

Husbands' Dominance in Decision-Making About Women's Health: A Spatial Diffusion Perspective in Sub-Saharan Africa

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ABSTRACT This article maps spatial and temporal variation in husbands' dominance in decision-making about their wives' health using pooled Demographic and Health Surveys from 28 countries in sub-Saharan Africa in an earlier (i.e., 2001–2005) and later (i.e., 2010–2014) period. First, we use adaptive bandwidth kernel density estimation to show how aggregate country-level estimates of husbands' decision-making dominance mask enormous spatial heterogeneity within countries. Our maps also reveal a geographic clustering of cells with similar levels of husband's decision-making dominance both within and between countries. Next, we use panel fixed-effects spatial regression methods to show that decreases in husbands' decision-making dominance in neighboring cells are associated with decreases in husbands' decision-making dominance in the reference cell. These findings support a diffusion explanation for declines in husbands' decision-making dominance over time. Our analyses also indicate that schooling and urbanization may be important channels through which diffusion occurs, which we speculate is because these are places where people are exposed to new ideas and gender norms.

KEYWORDS Africa • Decision-making • Families • Spatial analysis • Diffusion

Introduction

Women's abilities to actively participate in decision-making about their own health are essential for their reproductive, physical, and psychological well-being and for that of the next generation (Amugsi et al. 2016; Hindin 2000; Smith et al. 2003; Uthman et al. 2010). Nonetheless, around the world, many women lack the autonomy to participate in these crucial decisions, often because of social norms that grant other (usually male) family members decision-making authority. In sub-Saharan Africa (SSA)—the setting of this study—women's participation in health decision-making is among the lowest in the world, and women commonly report that their husbands make decisions about their own health without their participation (Pesando and GFC Team 2019). Nonetheless, within Africa, there is substantial variation in the extent of husbands' decision-making dominance. For example, in a study of six African countries, the percentage of women who reported that their husband alone made their

health-related decisions ranged from a high of 75% of women in Burkina Faso to a low of 22% of women in Burundi and Mozambique (Lee et al. 2017).

There has been considerable interest in improving women's autonomy in health decision-making in SSA as part of a broader platform of women's empowerment embedded in the United Nations Millennium Development Goals, Sustainable Development Goals, and other international initiatives. Why women's participation in health decision-making varies so much across contexts in SSA and how this has changed over time are still not well understood. Indicators that track changes in women's autonomy (including health autonomy)—such as the United Nations' gender inequality index (United Nations 2019)—provide valuable measures of aggregated trends. However, they are available only at the national level and thus potentially hide considerable within-country heterogeneity, such as between urban and rural areas and across ethnolinguistic and administrative boundaries. Aggregated indicators also reveal very little about the social and demographic processes through which norms related to women's autonomy spread across time and space. Aggregated indicators are thus limited in studying processes of social diffusion in which ideas, norms, and values spread among micro-level actors (Coale and Watkins 1986).

This study uses spatial analysis techniques to map spatial variation in women's reports that their husbands are the sole authority in decisions about their own health (hereafter, *husbands' decision-making dominance*) throughout SSA. We start by producing high-resolution maps that illuminate spatial patterns of husbands' decision-making dominance using pooled Demographic and Health Surveys from across SSA in an earlier (i.e., 2001–2005) and later (i.e., 2010–2014) period. These maps allow us to explore heterogeneity both within and between countries in husbands' decision-making dominance over time and over space.

The next part of our analysis explores the contextual factors that predict declines in husbands' decision-making dominance. Using panel fixed-effects spatial regression methods that allow for spatial dependence in both the dependent and explanatory variables, we test whether the diffusionist perspective on demographic change provides a relevant framework for explaining declines in husbands' decision-making dominance over time and space. More specifically, we investigate whether declines in husbands' decision-making dominance spread across neighboring geographic entities over time (which supports a diffusion perspective). To better understand the mechanisms through which diffusion may occur, we also explore whether key spatial explanatory variables—including schooling and urbanization—are associated with declines in husbands' decision-making dominance over time.

What Do Decision-Making Measures Capture?

Decision-making measures have been widely used to assess women's abilities to make strategic choices that impact personal and family well-being (Hindin 2000; Peterman et al. 2015; Smith et al. 2003). The extent to which women (as opposed to their husbands) participate in decisions about key aspects of their lives has been used as a proxy for women's autonomy (Acharya et al. 2010; Hindin 2000; Lee et al. 2017; Osamor and Grady 2016), bargaining power (Harari 2019; Mabsout and van Staveren 2010; Peterman et al. 2015), and empowerment (Kishor and Subaiya 2008; Upadhyay

and Karasek 2012). Given that autonomy, bargaining power, and empowerment are deeply complex and multifaceted concepts, the demographic literature recognizes that no single measure fully encapsulates these complicated constructs (Kabeer 1999; Oppenheim-Mason 1986).

Responses to decision-making questions are also deeply tied to prevailing gender norms about whether it is acceptable or common for men to make decisions for their wives in a given society (Schuler et al. 2011). In many cases, gender norms that deem female autonomy to be appropriate may be a necessary precursor to women's ability to exercise autonomy (Benson 1990). Thus, responses to questions about husbands' decision-making dominance capture important information about both women's autonomy in decision-making and the normative acceptability of women's autonomy in decision-making.

Although decision-making questions are widely used in survey research, important critiques of what decision-making measures capture have noted that it is notoriously difficult to fully understand the "black box" of what happens in the family (Haddad et al. 1997; Peterman et al. 2015). For example, husbands and wives sometimes provide different responses to questions about property control and ownership and other dimensions of family decision-making (Doss et al. 2014; Kilic and Moylan 2016). These discrepancies could be due to differences in opinions and understandings between couples or to social desirability bias if people answer questions based on how they think they *should* answer versus what actually transpires in the family. It is plausible that social desirability bias might impact women's reporting of husbands' decision-making dominance in either direction (i.e., underreports or overreports) depending on their perception about the most socially acceptable response. If this were the case, reports of husbands' decision-making dominance would nonetheless capture important information about the socially desirable responses to questions about husbands' decision-making about their wives' health.

A Diffusion Perspective on Changes in Husbands' Decision-Making Dominance

Diffusion of new ideas, information, norms, and behaviors are central to theories of demographic change. The *diffusion perspective*—which focuses on how new information and ideas are disseminated through micro-social processes—arose in reaction to modernization theories that predicted that industrialization and modernization should lead to predictable changes in the family and gender relations, such as the rise of the nuclear family, smaller family sizes, and increased female autonomy (Goode 1963). Whereas modernization theories predict social and demographic changes in reaction to "top-down" structural social transformations, *theories of diffusion* predict that social and demographic change can rise from the micro-level as new ideas and information are diffused through local-level social interactions and networks (Bongaarts and Watkins 1996; Kohler et al. 2002; Montgomery and Casterline 1996). Although diffusion is often thought to be distinct from modernization, it is also possible that the diffusion of norms and behaviors corresponds with the spread of modernization and technological progress.

Initial support for the social diffusion perspective came from studies showing that fertility decline in pre-transition Europe occurred first in places with cultural, eth-

nic, and linguistic similarities rather than in places that were forerunners of industrialization (Coale and Watkins 1986). Importantly, these findings suggested that the diffusion of norms and ideas among culturally similar groups were better predictors of fertility change than industrial development. The concept of *ideational diffusion* has also been implicit in theories of the second demographic transition (Lesthaeghe 2014; van de Kaa 2001) and developmental idealism (Thornton 2001; Thornton et al. 2015), both of which emphasize that the diffusion of ideas, ideals, and norms plays an important role in shaping contemporary gender and fertility norms and conceptions of the family.

In SSA, husbands' decision-making dominance has historically been high (Pesando and GFC Team 2019). However, changes in education, urbanization, media, and communication in recent decades might correspond with declines in husbands' decision-making dominance. A diffusion perspective would suggest that declines in husbands' decision-making dominance would spread among connected networks of actors and communities as ideas about the acceptability of women's autonomy in decision-making are disseminated, debated, and discussed. Key social institutions and public spaces play an important role in providing venues where ideas can be actively shared. Given the advent of mass schooling in SSA (Psaki et al. 2017), schools in particular have been cited as important for the dissemination of new ideas about gender norms via textbooks and learning materials, interaction with new peer groups, and exposure to women in new roles, such as teachers (Caldwell 1980). The increasing pace of urbanization in Africa may also be important for the diffusion of gender norms as more and more people live in urban spaces that expose them to new people, ideas, media, and experiences (Fox 2012). At the same time, technological changes—such as the spread of cell phones and the internet—coupled with the rise of global media and entertainment systems also play a role in the promulgation of ideas about women's autonomy (Billari et al. 2020; Jensen and Oster 2009). All these advances may be reinforced by development programming and outreach that center on an idealized set of norms and values, which often includes gender egalitarianism and women's empowerment (Pierotti 2013; Thornton et al. 2015; Thornton et al. 2014).

Data and Measures

Our analysis uses Demographic and Health Surveys (DHS) data, which are collected by ICF International in collaboration with host-country governments. Since the 1980s, the DHS Program has collected standardized, nationally representative, cross-sectional surveys on reproductive health, women's status, and demographic well-being across low- and middle-income countries. The DHS usually uses a two-stage sampling procedure that first identifies primary sampling units (also known as *clusters*) and then randomly selects households within those clusters for interviews. All women in the household aged 15–49 are interviewed, and sampling weights can be applied so that the sample is nationally representative of reproductive-age women.

Starting in the 1990s, but most systematically since the early 2000s, GPS coordinates of the clusters were also collected, which allows linking interviewed women to their geographic location at the time of the survey. The GPS coordinates assigned are the central points of the clusters in which the women live. We use these coor-

dinates to create what is referred to in the spatial literature as a “grid cell” (e.g., 0.50×0.50 -degree grid cell; about 50 kilometers at the equator¹), which is our principal unit of analysis.² We use grid cells, rather than clusters, as our unit of analysis for two main reasons. First, because clusters are not kept consistent between DHS survey rounds, they cannot be used to compare the same geographic entities over time or to perform any longitudinal analysis that examines diffusion processes. Second, estimating spatial models requires grid cells that are polygons (e.g., squares) as opposed to clusters; the latter are points and thus do not share any common edge or a common vertex. For further details on the choice of grid cells as the main unit of analysis, see section A, online appendix.

For this analysis, we pool micro-level DHS data from 28 SSA countries using 15 DHS surveys collected in the period 2001–2005 and 31 DHS surveys collected in the period 2010–2014.³ Women interviewed between 2001 and 2005 and between 2010 and 2014 are, respectively, included in the 2000s and 2010s periods. When more than one survey is available for one country-period, these are combined to create one single country-period. We use all DHS survey waves for SSA that include GPS data and information on both husbands' decision-making dominance about women's health and women's education, providing us with a total of 357,526 women living in 21,528 clusters; see Figure 1 for the spatial distribution of clusters. Table 1 presents additional information about the characteristics of the samples (all data are weighted using the DHS sampling weights).

The main outcome of interest is constructed based on a question asking the female respondent who in the family is the main decision-maker about her own health. We construct a variable for the share of women in a given grid cell in which the women's partner/husband is the sole decision-maker on the women's health.⁴ We focus on women's—rather than men's—reports because male respondents are not asked this decision-making question. (In section B of the online appendix, we provide evidence of consistency between women's and men's responses to a question about decision-making about large household purchases.) On average, 49.6% of women reported that their husband decides alone about their own health ($SE = 0.003$). Over the time frame of the study, women shifted away from reporting that their partners are the

¹ We use this spatial resolution because it allows us to better illustrate within-country variation and estimate spatial models. The computing time needed to estimate spatial models for large data sets is prohibitive when using a higher spatial resolution (smaller cells, such as a 0.10×0.10 -degree grid cell—about 10 kilometers at the equator). In section D of the online appendix, we show that the results are robust to using a lower spatial resolution (larger cells; i.e., 1×1 -degree grid cell—about 100 kilometers at the equator).

² To maintain respondent confidentiality, DHS randomly displaces the latitude and longitude position of clusters up to 2 kilometers for urban clusters and up to 5 kilometers for rural clusters, with 1% of the rural clusters being displaced up to 10 kilometers. This displacement may cause some clusters to lie outside the country boundaries. We change the coordinates of the clusters outside national boundaries to be the nearest point on the country's border. To do this, we use administrative boundary shapefiles obtained from the freely available Database of Global Administrative Areas and projected using the World Geodetic System 1984 projection.

³ Combining the 2001–2005 DHS and the 2010–2014 DHS gave us the maximum number of surveys that had a 10-year period of geocoded data collection during the time frame in which we compiled and analyzed the data (2017–2020).

⁴ Because this question is asked to married and cohabiting women in surveys collected in the period 2010–2014 and to all women in surveys collected in the period 2001–2005, we restrict the sample for the construction of this variable to married and cohabiting women for consistency across periods.

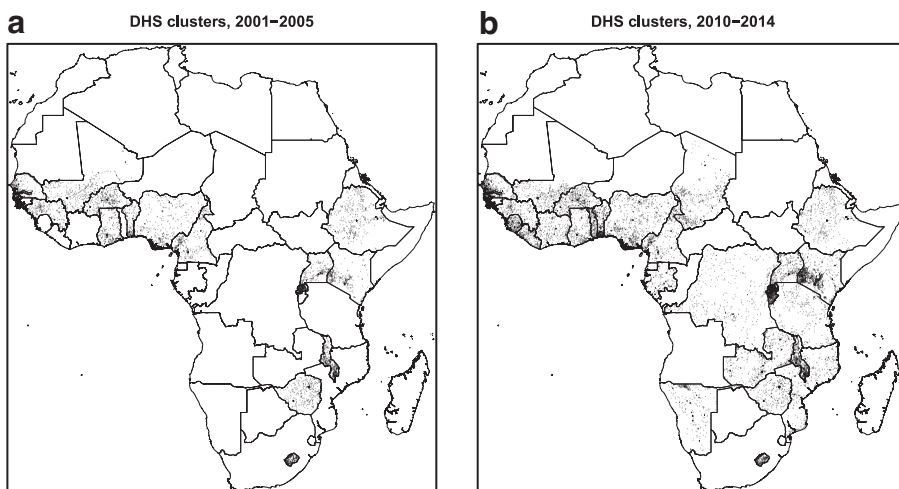


Fig. 1 Maps of DHS respondents' geographic location in 2001–2005 and 2010–2014

main decision-maker (from 55% in the 2000s to 47% in the 2010s) toward reporting that this decision is jointly made with their partners (from 20% in the 2000s to 36% in the 2010s).

In our main analysis, we investigate two social trends hypothesized to play a key role in diffusion: (1) the spread of women's education and (2) urbanization. We focus on these two theoretically important variables because of data availability, although we acknowledge that other variables that are not available in our data—for example, the spread of NGOs, the internet, and cell phones—likely also play a role in diffusion. As a supplement, we also include a measure of traditional media exposure (i.e., newspaper, radio, television) in our models, although these analyses indicate that associations between traditional media exposure and husbands' decision-making dominance appear to operate through urbanization and schooling (see the online appendix, section C, for further details).

We measure women's education by creating a variable for the percentage of women in the grid cell who have at least some education at the time of survey using DHS data (e.g., have ever been to school). We focus on ever attending school because of the very low schooling levels in our sample, but the model results are robust to using primary completion. On average, 64% of women had at least some education at the time of the survey ($SE=0.003$).

We measure urbanization by creating a variable for nighttime light intensity in the grid cell: lights from cities, towns, and other sites with persistent lighting, including gas flares. Nighttime light intensity is a commonly used measure of urban growth (Schneider et al. 2010) and economic activity (Ghosh et al. 2010).⁵ Data on night-

⁵ We prefer this measure to the DHS measure of urbanization for several reasons. First, the DHS measure of urbanization cannot be used in this analysis because it is dichotomous and not continuous at the cluster level; further, because the spatial interpolation requires a prevalence value at each DHS point (Larmarange et al. 2011), we need a continuous measure of urbanization at cluster level (see the analytical strategy section). Second, the variable for nighttime light intensity provides a comprehensive measure of urbanization

Table 1 Characteristics of the DHS samples

Country	Year	Number of Clusters	N_{opt}	
			Husbands' Decision-Making Dominance	Women's Education
Benin	2001	247	67	94
Benin	2011	746	161	188
Burkina Faso	2003	397	166	222
Burkina Faso	2010	541	201	227
Burundi	2010	376	116	116
Cameroon	2004	464	98	190
Cameroon	2011	577	129	254
Côte d'Ivoire	2011	341	98	114
Chad	2014	624	207	202
Comoros	2012	242	33	89
Democratic Republic of the Congo	2013	492	131	311
Ethiopia	2005	528	133	181
Ethiopia	2011	571	172	163
Gabon	2012	331	70	361
Ghana	2003	410	62	107
Ghana	2014	423	119	190
Guinea	2005	291	75	152
Guinea	2012	300	106	135
Kenya	2003	398	68	217
Kenya	2014	1,579	190	611
Lesotho	2004	380	47	448
Lesotho	2014	399	157	609
Liberia	2013	322	126	136
Malawi	2004	520	140	203
Malawi	2010	827	170	362
Mali	2001	399	175	223
Mali	2012	413	198	180
Mozambique	2011	609	142	190
Namibia	2013	547	135	382
Nigeria	2003	360	102	103
Nigeria	2013	889	257	320
Rwanda	2005	456	84	192
Rwanda	2010	984	239	418
Rwanda	2014	984	239	418
Senegal	2005	366	144	163
Senegal	2010	782	269	266
Senegal	2012	782	269	266
Senegal	2014	782	269	266
Sierra Leone	2013	435	128	174
Tanzania, United Republic of	2010	458	93	197
Togo	2013	330	86	143
Uganda	2000	266	64	136
Uganda	2011	400	80	221
Zambia	2013	719	171	398
Zimbabwe	2005	396	136	380
Zimbabwe	2010	393	156	499

time light intensity are taken from the freely available data set of Global DMSP-OLS Nighttime Lights of the National Geophysical Data Center within the U.S. National Oceanic and Atmospheric Administration and are available for each year from 1992 to 2013 at a spatial resolution of 30 arc-second grids (about 1 kilometer at the equator). For our analysis, we use data for the years in which surveys were conducted,⁶ and we aggregate them at a 0.50×0.50 -degree resolution by taking the mean across all 30 arc-second grid cells. As expected, urbanization is low in our sample, ranging from 0 to 28.2, with an average of 0.25 (SE=0.014).

Methods

Spatial Interpolation

The first step of our analysis is to explore spatial and temporal heterogeneity in husbands' decision-making dominance in SSA. To this end, we apply spatial interpolation methods to estimate the prevalence value for the husbands' decision-making dominance indicator for each grid cell across time, defined as the ratio between the number of women who reported that their husband is the sole decision-maker about their health (positive cases) and the number of all women (control cases).⁷ Spatial interpolation is the process of using spatial points (e.g., DHS clusters, [Figure 1](#)) with known (prevalence) values to estimate (prevalence) values for all cells on the map and thus obtain gridded data. We adopt a kernel density estimation (KDE) technique with adaptive bandwidths encompassing an optimal number of persons surveyed through the DHS.⁸ KDE, a nonparametric method used to estimate grid cell densities based on observed data, produces a density surface around each spatial point that is highest at the point and diminishes with distance ([Larmarange et al. 2011](#)). The estimated prevalence value at each spatial point is then used to create prevalence surfaces showing the spatial variations in the variable of interest. Prevalence surfaces are choropleth maps in which grid cells are shaded proportionally to the measurement of the variable displayed. To have reliable maps, we remove unpopulated cells (using data from the freely available WorldPop data set [[Tatem 2017](#)]). In section D of the online appendix, we show that our descriptive findings are both valid and robust to different N_{opt} and spatial resolutions.

We create high-resolution maps that allow us to visually assess how husbands' decision-making dominance about women's health varies geographically. We also

that is based on lights from entire geographic areas and not just individual household amenities and assets reported in the DHS and aggregated up. In addition, the nighttime light intensity is produced from satellite images and thus avoids the drawbacks of self-reported data (e.g., measurement error).

⁶ This does not apply to surveys conducted in 2014, for which we use data from 2013.

⁷ We use sampling weights to calculate the number of positive and control cases.

⁸ Because the optimal N parameter ([Larmarange et al. 2011](#)) is a function of survey-specific parameters, it varies by survey ([Table 1](#)). Formally, it is described as follows:

$$N_{opt} = 14,172 \times n^{0.419} \times p^{-0.361} \times g^{0.037} - 91.011,$$

where p is the sample prevalence, n is the number of persons surveyed in the sample, and g specifies the number of sample clusters.

explore how husbands' decision-making dominance varies temporally by creating maps for both the earlier (e.g., the early 2000s) and later (e.g., the early 2010s) rounds of the DHS and by creating a map of the change in husbands' decision-making dominance between the earlier and later rounds (measured as the percentage variation from 2001–2005 to 2010–2014). The latter is done only for cells in the 15 countries that have *both* an earlier and a later round of the DHS. As a supplement, we create comparable maps for the education and urbanization variables.

We also measure the within-country versus between-country variation in husbands' decision-making dominance in each period. This step is important because many national boundaries in SSA were artificially imposed during the colonial period, and thus national boundaries frequently cut across ethnolinguistic groups and encompass highly heterogeneous populations. Given enormous within-country ethnic and social heterogeneity, there might be as much variation in husbands' decision-making dominance within countries as between countries. To empirically assess the importance of between- versus within-country variance, we regress our main variable of interest—husbands' decision-making dominance—on a set of country indicators using ordinary least squares regression (Burke et al. 2016). The *R*-squared of this regression represents the proportion of total variation in husbands' decision-making dominance that is explained by differences across countries.

Spatial Panel Data Modelling

The next step of our analysis is to assess whether there is evidence of diffusion of declines in husbands' decision-making dominance over time. Following the approach of Vitali et al. (2015) and Vitali and Billari (2017), we use spatial panel data modeling. The key novelty of our spatial panel modeling scheme is that it allows for spatial autocorrelation in both the dependent (e.g., husbands' decision-making dominance) and the explanatory variables (e.g., women's education and urbanization). Spatial autocorrelation in the dependent variable establishes the extent to which husbands' decision-making dominance in any given cell depends on husbands' decision-making dominance in neighboring cells. This autocorrelation allows us to understand whether declines in husbands' decision-making dominance spreads (i.e., becomes more similar) across neighboring cells between the earlier and later period (which supports a diffusion perspective). Given significant spatial autocorrelation in the dependent variable, the autocorrelation on the explanatory variables enables us to disentangle the extent to which decreases in husbands' decision-making dominance between the first and second period are associated with the cell's own characteristics (*direct effects*) as opposed to the characteristics of neighboring cells (*indirect* or *spatial spillover effects*). In what follows, we provide further details about the models used to explore these issues.

We start by reviewing a panel data fixed-effects model, which can be formally described as follows:

$$y_{it} = \mathbf{x}_{it}\boldsymbol{\beta} + \mu_i + \varepsilon_{it}, \quad (1)$$

where our dependent variable y_{it} is the proportion of women in cell i and year t reporting that their husband/partner is the sole decision-maker on the women's health, \mathbf{x}_{it} is

the vector of independent variables (proportion of women with education and urbanization in the cell), β is the matching vector of coefficients, μ_i denotes cell-specific fixed effects, and ε_{it} is the error term. Importantly, the cell fixed-effects approach controls for time-invariant cell-level characteristics, which likely include things such as socioeconomic and demographic characteristics that we would expect to remain fairly stable over the period of the study in most places.

The panel data fixed-effects model produces unbiased parameter estimates provided that our observations (in our case, the cells) are independent. The assumption of independence does not hold if, instead, observations are spatially dependent, in which case models including spatial effects are more suitable (see the online appendix, section E, for more details). Spatial effects are generally introduced into the model using a spatial weighting matrix, \mathbf{W} , which is a positive matrix whose rows and columns correspond to the cross-sectional observations, representing the neighboring structure across cells. Neighbors are here defined on the basis of a contiguity criterion, according to which two cells are neighbors if they share a common edge or a common vertex. An element of the matrix, w_{ij} , equals $1/\pi_i$ if $j \in N(i)$ and 0 otherwise; $N(i)$ defines the set of all neighbors of i , and π_i is the number of neighbors of i and expresses the existence of a neighbor relation between i and j .

After spatial dependence is established, the simple panel data fixed-effects model can be extended to include spatial effects. We show results using the panel data fixed-effects spatial Durbin model (SDM) specification because supplementary analyses suggest that it best describes our data (see section E of the online appendix for further details).

The panel data fixed-effects SDM is expressed as follows:

$$y_{it} = \lambda \sum_{j=1}^N w_{ij} y_{jt} + \mathbf{x}_{it} \beta + \sum_{j=1}^N w_{ij} \mathbf{x}_{ijt} \gamma + \mu_i + \varepsilon_{it}, \quad (2)$$

where λ is the coefficient of the spatially lagged dependent variable and is referred to as the spatial autocorrelation coefficient in the dependent variable, \mathbf{x}_{ijt} is the vector of independent variables measured in cell j and year t , and γ is the matching vector of coefficients. This setup allows husbands' decision-making dominance in cell i and year t , y_{it} , to depend on husbands' decision-making dominance observed in neighboring cell j and year t , y_{jt} , as measured by λ . A positive and significant estimate of λ indicates that decreases in husbands' decision-making dominance between earlier and later periods in the reference cell i are significantly associated with decreases in husbands' decision-making dominance in neighboring cells between earlier and later periods. A diffusion perspective is supported if the level of husbands' decision-making dominance in *forerunner cells*—that is, cells with relatively low levels of husbands' decision-making dominance in the first period—spreads to neighboring *follower cells* in the second period because their level resembles that of forerunner cells over time.

The panel data fixed-effects SDM also allows us to explore potential mechanisms through which diffusion processes may operate. More specifically, the model allows husbands' decision-making dominance in each cell i to depend on a set of characteristics measured in the same cell (i.e., direct effects) and on an average of the same characteristics measured in neighboring cells (i.e., indirect or spatial spillover effects). The latter expresses the extent to which husbands' decision-making dominance in

cell i is affected by women's education and urbanization averaged over its neighboring cells, and thus it allows us to identify the factors that correlate with the spread of declines in husbands' decision-making dominance over time. This is important because the diffusion perspective emphasizes interaction between neighboring communities as a means of spreading information and norms.

To interpret results, LeSage and Pace (2009) argued that parameter estimates from the SDM should be used to compute impact estimates as the marginal effects of a variation in the explanatory variable on the dependent variable. (See the online appendix, section E, for a detailed explanation of the computation and interpretation of the direct, indirect, and total effects.) Note that for simplicity, we have sometimes used causal language in describing the methods (and employed the terms *direct* and *indirect effects*, which are standard in the literature), but we caution against making causal inferences in interpreting our results. Husbands' decision-making dominance may have reverse causal effects on our independent variables, and there may be time-variant variables not captured by our model.

Results

Descriptive Findings

In this section, we start by presenting prevalence maps of husbands' decision-making dominance about women's health in the 2000s and 2010s both at the country (Figure 2, panels a and c) and local levels (Figure 2, panels b and d). The country-level maps, which would be consistent with aggregated indicators of women's status that average across the country, show marked heterogeneity across countries in husbands' decision-making dominance. For example, in the first period (2001–2005), the prevalence of husbands' decision-making dominance ranges from a low of 17.1% in Zimbabwe to a high of 75.2% in Burkina Faso. In the second period (2010–2014), the prevalence of husbands' decision-making dominance ranges from a low of 9.0% in Lesotho to a high of 83.6% in Mali. Country-level estimates suggest that Western African countries have a higher prevalence of husbands' decision-making dominance in both periods than Eastern and Southern countries (with a few important exceptions), which could be related to many things, including differences in socio-cultural factors or underlying health conditions.

Unlike the country-level maps (Figure 2, panels a and c), the local-level maps (Figure 2, panels b and d) demonstrate considerable within-country heterogeneity in the prevalence of husbands' decision-making dominance. For example, in the country-level estimates, Ghana appears to be a regional outlier with a lower prevalence of husbands' decision-making dominance compared with neighboring countries. However, the local-level maps show that in the first period, southern Ghana (which borders the ocean) has a low prevalence of husbands' decision-making dominance, but northern Ghana has a much higher prevalence of husbands' decision-making dominance that more closely resembles its neighbors. Likewise, the country-level estimates suggest that in Mali, the prevalence of husbands' decision-making dominance increased between the first and second periods. However, the local-level maps show that this increase was largely concentrated in the central areas of the country, whereas

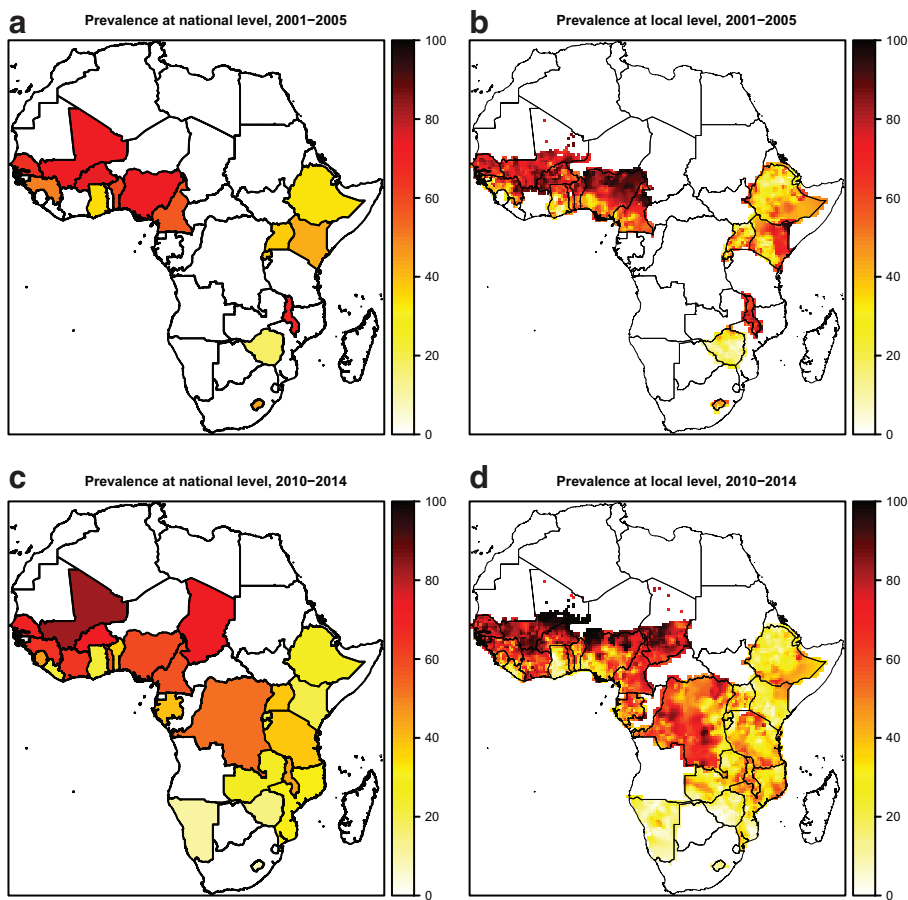


Fig. 2 Maps of the prevalence of husbands' decision-making dominance at the national level (panels a and c) and local level (panels c and d) in 2001–2005 (panels a and b) and in 2010–2014 (panels c and d). Prevalence of husbands' decision-making dominance is defined as the proportion of women in the country/grid cell and year reporting that their husband/partner is the sole decision-maker regarding the women's health. The maps reflect administrative boundaries and population; grid cells with fewer than 10 people per 1 kilometer \times 1 kilometer are colored in white.

the southern areas of the country changed less. In addition to these examples, the local-level maps show that in the 2000s, the southern areas of Guinea and Nigeria had particularly low proportions of husbands' decision-making dominance compared with other parts of the country, whereas the eastern areas of Ethiopia and Kenya had higher proportions of husbands' decision-making dominance relative to other parts of the country. Similarly, in the 2010s, proportions of husbands' decision-making dominance were very high in the northern areas of Burkina Faso and Nigeria and in the central areas of Chad and Mali, relative to other areas of the country.

The maps in [Figure 2](#) visually reveal that cells with high values of husbands' decision-making dominance are clustered geographically, and the same is true for cells with low values of husbands' decision-making dominance, which may be indic-

ative of spatial autocorrelation in the decision-making indicator and might be consistent with a diffusion hypothesis. Of course, it is also possible that the geographical concentration of cells with similar values of husbands' decision-making dominance could reflect other factors, such as the clustering of ethnic groups with similar gender norms.

Formally, the presence of global spatial autocorrelation is tested using the Moran's I index, a cross-product statistic between a variable and its spatial lag that tests whether the value of a variable observed in a given location is independent of the value observed in a neighboring location. (See section F of the online appendix for details about the calculation of the Moran's I index and associated p value.) In our data, the Moran's I index equals .89 ($p < .001$) in the 2000s and .91 ($p < .001$) in the 2010s, suggesting a strong and positive spatial interdependence in our indicator: in other words, cells with similar values of husbands' decision-making dominance tend to be concentrated geographically. (See sections G and H of the online appendix for results of Moran's I in the raw data set and local Moran's I [i.e., local indicator of spatial autocorrelation], respectively.)

We further explore the role of heterogeneity within versus between countries in husbands' decision-making dominance by calculating the R -squared of a regression of our indicator on a set of country dummy variables. We find that between-country variation accounts for 57.7% of the total variation in husbands' decision-making dominance in 2001–2005 and 67.6% of the total variation in husbands' decision-making dominance in 2010–2014. Similarly, between-country variation accounts for 13.9% of the total variation in changes in husbands' decision-making dominance between 2001–2005 and 2010–2014. Therefore, around 86.1% of the variation in changes in husbands' decision-making dominance is attributed to factors that vary over space and time within countries, thus highlighting the importance of a spatial approach that takes into account this within-country spatial heterogeneity. As section I of the online appendix shows, although we cannot rule out sampling error, results suggest that our estimates are highly reliable.

As a supplement, we also analyze the spatial distribution of the independent variables that we use in our empirical model—women's education and urbanization—in the 2000s and 2010s (Figures A3 and A4, online appendix). Substantial cross-country variation in women's education is evident in both periods. At the national level, the proportion of women with at least some education ranges from a low of 19.6% in Burkina Faso to a high of 97.9% in Lesotho in the first period, and from a low of 24.2% in Mali to a high of 99.0% in Lesotho in the second period. At the local level, the maps of women's education and husbands' decision-making dominance seem to follow the same pattern. That is, cells with high proportions of women with some education appear to have low proportions of husbands' decision-making dominance, and so on. As expected, higher levels of urbanization are more common around large cities (e.g., Lagos, Nairobi, and Harare). Analyses of the Moran's I index for the variables women's education and urbanization reveal a positive global spatial autocorrelation in the 2000s (i.e., .94 for women's education and .65 for urbanization) and 2010s (i.e., .95 for women's education and .45 for urbanization); this finding indicates that, similar to previous results for husbands' decision-making dominance, cells with similar characteristics of women's education and urbanization are closely distributed in space.

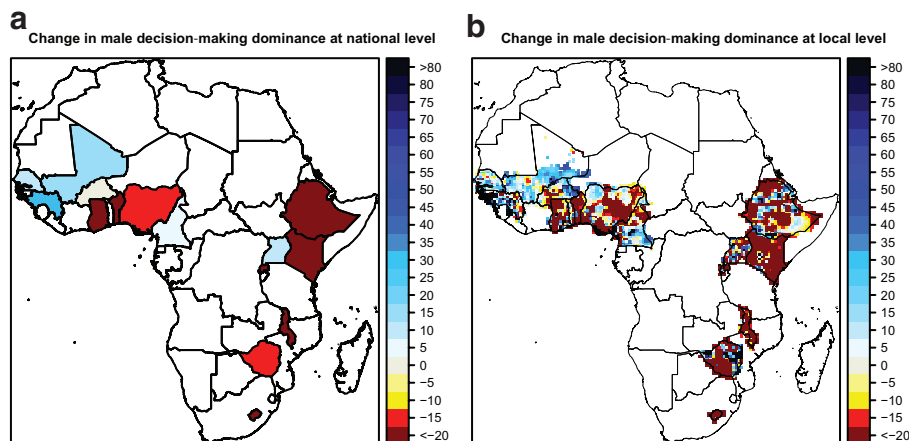


Fig. 3 Maps of the change in husbands' decision-making dominance at the national level (panel a) and local level (panel b) between 2001–2005 and 2010–2014. Change is defined as the relative change between the less recent value and the most recent value: $(value_2 - value_1) / value_1$, where $value_1$ and $value_2$ are the prevalence value of the variable in the country/cell in 2001–2005 and 2000–2014, respectively. Prevalence of husbands' decision-making dominance is defined as the proportion of women in the country/grid cell and year reporting that their husband/partner is the sole decision-maker regarding the women's health. The maps reflect administrative boundaries and population; grid cells with fewer than 10 people per 1 kilometer \times 1 kilometer are colored in white.

In Figure 3, we present maps of change in husbands' decision-making dominance at the country and local levels between the first and second periods. The map showing the temporal change at the country level suggests that husbands' decision-making dominance decreased over time in most countries (panel a). However, the local-level map shows that decreases were not homogenous within countries (panel b). In particular, the local-level map shows that some areas have experienced a decline over time in husbands' decision-making dominance (red to yellow cells), whereas other areas experienced an increase (blue cells). In particular, Mali, Senegal, Central and Western Guinea, Eastern Burkina Faso and Zimbabwe, Northern Nigeria and Uganda, and Southern Cameroon had the most increases in the prevalence of husbands' decision-making dominance between the first and second periods.

As a supplement, we also analyze the change in women's education and urbanization at the country and local levels between the first and second periods (Figure A5, online appendix). We see substantial within-country variation in women's education over time. Nonetheless, although the proportion of women with at least some education decreased over time in a few areas, it increased in most areas. Urbanization mostly increased over time, but it remained constant in many areas. Increases in urbanization are found mostly around the capital cities, including in large parts of Malawi, Nigeria, and Rwanda, and along the coastal area of Benin, Ghana, and Senegal.

To validate our measure of husbands' decision-making dominance, we also explore whether declines in husbands' decision-making dominance about women's health correspond with changes in another measure of women's health autonomy: women's contraceptive use (Figure A6, online appendix). We find that husbands' decision-

Table 2 Results from panel data fixed-effects SDM

	Marginal Effects		
	Direct Effect	Indirect Effect	Total Effect
Women's Education	−0.213*** (0.022)	−0.452** (0.146)	−0.665*** (0.149)
Urbanization	−0.496 (0.342)	−9.969** (3.648)	−10.465** (3.768)
λ	0.908*** (0.008)		
$H_0: \gamma=0$	23.95***		
$H_0: \gamma + \lambda\beta=0$	17.31***		
AIC	21,417.74		
BIC	21,453.99		
Log-Likelihood	−10,702.87		
N	6,220		

** $p < .01$; *** $p < .001$

making dominance is significantly correlated with contraceptive use in both periods, with correlation coefficients of $-.42$ in the 2000s and $-.57$ in the 2010s (and p values smaller than $.001$). These strong correlation coefficients indicate that husbands' decision-making dominance corresponds with other concurrent changes in women's health autonomy and does not merely capture social desirability bias.

Estimation Results

In this section, we present the results from the panel data fixed-effects SDM estimated for the 3,110 cells with a value in *both* earlier and later periods. The online appendix (section E) shows the presence of spatial dependence within the panel data, which suggests that panel data models with a spatial effect are preferred.

To further test the appropriateness of a spatial model specification, we estimate a panel SDM; the results are shown in Table 2. The spatial autocorrelation coefficient in the dependent variable (λ) and the Wald test statistics are reported at the bottom of the table. The former is equal to $.91$ ($p < .001$), indicating spatial dependence of husbands' decision-making dominance across cells over time. Thus, a decrease in husbands' decision-making dominance in neighboring cells between the earlier and later periods is significantly associated with decreases in husbands' decision-making dominance in the reference cell over the same period. This finding provides support for a diffusion perspective that declines in husbands' decision-making dominance spread over time and space from forerunner to follower cells.

To better understand the mechanisms through which diffusion processes may occur, we turn to the interpretation of the direct effects based on the panel SDM (column 1), which can be interpreted as the association between education or urbanization and husbands' decision-making dominance at the cell level. We find that a one-unit increase in the percentage of women's education in the reference cell is associated

with a 0.213 decrease in the percentage of husbands' decision-making dominance in that same cell between the earlier and later periods (p value < .001). Urbanization also is negatively associated with husbands' decision-making dominance, although the association is not statistically significant at the 5% level.

We next look at the indirect effects of women's education and urbanization on husbands' decision-making dominance (column 2). Indirect effects can be interpreted as the association between women's education or urbanization in all neighboring cells and husbands' decision-making dominance in a given cell. We find that a 1 percentage point increase in the proportion of women with at least some education in neighboring cells is associated with a decrease of 0.452 percentage points in the proportion of husbands' decision-making dominance in a given cell over time. This strong indirect effect of women's education provides evidence suggesting that the diffusion of (or the spread of) declines in husbands' decision-making dominance in a given cell between the earlier and later periods is associated with having more educated women in neighboring cells.

As for urbanization, we find that a 0.32 point (the mean of the variable urbanization in the panel data set) increase in urbanization levels in all neighboring cells is associated with a decrease of 3.2 (i.e., 9.969×0.32) percentage points in the proportion of husbands' decision-making dominance in a given cell over time. This strong indirect effect of urbanization provides evidence suggesting that the diffusion of declines in husbands' decision-making dominance in a given cell over time is associated with living closer to more urbanized cells. Taken together, these results suggest that the spread of women's education and urbanization in neighboring cells is associated with decreases in husbands' decision-making dominance in a given cell.

The last column of Table 2 shows the estimated results for the total effects (direct plus indirect effects), which can be interpreted as the total marginal relationships between variation in husbands' decision-making dominance due to variation in women's education or urbanization. Our results show that increases in both women's education and urbanization are associated with decreases in husbands' decision-making dominance. Both factors have a negative total relationship with husbands' decision-making dominance.⁹

In sum, these findings support the perspective that new ideas and norms diffuse through geographically contiguous communities through a combination of social learning, social interactions, and social influence that can emanate from a variety of sources, including peer and kinship networks, schools, media, NGOs, markets, medical facilities, religious facilities, and other sites of public interaction.

⁹ We estimate additional alternative models (available upon request) as robustness checks. In these models, the spatial weighting matrix is defined differently. In particular, it is based on the rook's contiguity criterion—that is, on shared boundaries only, as opposed to shared edges and vertexes. Results are robust when the neighbors are defined by the queen contiguity of second order (i.e., the neighbors of our neighbors are our neighbors) and by the rook contiguity of first and second order. Another issue concerns cells in which there is no DHS cluster (i.e., empty cells) and the possibility that the diffusion effects might thus (at least partly) reflect the spatial interpolation, especially when empty cells are close to each other and cover a big area. To check this possibility, we exclude from the analysis all cells in which there is no DHS cluster (i.e., we include only cells that have at least one DHS cluster) and find that the results are robust to this exclusion. A final issue is that of outliers. It is important to understand whether results are driven by individual countries. We reestimate the panel data fixed-effects SDM, dropping one country at a time from the analysis. We find that the results are not idiosyncratic to one country, which increases confidence in the robustness and generalizability of our conclusions.

Conclusions

In this article, we mapped spatial and temporal variation in husbands' dominance in decision-making about their wives' health both within and between countries in SSA over the first decade of the twenty-first century. Our analyses showed how aggregate country-level estimates of this measure masked enormous spatial heterogeneity within countries. Indeed, we found that about 86% of the variation in changes in husbands' decision-making dominance across space and time could be attributed to factors that changed within (as opposed to between) countries. The spatial perspective has important implications for policy-makers who could use spatial approaches to identify and target policy interventions to geographic areas where women's participation in health decision-making is particularly low. Policy-makers might also want to pay particular interest to areas—such as Mali, Senegal, Central and Western Guinea, Eastern Burkina Faso and Zimbabwe, Northern Nigeria and Uganda, and Southern Cameroon—where husbands' decision-making dominance actually increased over time. The spatial perspective also could help policy-makers better design context-specific policies (even within the same country). For example, in areas where women have less autonomy in health decision-making (such as Northern Nigeria), women's and maternal health interventions may be effective only if they are targeted to both the woman and her partner. On the other hand, in areas where women have more autonomy in making these decisions (such as Southern Nigeria), it may be more appropriate to target women directly.

Our study also contributes to a rich demographic literature on social diffusion suggesting that ideas, norms, and values spread among micro-level actors, eventually culminating in broader social changes. Our spatial maps show that grid cells with similar values of husbands' decision-making dominance tended to be concentrated geographically, thus suggesting a role for diffusion processes in helping to explain the overall declines in husbands' decision-making dominance we observe between (approximately) 2000 and 2010. These findings were reinforced in our spatial panel analysis, which showed that a decrease in husbands' decision-making dominance in neighboring cells was associated with a decrease in husbands' decision-making dominance in the reference cell between the earlier and later periods. Taken together, these results support a diffusion perspective, although it is plausible that other unobserved factors might also be at play in explaining simultaneous changes between neighboring areas. Likewise, these analyses do not rule out the possibility that modernization processes also corresponded with diffusion, particularly if the spread of urbanization and education corresponded with modernization.

Our spatial panel analysis also provides insight into the pathways through which diffusion may have occurred. We showed that the prevalence of women's education and urbanization in a cell was negatively associated with husbands' decision-making dominance in that given cell (although only the former was statistically significant). Furthermore, we found that decreases in husbands' decision-making dominance in a given cell over time were associated with increases in women's education and urbanization in neighboring cells. Importantly, these findings suggest that analyses that ignore the existence of positive spatial spillovers may underestimate the ways in which women's education is associated with participation in decision-making.

Although our study makes important contributions to demographic understandings of how and why husbands' decision-making dominance about wives' health has changed over time and space, it has a number of limitations. First, it is plausible that some geographic boundaries were not observed in our data (e.g., lakes, mountains), which would make it difficult to interpret spatial trends in decision-making. This is a general concern with all spatial analyses of this type, and we addressed it to the best of our ability by removing unpopulated cells with known lakes, deserts, and so on.

A second limitation is that our panel fixed-effects models could not establish causality, leading to concerns about the possibility of reverse causation between our independent and dependent variables, as well as omitted variable bias. Our cell fixed-effects approach controlled for time-invariant cell-level characteristics; however, it is plausible other unobserved cell-level features changed over the period of study (i.e., underlying health circumstances of cells that may have impacted women's decision-making).

An additional limitation relates to our analyses of mechanisms. We tested two potential pathways for diffusion—schooling and urbanization—but other valuable pathways also might have mattered, such as changes in women's economic empowerment, the spread of cell phone technology, and promulgation of global NGOs. In addition, our analyses considered one component of education—school attendance—and the results might change with alternative measures (e.g., average years of education).

A final limitation is that our spatial panel data approach did not allow us to investigate how changes in individual factors were associated with contextual declines in husbands' decision-making dominance. To do so would require longitudinal individual-level data because diffusion entails a temporal dimension. The advantage of our approach is that it used repeated cross sections of household survey data to create longitudinal cell-level data, thus circumventing the scarcity of cross-national comparative microdata in low- and middle-income countries.

Our analysis demonstrates the importance of considering spatial heterogeneity in measures of women's status—in addition to aggregated indicators or summary statistics—to provide a more complete assessment of changes in women's status over time and space. In doing so, we extend literature that has used spatial methods to map changes in mortality, adolescent pregnancy, and education in Africa (Burke et al. 2016; Golding et al. 2017; Graetz et al. 2018; Neal et al. 2016) to explore spatial trends in other dimensions of family dynamics. To the best of our knowledge, this is the first time that spatial methods such as these have been applied to assess the spatial distribution and geographic diffusion of a measure that captures intrafamilial gender dynamics (such as decision-making), as opposed to morbidity or reproductive health. The availability of geocoded data is growing in the DHS (which is continuously updated) and in other sources, presenting a promising avenue for future policy-makers and researchers to explore whether the trends documented here apply to different spatial and temporal contexts. ■

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