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Spatial multilevel modelling male partners' influence on women's modern contraceptive use: a study in Angola and Zambia

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Abstract

The main objective of this paper was to model the relationship between married women's contraceptive use and the influence of their male partners. The study took place in Angola and Zambia, which stems from the fact that these countries ratified the Maputo Protocol that emphasises promotion of reproductive health among women. Most previous studies investigating women's progress towards the realisation of what is advocated in this protocol have overlooked the role of the male partners. Hence, it has become imperative to reduce this gap in the literature. This paper discusses the application of spatial multilevel modelling, which incorporates two levels of information based on the nature of the data available. This approach acknowledges the hypothesis that contraceptive use is a social phenomenon occurring within the geographical space and is therefore susceptible to autocorrelation. Findings confirm that the level of influence of male partners' exertion on women's contraceptive use is dependent on the situation in the country where it takes place as shown by various study variables analysed. The results indicate that socioeconomic and education factors play a major role, a phenomenon that calls for tailor-made reproductive health policies considering these aspects.

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Introduction

In general, previous studies that examine women's use of contraceptives typically consider certain factors like age, education, place of residence, and employment status (Bakibinga *et al.*, 2019; Lasong *et al.*, 2020; Chola *et al.*, 2020; Ahinkorah, 2020; Mwansa *et al.*, 2021) among other aspects. However, when it comes to married women or those who are in a legal cohabitation arrangement with their partners, little attention is given in the literature to these partners' influence. It has also been determined that a married woman's contraceptive use can be influenced by the use of contraceptives by other women in her neighbourhood (Mulamba, 2023). This behaviour aligns with Tobler's first law of geography: "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970).

Sub-Saharan Africa is one of the regions with the highest fertility rate coupled with maternal and infantile deaths. Consequently, the region is of great interest for studies on contraceptive use (Decker & Constantine, 2011; Weidert *et al.*, 2016; Prata *et al.*, 2017; Nieto-Andrade *et al.*, 2017b; Mangimela-Mulundano *et al.*, 2022). The multi-faced nature of investigations on contraceptive use also emerges from the reviewed literature. For instance, some studies focus on the relationship between socioeconomic characteristics and contraceptive use among adolescents in the context of high adolescent pregnancy rates in these countries (Mwanangombe *et al.*, 2020; Chola *et al.*, 2020; Sserwanja *et al.*, 2022; Chola *et al.*, 2023), while others seek to understand the rural-urban divide and past reproductive health experiences and their relationships with contraceptive use (White & Speizer, 2007; Morris & Prata, 2018; Lasong *et al.*, 2020; Sserwanja *et al.,* 2022). The work presented here is related to the Maputo Protocol, officially known as the Protocol to the African Charter on Human and Peoples' Rights on the Rights of Women in Africa, a legal framework adopted by the African heads of State and Governments in 2003 and enforced in November 2005 in Maputo, Mozambique. The protocol addresses a wide range of women's rights issues aiming at elimination of all forms of discrimination against women and promoting equal participation of both genders in politics, decision-making, marriage, family rights and reproductive rights. Based on findings for Angola and Zambia, this paper presents key policy insights aligned with Article 14 of the Maputo Protocol, particularly regarding women's reproductive health.

Previous studies

Literature on the subject matter thus abounds, but the approach taken in this paper is to limit the discussion to selected papers to derive key features in addition to exploring the neighbourhood effect mentioned earlier. In this regard, the main focus of Mangimela-Malundano *et al.*'s (2022) study was to test the relationship between women's autonomy and contraceptive use in Zambia. Indeed, this relationship has been validated. Mwansa *et al.* (2021) also confirmed that a woman's educational attainment and her family's (household) wealth status are positively associated with contraceptive use in Zambia. Other studies, including that by Lasong *et al.* (2020) have also found a positive relationship between a woman's education level and her family's economic status on contraceptive use. Although important, the work by Sserwanja *et al.* (2022) is limited in scope as it focused on adolescents and employed a logistic modelling approach to the data provided by the Demographic and Health Surveys (DHS), a programme supported by USAID. One key aspect of their findings is that there was a higher level of contraceptive use in rural areas than in urban areas among Zambian adolescents. A similar study that focused on adolescents was conducted by Chola *et al.* (2023), which applied Spatial Multilevel (SML) modelling to the DHS waves from 1996 to 2013/14. It was concluded in that study that female adolescents 'age and educational attainment are associated with contraceptive use, and the rural-urban disparities disappeared in some waves and re-emerged in others. Ultimately, the issue of adolescents' contraceptive use requires significant attention, particularly in Africa, where it is believed that many factors, including some cultural and societal norms, may impede this group's access to contraceptives. However, the present paper focuses on married women of reproductive age, which excludes women below 18, as the aim is to understand male partners' role in these women's contraceptive behaviour. Other studies on the phenomenon include that by Bakibinga *et al.* (2019), which focused on particular contraceptive methods, notably injectables, long-acting, and permanent strategies for married women in Zambia. They rejected the idea that the use of these contraceptive methods is associated with religion or region. However, characteristics such as the age of the woman, their education level, and the education level of their male partner were indeed related to their contraceptive use. A modified Poisson regression was also used by Morris and Prata (2018) to purposely establish whether there is a link between abortion history and contraceptive use among women in Luanda, Angola. Another study that stands out is that of Decker and Constantine (2011), as it depicts a bleak picture of reproductive health in Angola (a post-conflict country) in contrast with the rapid economic growth registered there. A mixed method consisting of logistic regression and other qualitative techniques was used to gain a deep understanding of these issues, where it was found that education level and wealth were indeed associated with contraceptive use in Angola. It was also emphasised by Prata *et al.* (2017) that the rural-urban divide, when it comes to contraceptive use, can partly be explained by the fact that rural areas in Angola were associated with lower levels of education and wealth resulting from many years of civil war, which led to the government's near abandonment of these communities. During the war, the government's presence was primarily felt in urban areas, while rebels were predominant in rural communities. The findings of the present paper, as discussed in the results section, similarly reflect the persistence of rural-urban inequality. Some previous studies closely related to the present paper's focus on male partners' role in women's contraceptive use. For instance, Assaf and Davis (2019) used DHS data to examine male partners' role in women's contraceptive use in a cross-section of African countries, including Angola and Zambia. Prata *et al.* (2017) specifically focused on male partners' support for family planning and contraceptive use in Luanda, Angola. However, these studies, particularly those that used the DHS data and adopted econometric modelling, overlooked a critical aspect of the spatially hierarchical nature of the data at hand. In addition, these studies did not consider as many independent variables of interest to capture male partners' influence, as is the case in the present study. Most of the above-mentioned studies employed the logistic modelling approach, except Chola *et al.* (2020), who claimed that a Multilevel Model (ML) was employed by pooling a series of DHS waves. Despite this claim, that paper did not discuss how the data were arranged to ensure repeated measures of characteristics on the same individuals in several waves. To the author's knowledge, the DHS is not a longitudinal (panel data) study where the same respondents are followed for several waves (*i.e.* DHS years). For argument's sake, if one can accept Chola *et al.*'s (2020) ML claim, one aspect remains overlooked, notably the lack of cluster considerations, which are, at the same time, geographical units.

Objective and expected contribution

The objective of this paper was to apply the SML approach to examine the relationship between married women's contraceptive use and the influence of their male partners in Angola and Zambia. In addition to focusing on the role of male partners, another key contribution is the application of the SML approach, which has been largely overlooked in previous research that have used DHS data at the micro level. Except for my previous study (Mulamba, 2023), most research has failed to consider the spatial dimension in the data. This paper is focused on married women's access to modern contraceptives[1] as a critical aspect of reproductive health and human development in Angola and Zambia, an interest related to the fact that despite both countries being signatories of the Maputo Protocol, there are persisting challenges regarding access to contraceptives. For instance, based on the DHS data (ICF, 2018), only about 10% and 48% of married or legally cohabitating with male partners use contraceptives in these countries, respectively. It was therefore sought to fill the gap by answering this main question: "Do husbands or male partners influence women's use of contraceptives in Angola and Zambia?" The influence of male partners was assessed through their age, education, employment status, fertility preferences and shared decision-making on women's health and contraceptive use. These variables were purposely chosen to examine whether a partner's education level, for instance, positively impacts a woman's use of contraceptives, based on the understanding that higher education empowers partners to recognize the importance of contraception. Understanding these interactions is crucial for shaping effective human development policies that promote reproductive health and women's empowerment in Angola and Zambia. Since the influence by the neighbourhood should therefore be considered when modelling the relationship between women's contraceptive use and the influence of their male partners, the DHS data for both countries were used to achieve this objective. Based on the preceding discussion, the second question that this paper sought to answer is: "Do women within the same clusters in Angola and Zambia exhibit similar behaviour regarding contraceptive use?" It is noted that previous studies, some of which used the

[1]For brevity, 'contraceptive' hereafter refers to modern contraceptives in this paper.

DHS or similar clustered data, only consider this one aspect of spatial dependence by adopting a ML modelling approach as one way of dealing with this spatial dependence in the data (Palamuleni, 2013; Ngome & Odimegwu, 2014; Okigbo *et al.*, 2017). In essence, The ML accounts for within-cluster (spatial) dependence by incorporating the clusters' random effects into the model. Without this, the estimated parameters would have been less accurate and more biased. Hence, ignoring the spatial dependence in the model increases the risk of incorrectly concluding that male partners influence women's contraceptive use when, in reality, this is not the case. Moreover, the ML approach assumes that clusters' random effects are independent, meaning nearby clusters don't influence each other regarding women's contraceptive use. This assumption may not always hold when using DHS data, which is spatial. As mentioned, according to Tobler (1970), nearby clusters are expected to exhibit greater similarities than those farther apart. In this case, one must apply a model that considers this effect. In this regard, SML is convenient as it accounts for spatial dependence between clusters, leading to more reliable and precise estimates than the ML model (Bivand *et al.*, 2017). Additionally, SML captures cluster-wide spill-over effects, where nearby areas influence each other, offering a more realistic representation of geographic variation. It must also be noted that one advantage of the SML approach is that it accounts for both within-cluster and between-cluster dependence. In addition, SML provides more accurate and realistic estimates, particularly when the data exhibits patterns influenced by geographical or spatial proximity. This also implies that evidence-based public health policies are less likely to be misguided.

Materials and Methods

Rationale

This study used DHS data, a dataset structured so that women – the subjects of this study – and their characteristics (variables) are nested within clusters. These clusters represent geographical units or groups of about three hundred households equivalent to enumeration areas designated by national statistical agencies for data collection in the respective countries. Following my previous argument (Mulamba, 2023), it is plausible for married women residing in the same clusters to exhibit similarities in their use of contraceptives. This phenomenon is known as spatial autocorrelation, something which occurs when a social or economic phenomenon in nearby locations (*e.g.* women in the same clusters) – or within any other connected context – displays similar values, indicating a correlation between them.

Data

Two sets of data, referred to as spatial data and attributes, were used for analysis. First, spatial data included the longitudes and latitudes of the centroids of 625 and 545 clusters,[2] as they are defined in the DHS data for Angola and Zambia. This information was sourced from the DHS dataset files "AOGE71FL" and "ZMGE71" for Angola and Zambia, respectively An adjacency matrix W was constructed to estimate SML models capturing spatial dependence among the clusters' random effects using inverse Euclidean distances between clusters. The matrix assigned a zero value for diagonal elements and the inverse of centroid distances for off-diagonal elements, ensuring that each cluster is a neighbour to all others. This approach follows Tobler's first law of geography (1970), where spatial weights decay with increasing distance. While alternative criteria, such as contiguity could be used, the distance criterion was chosen because the sampled clusters in the DHS dataset are not necessarily contiguous, as argued by Mulamba (2023). Table 1 gives the variables used for the analysis that were sourced from the "AOIR71FL" and "ZMIR71FL" DHS files with the women's characteristics nested within the clusters (ICF, 2018). Information related to women of reproductive age and their husbands/partners in the sample was also

[2]A cluster consists of 100 to 300 households and corresponds to the enumerated areas designated by the National Statistics Bureau in both countries.

Table 1. The study variables.

Variable	Description
Dependent	
Contraceptive	A categorical variable equal to "Yes" if a woman uses contraceptives; otherwise "No".
Independent	
Both	A categorical variable equal to "Yes" if both the woman and her partner usually decide together on the woman's healthcare issues; otherwise "No".
Education woman	A woman's education expressed as the number of years in school.
Education partner	Education expressed as the number of years in school for the woman's partner.
Working woman	A categorical variable equal to "Yes" if the woman is currently working; otherwise "No".
Working partner	A categorical variable indicating whether a woman's partner is working. It is equal to "Yes" if he is working; otherwise "No".
Fertility woman	A categorical variable equal to "Yes" if the woman has indicated that she desires to have another child; otherwise "No".
Fertility with partner	A categorical variable equal to "Yes" if the woman has indicated that she desires more children than her partner; otherwise "No".
Wealth	A categorical variable indicating the wealth index, to which the woman belongs, where "Yes" is equal to poorest, two to poor, three to middle, four to richer than middle and five richest.
Age - woman	Age of the woman in years.
Age - partner	Age of the partner in years.
Residence	A categorical variable equal to "Yes" if a woman resides in an urban area; otherwise "No".
Religion	A categorical variable indicating the religion to which a woman belongs. The reference category is Catholic, while the other two categories are protestant and other.

selected from this file. Therefore, for every married woman of reproductive age (15–49 years) selected, her husband's or male partner's characteristics (*i.e.* educational attainment, employment status, etc.) were also selected to ensure dyad (a type of social network that includes two linked individuals) observations. The original multinomial variable indicating the current contraceptive method was transformed into a binomial indicator considered as the dependent variable. Four independent variables, represented by "both", "education partner", "working partner" and "fertility with partner", were of particular relevance for the capture of male partners' role in a woman's use of contraceptives. Whether the male partners' are involved in their female partners' health decisions is indicated by "both". This variable was included to find out if male partners' involvement in their female partners' health decisions has an influence on the women's use of contraceptives. The variable named "education partner" assumes that more educated male partners are more likely to understand the benefits of contraceptive use for their partners and may therefore encourage them to use contraceptives. Education typically leads to higher incomes, which, in turn, may lead to a desire for fewer children among husbands or partners that, in consequence, may lead to women being more likely to use contraceptives (Degraff *et al.*, 1997; Chacko, 2001). It can also be assumed that there is a positive correlation between women's use of contraceptives and having a "working partner" for the same reasons as noted above. Finally, as argued by Mulamba (2023) and Sarnak *et al.* (2021), fertility preference of male partners or husbands is a crucial determinant of contraceptive use among women. In this regard, "fertility with partner" is another variable through which a male partner's influence on his wife's use of contraceptives can be captured.

Moreover, eight control variables were selected based on the literature and data availability. These variables include "age woman", "age partner", "working woman", "education woman", "fertility woman", "wealth", "residence", and "religion". A detailed discussion of the theorised relationships between these control variables and the dependent variables is provided by Mulamba (2023). For brevity, this discussion is not repeated here.

Spatial multilevel modelling (SML)

Angola and Zambia had 625 and 545 clusters, respectively, which were included in the analysis. These clusters correspond to non-overlapping geographical boundaries. Women were indexed by $i(i = 1, \dots, n)$, and the clusters indexed by $j(j = 1, \dots, n)$. After discarding some cases due to missing information, 7 256 and 7 120 women from Angola and Zambia, respectively were retained for the study. The number of women was greater than the number of clusters, or $m < n$ (or 625 <7256; 545 < 7120) for each study area. Women's characteristics were considered Level One observations for econometric modelling purposes, while clusters were considered Level Two observations. Furthermore, the dependent variable was categorical and equal to 1 if a woman indicated that she used contraceptives ($Y_{ij} = 1$), and 0 if she did not ($Y_{ij} = 0$). Because of the distribution type of the dependent variable, the logistic transformation was traditionally applied to ensure that the model was estimable. This transformation entailed predicting the probability of a woman being part of a target group using contraceptives, represented by the expression $Prob\ (Y_{ij} = 1)$.

The logit was used to ensure the linear relationship between the independent variables and the probability of a woman using contraceptives. It is normally used in logistic regression instead of the probabilities bound to 0 and 1 as mentioned above. It is important to note that the logit transforms the predicted likelihood of target group membership. Equation (1) represents the logit transformation of women's likelihood of using contraceptives. In this specification, the $logit(p_{ij})$ stands for the log odds of a woman i in a cluster j using contraceptives. In addition, the vector of K independent variables is denoted by $X^T_{ij} = (X_{ij1}, \dots, X_{ijk})$.

$$logit(p_{ij}) = \ln\left(\frac{Prob(Y_{ij}=1)}{Prob(Y_{ij}=0)}\right) \qquad \text{(Eq. 1)}$$

Two main steps were followed to estimate and test the spatial multilevel logistic models. All models were estimated in the Bayesian context (Bivand *et al.*, 2015) using the integrated nested Laplace approximation algorithm programmed in the R-INLA package (https://www.r-inla.org).

Model specifications

Step 1

Equation 2 illustrates step 1 which is the non-spatial multilevel logistic model:

$$\begin{aligned} logit(Y_{ij} = 1) &= \alpha_{ij} + u_j \\ u_j &\sim N(0, \tau_u) \\ \pi(\tau_u) &\sim N(\mu_\alpha, \sigma^2_\alpha) \\ \pi(\tau_u) &\sim logGamma(1, 10^{-5}) \end{aligned} \qquad \text{(Eq. 2)}$$

where $a_{i,j}$ is the overall intercept of log odds of a woman using contraceptives across all clusters *i.e.* the fixed effects; u_j the intercept attributable to cluster *j, i.e.* the random effects; $\tau_u = \frac{1}{\sigma^2_u}$,; and π prior distributions of the relevant parameters; (for more details on R-INLA priors, see Wang *et al.*, 2018)

For computation purposes, the algorithm in R-INLA uses its inverse (τ_u), also referred to as precision, instead of the variance for the random effects. However, when reporting on estimates in the section related to results, the variance and not the precision is presented for interpretation, while π indexes prior distributions of the relevant parameters to be estimated following the Bayesian approach. The inverse of its variance (τ_u) is estimated as it conveys valuable information for analysis. Eq. 2 tests the appropriateness of a multilevel model against a single-level model. Technically, it tests whether the between-clusters variance is large enough to explain the log odds of a woman using contraceptives. This means that, after estimating Eq. 2, the Intra-Class Correlation Coefficient (ICC), also known as the variance partition coefficient, must be calculated. An ICC indicates the proportion of the variation in the use of contraceptives that is due to differences between the clusters rather than differences within individual women and can be calculated from the estimated non-spatial null multilevel logistic model as follows:

$$ICC = \frac{\sigma^2_u}{\sigma^2_u + \left(\frac{\pi^3}{3}\right)} \qquad \text{(Eq. 3)}$$

where $(\pi^3/3) \approx 3.29$ is the standard logistic distribution of the level 1 variance component.

A higher value of ICC implies there is dependence between households within wards, whereas a lower ICC shows independence. The conventional threshold of 0.05 determines whether the between-clusters variance is significant (Heck *et al.*, 2014).

Step 2

Provided that the suitability of multilevel over single-level logistic models is confirmed, the next step, entailed estimating what is referred to as a random intercept logistic model, can be taken. The next equation represents the specification of a random intercept logistic model as follows:

$$\begin{aligned} &logit(Y_{ij}=1)=\alpha_{ij}+X_{ijk}^{T}\beta+u_j \\ &\pi(\alpha_{ij})\sim N(\mu_\alpha,\sigma_\alpha^2) \\ &\pi(\beta)\sim N(\mu_\beta,\Sigma_\beta) \end{aligned} \qquad \text{(Eq. 4)}$$

where the terms remains the same as in Eq. 2, except that the matrix of independent variables with their associated vector of K slopes (β) is now incorporated. This equation predicts the log odds that a woman *i* in cluster *j* uses contraceptives as a function of the overall intercept (a_{ij}), with selected independent variables that include the four variables of particular interest (*i.e.* "both", "education partner", "working partner" and "fertility partner") and the vector of the clusters' random effects (u_j). This model allows the intercept to vary between clusters, e.g., the intercept of the log odds that a woman in a specific cluster uses contraceptives is $a_{ij}+u_j$. As in Eq. 2, it is the precision (τ_u) (or the variance) that is estimated.

Three specifications are derived from Eq. 4 based on the behaviour of the random-effects component. The first assumption posits that the random effects are independent with zero mean and a constant variance. Since the random effects are related to spatial units, which are clusters, the assumption of independence also means that the random effects are not spatially structured. The next equation represents a model where the random effects are identical and independent, also referred to as the ML or IID model:

$$\begin{aligned} &logit(Y_{ij}=1)=\alpha_{ij}+X_{ijk}^{T}\beta+u_j \\ &u_j\sim N(0,\tau_u) \\ &\pi(\tau_u)\sim logGamma(1,10^{-5}) \end{aligned} \qquad \text{(Eq. 5)}$$

The above-represented assumption suggests that Eq. 5 is treated as a non-spatial, multilevel model. This model, together with the three spatial models discussed below, was estimated and then compared using the Deviance Information Criterion (DIC), as well as the Watanabe–Akaike Information Criterion (WAIC) to select the best-performing model.

The equation below represents a specification where it is assumed there is a strong autocorrelation of random effects among neighbouring wards. As illustrated, this assumption introduces the notion of spatial dependence in the random effects component. It is also important to note that the random effects in these models are represented with a conditional autoregressive prior to inducing spatial autocorrelation through the neighbourhood structure of the clusters, as discussed below.

$$\begin{aligned} &logit(Y_{ij}=1)=\alpha_{ij}+X_{ijk}^{T}\beta+u_j \\ &u_j|u_{-j},W,\tau_u,\rho\sim N\left(\frac{\rho\sum_{i=1}^{P}w_{ji}u_j}{\rho\sum_{i=1}^{P}w_{ji}+1-\rho},\frac{\tau_u}{\rho\sum_{i=1}^{P}w_{ji}+1-\rho}\right) \\ &\pi(\tau_u)\sim logGamma(1,10^{-5}) \end{aligned} \qquad \text{(Eq. 6)}$$

where u_j represents (u_1, ... , u_j, ... , u_{j+1}, ... , u_P) is a non-negative and symmetric *P-by-P* adjacency matrix. Its elements are denoted by w_{ji} to show whether two non-overlapping areal units, cluster *j* and cluster *i*, are spatially close to each other.

The next section discusses the construction of the adjacency or spatial weight matrix. At this point, it can be said that the diagonal elements of *W* are set to zero, *i.e.*, $w_{jj}=0$ as a non-overlapping areal unit cannot be a neighbour to itself and the spatial dependence parameter ρ, is set to 1 to indicate a strong autocorrelation. Based on the condition related to ρ, Eq, 6 is a SML variant and also referred to as the intrinsic conditional autoregressive (ICAR) model. If the spatial dependence parameter is set to zero in Eq. 6, this is equivalent to assuming that the random effects are independent, as discussed in relation to Eq. 5.

This paper's final assumption is that there is a strong correlation between neighbouring clusters. In addition, the random-effects component is divided into two parts as presented in Eq. 7 below. This equation is also a SML variant, in the literature referred to as the Besag-York-Mollie (BYM) conditional autoregressive model (Besag *et al.*, 1991). Furthermore, Eq. 7 reflects a scenario where the spatial dependence parameter ρ, is pre-determined to be 1, implying a strong or perfect correlation. Since the spatial dependence is fixed at 1, there is no need to include it in the equation that follows here;

$$\begin{aligned} &logit(Y_{ij}=1)=\alpha_{ij}+X_{ijk}^{T}\beta+u_j \\ &u_j=\varphi_j+\theta_j \\ &\varphi_j|\varphi_{-j},W,\tau_u\sim N\left(\frac{\sum_{i=1}^{P}w_{ji}\varphi_i}{\sum_{i=1}^{P}w_{ji}},\frac{\tau_u}{\sum_{i=1}^{P}w_{ji}}\right) \\ &\theta_j\sim N(0,\tau_u) \\ &\tau_u,\tau_\theta\sim logGamma(1,10^{-5}) \end{aligned} \qquad \text{(Eq. 7)}$$

where all symbols are the same as in the preceding equations. In terms of the added terms in the random-effects component, it is important to note that φ_j is the spatially structured part of this component and equivalent to the random effects defined for the ICAR model in Eq. 6, whereas θ_j is assumed to follow a Gaussian distribution. It is also important to note that all the equations mentioned above were estimated using the ridge-penalised regression approach to address potential collinearity among predictors.

The information depicted in Table 2 was used to select models that fit data according to the stepwise procedure described in the preceding section. The first column shows the four specified models for Angola and Zambia, with only key statistics reported for the selection.

Results

For Angola, the ICC was found to be 0.37, indicating that 37% of variability in the dependent variable (*i.e.* log odds of a woman *i* in cluster *j* using contraceptive use) is attributed to cluster-wide factors, while the corresponding value for Zambia was 7%. Therefore, a single-level regression specification is ruled out in favour of ML for both Angola and Zambia's data (Table 2).

Based on this outcome, the next step entailed estimating the suitability of the IID, ICAR, and BYM models. As a reminder, the IID represents a non-spatial multilevel model, whereas the ICAR and BYM models are spatial multilevel models. The DIC and WAIC statistics for these models, which are crucial for selecting the most suitable model, are reported in Table 2. The basic principle is that a model is deemed suitable for the data at hand if its reported DIC or WAIC statistic is lower than other models. The IID models were thus selected as the most suitable choice for Angola and Zambia, as indicated by their comparatively lower DIC and WAIC statistics, respectively.

The results obtained from the DIC and WAIC analyses suggest that the SML approach used in this study to explore male partners' influence on women's contraceptive use is not necessarily different from the IID model since the clusters' random effects cannot be considered as interacting spatially among themselves. Therefore, it appears that the spatial factors that affect women's contraceptive use in Angola and Zambia are independent and not interrelated (Figure 1). The finding that SML is unsuitable for the data from Angola and Zambia is similar to my previous conclusion for South Africa (Mulamba, 2023). Consequently, only the estimates of the IID models are for Angola and Zambia in Tables 3 and 4, respectively. For ease of reference, Tables 3 and 4 are discussed separately, then some comparisons are drawn between them. Second, the IID model, represented by Equation (5), was estimated following the Bayesian ridge-penalised econometric approach. Thus, the parameter estimates are reported in terms of the mean, 2.5, 50 and 97.5 percentile, respectively, to determine the significance of the estimates. For instance, a simple way of concluding whether an estimate is statistically significant is to check whether the value of 0 is not included in the interval from the mean to the 97.5 percentile.

Results for Angola

Starting with the four variables of particular interest, it is evident that only "Both", "Education partner" reach statistical significance. This indicates that couples make health decisions together or through the partners' education attainment. The posterior mean[3] of 0.242 for the "Both" variable means that there was an overall positive response (expressed as "Both: yes" in Table 3) indicating that, on average, both partners make decisions regarding the woman's health together, in which case there is an increase in the probability that the woman would use contraceptives irrespective of which cluster she resides in, all other things being equal. This also means that when both a woman and her partner make decisions about her health matters together, this is associated with a

[3]In simple terms, posterior mean means the expected value of a parameter. It is actually obtained by averaging all possible outcomes, but weighted by their probabilities.

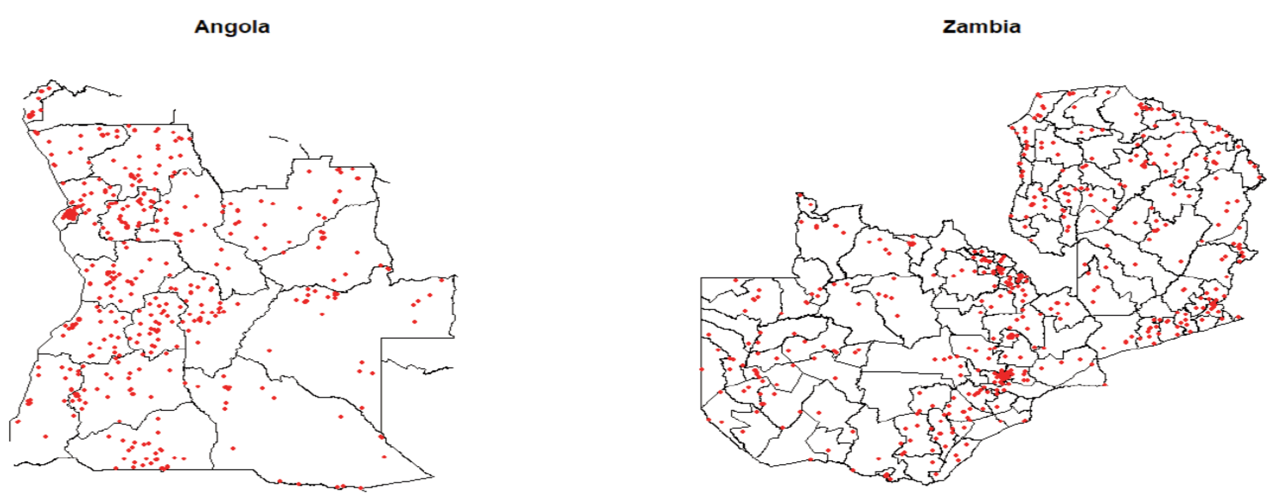

Figure 1. Spatial distribution of clusters in Angola and Zambia.

Table 2. Key statistics for the model selection.

Model	Angola DIC	Angola WAIC	Angola ICC	Zambia DIC	Zambia WAIC	Zambia ICC
NSML	4292.335	4225.379	0.37	9705.53	9703.70	0.07
IID	3849.296	3846.805		9607.60	9606.50	
ICAR	3911.797	3911.625		9709.77	9709.92	
BYM	3867.929	3866.936		9658.91	9657.74	

NSML, non-spatial multilevel logistic model; IID,?; ICAR, intrinsic conditional autoregressive model; BYM, Besag-York-Mollie (BYM); DIC, deviance information criterion; WAIC, Watanabe–Akaike information criterion; ICC, class-correlation coefficient.

27% (exponential of 0.242 minus one) increase in the likelihood of a woman using contraceptives, regardless of her cluster.

Likewise, with each additional year of education a male partner attained, there is a corresponding increase in the likelihood of a woman using contraceptives, irrespective of the cluster she resides in. This correlation is supported by the statistically significant positive posterior mean of the variable "Education partner", as depicted in Table 3. Another way to understand this result is that for every extra year of education a woman's male partner completes, there is a 34% rise (exponential of 0.294) in the odds of the woman's contraceptive use. Moreover, the estimated effects of certain control variables offer interesting results. For example, Table 3 reports positive associations between the income-related variables suggesting that economically advantaged women, or those from affluent households, are more inclined to use contraceptives. Conversely, this finding shows that women from disadvantaged backgrounds have diminished access to or affordability challenges associated with contraceptives. This disparity may underscore the obstacles women from impoverished backgrounds face, particularly those in rural areas, in accessing reproductive health resources.

Up to this point, the interpretation of estimates in Table 3 only focused on the so-called fixed-effect component of the IID model for Angola. In simple terms, each of the reported estimates should be understood as a change in the odds that a woman uses contraceptives, irrespective of the cluster in which she resides. The fact that a multilevel model (*i.e.* IID) was adopted rather than a single-level model means that there is some similarity in contraceptive use behaviours within clusters, whereas women from different clusters behave differently. For example, the posterior mean of the constant (-3.662) refers to the logit of a woman using contraceptives regardless of the cluster in which she resides. On the contrary, the logit posterior mean of a woman i residing in cluster j would be $-3.622+u_j$. This figure corresponds to the posterior mean of the fixed-effect component (of a woman using contraceptives), augmented by the estimated random effect specific to cluster j.

Results for Zambia

The results within the fixed-effect component in Table 4 illustrate the posterior estimates of "Working partner" and "Fertility with partner" as statistically significant. The finding related to the employment status of male partners suggests that male partners in Zambia, on average influence women's contraceptive use through their employment status. Therefore, when women desire more children than their partners, it is noted that they will likely use contraceptives. For instance, when a male partner is working, there is a 20% (exponential of 0.183) greater chance that his female partner will use contraceptives than when the male partner is unemployed. Similarly, the likelihood of a woman using contraceptives increases by 31% (exponential of 0.277) when she desires to have more children than her male partner, other things being equal. The finding related to the variable "Fertility with partner", as reported in Table 4, reveals the power relations in couples that disempower women. Women are often forced by their partners to use contraceptives even when they desire more children. Consequently, male

Table 3. Posterior estimates for Angola.

Parameter	Mean	SE	2.50%	50%	97.5%
Constant	-3.659*	0.340	-4.327	-3.658	-2.992
Both: yes	0.242*	0.101	0.044	0.242	0.439
Education woman years	0.373*	0.061	0.254	0.373	0.492
Education partner years	0.294*	0.068	0.161	0.294	0.427
Working woman: yes	0.314*	0.098	0.121	0.314	0.507
Working partner: yes	-0.038	0.153	-0.338	-0.038	0.261
Fertility woman: yes	-0.103	0.097	-0.293	-0.103	0.086
Fertility with partner: yes	0.100	0.092	-0.080	0.100	0.280
Wealth: poor	0.293	0.283	-0.262	0.293	0.849
Wealth: middle	0.820*	0.294	0.243	0.820	1.397
Wealth: richer	1.428*	0.304	0.831	1.428	2.024
Wealth: richest	1.657*	0.319	1.032	1.657	2.282
Age - woman	-0.247*	0.074	-0.393	-0.247	-0.102
Age - partner	-0.119	0.081	-0.279	-0.119	0.041
Residence: rural	-0.855*	0.191	-1.231	-0.855	-0.480
Religion: protestant	0.072	0.100	-0.125	0.072	0.269
Religion: other	0.013	0.113	-0.209	0.013	0.236
Variance of random effects	0.554*	0.071	0.413	0.554	0.695
DIC	3849.30				
WAIC	3846.80				
Marginal log-likelihood	-2006.26				
Number of observations (Level 1)	7256				
Number of clusters (Level 2)	625				

SE, standard error; DIC, deviance information criterion; WAIC, Watanabe-Akaike information criterion *statistically significant at at p=0.05.

partners exert some level of influence on women's use of contraceptives in Zambia, assumed to be partly due to cultural norms.

When it comes to the relationship between contraceptive use and a woman's other characteristics in Zambia (represented by the control variables), the following can be noted. First, in line with the NHE hypothesis put forth by Becker (1960), there is a positive relationship between a woman's education, her employment status and contraceptive use. For instance, an increase of one year in a woman's education attainment is associated with an 8% (exponential of 0.079) increase in the likelihood that she uses a contraceptive regardless of her residence cluster in Zambia. Similarly, a working woman has a 23% (exponential of 0.210) greater chance of using contraceptives than a non-working woman, all things being equal. The reported posterior mean related to the variable "Fertility woman: Yes", shows that the odds of a woman using contraceptives when she desires another child is 0.75 (exponential of -0.279) times lower than a woman who does not desire another child. It is important to note that this finding is intuitive, as expected. In addition, there is a negative relationship between age and contraceptive use among women in Zambia.

The economic status of the household is positively related to women's use of contraceptives in Zambia, as the reported posterior means of wealth categories are positive. This finding suggests that women from wealthy backgrounds are more likely to use contraceptives than those from poor households. One implication of this phenomenon is that the Zambian government must ensure access to contraceptives for all women. Ultimately, it cannot be determined whether there is a difference between women living in rural areas and those in urban communities when it comes to contraceptive use in Zambia, or differences based on religion; this is because the reported estimates are not statistically significant as shown in Table 4.

Discussion

Angola and Zambia were selected for this study to compare two Southern African countries with both similarities and differences. While a comprehensive discussion of these aspects is beyond the scope of this study, it is important to note that their geographic proximity suggests certain cultural and social parallels. However, Angola was specifically chosen as a post-conflict country, while Zambia has enjoyed peace and stability since gaining independence from Britain in 1964. Angola is one of the few Southern African nations that experienced prolonged armed conflict, which significantly impacted its economic and social infrastructure, including the healthcare system. Thus, comparing these neighbouring countries with contrasting historical experiences offers valuable insights into the role of male partners in women's contraceptive use in Southern Africa.

Improving access to quality reproductive health services is crucial for enhancing maternal and reproductive health, particularly in Africa, where fertility rates are high (Caldwell *et al.*, 1990; Mbacké, 2017; Atake & Ali, 2019). To illustrate, the fertility rate in sub-Saharan Africa was almost double the world average in

Table 4. Posterior estimates for Zambia.

Parameter	Mean	SE	2.50%	50%	97.5%
Constant	-0.639*	0.124	-0.881	-0.638	-0.396
Both: yes	-0.008	0.052	-0.110	-0.008	0.093
Education woman years	0.079*	0.035	0.01	0.079	0.147
Education partner years	-0.035	0.034	-0.102	-0.035	0.031
Working woman: yes	0.210*	0.053	0.107	0.210	0.314
Working partner: yes	0.183*	0.086	0.014	0.183	0.351
Fertility woman: yes	-0.279*	0.062	-0.399	-0.279	-0.158
Fertility with partner: yes	0.277*	0.052	0.174	0.277	0.379
Wealth: poor	0.185*	0.076	0.035	0.185	0.334
Wealth: middle	0.400*	0.083	0.237	0.400	0.564
Wealth: richer	0.405*	0.107	0.195	0.405	0.615
Wealth: richest	0.382*	0.128	0.131	0.382	0.632
Age - woman	-0.136*	0.048	-0.231	-0.136	-0.041
Age - partner	-0.066	0.045	-0.155	-0.066	0.023
Residence: rural	0.119	0.085	-0.047	0.119	0.287
Religion: protestant	-0.024	0.068	-0.158	-0.024	0.110
Religion: other	0.050	0.212	-0.365	0.050	0.466
Variance of random effects	0.411*	0.039	0.333	0.411	0.489
DIC	9607.580				
WAIC	9606.500				
Marginal log-likelihood	-4903.390				
Number of observations (Level 1)	7120				
Number of clusters (Level 2)	545				

SE, standard error; DIC, deviance information criterion; WAIC, Watanabe–Akaike information criterion *statistically significant at at p=0.05

2021, at 4.6 births per woman (World Bank, 2023). According to the same source, Angola and Zambia had fertility rates of 5.3 and 4.3 births per woman in 2021. This situation underscores the need for African governments to prioritize the effective implementation of the Maputo Protocol (African Union, 2003), which promotes women's rights and gender equality. By increasing access to affordable contraceptives, the protocol can help lower fertility rates, alleviate poverty linked to strained public resources and support human development. Furthermore, establishing a clear link between the Maputo Protocol and the subject of this paper is crucial. Understanding the behaviours and characteristics of men that may hinder access to health and reproductive rights is essential for designing informed public policies and interventions. These behaviours and characteristics are often rooted in deeply entrenched patriarchal structures within African society.

Key determinants and differences

Results provide nuanced answers to the posed research question in this paper. They show that in both Angola and Zambia, male partners influence women's contraceptive use, but through different mechanisms. In Angola, this influence is linked to partners' education levels and their involvement in health decisions; specifically, when couples make health decisions together, the likelihood of contraceptive use increases. In contrast, male partners' employment status plays a crucial role in Zambia. Women with employed partners are more likely to use contraceptives, while those desiring more children than their partners have an even higher likelihood of contraceptive use, highlighting power dynamics in the decision-making. Both countries show economic disparities in contraceptive access, with wealthier women more likely to use them. However, while rural residence is a significant barrier in Angola, no clear urban-rural divide is observed in Zambia. These findings underscore the need for country-specific policies rather than generalized assumptions about male partners' roles in contraceptive use.

Further, results from Angola shows that when both partners make decisions about the woman's health matters together, there is an increase in the likelihood of a woman using contraceptives, regardless of her cluster. Importantly, this finding contradicts my previous conclusion for South Africa (Mulamba, 2023), where it is shown that the odds of a woman using contraceptives is 0.75 lower when both a woman and her partner make decisions regarding her health together. One possible explanation for this discrepancy could be related to cultural differences between Angola and South Africa. However, further investigation, which is beyond the scope of this paper, is required to shed more light on this matter.

The strong rise in the odds of the woman's contraceptive use with economic advantage seen in Angola is an important result, which is supported by other researchers. Tawiah (1997), Addai (1999), Blackstone (2017) and Mulamba (2023) all came to the same conclusion. The finding related to "Working woman" also validates the Becker's NHE hypothesis (1960), which stipulates that there is a relationship between a woman' socio-economic status and her fertility choice.

Finally, the reported negative but significant posterior mean of the variable "Age woman" is an indication that the odds of using contraceptives are lower for older women compared to young ones in Angola, while the reported negative posterior mean for "Rural" underlines that women in rural areas are less likely to use contraceptives in Angola. This finding is consistent with the conclusion arrived at by Decker and Constantine (2011).

Conclusions

The main objective of this paper was to test whether married women's use of contraceptives in Angola and Zambia is influenced by their male partners. Due to the nature of the DHS data and based on the premise that social phenomena such as contraceptive use are somehow influenced or a result of latent factors of the locations (or societies) in which they occur, an SML approach was adopted. After a rigorous analytical procedure, it was decided that the IID model was suitable to analyse the data for both Angola and Zambia. The IID model's findings revealed that the channels through which male partners influence women's use of contraceptives differ. This has led to the conclusion that it is more important to conduct this type of analysis on a case-by-case basis than generalising based on one case experience. In other words, the results confirmed that male partners influence women's use of contraceptives depending context of each country, with emphasis on economic and educational differences.

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