Social Science & Medicine 382 (2025) 118355

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Female house ownership drives the positive association between matriliny and women's health in Meghalaya (India)

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ARTICLE INFO

Handling Editor: Alexandra Brewis

Keywords:
Matriliny
Female ownership
Health
India

ABSTRACT

Matrilineal kinship, which traces descent through the mother's lineage, has been shown to have health benefits for both women and children, but the specific practices by which matriliny enhances female health outcomes remain unclear. In this study, we analyzed the 2015 Demographic and Health Survey data from Meghalaya, India (4,109 women, 809 men, 3,197 children), a region where matrilineal and non-matrilineal communities coexist with a mixed combination of post-marital residence and inheritance transmission. We considered two practices usually associated with matrilineal systems (i) female house ownership and (ii) matrilocal post-marital residence. We find no evidence for improved health with spatial proximity with kin. Instead, we demonstrate that female (vs. male) ownership correlates with substantial health benefits for women, including reduced risks of being anemic (OR = 0.72, SE = 0.093, $p < 0.001$) and underweight (OR = 0.59, SE = 0.135, $p < 0.001$), for men, albeit to a lesser extent, and for children. Boys and girls living in households owned by women are more likely to receive medical care when sick (+200 %). The associations between female house ownership and better health outcomes remain after adjusting for age, wealth disparities, geographical area, fertility, or time since last birth. These results suggest that in Meghalaya, female economic status is a key pathway for explaining diversity in health outcomes, providing novel insights to bridge the gender health gap.

1. Introduction

Matrilineal systems, in which descent is traced through the female line (Schneider and Gough, 1961), have been linked to notable health benefits for women (Leonetti et al., 2007; Lowes, 2020; Reynolds et al., 2020). However, the mechanisms underlying these benefits remain poorly understood. Matrilineal kinship determines social ties, such as clan membership and proximity to maternal relatives, and it structures the distribution of inheritance. Women in these systems often have greater control over material resources and tend to live near their kin through matrilocality (also known as matrilocal residence), factors that may contribute to improved health outcomes for women. Nevertheless, the interplay between maternal kin proximity and female-biased inheritance is complex (Fortunato, 2019), and no study has yet examined how each factor independently influences women's health in matrilineal societies. Using a contemporary anthropological framework that differentiates key matrilineal practices—namely female home ownership and matrilocal residence—this study seeks to clarify the pathways linking matriliny to the health of women, men and children.

Matrilineal kinship has been linked to multiple positive outcomes for women (Whyte, 1978) and is more likely than patrilineal kinship to promote gender equality (Chen et al., 2023; Mattison et al., 2021; Reynolds et al., 2020). In Meghalaya, an Indian tribal state, women who reside with their mothers experience better reproductive outcomes (Leonetti et al., 2007) and higher political participation than patrilineal women (Brule and Gaikwad, 2020), leading to an inverted gender gap in political engagement and attitudes toward public welfare policies among matrilineal individuals.

At the behavioral level, economic experiments in matrilineal and patrilineal societies in India, China, and Tanzania suggest that gender differences in competition, cooperation, and time preferences are reduced or reversed in matrilineal settings (Ellena and Nongkynrih, 2017; Gneezy et al., 2009; Gong and Yang, 2012). More recently, this trend has been observed in health outcomes: Using a regression discontinuity design, Lowes (2020) found that matrilineal women in sub-Saharan Africa report lower rates of domestic violence than

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https://doi.org/10.1016/j.socscimed.2025.118355
Received 17 September 2024; Received in revised form 17 June 2025; Accepted 30 June 2025
Available online 1 July 2025

patrilineal women from the same region, a pattern also observed when comparing matrilineal Garo and patrilineal Bengali communities (Karim et al., 2021). Similarly, matrilineal Mosuo women have lower risks of inflammation and hypertension than their patrilineal counterparts, while men exhibit the opposite pattern (Reynolds et al., 2020).

Although existing research suggests that matriliny may enhance women's health, most studies are conducted between matrilineal and patrilineal communities. Such cross-level comparisons provide valuable insights into how gender norms and institutions shape behavior and health outcomes. However, they may create misleading impressions of matrilineal benefits if matrilineal populations have better baseline health due to unrelated factors, rather than the influence of matrilineal norms themselves (e.g. see Lawson et al.'s (2015) study on polygyny and child health for similar methodological consideration). By contrast, our study investigates, within a matrilineal context, which aspects of matrilineal kinship organization appear to be most closely associated with variation in health outcomes. While our results are not directly comparable to other studies focused on matri/patri comparisons, this approach facilitates a greater understanding of which mechanisms (i.e. social, economic, and cultural) are most important in influencing health in matrilineal contexts.

A positive association between women's health and matriliny may arise through at least two pathways. First, matrilineal women often maintain strong ties with their kin, who provide support in conflicts with husbands. In sub-Saharan African populations, Lowes (2020) found that spousal cooperation is weaker in matrilineal than in patrilineal communities. Proximity to maternal relatives may also reduce the risk of violence from husbands or in-laws, forms of abuse that are more common in patrilineal societies (Smuts, 1992). Additionally, men's obligations to their natal kin and their relatively lower paternal investment in children (Mattison et al., 2019) may further discourage domestic violence by reducing concerns about paternity certainty. Matrilineal kin also enhance women's ability to make reproductive choices (Leonetti et al., 2007) and exert control over household spending, including health expenditures (Lowes, 2020). Furthermore, maternal relatives assist with child-rearing by providing care and resources, thereby alleviating physical and mental burdens. Second, matrilineal descent is often accompanied by matrilineal inheritance, granting women greater access to material resources. In Peru, property rights for women were linked to lower birth rates (Field, 2003), suggesting that property ownership increases women's reproductive autonomy. With greater economic independence, matrilineal women may also invest more in their children's health and education than patrilineal women. Studies indicate that where women control economic resources, children receive better care, and gender disparities in health and education decrease (Dizon-Ross and Jayachandran, 2022). Thus, while matrilineal kinship enhances women's ability to invest in their children, it may also intensify competition for resources, particularly among female relatives. To our knowledge, no studies have systematically disentangled the contributions of key matrilineal practices—female house ownership, matrilocal residence—to improved health outcomes for women in matrilineal systems.

We examine how two matrilineal practices—female house ownership (inheritance rules) and female proximity to kin (post-marital residence)—independently relate to the health of women, men and children using Demographic and Health Survey data from Meghalaya, a North-Eastern Indian state. Most communities of Meghalaya are recognized as Scheduled Tribes (ST) under the Indian Constitution—an official classification for socioeconomically disadvantaged groups who often live below the poverty line and have limited access to healthcare and nutritional supplements (Chyne et al., 2017), thus increasing their vulnerability to a range of health issues. While Meghalaya is home to Tibeto-Burman and Austroasiatic language-speaking groups who follow a matrilineal kinship system, and is considered the least patriarchal state in India (Singh et al., 2022), it exhibits diversity in matrilineal practices. This diversity arises from cultural exchanges (e.g., male ownership is more common near the Bangladesh and Tripura borders), shifting attitudes (e.g., parents opting for equal wealth distributions), socioeconomic developments like urbanization, or migration for work, which encourages children to leave rural native homes. Matriliny in Meghalaya is also flexible, adapting to contextual needs. For example, patrilocal post-marital residence may occur in matrilineal communities when households lack daughters. These factors have led to mixed patterns of inheritance and post-marital residence (Fig. 1).

Drawing on the natural variation in matrilineal practices, we disentangle the respective effects of female house ownership and matrilocality on the health of women, men, and children by analyzing data from the 2015 Demographic and Health Survey—the only DHS dataset for Meghalaya capturing gender-specific house ownership. First, we examined matrilineal practices in relation to women's anemia (n = 4,109). Anemia, a condition that compromises the body's ability to transport oxygen, leads to weakness, fatigue, and heightened mortality risk for pregnant women. Women are typically more susceptible to anemia than men, due to biological factors (e.g., menstruation and pregnancy) and socioeconomic inequalities (Behera et al., 2024). Recent data indicate that 57 % of women and 14 % of men in 2019–2021 were anemic in this region (NFHS-5), closely mirroring national averages (57 % and 25 %, respectively, in India as a whole; Das et al., 2024). Both anemia and undernutrition disproportionately affect rural, low-income populations, which are overrepresented in Northeast India—an area historically inhabited by marginalized ethnic minorities. Thus we also analyzed BMI to explore potential underlying causes of anemia, as the co-occurrence of anemia and underweight status may indicate nutritional deficiency, particularly iron deficiency. Second, we investigated whether any association between matrilineal practices and anemia/BMI extends to men (n = 809). Third, we analyzed how matrilineal practices correlate with the health of children (n = 3,197), by investigating infant mortality, childhood illnesses, and parental health-seeking behaviors. Taken together, our findings indicate that female economic status—rather than matrilocal residence—emerges as the primary driver of improved health outcomes for women, men, and children.

2. Materials and methods

2.1. Study populations

Meghalaya, a state in North-East India, is primarily inhabited by three groups listed as Scheduled Tribes: the Khasis, Jaintias, and Garos. Meghalaya ranks high in several dimensions of women's empowerment, contrasting with broader trends in India. For example, 48 % of women in Meghalaya own land, compared to 34 % nationwide. In a recent patriarchy index that includes measures such as domestic violence, son preference, and patrilocality, Meghalaya ranked as the least patriarchal state in India (Singh et al., 2022). Meghalaya is predominantly rural, with agriculture centered on ginger, rice, potato, and betel nut cultivation. The absence of cattle and heavy ploughs, which require substantial upper body strength, places a stronger emphasis on women's participation in agriculture—although no studies have formally quantified their workload. Their involvement in physically demanding tasks, such as firewood collection, combined with domestic responsibilities, may contribute to physical exhaustion (Borah, 2015). However, matrilocality and female ownership are expected to enhance women's bargaining power and potentially reduce their workload compared to patrilocality, as Chen et al. (2023) observed in southwest China. In Meghalaya's matrilineal systems, ancestral land and houses are typically inherited by the youngest daughter, who is responsible for family rituals and parental care.

Geographical variation in a number of matrilineal indicators is illustrated Fig. 1. Note that the Garo and Khasi differ in the strength of

[1] https://dhsprogram.com/topics/gender/index.cfm

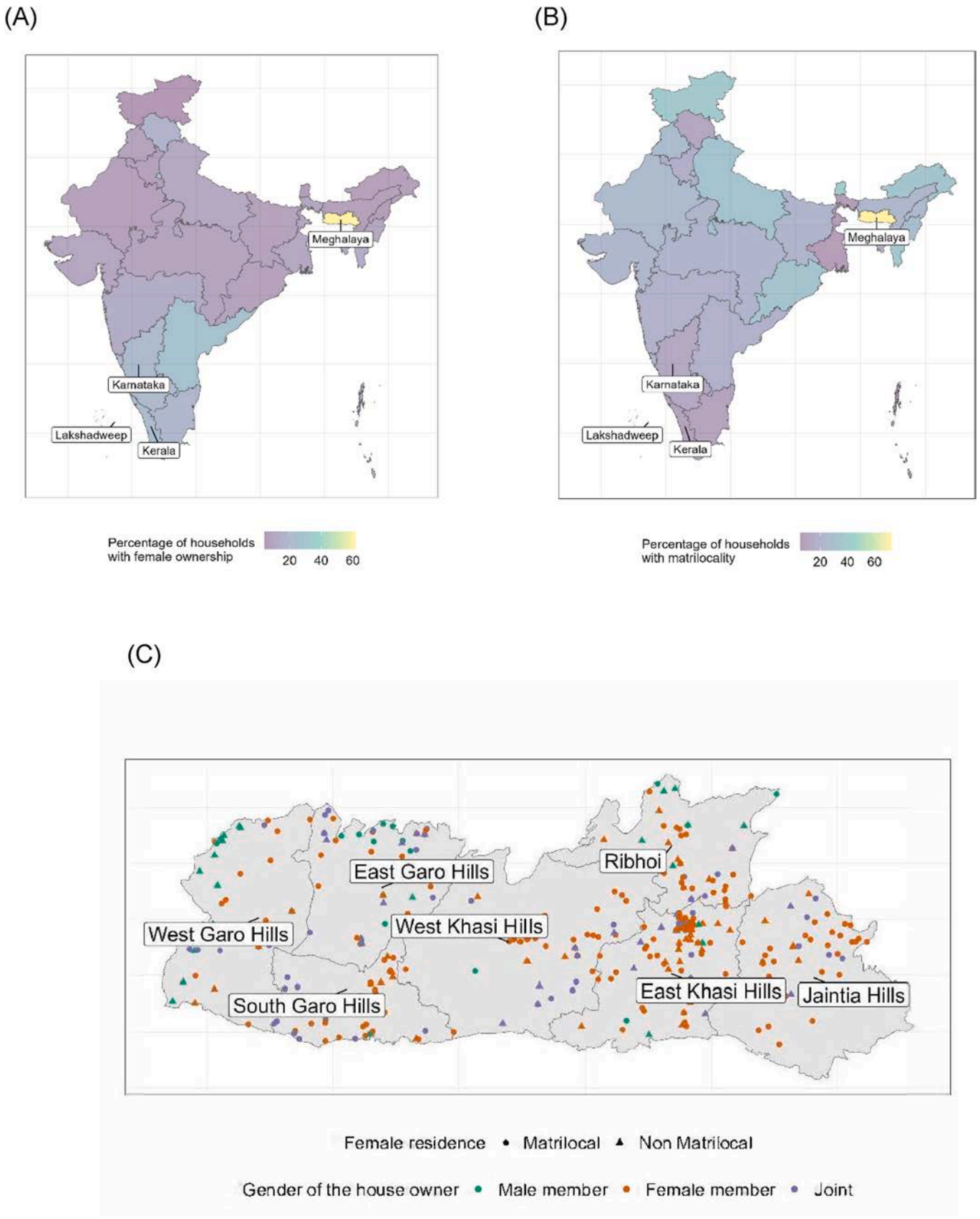

Fig. 1. **(A)** Percentage of households in each state where female members (vs. male or joint) own the house in India. **(B)** Percentage of households in each state where women live in their place of birth. Labeled states are traditionally matrilineal. **(C)** Distribution of kinship practices in Meghalaya, India (gender of the house owner and women's residence). Each point represents a cluster of 30 households. Matrilineal labels (residence and gender of the house owner) indicate the majority practice (>50 %) within each cluster Source: IPUMS (India, 2015).

matrilineal ties, marriage rules, and descent group composition (Nakane, 1967). The eastern regions, inhabited primarily by the Khasi, show higher levels of female property ownership than the western regions, where property is more often owned by men or held jointly. Furthermore, inheritance patterns have been influenced by economic development and legal changes in areas characterized by disparate exposure to wage labor, the cash economy, and recent laws permitting parents to allocate self-acquired property to sons. Such changes have contributed to a shift in bilateral inheritance in these economically developed areas, with increases observed in male property ownership (Nongbri, 2000). Additionally, deviations from matrilineal norms are more prevalent along Meghalaya's borders (Fig. 1) due to cultural exchanges with neighboring non-matrilineal communities. For instance, some Garos from Tripura or Bangladesh follow patrilocal residence or pass family names from father to son (Marak and Chaudhuri, 2020).

2.2. Study sample and selection

The 2015 DHS data for Meghalaya were obtained from IPUMS-Demographic and Health Survey (Heger Boyle et al., 2024). The sample was constructed using a two-stage cluster sampling approach. In the first stage, primary sampling units (PSUs) were selected from the national census with probability proportional to size within each stratum (defined by geographic region and urban-rural classification). The number of clusters per stratum was determined by its proportion of the total population. In the second stage, 30 households per cluster were randomly selected. A detailed description of the sampling strategy is available in the DHS report[1]. Three datasets were downloaded from IPUMS: women (N = 8,897), household members (N = 37,470), and children (N = 3,235). Of the 8,897 women interviewed, 2,142 observations were excluded, including pregnant women (n = 541) and cases with missing data on house ownership by gender or outliers for key variables (hemoglobin level, BMI, and age; n = 165). Outliers were defined as values greater or lower than three standard deviations from the mean.

2.3. Variables

2.3.1. Health data

Anemia (Yes, No). Anthropometric measurements and blood tests were collected by DHS personnel from adults aged 15–49. Hemoglobin levels were obtained from a finger-prick blood sample analyzed using a HemoCue device, with altitude adjustments applied (adjusted for altitude). Further details are available at the DHS Program website. Anemia is characterized by low blood hemoglobin concentration (Kassebaum et al., 2016), which impairs oxygen transport in the body. For women, anemia is defined as a hemoglobin level below 12 g per deciliter of blood, while for men, it is diagnosed when hemoglobin concentration falls below 11 g per deciliter. Anemia can result from nutritional deficiencies, such as iron deficiency, as well as pregnancy-related depletion or infection. In our sample, 60 % of women and 18 % of men are classified as anemic (Table S1), which mirrors national trends.

BMI (Underweight, Healthy, Overweight, Obese). BMI alone is not a reliable health indicator—it provides no information about body fat percentage or distribution, which are better predictors of cardiovascular disease, diabetes, and hypertension (Pischon et al., 2008); here we use BMI alongside anemia to evaluate the importance of undernutrition as a driver of anemia. BMI (body weight/height^2) was categorized using India-specific cutoff values (Aziz et al., 2014): underweight (BMI $<$18.5), healthy (BMI 18.5–23), overweight (BMI 23–24.9), and obese (BMI $\geq$25). Women in our sample have a higher average BMI than men (21.9 vs. 21.5), a pattern that is consistent with national trends (22.5 vs. 21.65 in India).

2.3.1.1. Children's disease (0,1) and care-seeking (0,1). Children were coded as sick if they had diarrhea, fever, and/or pneumonia-related symptoms (e.g., fever and cough) in the two weeks prior to the survey. The selection of these disease indicators was based on data availability, as each country's DHS team identifies the most common and relevant illnesses. Pneumonia and diarrhea are leading causes of mortality in low- and middle-income countries (LMICs), while fever serves as an important indicator in malaria-endemic regions. The care-seeking indicator was computed by restricting the sample to children reported as sick. Among them, healthcare was coded as 1 if the child received any treatment (i.e., was taken to a public or private facility/practitioner or given medication for the illness) and 0 otherwise.

2.3.2. Matriliny dimensions

2.3.2.1. Residence (matrilocal, non-matrilocal). Residence was coded using the variable "years lived in the place of residence" (coded as "always" or with the number of years). If a respondent answered "always," the residence was classified as matrilocal as a married woman residing in her natal location is likely to live near her kin; otherwise, it was classified as non-matrilocal. Matrilocality refers to the practice of a couple residing in the wife's home or village or living with her relatives. Ideally, one would assess whether the husband remains in his natal village to rule out cousin marriages within the same village, which are common among the Khasi (Nongbri, 2013). However, the available variable was only reported for women. In this study, matrilocality is used as a proxy for the presence of kin, a key mechanism identified in the literature to explain improved outcomes for matrilineal women (Smuts, 1995). Although an imperfect measure, this variable serves as a reasonable proxy for women's spatial proximity to their kin.

2.3.2.2. House ownership (male member, female member, or joint ownership). DHS provides household-level data on the gender of the house owner. Female ownership serves as a proxy for the economic dimension of matriliny, although joint ownership may also reflect matrilineal norms, particularly among the Khasi, where only the youngest daughter inherits the parental home. Matrilocality and female ownership are considered reliable proxies for matrilineal norms when compared to other states of India (see Results, b). The term "gender" is used to emphasize that, in our study, health differences between individuals classified as "women" or "men" are the result of power relations, unequal access to resources and social norms that shape female roles (caring for parents, sacrifice for the family) and male roles.

2.3.3. Adjustment Variables

As potential confounders, we identified geographic area (urban/rural), education (five levels), wealth (household-level quintile within the country), marital status, number of household members, and age. Individuals reliant on agricultural income, which is more common in rural areas, are more likely to adhere to matrilineal norms (e.g., in China; see Mattison, 2010) and to experience poorer health outcomes due to nutritional deficiencies and limited access to healthcare. Education is positively associated with both residence in a female-owned house (Table 1) and lower risks of anemia and underweight status (Table 2). Age and marital status influence health and the likelihood of residing in one's natal home. Additionally, the number of household members may mediate the relationship between matriliny and health. Women residing in their natal home tend to live in larger households than neolocal women, and household size affects women's health in complex ways, depending on the age of the women and their kin (Shenk et al., 2021). Although this study is cross-sectional and does not establish causality, we used Directed Acyclic Graphs (DAGs, Fig. S1 and S2) to avoid inappropriate statistical adjustments (Williams et al., 2018). DAGs indicate that adjustments should be made for Education, Wealth, and Urban/Rural area, as these variables influence both the exposure and the

Table 1
Descriptive statistics: Matriliny.

Variables	House ownership				Matrilocality		
	Male member, N = 716[a]	Female member, N = 2,484[a]	Joint, N = 909[a]	*p*-value[b]	Matrilocal, N = 2,737[a]	Non matrilocal, N = 1,372[a]	*p*-value[c]
Age				0.6			0.3
15–24	110 (15.4 %)	379 (15.3 %)	123 (13.5 %)		397 (14.5 %)	215 (15.7 %)	
25–34	268 (37.4 %)	904 (36.4 %)	328 (36.1 %)		987 (36.1 %)	513 (37.4 %)	
35–49	338 (47.2 %)	1,201 (48.3 %)	458 (50.4 %)		1,353 (49.4 %)	644 (46.9 %)	
Total children ever born	3.3 (2.2)	3.3 (2.2)	3.4 (2.2)	0.6	3.3 (2.2)	3.4 (2.3)	**0.035**
Total years education	5.0 (4.5)	5.7 (4.5)	6.2 (4.6)	**< 0.001**	5.9 (4.5)	5.4 (4.6)	**< 0.001**
Time since last birth				0.3			**0.001**
< one_year	116 (17.3 %)	407 (17.1 %)	170 (19.4 %)		426 (16.3 %)	267 (20.4 %)	
> one year	554 (82.7 %)	1,967 (82.9 %)	707 (80.6 %)		2,188 (83.7 %)	1,040 (79.6 %)	
Urban/rural				**0.001**			0.6
Urban	93 (13.0 %)	332 (13.4 %)	80 (8.8 %)		341 (12.5 %)	164 (12.0 %)	
Rural	623 (87.0 %)	2,152 (86.6 %)	829 (91.2 %)		2,396 (87.5 %)	1,208 (88.0 %)	
Matrilocal				**< 0.001**			
Matrilocal	328 (45.8 %)	1,787 (71.9 %)	622 (68.4 %)				
Non matrilocal	388 (54.2 %)	697 (28.1 %)	287 (31.6 %)				
Marital status				**< 0.001**			**0.005**
Married	694 (96.9 %)	2,058 (82.9 %)	859 (94.5 %)		2,376 (86.8 %)	1,235 (90.0 %)	
Widowed	4 (0.6 %)	183 (7.4 %)	16 (1.8 %)		141 (5.2 %)	62 (4.5 %)	
Divorced	6 (0.8 %)	50 (2.0 %)	5 (0.6 %)		40 (1.5 %)	21 (1.5 %)	
Separated/not living together	12 (1.7 %)	193 (7.8 %)	29 (3.2 %)		180 (6.6 %)	54 (3.9 %)	
Wealth quintile				**< 0.001**			**< 0.001**
Poorest	143 (20.0 %)	242 (9.7 %)	98 (10.8 %)		261 (9.5 %)	222 (16.2 %)	
Poorer	291 (40.6 %)	908 (36.6 %)	324 (35.6 %)		970 (35.4 %)	553 (40.3 %)	
Middle	150 (20.9 %)	898 (36.2 %)	314 (34.5 %)		988 (36.1 %)	374 (27.3 %)	
Richer	92 (12.8 %)	306 (12.3 %)	126 (13.9 %)		377 (13.8 %)	147 (10.7 %)	
Richest	40 (5.6 %)	130 (5.2 %)	47 (5.2 %)		141 (5.2 %)	76 (5.5 %)	
Gender of the house owner							**< 0.001**
Male member					328 (12.0 %)	388 (28.3 %)	
Female member					1,787 (65.3 %)	697 (50.8 %)	
Joint					622 (22.7 %)	287 (20.9 %)	

[a] n (%); Mean (SD).
[b] Pearson's Chi-squared test; Kruskal-Wallis rank sum test.
[c] Pearson's Chi-squared test; Wilcoxon rank sum test.

Table 2
Kinship practices and kinship norms (state-level).

Variable	Matrilineal, N = 35,860[a]	Non-matrilineal, N = 539,633[a]	*p*-value[b]
Marital status			**< 0.001**
Never married	8,606 (24 %)	133,334 (25 %)	
Married	25,154 (70 %)	384,543 (71 %)	
Widowed	1,382 (3.9 %)	14,819 (2.7 %)	
Separated/not living together	493 (1.4 %)	2,448 (0.5 %)	
Matrilocal			**< 0.001**
Matrilocal	8,160 (23 %)	113,107 (21 %)	
Non-matrilocal	27,700 (77 %)	426,526 (79 %)	
House ownership			**< 0.001**
Male member	22,433 (63 %)	476,150 (88 %)	
Female member	10,961 (31 %)	56,397 (10 %)	
Joint	2,466 (6.9 %)	7,086 (1.3 %)	

[a] n (%).
[b] Pearson's Chi-squared testMatrilineal states include Meghalaya, Kerala, Karnataka, and Lakshadweep.

outcome. Although these graphs do not suggest adjusting for age and the number of household members, as it has no causal impact on matriliny, we included them as a control to examine their relationship with anemia, following the approach used in other studies (e.g., Shenk et al., 2021).

2.4. Modelling

Logistic regression was used to analyze the relationship between matrilineal features and anemia. Since BMI was categorized (underweight, healthy, overweight/obese), multinomial logistic regression was applied to estimate the probability of being underweight or overweight relative to a healthy BMI, following previous studies on BMI determinants (Stuart and Panico, 2016). The analyses on women were pre-registered on OSF six months before data analysis and conducted using R 4.2.2. In the main text, we report unweighted estimated coefficients in tables and use figures to present the odds ratios and predicted probabilities. For categorical independent variables, we assessed the significance of each level (relative to the reference category) using a Wald test. Additionally, we ran likelihood ratio tests (Anova Type III) to determine the overall significance of categorical variables. To address potential biases in standard error estimation, we conducted robustness analyses that accounted for sampling weights and clustering, using the *survey* package in R. As further robustness checks, we ran regressions controlling for women's fertility and multiple measures of socio-economic status (see Adjustment Variables). Additionally, we estimated regressions using different reference categories for the ownership variable (female ownership vs. joint ownership). The results of our robustness checks are reported in the Supplementary Information.

3. Results

We approximated two kinship rules: (i) female house ownership, inferred using the DHS variable *gender of the house owner* (categorized as female-owned, male-owned, or shared); and (ii) matrilocal residence, determined by *years lived in the place of residence* (always vs. not always). These variables serve as reliable proxies for matrilineal practices, as female house ownership and matrilocality are notably more prevalent in the four Indian states with substantial matrilineal communities (Meghalaya, Kerala, Karnataka, and Lakshadweep), compared to the rest

of India. The difference is more pronounced for female house ownership (31 % in matrilineal states vs. 10 % in non-matrilineal states; see Table 2, and Fig. 1A and B).

In our sample, practices of matrilocality (66.6 %) and female house ownership (60.5 %) are normative, as expected. Female house ownership is partly a result of matrilineal inheritance rules practiced by the Khasi, Jaintias and Garo, the three main ethnic groups in Meghalaya, where property is traditionally passed to the youngest daughter (the *Khadduh* among the Khasi and the *Nokna* among the Garo). This inheritance pattern contributes to matrilocality. In our sample, female house ownership is strongly associated with having always lived in the same village since birth ($r = 71$ %), matrilocal women are more likely to own their house, 10.6 % are underweight, and 30 % have a BMI over 23 (65 % vs. 50 % among non-matrilocal; see Table 1). In contrast, shared

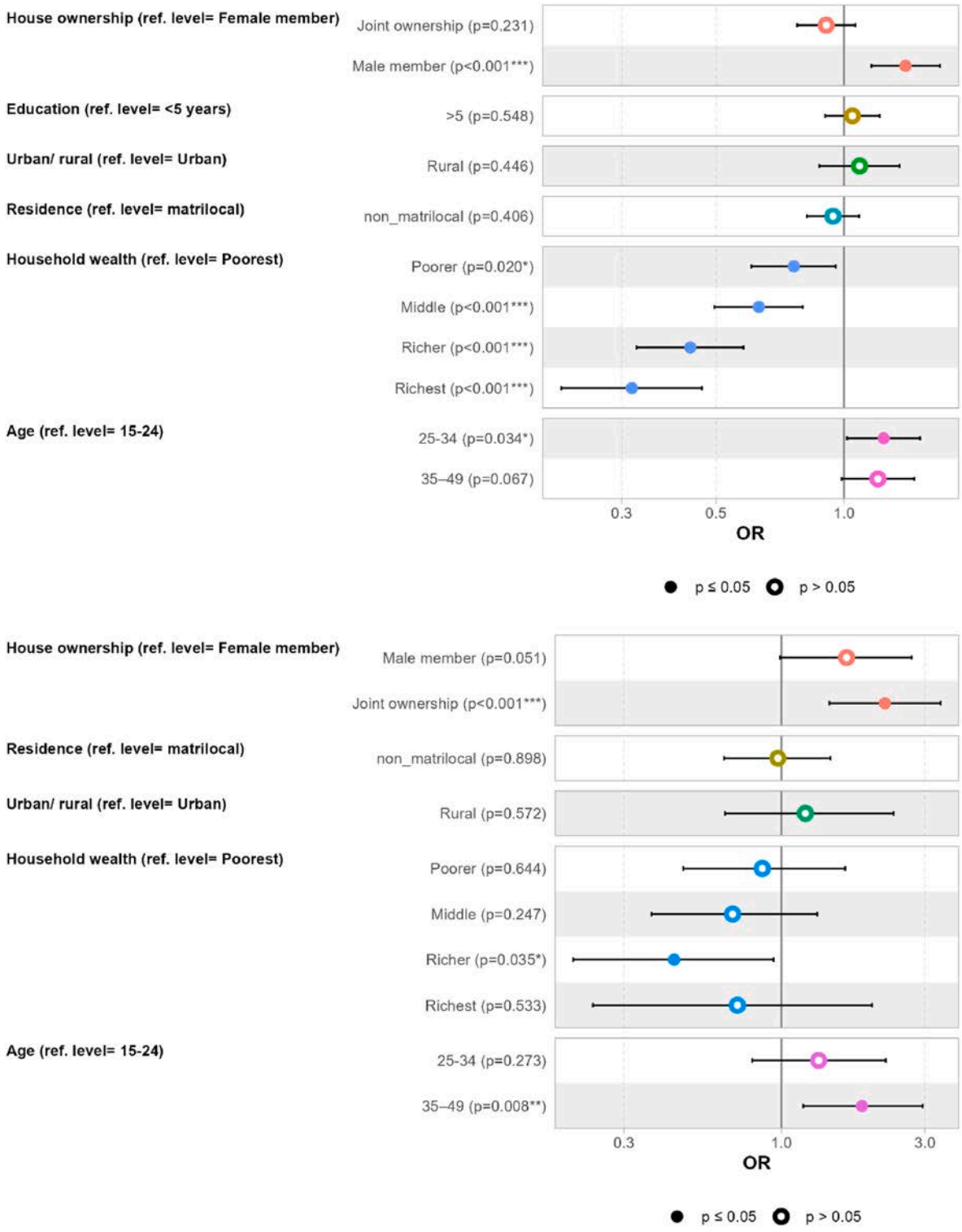

Fig. 2. Estimated parameters of a generalized linear model with a logit link function. The dependent variable is being anemic (0/1). Parameter values have been exponentially transformed to express odds ratios. Error bars represent 95 % confidence intervals. (**A**) Sample of women (N = 4,016), (**B**) Sample of men (N = 809). Full circles indicate significant associations, while open circles indicate non-significant.

ownership (22 %), and male ownership (17.4 %) are more frequently linked to non-matrilocality (55 %) and self-acquired property (Table 1). Women following matrilineal practices do not differ in age from non-matrilineal women; however, they have higher levels of education and are more likely to be separated or not living with their husbands (Table 1).

a) Matrilineal Practices and Women's Health

We examined anemia and undernutrition, as these conditions reduce productivity and perpetuate poverty, thus generating a dangerous cycle in which poverty-related malnutrition provokes iron-deficiency and increases the risks of anemia (Banerjee and Duflo, 2012). Anemia prevalence in Northeast India remains high among women at 40 % (Mog et al., 2023), with an even higher rate of 60 % among women in our sample being anemic (Table S1). In a pre-registered logistic regression analysis, adjusting for age, wealth, education, and urban/rural residence (https://doi.org/10.17605/OSF.IO/PAZD6), we found that women living in female-owned houses had a 28 % lower risk of anemia compared to those in male-owned houses (OR = 0.72, SE = 0.093, $p < 0.001$, Table S2). This association was independent of matrilocality (Fig. 2, Table S3), and are not explained by fertility differences across matrilineal dimensions (e.g., time since last birth, number of children; Table S3). Moreover, the association remained consistent in an alternative model using joint ownership as the reference category, where female ownership was associated with lower odds of anemia than male ownership (OR = 1.10, SE = 0.081), while male ownership was associated with significantly higher odds (OR = 1.53, SE = 0.109, $p < 0.001$, Table S4).

Next, a pre-registered multinomial analysis, adjusting for the same variables, found that women living in male-owned households had a 68 % higher risk of being underweight rather than healthy compared to those in female-owned houses (OR = 1.68, SE = 0.131, $p < 0.001$, Table S5). This association was also independent of matrilocal residence. Notably, the risk of being overweight or obese was not associated with female ownership or matrilocality (Fig. 3), although it did increase sharply with household wealth (Table S5). Similar results were found in a subsample of married women, as most unmarried women in our sample reside in their place of birth and are categorized as matrilocal. The findings are robust to sensitivity analyses accounting for complex survey design (see Methods).

b) Matrilineal Practices and Men's Health

Next, we examined whether house ownership patterns have different associations with health outcomes for men versus women. To evaluate sex differences in pathways to anemia and nutritional status, we pooled data and conducted logistic regressions including interaction terms between gender of the house owner and respondent sex (Table S6). In this sample, men show a 89 % reduction in anemia risk compared to women (OR = 0.11, SE = 0.015, $p < 0.001$). Living in a house owned by a man, compared to living in a house owned by a woman, was associated with an increased risk of anemia for women (OR = 1.41, SE = 0.130, $p < 0.001$) and showed a similar magnitude of association for men, though with greater uncertainty (non-significant). Male house ownership showed no sex-specific association with underweight but was associated with a significantly higher risk of being overweight for men (OR = 1.70, SE = 0.401, p = 0.03). Joint ownership showed contrasting associations by sex for anemia risk. For women, jointly-owned households showed no significant difference from female-owned households (OR = 0.92, SE = 0.074, Table S6). However, for men, joint ownership was associated with a markedly increased risk of anemia compared to its effect in women (OR = 2.53, SE = 0.576, $p < 0.001$, Table S6).

Sex-stratified analyses confirmed these patterns: among women, jointly-owned and female-owned households had comparable protective associations with anemia risk (OR = 1.10, SE = 0.081, Table S4). Among men, jointly-owned households were associated with a higher anemia risk compared male-owned households (OR = 2.09, SE = 0.254, p = 0.007, Table S7). Among women, male ownership raises the predicted probability of anemia to 75 %, which is 20 percentage points higher than the national average for anemic women in India. Among men, both male ownership and joint ownership are associated with increased anemia risk, with the predicted probability reaching 36 % under joint ownership—16 percentage points above the national average for men (Fig. 4).

Joint ownership also showed sex-specific associations with weight status, being associated with lower risk of unhealthy weight (underweight and overweight) for women but higher risk for men (Table S5). While we found significant associations between anemia, BMI and gender of the house owner, we found that the presence of matrilocal women in the household did not associate with men's anemia risk. We could not assess associations with men's spatial proximity with kin as male residence was not available in the data. While female ownership reduces the risk of underweight among women, it is associated with lower probabilities of overweight and obesity among men (Table S5). For men, male ownership is linked to a predicted probability of overweight of 19 %, compared to 16 % under joint ownership and 12 % under female ownership. For women, the risk of being underweight increases from 10 % under female ownership to 15 % under male ownership (Fig. 5)

c) Female House Ownership and the Health of Children Under the Age of 5

We tested the hypothesis that female house ownership benefits the health of children, particularly girls. Female house ownership, rather than matrilocality, was chosen as a proxy for matriliny, as this indicator is associated with better health outcomes for both women and men in the analyses above. Our first finding ran contrary to our prediction, showing that female house ownership was significantly associated with a higher risk of sickness in children (OR = 1.41, SE = 1.108, $p < 0.001$, ref. level = male ownership; Table 3). This association was observed in a mixed logistic regression model adjusting for child age, maternal education, number of children, wealth, and urban/rural residence. One possible explanation for this puzzling result is that women are more likely to answer the survey in female-owned households and over-report child sickness. However, we found that while women are more likely to respond in female-owned households, they do not over-report child sickness compared to men (Table S9). A more plausible explanation is a reporting bias in female-headed households due to increased attention paid to child health by all household members. This hypothesis is consistent with the higher number of reported childhood illnesses in wealthier and more educated households (OR = 1.27, 0.271, see Table 3, first column).

To verify that the increased reporting of child illness in female-owned households is due to reporting bias rather than higher levels of sickness, we compared infant mortality rates between households owned by women and men (Fig. 6). Findings that infant mortality was lower in female-owned households (OR = 0.77, SE = 0.267, Table 3) support the reporting bias hypothesis for matrilineal households. Similar results were found by Rockers and McConnell (2017) in their study using DHS data from sub-Saharan African countries, where girls were reported to have fewer fevers than boys yet also had higher mortality rates compared to boys.

Our second finding aligns with our prediction and hypothesis that children in female-owned households were more likely to receive medical treatment when sick compared to those in male-owned households (OR = 2.75, SE = 0.206, $p < 0.001$; Table 3). This association remained robust even after including the respondent's gender in the model (Table S11). Finally, we found no evidence for daughters in healthcare investment. The odds of receiving medical treatment when sick were similar for both boys and girls across all house ownership

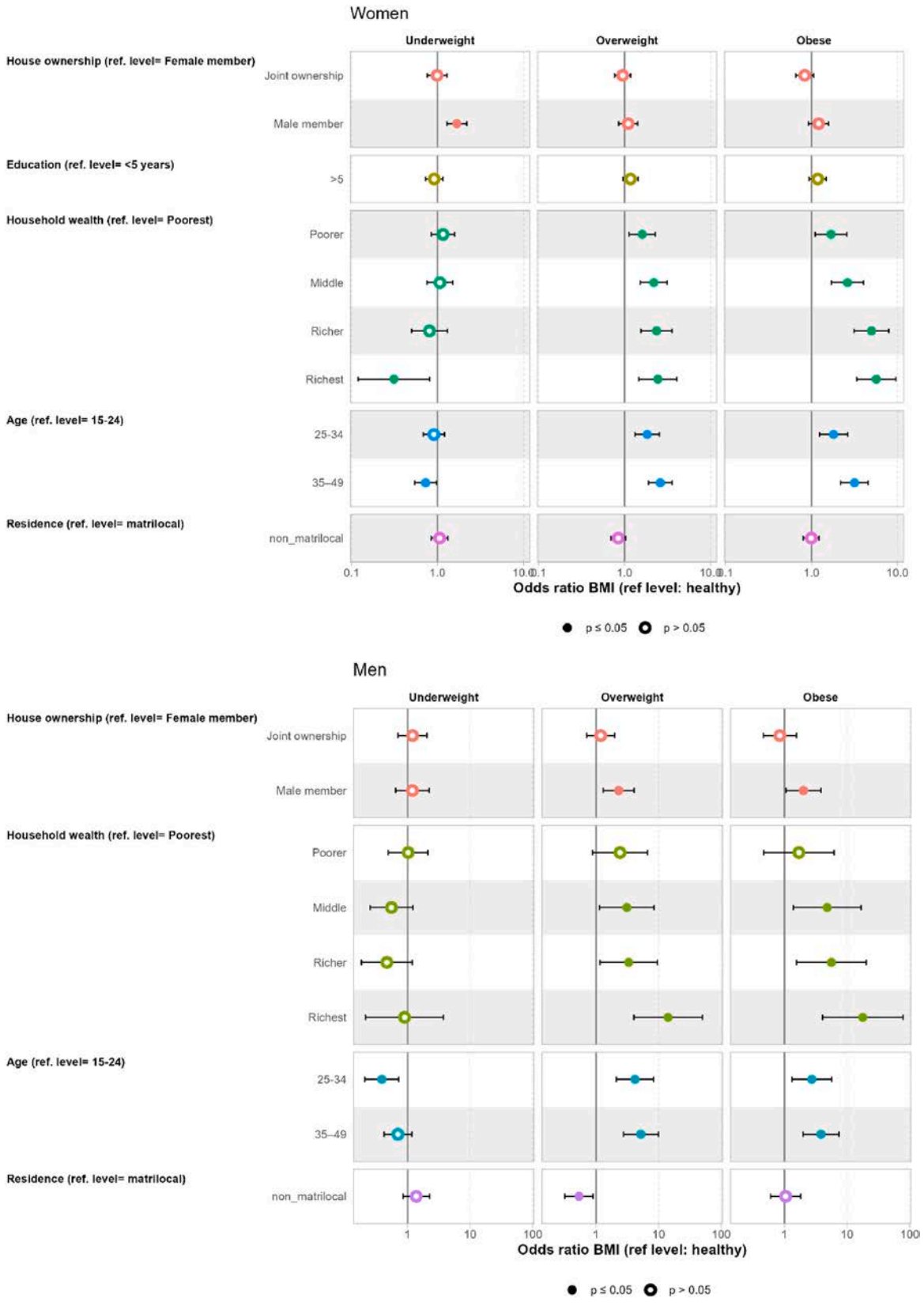

Fig. 3. Estimated parameters of a multinomial generalized linear model for predicting BMI (4 levels). Parameter values have been exponentially transformed to express **relative** odds ratios, which represent the relative probability of being underweight (rather than having a healthy BMI). For example, this probability is 41 % higher for women living in male-owned households compared to those in female-owned households. This is calculated as $\frac{\frac{p(\text{underweight})}{p(\text{healthy})}\text{Male}}{\frac{p(\text{underweight})}{p(\text{healthy})}\text{Female}}$. Error bars represent 95 % confidence intervals. The women's sample includes 4,016 observations, and the men's sample includes 809 observations. Full circles indicate significant associations, while open circles indicate non-significant.

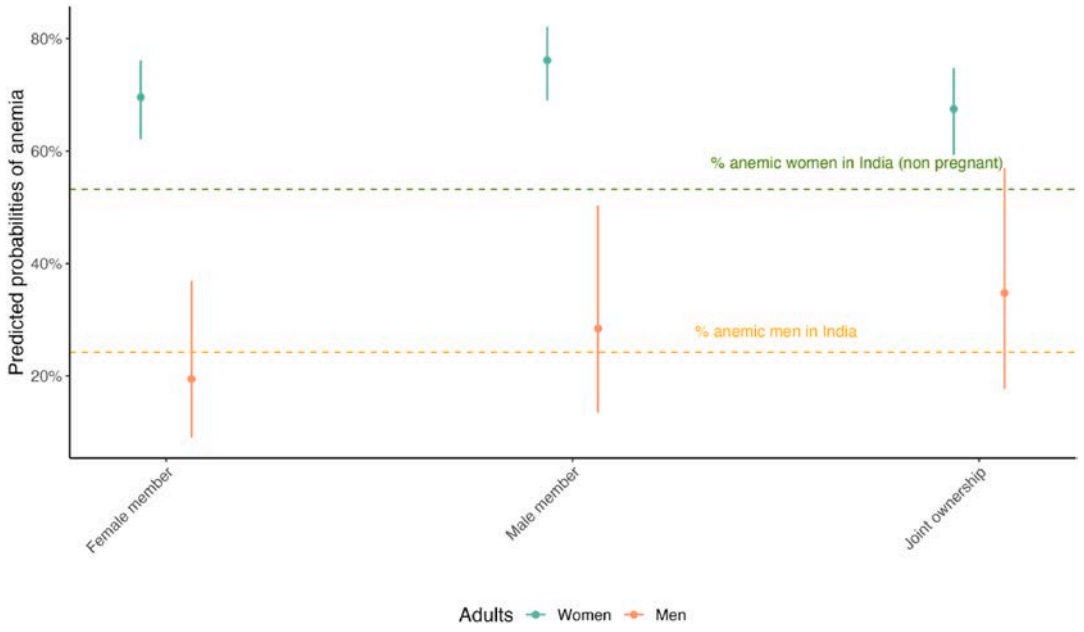

Fig. 4. Predicted probability of being anemic according to house ownership status by gender. Predicted values are adjusted for household size, age, geographical area, and household wealth, for both men and women. The pooled analysis with both sexes can be found Table S6.

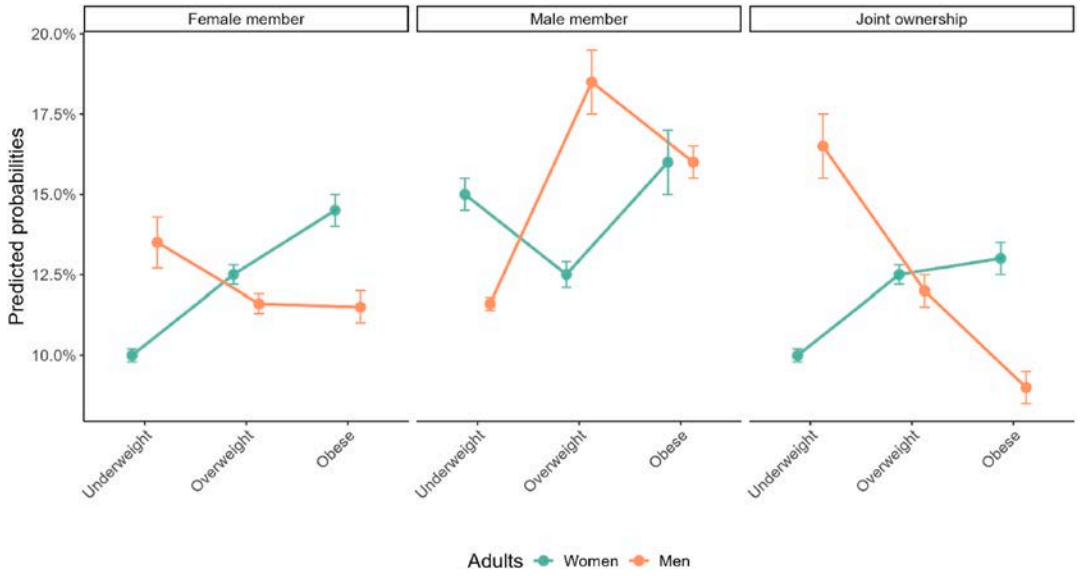

Fig. 5. Predicted probabilities of an unhealthy BMI according to house ownership gender. Predicted values are adjusted for household size, age, geographical area, and household wealth, for both men and women. The reference level is a healthy BMI.

types.

4. Discussion

Using representative large-scale demographic and health data from the least patriarchal state in India, we provide evidence that matrilineal practices positively associate with the health of women and their children through economic pathways. In Meghalaya—one of India's poorest states, where 70 % of women belong to the second or third wealth quintile nationally—anemia and undernutrition are less prevalent in households with female ownership, a practice followed by more than 60 % of the population in the state. For men, female house ownership is also protective against anemia and reduces the risk of being overweight or obese, contributing to overall health improvements and closing the gender gap. In contrast, we find no evidence that spatial proximity to maternal kin influences the health of women or their children, nor do we find evidence of a gender gap in parental investment in healthcare among children. This suggests that female economic autonomy plays a greater role in promoting women's health than other matrilineal socio-cultural pathways in this transitioning population. Although female ownership is associated with higher household wealth, the observed health benefits persist beyond wealth disparities, indicating that control over resources—rather than merely residing in a wealthy household—mediates the relationship between female house ownership and health. These findings highlight the role of matrilineal determinants in shaping women's health within a matrilineal society, although the same mechanisms may not explain differences in health between matrilineal and patrilineal women. Kin support may be more crucial in contexts where husbands or in-laws pose a threat to women's physical integrity (Smuts, 1995).

Table 3
Mixed logistic regressions, children.

Variables	Sick			Medical Treatment if Sick			Infant Mortality		
	OR[a]	95 % CI[a]	*p*-value	OR[a]	95 % CI[a]	*p*-value	OR[a]	95 % CI[a]	*p*-value
Gender			0.15			>0.9			0.13
Boy	–	–		–	–		–	–	
Girl	1.12	0.96, 1.30		1.00	0.71, 1.40		0.74	0.50, 1.09	
Current age of child in years	0.94	0.91, 0.97	**< 0.001**						
Urban/rural			**0.001**			**0.013**			0.054
Urban	–	–		–	–		–	–	
Rural	1.61	1.21, 2.17		0.30	0.09, 0.80		2.69	0.98, 11.1	
Wealth			**0.035**			**0.009**			0.3
Poorest	–	–		–	–		–	–	
Poorer	1.41	1.12, 1.77		1.56	0.98, 2.47		1.16	0.68, 2.09	
Middle	1.46	1.13, 1.88		2.52	1.46, 4.38		1.52	0.83, 2.86	
Richer	1.36	0.96, 1.95		2.88	1.24, 7.37		1.32	0.47, 3.33	
Richest	1.27	0.73, 2.16		1.13	0.35, 4.45		0.00	0.00, 0.67	
Education	1.04	1.02, 1.06	**< 0.001**	1.04	0.99, 1.08	0.15	0.95	0.90, 1.00	**0.048**
Gender of the house owner			**0.007**			**< 0.001**			0.5
Male member	–	–		–	–		–	–	
Female member	1.37	1.10, 1.71		3.00	1.97, 4.55		0.77	0.48, 1.30	
Joint	1.45	1.13, 1.86		4.85	2.85, 8.40		0.70	0.39, 1.28	

[a] OR = Odds Ratio, SE = Standard Error, CI = Confidence Interval.

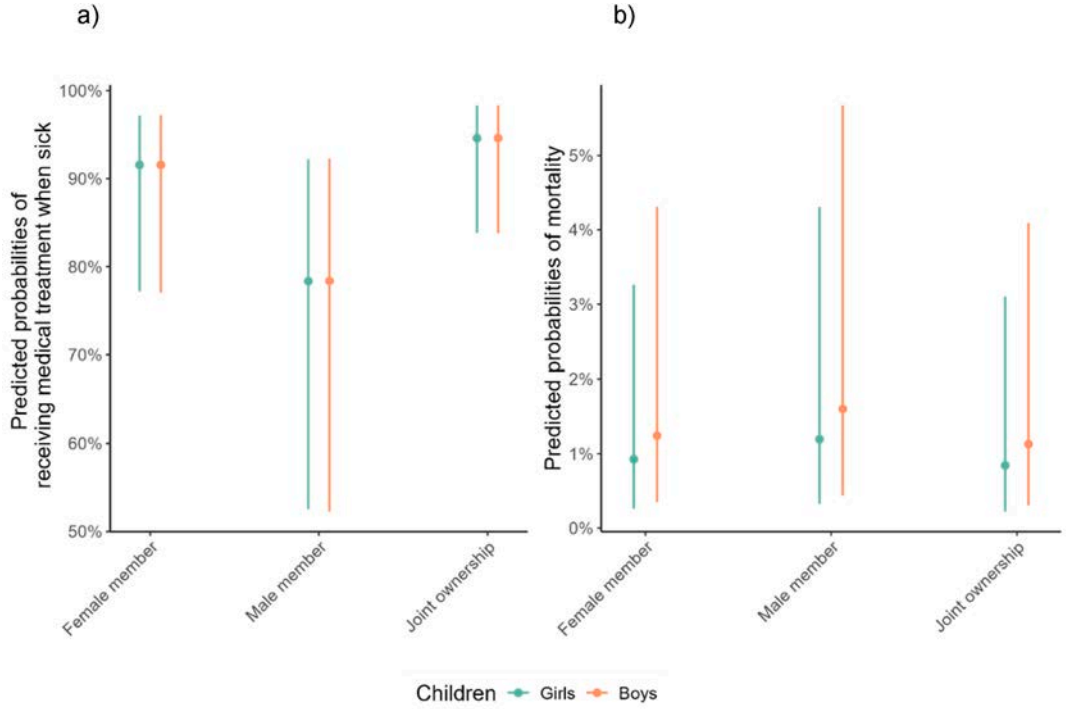

Fig. 6. (a) Predicted probabilities of receiving medical treatment if sick, by gender (<5) and (b) mortality risk according to ownership gender.

The findings suggest that female ownership may be key to reducing health inequalities. First, living in a female-owned household is a protective factor against anemia for both women and men, independent of household wealth. Anemia and undernutrition are major global health threats, with anemia alone accounting for 50 million years of healthy life lost due to disability in 2019. In India, 57 % of women aged 15–49 suffered from anemia in 2019, a four-percentage-point increase since 2015. The lower risk of anemia in female-owned households may stem from greater consumption of nutrient-rich foods. However, the negative relationship between anemia and the house owner's gender remains independent of BMI, suggesting that nutritional differences alone do not fully explain the reduced risk. Instead, limited healthcare access may play a role, as 21 % of women in male-owned households reported restricted access to healthcare compared to 5.7 % of women in female-owned households (Table S10), potentially due to reduced household bargaining power.

Our results also indicate that female house ownership balances energy intake between women and men, leading to healthier BMI levels. Compared to those in female-owned households, women in male-owned households face a higher risk of being underweight, while men are more likely to be overweight or obese. This gender disparity aligns with literature on "dual burden households" in LMIC countries (Doak et al., 2005), where overweight and underweight individuals coexist within the same household. The protective effect of female ownership may result from a more equitable distribution of household nutritional resources or a reduced domestic and agricultural workload for women with autonomy, as observed in matrilocal versus patrilocal communities in southwest China (Chen et al., 2023). Future qualitative and

quantitative studies should further explore the mechanisms that contribute to reducing the gender nutritional gap. In-depth examinations of factors such as women's financial autonomy and decision-making power over household expenditures could provide valuable insights and enrich the literature. Moreover, additional anthropometric measures of abdominal adiposity — such as sagittal abdominal diameter, waist-to-hip ratio, and waist-to-height ratio (Pray et al., 2023) would provide valuable insights into the relationship between matriliny and the risk of cardiovascular disease, diabetes, and hypertension.

Matrilocal residence is not associated with women's health, as measured by anemia status or BMI. This may reflect the ambivalent role of kin in health outcomes: While maternal kin can provide support by assisting with domestic tasks, they may also increase competition for resources and reduce individual nutritional intake (Sear, 2008; Shenk et al., 2021). These negative effects may be particularly pronounced for women, who are often expected to prioritize their kin's dietary needs over their own. The observed association between household size and the risk of being underweight supports the idea that, for women of reproductive age, additional household members may be more of a burden than a source of support. However, we are unable to precisely quantify the number of maternal kin living nearby or their patterns of social interaction. It is also possible that maternal kin influence other aspects of health, such as life satisfaction or healthcare access, which were not analyzed here. In the context of recently increasing market integration, economic development and wage labor may reduce reliance on kin support. Market integration diminishes the proportion of kin in individuals' support networks (Colleran, 2020; Hackman and Kramer, 2021), likely because economic resources, such as cash and wages, become more critical than social capital. Additionally, the expansion of public and private insurance systems may further reduce the family's role as a safety net against economic and health uncertainties.

Finally, sick children of both sexes are more likely to receive care in matrilineal households. Combined with the finding that female property owners are more likely than non-owners to obtain permission for accessing healthcare (Table S10), this supports the idea that greater autonomy and bargaining power for women within couples underlie the relationship between health and matriliny. When women possess material resources, they are better able to invest in their own health and that of their children. While (Lowes, 2020) suggests that children, especially girls, fare better in matrilineal settings, likely reflecting daughter-biased parental investment—one proposed driver of matriliny (Holden et al., 2003), we found no sex differences in child mortality, illness, or parental care in households owned by women. From a behavioral ecology perspective, the loss of a child is costlier for women than for men, as they have already invested more in their offspring (Trivers, 1972; but see Kokko and Jennions, 2008 for a critique of Trivers' theory). These initial sex differences in reproductive strategies may explain why women are more motivated to ensure their children's health, regardless of her sex. Mothers also have more incentives to secure their children's survival, as they do not face maternity uncertainty, as opposed to fathers. This certainty, combined with their greater obligatory investment in offspring through pregnancy and lactation, strengthens their evolutionary drive to ensure their children's well-being and future reproductive success (Mace and Buss, 2015). However, given the importance of passing on property to daughters and their role in caring for parents in Meghalaya, we may expect differences in parental investment on other indicators that do not involve the loss of a child. Future research could investigate gender differences in education and anthropometric indicators within matrilineal societies.

This article contributes to public health discussions in Meghalaya in two key ways. First, our findings align with qualitative data indicating that diet has deteriorated over the past few decades, with meat becoming scarcer in Meghalaya due to the disappearance of certain animals and an increased reliance on processed market foods (FAO, 2021; FAO and Alliance of Bioversity International and CIAT, 2021). While these dietary shifts may contribute to rising nutrition-related diseases, promoting women's economic autonomy remains a crucial strategy for improving public health. In rapidly developing regions like Meghalaya, women may be at greater risk than men of being overweight or obese, a trend often attributed to occupational differences and lower physical activity levels (Singh and Chattopadhyay, 2023). However, economic autonomy for women could mitigate the negative health effects of economic growth on their well-being. Second, our results indicate that joint property ownership—now becoming the norm in Meghalaya—benefits the health of women and children. However, preliminary evidence suggests that men in male-ownership houses may experience declines in specific health markers compared to those in female-owned households. Specifically, we identify a reversed pattern compared to other regions undergoing economic transition regarding the gender gap in overweight and obesity (Kanter and Caballero, 2012): in Meghalaya, wealthier men are at a higher risk of overweight and obesity than wealthier women. Policymakers should consider this specificity when designing public policies.

The reason why house ownership is more strongly associated with overweight and obesity in men than in women remains unclear. First, men with greater economic power may have increased access to alcohol, as shown by Doss in Ghana (Doss, 1996), which could lead to higher caloric intake. Another hypothesis is that male owners engage in less physical activity compared to female property owners. A final factor, which does not exclude the previous two, is that men tend to be more negligent about their health, as masculine norms encourage detrimental behaviors (alcohol and tobacco consumption, not seeking medical care, physical aggression, Mahalik et al., 2007). Our findings suggest that female ownership promotes a healthier BMI for both genders—reducing underweight in women and overweight in men—contrasting with studies showing a reversed gender gap in matrilineal vs. patrilineal systems (Reynolds et al., 2020).

4.1. Strength and limitations

Our study draws on nationally representative data and validates measures of matrilineal dimensions using data from other Indian states with substantial matrilineal communities. We account for wealth and education disparities, demonstrating that associations with matrilineal practices persist beyond wealth inequalities. Meghalaya provides a unique setting to examine the effects of kin proximity and female house ownership on women's health, as these factors are not always correlated (see Fig. 1). Notably, matrilocal women do not necessarily own their houses: 12.3 % live in households where a man is the owner, and 23.7 % are in households with joint male-female ownership (Table S1).

This study also has several limitations. First, the analysis is based on a 2015 survey, and associations may have shifted by 2024. However, female house ownership has been under threat for at least two decades due to laws favoring bilateral rather than matrilineal inheritance of material assets (Nongbri, 2000), suggesting that our findings remain relevant. Second, we use female house ownership as a proxy for matrilineal inheritance, though in some cases ownership may result from self-acquired property. Third, we infer matrilocal residence by matching birthplace and current residence but geographical proximity does not necessarily translate into social proximity or support as it brushes over potential conflicts and variation in kin availability. Fourth, we assess women's property ownership, which should not be equated with decision-making power. In Meghalaya, individuals remain deeply embedded in their families, and women—particularly heiresses—are expected to support relatives in need. Their autonomy in decision-making is likely constrained in this context, where intensive kinship structures prevail. Finally, our findings focus on select indicators of physical health, which may not align with mental health outcomes. Future research should extend this inquiry to other dimensions of health, particularly mental health, which remains understudied in the context of matriliny.

5. Conclusion

House ownership is recognized as a key factor in reducing wealth inequality (Carroll and Cohen-Kristiansen, 2021). Our findings indicate that female house ownership should be considered a critical pathway to reducing health inequalities. In a society transitioning toward greater market integration and patrilineal norms, maintaining the traditional practice of female house ownership benefits the health of women, men, and children. Alongside financial support to combat undernutrition among disadvantaged families and informational campaigns to address malnutrition among the wealthiest, health authorities should develop public policies that promote female economic autonomy.

CRediT authorship contribution statement

Loïa Lamarque: Writing – review & editing, Writing – original draft, Visualization, Methodology, Data curation, Conceptualization. **Banrida Langstieh:** Writing – review & editing, Supervision, Conceptualization. **Michel Raymond:** Supervision. **Alexandra Alvergne:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2025.118355.

Data availability

Data will be made available on request.

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