causal pathways, enriching both epidemiological and policy understanding.

Finally, qualitative research in hotspot regions like Atlantique is essential to uncover lived experiences, cultural dynamics, and barriers to service uptake. Participatory methods such as community mapping and narrative interviews could complement quantitative findings and ensure that interventions are grounded in local realities. Together, these research directions can advance a more nuanced, equitable, and context-sensitive understanding of unintended pregnancy in Benin and beyond.

Strengths and limitations

This study offers a contribution to reproductive health research in Benin by integrating geospatial and multivariate techniques to examine unintended pregnancy. The use of Local Indicators of Spatial Association (LISA) and Getis-Ord Gi* hotspot analysis enabled the identification of statistically significant clusters and spatial autocorrelation, revealing geographic disparities that are often obscured in national-level data. The agreement between both spatial methods enhances the robustness of the findings and supports the validity of the spatial patterns observed. Additionally, the inclusion of a multivariate logistic regression model with a strong fit (C-statistic = 0.732) allowed for the identification of key socio-demographic determinants, providing a comprehensive understanding of both place-based and individual-level risk factors.

Despite these strengths, several limitations must be acknowledged. First, the analysis was conducted at the department level, which may mask intra-regional variation and micro-level clustering. Finer spatial resolution, such as commune or enumeration area could reveal more nuanced patterns. Second, the cross-sectional nature of the data limits causal inference and temporal analysis; unintended pregnancy is a dynamic outcome influenced by changing social and economic conditions. Third, potential underreporting due to stigma or recall bias may affect the accuracy of self-reported pregnancy intention, particularly among adolescents and unmarried women. Finally, neutral zones—regions with moderate prevalence but no spatial significance may reflect hidden heterogeneity that warrants further investigation through multilevel modeling or qualitative inquiry.

Overall, the methodological approach balances spatial precision with epidemiological rigor, offering a replicable framework for future studies in similar contexts. Transparency in limitations strengthens the interpretive credibility and underscores the need for continued investment in spatially disaggregated reproductive health data.

Conclusion

This study provides a spatial perspective on unintended pregnancy in Benin, revealing significant geographic disparities that warrant targeted policy attention. By applying spatial autocorrelation and hotspot analysis to nationally representative data, we identified persistent clusters of elevated prevalence, most notably in the Atlantique department suggesting localized drivers that may be obscured in aggregate statistics. These findings support integrating geospatial methods into reproductive health planning, with granular, subnational data and, where feasible, multilevel and mixed-methods approaches to inform equitable resource allocation in line with Sustainable Development Goal 3.7.

Authors' contribution

JD conceived the study, performed the statistical and spatial analyses, and wrote the manuscript.

Conflict of interest

The author declares no conflict of interest.

Generative AI

Generative artificial intelligence tools were used for translation and linguistic proofreading of the manuscript. The author reviewed and edited the resulting content and takes full responsibility for the accuracy and integrity of the work.

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