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Research Article

**Diffusion of innovation in family size ideation and
acceptability of contraceptive use between
migrants and non-migrants in rural Senegal**

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Diffusion of innovation in family size ideation and acceptability of contraceptive use between migrants and non-migrants in rural Senegal

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Abstract

BACKGROUND

Urban–rural diffusion of family-building ideals, beliefs, and behaviors has long been hypothesized to drive fertility transitions. Though the idea is supported on the aggregate level, little prior research has addressed individual-level diffusion. Understanding such mechanisms may be especially important in the high-fertility context of sub-Saharan Africa.

OBJECTIVE

We estimate the association of exposure of rural residents in a small Senegalese population to urban migrants and non-migrant urban residents in their social networks and their beliefs about ideal family size and the acceptability of contraceptive use. We address hypothesized mediating mechanisms and moderating effects of network density.

METHODS

Data are drawn from the Niakhar Social Networks and Health Project, a large-scale social network survey, and the Niakhar Demographic and Health Surveillance System. Nested models are estimated with migrant exposure operationalized as both the proportion of migrants and the average duration of migration to the capital, Dakar, in respondents' social networks.

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RESULTS

Contraceptive approval and numeric response to ideal family size are strongly associated with migrant exposure in men's social networks but not women's. This is explained by differences in network density and the prevalence of these ideals in networks. Migrant exposure is associated with lower ideal family sizes for both men and women.

CONTRIBUTION

We find support for social learning and influence effects associated with exposure to migrants on key ideals and beliefs about family size and contraception use, and we find moderating effects of network density. Our findings have potentially important implications for family planning policy and programmatic efforts in the region.

1. Introduction

Although fertility has declined in many lower- and middle-income countries (LMICs), large parts of sub-Saharan Africa continue to have fertility well above replacement levels. It is projected that this region will add more than 1 billion people between now and 2050, accounting for more than half of the total population growth in the world (United Nations Department of Economic and Social Affairs, Population Division 2022).

At the same time, the region has seen dramatically increased intranational and intraregional migration, particularly rural-to-urban and circular migration (Cattaneo and Robinson 2020; Selhausen 2022). Rural migrants arriving and living in urban environments are exposed to a different social, cultural, and economic milieu, often with distinctly lower fertility preferences and ideals and higher rates of contraceptive use than in their rural communities of origin.

This raises the possibility that the (relatively lower) fertility ideation and achieved fertility of urban–rural migrants and urban residents may be important mechanisms in the diffusion of smaller family ideals and both contraceptive knowledge and acceptability in migrants' communities of origin. Such an urban–rural diffusion mechanism has long been hypothesized, but despite some supportive evidence, it has largely lacked robust empirical support. Providing this support may yield important insights for developing family planning messaging aimed at exploiting urban–rural network ties, which in turn may help speed nascent or stalled fertility transitions.

Empirical research has largely been unable to adequately test for diffusion effects primarily because the fundamental social learning and evaluation mechanisms take place at the individual level. In this paper, we use data from a unique social network survey in rural Senegal to fill this gap. Specifically, we estimate the associations between the migration experience of respondents' social network members (or alters), respondents'

exposure to urban residents, and their responses to questions concerning ideal family size and the acceptability of contraceptive use among married women.

2. Background

Although LMICs in Asia and Latin America are nearing the end of fertility transitions begun in the 1970s, many countries in sub-Saharan Africa continue to have fertility levels well above replacement. Though declines began in the region in the 1980s and 1990s, they have been unusually slow by both historical and contemporary standards, with periodic or temporary stalls or reversals of downward fertility trends seen in a number of countries (Bongaarts and Casterline 2013; Schoumaker 2019; Shapiro and Hinde 2017).

There have been several proposed explanations for sustained high fertility and anemic fertility declines. Proponents of family planning programs have pointed to supply-side factors associated with the lack of access to contraception and its cost. While issues related to the supply of contraception remain in some areas, they have diminished in recent decades, and the elevated demand for children in sub-Saharan Africa is undeniable. In the 33 countries with Demographic and Health Surveys after 2010, the median average ideal family sizes for women aged 15–49 and men aged 15–54/59 were 4.8 and 5.5, respectively. The median wanted total fertility rate (TWFR) was 4.5 (ICF 2012). Demand measured in this way has been shown to be strongly associated with the speed and magnitude (or lack thereof) of fertility declines (Casterline and Agyei-Mensah 2017; Sánchez-Páez and Schoumaker 2022).

This elevated demand may be induced in part or in combination by a variety of structural factors, including stagnant or slowing economic growth, low levels of female education, high infant and child mortality, and a relative lack of available support from nonfamilial institutions. Prominent contemporary ideational explanations for sustained high demand for children (which may be in part shaped by the structural factors cited above) include the lack of culturally structured schemas concerning the limitation of fertility, uncertainty concerning adult and child mortality, lack of knowledge about contraception, concerns about its potential side effects, and, at a more basic level, the moral and social acceptability of contraceptive use (Bongaarts and Casterline 2013; Casterline and Sinding 2004; Frye and Bachan 2017; Hayford and Agadjanian 2011; Sandberg 2005; van de Walle 1992).

A major driver of both the demand for children and knowledge of contraceptive use, safety, and moral acceptability, which may act independently of or interact with these factors, is diffusion of beliefs and behaviors through social learning, social influence, and social comparison. These can broadly be classified as social effects (Casterline 2001). Social learning relates to the relative degree of exposure to new information through

interaction; social comparison involves the perceived status value of adopting the associated behavior. Social influence may be conceptualized as the cumulative social environment (both in informational content and interactional structure) individuals are exposed to, entailing normative constraints and/or pressure for or against particular beliefs and behaviors.

Social effects have long been hypothesized to be central mechanisms driving fertility transitions (Bernardi and Klärner 2014; Bongaarts and Watkins 1996; Caldwell 1976; Casterline 2001; Watkins 1986). A main focus of both the theoretical and empirical literature in this regard has been on the diffusion of contraceptive knowledge (including potential side effects) and use through social learning, with some research also pointing to social influence effects (Alvergne et al. 2011; Behrman, Kohler, and Watkins 2002; Billari, Philipov, and Testa 2009; Bond, Valente, and Kendall 1999; Bongaarts and Watkins 1996; Kohler 1997; Kohler, Behrman, and Watkins 2001; Lowe and Moore 2014; Montgomery and Casterline 1996; Valente et al. 1997).

One specific diffusion process that has long been hypothesized to be of critical importance to fertility declines is that from urban migrants to rural populations. In both historical and contemporary fertility transitions, the fertility of urban populations has consistently been seen to be lower than that of adjacent rural populations. Reasons for this potentially include the higher costs (including housing, food, and importantly education) and diminished benefits (in terms of agricultural chores) of raising children in a more highly monetized economy, opportunity costs associated with human capital development, labor market participation and leisure activities in urban areas, and increased access to and knowledge of contraception and family planning (Kulu 2013; Lerch 2019b).

In less developed countries, ideal or preferred family size is often lower, and knowledge and use of contraception higher, among rural–urban migrants relative to non-migrants in their origin populations (Brockhoff and Yang 1994; Lee and Farber 1984; Lindstrom 2003; Lindstrom and Hernández 2006; Lindstrom and Saucedo 2002; McKinney 1993; Thompson 1953; Zárate and Zárate 1975). This phenomenon has been at least partially attributed to the adaptation of migrants' ideation, behaviors, and norms to those prevalent in urban areas (Boujija, Bignami, and Sandberg 2024; Hervitz 1985; Lee and Pol 1993; Lerch 2019a; Lindstrom 2003; Lindstrom and Saucedo 2002; White et al. 2008). Fertility and family-building characteristics, ideals, and beliefs adapted to an urban context are substantive content that returned migrants bring to interactions with members of their origin communities and are thought to diffuse or influence the beliefs and behaviors of non-migrants (Levitt and Lamba-Nieves 2011).

The broad hypothesis that fertility beliefs and behaviors diffuse from rural–urban migrants to rural residents has received some support in aggregate-level analyses of trends in fertility rates and migration in both historical and contemporary transitions

(Anwar and Mughal 2016; Beine, Docquier, and Schiff 2013; Bertoli and Marchetta 2015; Daudin, Franck, and Rapoport 2016, 2018; Fargues 2006). While strongly suggestive of urban–rural diffusion, by design these analyses cannot identify specific interpersonal mechanisms through which diffusion takes place.

Limited support for such mechanisms has been found. Urban residence of marriage witnesses, operationalizing exposure to urban migrants and residents within rural couples' social networks, has been seen to be associated with lower ages at last birth and smaller completed family sizes in the context of the historical Dutch fertility transition (Bras 2014). Having family members who have migrated has also been found to be associated with knowledge of contraceptive technologies and use of contraception among women in Mexico, Afghanistan, and Guatemala (De 2013; Lindstrom and Muñoz-Franco 2005; Roosen and Siegel 2018).

However, prior analyses have been constrained in operationalizing migrant exposure primarily through indicators for whether any member of a respondent's family or household had previously migrated. Such measures implicitly censor exposure to nonfamilial and non-household migrants as well as non-migrant urban residents (hereafter "urban residents"). This latter category of individual is universally neglected in the consideration of urban–rural diffusion. In rural populations with a history of urban–rural migration, however, ties of kinship, friendship, and commercial interests may be actively maintained with such urban residents (Boujija, Bignami, and Sandberg 2024). Finally, since household or familial livelihood strategies aimed at diversifying sources of income and risk may motivate and structure migration decisions of their members (Kandel and Massey 2002; Stark and Bloom 1985; Taylor 1999), such measures may be capturing the effects of these strategies rather than social effects.

Previous research has been limited as well in the ability to estimate which potential aspects of migrant exposure may be important in shaping non-migrants' beliefs and behaviors. The most comprehensive of the analyses discussed above, from Guatemala, is the only one to have attempted to do so. Controlling for respondents' knowledge of contraceptive methods, the association between urban migrant exposure and respondents' contraceptive use was diminished by about half. This suggests that a large part of the effect of exposure was purely informational remittance (Lindstrom and Muñoz-Franco 2005). A relatively large association remained, however, suggesting other factors driving the influence of migrant exposure on contraceptive use.⁵

As noted above, in addition to levels of exposure to network alters with particular characteristics or knowledge, diffusion of innovation has long been hypothesized to

⁵This interpretation is counter to that proposed by the authors. Controlling for contraceptive knowledge, they find an odds ratio of 1.44 (relative to 1.87 when contraceptive knowledge is not controlled) with a p-value of 0.073 using a two-tailed test. In this case, since exposure to migrants is a directional hypothesis, a one-tailed test is appropriate, implying a p-value of 0.037 and 44% higher odds of contraceptive use with exposure.

depend on aspects of network structure (Valente 1995). Most important among these are network size and density. Larger social networks may be less constraining, as individuals have access to more nonredundant information. The degree to which that is the case, however, will depend on network density: how tightly members of a network are interconnected. Formally, density measures the proportion of dyadic ties between members of a network relative to all such possible ties. Higher levels of density are thought to restrict the availability of novel information and ideas, potentially constrain the acceptability of expressing ideas at odds with those of the majority of the network, or even circumscribe the universe of ideational and behavioral options to those held within it through social influence (Burt 1987).

Because network data in demographic research are relatively rare, assessing the influence of network density has received little attention. To our knowledge, only two prior works using data from small ego-centric networks (which only measure ties from the respondent, or ego, to their alters) and respondent reports of ties between alters have addressed the possible interaction between alter characteristics and social network density related to fertility behaviors (Kohler, Behrman, and Watkins 2001; Rossier and Bernardi 2009). Kohler et al. developed a model that distinguishes learning from influence through the interaction between network prevalence of contraceptive use and density in rural Kenya. They suggest that when social learning is predominant, the prevalence of contraceptive use among network members will influence a respondent's (an ego's) use regardless of network density, but the strongest effects will be seen in less connected networks. They posit in contrast that if influence is the predominant mechanism, one would expect stronger gradients associated with increased network prevalence of contraceptive use in denser networks.

3. Methods

3.1 Context

The data used here come from the first panel of the Niakhar Social Networks and Health Project (NSNHP), collected in 2014 (Delaunay et al. 2019). The NSNHP is a large-scale social network project conducted in collaboration with the Niakhar Demographic and Health Surveillance System (NDHSS) (Delaunay et al. 2019). The NDHSS is a prospective longitudinal surveillance system maintained by the Institut de Recherche pour le Développement (IRD) in the Niakhar and Diarère districts of the department of Fatick (Sine-Saloum), 135 km east of Dakar, Senegal (Delaunay et al. 2013; Delaunay, Desclaux, and Sokhna 2018). It encompasses eight villages that have been under demographic surveillance since 1963 and 22 villages that were brought under

surveillance in 1983. The population of the surveillance area doubled, to 44,000 individuals, in the 30 years leading up to the first panel of the NSNHP in 2014.

The population of the NDHSS is 96.7% ethnically Sereer, and the dominant Western religion is Islam, followed by Christianity. A significant syncretism exists, however, with an indigenous monotheism practiced to a greater or lesser extent by most of the population. Residence in the surveillance zone is organized in kin-based residential compounds composed of one or more households, or hearths. Economic production and consumption are organized at the household level and are largely agropastoral, characterized by rain-fed agriculture (with rotation of millet, groundnuts, and fallow) and livestock production of cattle, sheep, and goats (Lericollais 1999). Diversification of crops has been ongoing for several decades due to the government's withdrawal of support from the production of groundnuts and a rise in rainfall levels that favors the cultivation of watermelon and market gardening (Masse et al. 2018).

Circular movements of migration toward urban areas, particularly the capital, Dakar, have intensified in recent decades (Lalou and Delaunay 2015). In 2014 the majority of residents in the NDHSS surveillance zone above the age of 16 (47% of men and 59% of women) had experienced at least one migration spell to Dakar, generally either temporary or circular, with permanent migration relatively rare (Boujija et al. 2022; Delaunay et al. 2016). Virtually all residents have at least some contacts with prior migrants to Dakar, non-migrant residents of the capital, or both.

In 1963 the total fertility rate (TFR) in the surveillance zone was seven children per woman. After a slight increase in the 1980s, the TFR declined slowly to six children per woman for the period 2009–2014 (Bras, Remund, and Delaunay 2023; Buiatti and Delaunay 2017; Garenne et al. 2018).

To put urban–rural differences in fertility ideation into both national and regional context, an analysis of the 2014 Demographic and Health Survey (DHS) is included in the appendix as Table A-1. This table demonstrates substantial differences in fertility practice and ideation between urban and rural residents in Senegal overall and between residents of the capital and the Fatick region. Urban residents as a whole report significantly higher levels of current use of modern contraceptives, more intention to use modern contraception among those not currently using it, higher levels of numeric response to a question concerning ideal family size, and smaller ideal family sizes than those reported by residents of rural areas. The same is true for the comparison between residents of Dakar and Fatick, except for the numeric response to the ideal family size question. While ideal family size and the use of contraception are seemingly self-evidently important to consider concerning fertility beliefs and behaviors, the importance of numeric response deserves a bit of exegesis. A nonnumeric response to this type of ideal or desired family size question (such as “It’s up to God,” “as many as possible,” or “I don’t know”) in lieu of a numeric response is a consistent feature of all fertility surveys

in LMICs. Though such responses are acknowledged as clearly important for understanding fertility intentions and desires, there has been considerable debate concerning what they represent. Early explanations suggested that these types of responses indicated a lack of cognitive capacity to think about family size numerically (and an association with limited formal education) or a lack of culturally structured schemas concerning the limitation of fertility. More recent work has focused on the potential influence of uncertainty about future childbearing associated with infant and child mortality, economic conditions, marital instability, and adult child mortality in motivating nonnumeric response (Frye and Bachan 2017; Hayford and Agadjanian 2011; Sandberg 2005). Numeric response, then, in a complementary fashion may be indicative of cultural schemas or perceptions of risks associated with greater certainty concerning ideal family size and therefore could be an important ideational element diffused from urban migrants or residents to rural non-migrants.

Ideal family size, measured in the NSNHP with a question concerning the advice respondents would give to newly married couples, was estimated to be 6.1 children for men and 5.9 for women in 2014. These numbers are similar to the Fatick regional-level estimates from the 2014 DHS of 6.6 for men and 5.5 for women, though these were obtained using a slightly different question.⁶ In the DHS survey, 43% of men and 10% of women in the Fatick region gave nonnumeric responses to this question. Nonnumeric response was higher in the NDHSS surveillance zone – 49% for men and 47% for women – due at least in part to the difference in question wording and intensity of probing.⁷

Finally, as is the case for West Africa as a whole, objections to the use of contraception may be an impediment to the use of family planning services. Among Senegalese women identified as having an unmet need for contraception in the 2010–2011 DHS, the modal response for non-use (33%) was objections on the part of women, their spouses, or someone else (Sedgh and Hussain 2014). That these objections may be associated with moral judgments concerning sexuality is suggested in the 2014 DHS, where only 59% of men disagreed that the use of contraception leads to promiscuity. This was reinforced by the NDHSS survey, in which only 49% of men and 59% of women said that married women who used contraception were morally respectable.

⁶ The DHS asks specifically about the number of children a respondent wants to have or, for those who already have children, how many they wanted before they began childbearing. This question has been criticized for potential post hoc rationalization for respondents who already have children (Kiesler 1977). Our question was specifically chosen to avoid this type of issue.

⁷ Only one probe for a numeric response after an initial nonnumeric response was used in the NSNHP. In the DHS, the interviewer instructions are to “insist” on a numeric response through the use of multiple probes. This undoubtedly is the cause of lower rates of nonnumeric response in those surveys (Frye and Bachan 2017). Though probing can decrease item nonresponse (such as “I don’t know”), any probing of item-missing nonresponse may induce measurement error through satisficing effects (Kuha et al. 2018; Schuman and Presser 1996), which may be exacerbated by multiple, repeated probes, as in the DHS.

3.2 Hypotheses

Following the discussion above, one may anticipate that higher levels of exposure to migrant alters and urban residents will be associated with ideational responses more aligned with those held in urban areas. We hypothesize that, controlling for neighborhood context and individual-level mechanisms that may bias estimates of network effects, greater migrant exposure in rural residents' social networks will be associated with higher probabilities of giving numeric responses concerning ideal family size and the belief that contraceptive use is acceptable, as well as lower numeric ideal family sizes.

Family-building characteristics, ideals, and beliefs of migrant alters are, as noted above, at least part of the substantive content that potentially diffuses in interaction with residents of their origin community. Given that, we may further expect this to mediate any effects of migrant exposure on these outcomes. In this analysis, we hypothesize that such mediation may occur through migrant alters' family sizes, wealth, adherence to traditional health ideation, and, perhaps most importantly, fertility beliefs and ideals.

Finally, following the discussion above concerning network density and migrant exposure, we expect that if fertility ideation of those in more tightly interconnected or denser social networks (which may constrain informational availability and reinforce normative constraints) is more responsive to exposure to migrant network alters, it will be indicative of the predominance of social influence. If the response is the same or stronger in less dense networks, it will be indicative of the predominance of social learning.

3.3 Data

The NSNHP collected characteristics of social network ties through 16 name generators across four theoretically key domains of interaction. These included affective ties, those primarily associated with exchange or support, those whose saliency was primarily due to frequency of or time spent in interaction, and role-relational ties, structural or institutional ties potentially entailing obligation (Marin and Hampton 2007).⁸ Name generators were chosen to capture the widest breadth of personal networks possible with a constrained number of questions based on qualitative work assessing patterns of social interaction in the population. Their efficiency in eliciting the largest number of unique (nonredundant) alters in an initial exploratory survey using 42 commonly used name generators adapted for the local context (Delaunay et al. 2019). The final name generators represent primarily strong ties, and though they do not capture the entire scope of

⁸A full list of name generators used is provided in Table A-9 in English translation from the Sereer.

interaction individuals were exposed to, additional name generators in the exploratory survey yielded increasingly marginal returns of unique alters.

The number of alters elicited was not restricted in any of the name generators, and on average the survey elicited approximately 24 unique, namable alters from each respondent across these name generators (Delaunay et al. 2019). Both respondents and elicited alters were linked to their respective records in the NDHSS, including their full migration histories. The survey also contains an extensive respondent questionnaire covering a number of substantive topics, including fertility ideation and the moral acceptability of contraception.

The NSNHP survey of 2014 consisted of two data collections with identical instruments. The first, the population sample, was a simple random sample of resident adults and adolescents aged 16 and above drawn from the NDHSS data. The second was a complete census of adults and adolescents aged 16 and above in one village (Yandé, the “sociocentric” village). This village was purposively selected from the 30 villages in the surveillance zone for several reasons: It is one of the original eight villages with surveillance data dating back to 1963. It is a relatively large community, with established institutions (a health post, schools, a commercial area, and a town center), but it does not have the size or geographic dispersion of the two major towns in the NDHSS zone. It is also ethnically homogenous but religiously diverse (with a significant community of Catholics in addition to the majority Muslim population). Most importantly, it has three characteristics that constrain sociability and interpersonal interaction to other individuals within its boundaries to a greater degree than in other villages in the zone, a critical criterion for adequate identification of sociocentric network structure (Laumann, Marsden, and Prensky 1983). First, residences in the village are concentrated in a small set of neighborhoods around the center of the village, and these neighborhoods are relatively isolated geographically from population centers of the surrounding neighboring villages. Second, while in many villages in the surveillance area, land used for agriculture is located at some distance from users’ households, in the sociocentric village, agricultural land is in relatively close proximity to households, limiting residents’ exposure to those from other villages while in the fields. Finally, unlike larger villages in the zone, it is located on only one local road, removed from the highway connecting major regional population centers. These characteristics in combination strengthen the assumption of a realist boundary specification with regard to social association within the village. A detailed description of the NSNHP methodology is presented in Delaunay et al. (2019).

We restrict the present analysis to the sociocentric village for the reasons above and because these data make it possible to measure respondents’ ego network density as well as key characteristics of their network alters (including their health ideation, ideas about contraception acceptability, and ideal family sizes) provided by the alters themselves in

the survey instrument, avoiding likely bias associated with respondent reports of these characteristics (Behrman, Kohler, and Watkins 2002; Sandberg 2018; White and Watkins 2000).

3.3.1 Dependent variables

As discussed above, respondents (and their network alters, if also residing in the village and represented in the survey) were asked a question concerning the ideal number of children they would recommend a newly married couple should have. We model here both numeric response as a binary indicator and a continuous measure of numeric ideal family size for those giving numeric responses. Approval of contraceptive use is measured through a question concerning whether respondents believed married women using contraception were “respectable” (*niwéle* in Sereer), an idiomatic expression connotating moral acceptability.

3.3.2 Independent variables

We operationalize exposure to migrants in two ways. We first consider the proportion of prior or current migrants to Dakar in respondents’ personal networks, composed of all uniquely cited individuals across all name generators. Because temporary labor migration tends to be of short duration and exposure to urban values and norms concerning fertility likely increases with the amount of time migrants spend in urban areas, we also consider a measure of the average number of years network alters have lived in the capital, a conventional operationalization of adaptation in the urban migration literature (Boujija et al. 2022). Both measures are derived from NDHSS migration histories. As discussed above, since returned migrants may not be the only source of exposure to urban ideals and beliefs within social networks, in all models we also consider exposure to residents of the capital who have never lived in the village. A minority of respondents in Yandé cited such urban residents (slightly more than one-third), and the distribution is highly right-skewed. Ninety percent of respondents cited fewer than three, with a mean of approximately 0.5 for non-migrants and 0.7 for prior migrants in previous research on a nearly identical sample (Boujija et al. 2022). For this reason, we operationalize this with a simple binary variable indicating the presence of one or more such people in their personal networks.

To test potential mediation of any association between migrant exposure and the dependent variables through the experiences and/or beliefs of migrants, we utilize five measures. The first is a measure of the number of children ever born to migrant alters

relative to others of the same age and sex in the village. Migrant alters in the analytic sample used here⁹ are slightly younger, on average about age 33 versus age 41 for non-migrant alters. Though the average male and female proportions of migrant alters are virtually the same, there is substantial variability between respondents. To address potential bias caused by differences in fertility between migrant and non-migrant alters associated with differential age and sex distributions, our measure is constructed as the residual of an OLS regression of children ever born from the NDHSS on the interaction of a quadratic specification of age and sex for the population of the village as a whole, which yielded an R^2 value of 0.44.

We hypothesize that any mediating effect of this variable will be due to exposure to (potentially smaller) family sizes among migrant alters rather than direct diffusion of ideals concerning family size and contraceptive acceptability. We expect that the fewer children on average among migrant alters, the higher the likelihood of numeric response and approval of contraception and the lower the ideal family size.

The second and third measures are the average relative agricultural and material wealth of migrant alters in respondents' networks. Agricultural and material wealth measures are derived from an exploratory factor analysis using 12 variables from a census of household wealth conducted simultaneously with the first panel of the NSNHP, unit-standardized relative to other households in Yandé (Delaunay et al. 2019; Sandberg et al. 2019). For the entire village, these variables have means of zero and standard deviations of one, distributional characteristics that differ slightly here due to analytic sample restrictions across the different analyses. It is expected that greater material wealth among migrant alters (potentially stemming from the migration experience) will be associated with a higher likelihood of numeric response and contraceptive approval through comparison or evaluation mechanisms (cf. Liebenstein 1975). We have no strong expectations concerning agricultural wealth. It may be that greater agricultural wealth will be associated with lower numeric response, lower contraceptive approval, and higher ideal family sizes, as agricultural production in the zone still mostly depends on family labor, but whether this type of effect would be associated with migrant alters is unknown.

The next mediation candidate is migrant alters' average probability of adherence to traditional health ideation. This variable, derived from a measurement model of health schemas using NSNHP survey data, captures the probability that each alter ascribes to ethnomedical health beliefs and behaviors rather than Western, biomedical ones (Sandberg et al. 2019). We hypothesize that any mediating influence of this measure on associations related to migrant exposure will suggest the influence of general diffusion of migrants' less traditional ideas related to health and reproductive behavior.

Finally, we include a measure of the average response to the dependent variable among migrant alters in each analysis. These endogeneity measures capture potential

⁹ That for the analysis of numeric response, detailed below.

direct diffusion of ideals. In the case of numeric response, we use a measure of the proportion of migrant alters giving numeric responses. For contraceptive acceptability, the measure is the proportion indicating they believe use by married women is morally acceptable. For the analysis of numeric ideal family size, we use a measure of average numeric ideal family size among migrant alters.

In the second set of analyses, we test for hypothesized moderating effects of any association between exposure to migrants and urban residents and the dependent variables associated with network density. For this, we include a measure of ego network density omitting ego.

3.3.3 Controls

A number of individual and network characteristics may introduce endogeneity in the association between exposure to migrants and our outcomes through homophilous network selection. Individuals tend to associate more with those who are similar to them than those who are not and are constrained in their choice of alters by the characteristics of the pool of individuals available to them. Social networks have been shown to be strongly homophilous with regard to age, religion, education, occupation, and gender (McPherson, Smith-Lovin, and Cook 2001). If these or other characteristics through which network composition is selected are uncontrolled and simultaneously influence both exposure to migrants and the outcome measures, estimates of social effects will be biased. Methods used to address this include conditioning and propensity score matching on observable individual and network characteristics as well as fixed and random intercept models (Aral, Muchnik, and Sundararajan 2009; Goldsmith-Pinkham and Imbens 2013; Lin 2010; Shalizi and Thomas 2011).

In this analysis we employ both conditioning and fixed effects strategies. Control variables include, on the individual level, categorical operationalizations of sex (reference female), educational attainment (primary, secondary, or higher; reference no education), religion (Catholic, traditional/other; reference Muslim), and continuous operationalizations of respondents' age, number of children ever born, household agricultural and material wealth, attachment to traditional health ideation, own cumulative duration as a migrant to Dakar, and average duration of migration to Dakar among people living in the same residential compound as the respondent (to control for household-level economic strategies, as discussed above). Both of the latter variables are measured in years. Finally, to control broader structural influences on diffusion of information, we specify the total number of alters in respondents' social networks in all equations.

3.4 Modeling and estimation

For all analyses presented we use a nested modeling strategy. In the initial set of analyses, we estimate simple zero-order (or bivariate) associations with our outcome measures and both exposure variables (migrant alters and urban residents) first and then again in the presence of the controls. All models are estimated using STATA 18.5. We next estimate models testing for mediation of any identified associations with migrant alter exposure working through these alters' characteristics. To address the possibility that men and women may respond differently to migrant or urban resident exposure, all models are estimated with an interaction between these measures and sex. In analysis of the hypothesized moderating effect of network density, we estimate a separate set of models with only the individual controls, the average duration of migration to the capital in respondents' networks, and the four-way interaction between migrant alter exposure, sex, network density, and prevalence of the dependent variable within individuals' networks. To account for spatial variability in unobserved factors that may be associated with both fertility ideation and interpersonal migrant exposure at the neighborhood level (such as aggregate levels of education, intrafamilial patterns of resource allocation, and historical patterns of migration), all models are estimated with fixed effects at the neighborhood level (for nine neighborhoods within the village). This specification allows us to estimate independent associations of direct interpersonal exposure to migrants as well as respondents' own migration experience and that of other members of their residential compounds net of such characteristics.

The models for numeric response to the questions concerning ideal family size and contraceptive acceptability employ conditional logit estimators; those for numeric ideal family size use OLS. Estimates from the logit models are presented as average marginal and discrete changes in probability. While comparison of estimated coefficients across models with nonlinear estimators is not appropriate, this is not the case with average marginal effects (Mize, Doan, and Long 2019).

Because these data are a census of adults in the village, all estimates are population parameters and references to statistical inference should be approached carefully, if at all. For the sake of convention, we have provided 95% confidence intervals for our tabular estimates in the body text and indicators of statistical significance in the appendix tables, the latter being both two-tailed and one-tailed (where directional hypotheses were made). The confidence intervals and p-values referenced in these tables should best be considered as additional indications of the strength of associations estimated and the amount of variance in the estimates rather than indicating the probability of differences in some broader population.

4. Results

Table A-2 presents descriptive statistics for the dependent, independent, and control variables for each set of models in the present analysis. In our analytic sample, approximately 48% of both men and women gave numeric responses to the ideal family size question. Among those who did, numeric ideal family size was, as noted above, estimated to be 6.15 children for men and 5.91 children for women. Among women, 58% said they believed contraceptive use by married women to be morally acceptable, compared to only 48% of men. On average, 50% and 56% of men's and women's networks, respectively, were individuals with at least some migration experience in the capital, with an average of 2.18 years of migration among network alters for men and 2.73 years for women. Twenty-seven percent of males were estimated to have at least one non-migrant resident of Dakar in their networks; 38% of females. Migrant alters on average had one-third of a child less than they would have if they had the same age- and sex-specific fertility as the population of the village as a whole. They resided in households that had 0.14 standard deviations more agricultural wealth and 0.40 standard deviations more material wealth than the village average. Fifty-eight percent of migrant alters approved of contraception use among married women, 53% provided numeric responses on ideal family size, and those who did expressed an ideal family size of 5.63 children, on average, with substantial variability. The average age of respondents was approximately 37 years, and slightly more than half (54%) were female. On average, respondents had achieved fertility of approximately three children and were close to the village average in terms of both material and agricultural wealth. The majority (66%) had no formal education, with a further 18% having at most primary education. The majority of respondents (86%) were Muslim, approximately 11% were Catholic, and 2.5% were adherents of the traditional monotheism. Between one-quarter and one-third of respondents were classified as adhering to traditional health ideation. Individuals themselves spent on average between 1.6 and two years in migration to Dakar, and their household migration to the capital averaged approximately two years, again with substantial variability.

Table 1 presents estimates of means and standard deviations for the hypothesized mediating factors for migrant and non-migrant alters in respondents' networks using the analytic sample for the numeric response analysis. Missing data for each comparison is a result of respondents having no alters in one of these categories.

As expected, compared to non-migrant alters, migrant alters have on average smaller family sizes and are less likely to adhere to traditional health schemas. They are also more likely to give numeric answers concerning ideal family size, to have smaller ideal family sizes when they do, and to find contraception morally acceptable for married women.

Table 1: Means (standard deviations) of migrant alter and non-migrant alter characteristics, with mean within-respondent differences and 95% confidence intervals, Yandé

Characteristic	Migrant alters mean (SD)	Non-migrant alters mean (SD)	Difference (95% CI)	N
Residual children ever born	−0.289 (0.986)	0.302 (1.365)	−0.590 (−0.685, −0.496)	1071
Traditional ideation	0.267 (0.194)	0.339 (0.218)	−0.072 (−0.087, −0.057)	1063
Agricultural wealth	0.141 (0.420)	0.132 (0.453)	0.009 (−0.015, 0.033)	1071
Material wealth	0.410 (0.587)	0.423 (0.622)	−0.013 (−0.046, 0.019)	1071
Numeric response to ideal family size	0.525 (0.267)	0.414 (0.258)	0.111 (0.090, 0.131)	1061
Numeric ideal family size	5.725 (1.362)	6.317 (1.623)	−0.591 (−0.726, −0.456)	864
Contraceptive acceptability	0.592 (0.258)	0.502 (0.282)	0.090 (0.069, 0.111)	1052

Notes: Each row reports the mean (with standard deviation in parentheses) of an alter-level characteristic averaged across each respondent's migrant alters and non-migrant alters separately, restricted to respondents who have at least one alter in each category. The difference column reports the mean within-respondent difference (migrant alters minus non-migrant alters), with 95% confidence intervals from a paired t-test in parentheses.

Source: Compiled by the authors from NSNHP Panel I, 2014.

4.1 Multivariable analysis

As discussed above, to test the hypotheses outlined here, we estimated nested models of each dependent variable on each of the migrant exposure measures, the proportion of migrant alters, and years of migrant alter migration experience in respondents' networks alone, with the controls, with each mediation candidate separately, and with the mediation candidates jointly, with results presented in Tables A-3 through A-8. Table 2 presents a concise summary of key estimates from these models, meant to simplify interpretation of the association between migrant alter exposure and the dependent variables and any effects of the mediation candidates. Panel A presents estimates drawn from the models of numeric response to the question concerning ideal family size, contraceptive acceptability, and numeric family size in which the migrant exposure variable is the proportion of migrant alters within respondents' networks (Tables A-3, A-5, and A-7). Panel B presents analogous models using the average number of years in Dakar among migrant alters as the exposure variable (Tables A-4, A-6, and A-8).

Table 2: Estimated marginal effects of network exposure to migrants and Dakar residents on numeric response to ideal family size, contraceptive acceptability for married women, and numeric ideal family size among numeric respondents

	Numeric response (N = 1075)			Contraceptive acceptability (N = 1014)			Numeric ideal family size (N = 521)		
	Zero	Ctrl	Med	Zero	Ctrl	Med	Zero	Ctrl	Med
Panel A: Proportion of migrant alters in network									
Proportion migrant alters (women)	0.300 (0.07, 0.53)	-0.044 (-0.28, 0.19)	-0.051 (-0.27, 0.17)	0.023 (-0.21, 0.26)	-0.055 (-0.28, 0.17)	-0.042 (-0.22, 0.15)	-4.100 (-6.09, -2.12)	-2.880 (-5.03, -0.74)	-2.820 (-4.99, -0.66)
Proportion migrant alters (men)	0.405 (0.30, 0.51)	0.299 (0.12, 0.48)	0.256 (0.08, 0.43)	0.263 (0.04, 0.49)	0.239 (0.02, 0.45)	0.218 (0.04, 0.41)	-1.620 (-3.52, 0.28)	-0.990 (-2.95, 0.97)	-1.050 (-3.08, 0.98)
Any Dakar residents (women)	0.073 (-0.01, 0.16)	0.018 (-0.05, 0.09)	0.017 (-0.05, 0.08)	-0.013 (-0.10, 0.07)	-0.029 (-0.09, 0.04)	-0.022 (-0.08, 0.03)	-0.420 (-0.99, 0.16)	-0.220 (-0.79, 0.35)	-0.230 (-0.80, 0.34)
Any Dakar residents (men)	0.095 (0.00, 0.19)	0.002 (-0.08, 0.08)	0.004 (-0.07, 0.08)	0.092 (-0.01, 0.19)	0.044 (-0.04, 0.13)	0.044 (-0.03, 0.12)	-0.890 (-1.54, -0.24)	-0.510 (-1.17, 0.15)	-0.520 (-1.18, 0.14)
Migrant alter children ever born	-0.004 (-0.03, 0.02)	—	-0.008 (-0.03, 0.02)	0.025 (0.01, 0.06)	—	0.004 (-0.02, 0.03)	0.184 (-0.02, 0.39)	—	0.190 (-0.04, 0.42)
Migrant alter agricultural wealth	0.018 (-0.08, 0.12)	—	0.057 (-0.03, 0.14)	0.078 (-0.02, 0.18)	—	0.065 (-0.02, 0.15)	0.248 (-0.40, 0.89)	—	-0.365 (-1.14, 0.41)
Migrant alter material wealth	0.068 (0.01, 0.13)	—	0.023 (-0.04, 0.09)	0.057 (-0.01, 0.12)	—	-0.000 (-0.06, 0.06)	-0.435 (-0.86, -0.01)	—	-0.503 (-1.08, 0.07)
Migrant alter traditional ideation	-0.260 (-0.42, -0.10)	—	-0.079 (-0.22, 0.06)	-0.132 (-0.31, 0.04)	—	-0.047 (-0.18, 0.09)	0.940 (0.28, 2.15)	—	0.004 (-1.28, 1.29)
Migrant alter endogeneity	0.226 (0.13, 0.32)	—	0.072 (-0.02, 0.16)	0.167 (0.06, 0.28)	—	0.082 (0.00, 0.17)	0.180 (-0.01, 0.36)	—	0.086 (-0.11, 0.28)
Panel B: Average migration years among network alters									
Average network migration years (women)	0.049 (0.01, 0.08)	0.006 (-0.03, 0.04)	0.003 (-0.03, 0.04)	0.023 (-0.01, 0.06)	0.014 (-0.02, 0.05)	0.014 (-0.02, 0.04)	-0.490 (-0.72, -0.25)	-0.360 (-0.61, -0.11)	-0.324 (-0.58, -0.06)
Average network migration years (men)	0.028 (-0.01, 0.06)	0.018 (-0.02, 0.05)	0.016 (-0.02, 0.05)	0.038 (0.01, 0.07)	0.031 (0.00, 0.07)	0.033 (0.00, 0.07)	-0.160 (-0.39, 0.06)	-0.090 (-0.32, 0.14)	-0.061 (-0.30, 0.18)
Any Dakar residents (women)	0.073 (-0.01, 0.16)	0.023 (-0.06, 0.10)	0.022 (-0.05, 0.10)	-0.013 (-0.10, 0.07)	-0.034 (-0.11, 0.04)	-0.028 (-0.10, 0.04)	-0.420 (-0.99, 0.16)	-0.210 (-0.77, 0.36)	-0.250 (-0.83, 0.33)
Any Dakar residents (men)	0.095 (0.00, 0.19)	0.014 (-0.08, 0.11)	0.014 (-0.08, 0.10)	0.092 (-0.01, 0.19)	0.056 (-0.04, 0.15)	0.059 (-0.03, 0.15)	-0.890 (-1.54, -0.24)	-0.530 (-1.19, 0.12)	-0.561 (-1.22, 0.10)
Migrant alter children ever born	-0.004 (-0.03, 0.02)	—	-0.007 (-0.04, 0.02)	0.025 (-0.01, 0.06)	—	0.011 (-0.02, 0.04)	0.184 (-0.02, 0.39)	—	0.130 (-0.10, 0.36)
Migrant alter agricultural wealth	0.018 (-0.08, 0.12)	—	0.070 (-0.03, 0.17)	0.078 (-0.02, 0.18)	—	0.085 (-0.01, 0.18)	0.248 (-0.40, 0.89)	—	-0.398 (-1.18, 0.38)
Migrant alter material wealth	0.068 (0.01, 0.13)	—	0.026 (-0.05, 0.10)	0.057 (-0.01, 0.12)	—	-0.000 (-0.07, 0.07)	-0.435 (-0.86, -0.01)	—	-0.486 (-1.06, 0.09)
Migrant alter traditional ideation	-0.260 (-0.42, -0.10)	—	-0.097 (-0.26, 0.07)	-0.132 (-0.31, 0.04)	—	-0.054 (-0.21, 0.10)	0.940 (0.28, 2.15)	—	-0.048 (-1.34, 1.25)
Migrant alter endogeneity	0.226 (0.13, 0.32)	—	0.096 (-0.01, 0.20)	0.167 (0.06, 0.28)	—	0.091 (-0.00, 0.19)	0.180 (-0.01, 0.36)	—	0.082 (-0.11, 0.28)

Notes: Numeric response and contraceptive acceptability columns report average marginal effects on probability from conditional fixed effects logistic regression. Numeric ideal family size columns report OLS coefficients from linear fixed effects regression. The bivariate model for agricultural and material wealth jointly specifies both variables. Zero = zero-order (bivariate) marginal effect or coefficient. Ctrl = estimate from a model, including individual-level controls plus migrant exposure and Dakar residents indicator. Med = estimate from the same model plus all migrant alter mediators.

Source: Compiled by the authors from NSNHP Panel I, 2014.

Each panel consists of estimates from three select models. For each dependent variable, the first column (zero) presents the zero-order marginal change associated with the independent variable and the presence of urban residents by sex, and the mediation candidates.¹⁰ The second column (ctrl) presents estimates from a specification, including both the migrant alter and urban resident variables by sex simultaneously with the controls (M2 in the appendix tables). The third column (med) adds the measures of average residual number of children born to migrant alters, average standardized migrant alter agricultural and material wealth, average probability of migrant alters' traditional ideation, and the endogeneity variable to the specification from the controls model (M7 in the appendix tables).

4.1.1 Numeric response concerning ideal family size

The first three columns present estimates of the probability of numeric response to the ideal family size question. In the zero-order estimates in Panel A, we see strong associations between numeric response and both the proportion of migrant alters and the presence of urban residents for men and women. Among the mediation candidates, we see, as expected, negative associations between the average residual number of children born to migrant alters and migrant alters' traditional health ideation, positive associations with migrant alters' material wealth, and the proportion of migrant alters giving numeric responses.

In the presence of the controls, the association with the proportion of migrant alters is completely explained for women (and in fact becomes slightly negative) but remains strong for men. The male–female difference in these marginal effects is 0.343 (95% CI [0.060, 0.626]). Here, a man with one-quarter of his network composed of migrant alters has a predicted probability of numeric response of 0.63; with three-quarters of the network being migrant alters, the probability is 0.78. Overall, one standard deviation increase in the proportion of migrant network alters from the median for men is associated with an estimated 4.7 percentage point increase in the probability of giving a numeric response.¹¹ For perspective, this is almost as large as the marginal difference associated with primary relative to no education in the same model, 6 percentage points, as seen in Model 2 in Table A-3. The association with the urban resident indicator is completely explained by the controls for men. For women, only a slight association remains. Having

¹⁰The exception here is that the wealth variables are specified jointly in the same model.

¹¹This estimate is calculated based on a median of 0.5 and a standard deviation of 0.16 for the proportion of network alters. Though there are slight differences in the actual estimates of these between men and women and by analytic sample, these approximate distributional characteristics are used throughout to ease interpretation.

at least one urban resident in a woman's network was associated with a 1.8 percentage point greater predicted probability of giving a numeric response.

In the third column, with all mediation candidates specified simultaneously along with the controls, the associations between numeric response and the proportion of migrants in men's networks remain strong. Jointly, the mediation candidates explain about 14% of the association between the proportion of migrant network alters and numeric response for men seen in the controls model. Specified individually, the strongest mediation effect was associated with the endogeneity variable (the proportion of migrant alters giving numeric responses: Model 6 in Table A-3), which reduced the association seen for men in the controls model by 13%.

Panel B presents estimates from these same models using average years of alter migration to measure migrant exposure. As in the analysis of proportion of migrant alters, average migrant alter migration duration is positively associated with the likelihood of numeric response for both men and women in the zero-order analysis. These associations are partially explained in the presence of the controls for men and are almost completely explained for women. For men, each additional year of average network migration duration is associated with a 1.8 percentage point higher probability of numeric response. Extrapolating this, men whose networks had an average migration experience (approximately two years) are estimated to be almost 4 percentage points more likely to give numeric responses than those whose networks had none. Jointly, the mediation candidates explain about 13% of the association seen in the controls model for men, essentially all of it due to the endogeneity variable, which when specified by itself explains 13% of the male effect.

4.1.2 Contraceptive acceptability

The next three columns present estimates of the probability that respondents agree that contraceptive use is morally acceptable for married women. In the zero-order models in Panel A, we see relatively small associations between the proportion of migrant alters and the presence of urban residents in respondents' networks for women, with large positive associations for men.

Specified with the controls, the marginal effect of the proportion of migrant network alters for women becomes slightly negative but remains positive for men. The male–female difference in marginal effects is 0.294 (95% CI [0.008, 0.579]). For men, going from a network with 25% migrant alters to one with 75% migrant alters is associated with a shift from a predicted probability of approving of contraception for married women from 0.58 to 0.69. More generally, a one standard deviation difference in the proportion of migrant network alters from the median is associated with a 3.7 percentage point

difference in the estimated probability of contraceptive acceptability. Having at least one urban resident in their network was associated with a 4.4 percentage point higher probability of contraceptive approval for men and a 2.9 percentage point *lower* probability for women.

Jointly, the mediation candidates explain approximately 9% of the marginal effect of proportion of migrant alters for men seen in the controls model, but the association remains substantively important. Specified individually, the endogeneity variable (Model 6, Table A-5) explains 11 percentage points of this association.

The situation is similar when looking at network migration duration in Panel B. Here there are moderate zero-order associations between this measure and contraceptive acceptability for both men and women that are only slightly diminished in the controls model. In that model, each year of network migration duration is associated with an increase in the probability of approving of contraception of 1.4 percentage points for women and 3.1 percentage points for men. The mediation candidates specified simultaneously leave the male marginal effect essentially unchanged. The endogeneity variable when specified by itself explains more than one-quarter of the (small) marginal effect in the controls model for women and 14% for men.

4.1.3 Numeric ideal family size

The last set of models in Table 2 presents summary results from the OLS models of numeric ideal family size for respondents giving a numeric response to the question. Because 26 respondents who gave numeric responses (5% of the total) had no migrant alters who also did so, in specifications including the network endogeneity measure, we have included an indicator variable to account for this, with zero indicating at least one migrant network alter giving a numeric response and one indicating those without such alters. Although this type of dummy variable adjustment for missing data may produce biased estimates for other variables specified in most instances, in special cases such as this, where valid values are structurally impossible, it does not (Allison 2001).

In the zero-order models, as expected, we see strong negative associations between ideal family size and both the proportion of migrant alters and urban residents in respondents' networks for men and women. These estimates suggest a differential impact of type of urban exposure by gender, with the proportion of migrant alters in networks being more strongly associated with ideal family size for women, the presence of urban residents for men.

These associations, though diminished in magnitude, remain substantively important in the presence of the controls. A one standard deviation increase in the proportion of migrant alters is associated with approximately one-half fewer ideal

children for women and one-eighth fewer ideal children for men. The predicted difference between a woman with one-quarter of her network being migrants and a woman whose network is three-quarters migrants is approximately 1.5 ideal children fewer (6.9 versus 5.4). Having at least one urban resident in their network is associated with one-quarter of an ideal child fewer for women and one-half of an ideal child fewer for men. For perspective, in the same model (Model 2, Table A-7), the marginal effect of approximately one standard deviation more in material wealth relative to others in the village is estimated to be associated with one-eighth fewer ideal children; having a secondary education relative to having none is associated with just over one-half of an ideal child fewer.

In the full mediation model, independent migrant and urban resident associations remain strong. For women, the mediators specified together explain only a small part (approximately 2%) of the marginal effect estimated in presence of only the controls. As seen in Table A-7, this is largely due, again, to the endogeneity variable, or the average ideal family size among migrant network alters.

In models with average network migration duration as an independent variable, presented in Panel B, we see similar results. In the controls model, each year of migration on average among network alters is associated with approximately one-third of an ideal child fewer for women and one-tenth of an ideal child fewer for men. As in the analysis of proportion of migrant alters, in combination the mediation candidates explain a small part of the association seen in the controls for women (approximately 10%) and a somewhat larger share for men (approximately one-third), though the male effect remains small in absolute terms. As shown in Table A-8, there are decreases in the marginal effect relative to the controls model associated with the number of migrant alters children ever born, and with the endogeneity variable (the average numeric ideal family size among migrant alters), for both men and women.

4.2 Network density and migrant exposure

As discussed above, less dense networks may provide sources of novel information or ideas facilitating social learning, while denser social networks may constrain the spread of new ideas through social influence. If social learning is the principal social effect observed, we would expect to see numeric response, contraceptive acceptability, and ideal family sizes change in the expected directions with increased migrant exposure regardless of density. In contrast, if social influence were predominant, we would expect that those in denser networks would have lower probabilities of numeric response, lower levels of contraceptive acceptability, and larger ideal family sizes at lower levels of

migrant exposure. We would also expect that these response gradients would be larger in denser networks as migrant exposure increases.

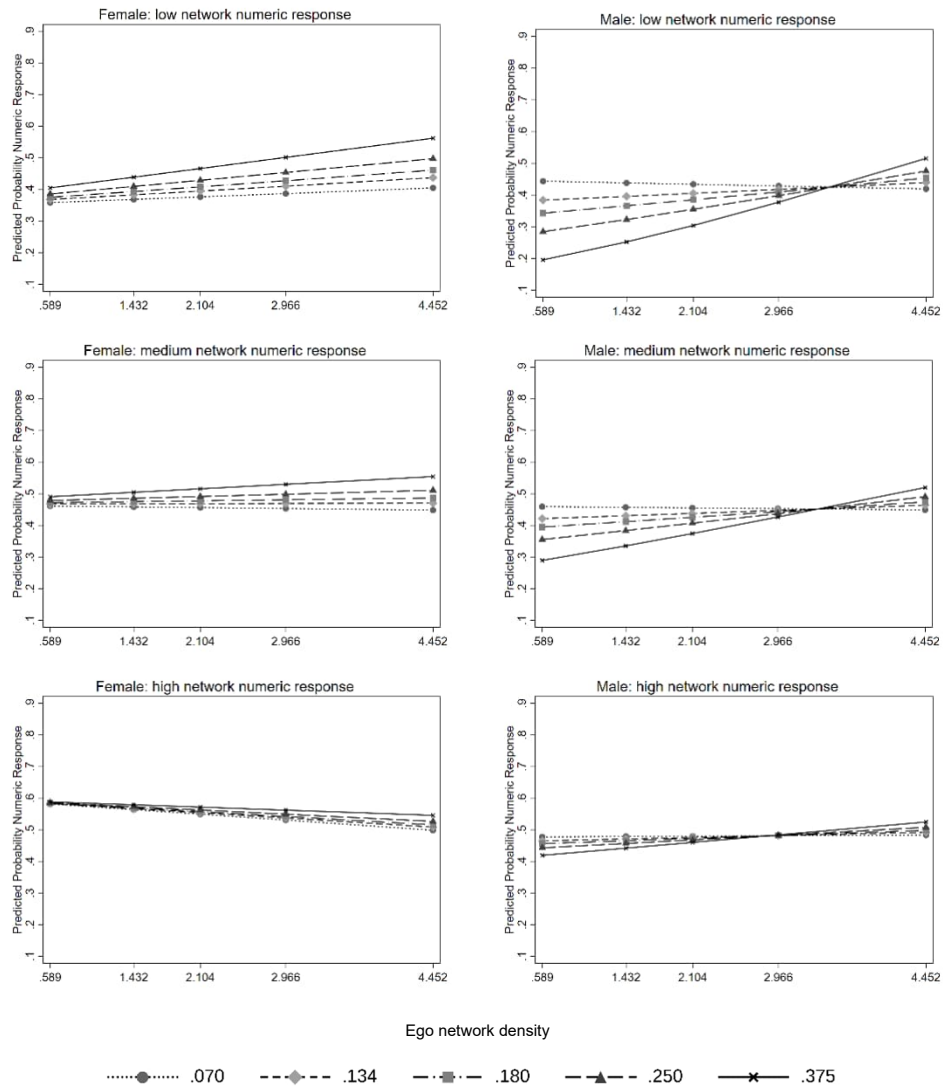
It should be noted, however, that any such interaction should also depend on the prevalence of the belief or ideal in each respondent's network. For example, we might expect migrant exposure to make a bigger difference in denser networks where the prevalence of a particular characteristic is low (for example, low levels of numeric response or contraceptive acceptability) but less of a difference where the prevalence is higher.

To address this, for each of our dependent variables we model the interaction between migrant exposure, network density, sex, and prevalence of the dependent variable in respondents' networks. For migrant exposure, we use only average network migration duration for the sake of brevity and interpretability. In the following analysis, we present marginal effects for men and women at the 5th, 25th, 50th, 75th, and 95th percentiles of the distributions of both average network migration years and network density. For the former, we allow these percentiles to be estimated separately for each variable. For network density, however, we fix these at average levels in the population, as they do not vary substantively between men or women. Estimates of these models (available from the authors on request) are presented graphically at the 10th (low-prevalence), 50th (medium-prevalence), and 90th (high-prevalence) percentiles of the distribution of network prevalence for each dependent variable.

4.2.1 Numeric response

Figure 1 presents the marginal change in probability from the density interaction model for numeric response. In the main effects models discussed above, the association between numeric response and average network migration years for women was completely explained by the controls. In the left panel of this figure, however, we see that though this is true at both medium (47%) and high (73%) levels of numeric response in women's networks (with a mildly negative association at the highest levels of prevalence), at lower levels of prevalence (with 24% of the network giving numeric responses), all densities increase, suggesting a partial learning effect, with denser networks increasing more quickly in response to migrant exposure than less dense networks, supportive of a strong social influence effect. For women, the difference-in-difference estimate between the 5th and 95th percentiles of density across the distribution of migrant exposure at the lowest levels of prevalence is 10 percentage points.

Figure 1: Numeric response to question on ideal family size on individual controls and interaction between sex, average network migration years, ego network density, and network numeric response prevalence, Yandé, Senegal, 2014



For men, this influence effect is more pronounced. At the lowest levels of prevalence, the densest networks have the smallest predicted probability of numeric response at the lowest levels of migrant exposure and the highest probability at the highest, with a difference-in-difference estimate between these across the distribution of average network migration duration of 32 percentage points. The same pattern, though somewhat muted, is seen at medium levels of numeric response within networks for men, with a difference-in-difference estimate of 23 percentage points. At the highest levels of network prevalence of numeric response, this virtually disappears.

4.2.2 Contraceptive acceptability

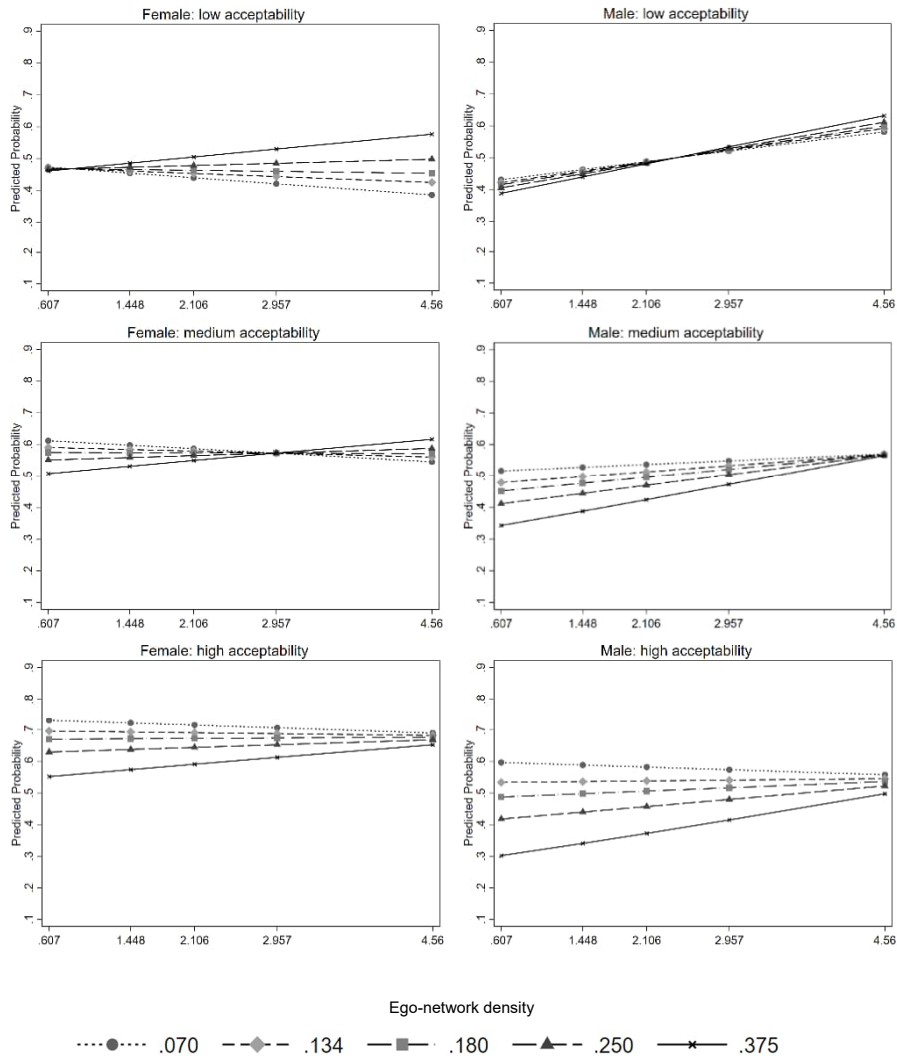
Much the same pattern is seen in the models for contraceptive acceptability in Figure 2. Across all levels of prevalence for both males and females, those in denser networks are estimated to have lower probabilities of judging contraceptive use acceptable at low levels of migrant exposure, but their estimated probabilities increase faster with migrant exposure than those in less dense networks.

For males at low levels of contraceptive acceptability in their networks (30%), migrant exposure appears to have a positive effect at all densities, larger in denser networks, suggesting both learning and influence mechanisms, with a difference-in-difference estimate of 9 percentage points across the distribution of exposure between the densest and least dense networks. The analogous difference-in-difference estimate for females is 20 percentage points; for women, estimated probabilities in less dense networks decrease slightly with exposure while those in the densest networks increase, consistent with social influence rather than social learning. Though the differences by density continue to be large, at medium (55%) and high (79%) levels of network acceptability, any learning effect appears to wane, as one would expect.

4.2.3 Numeric ideal family size

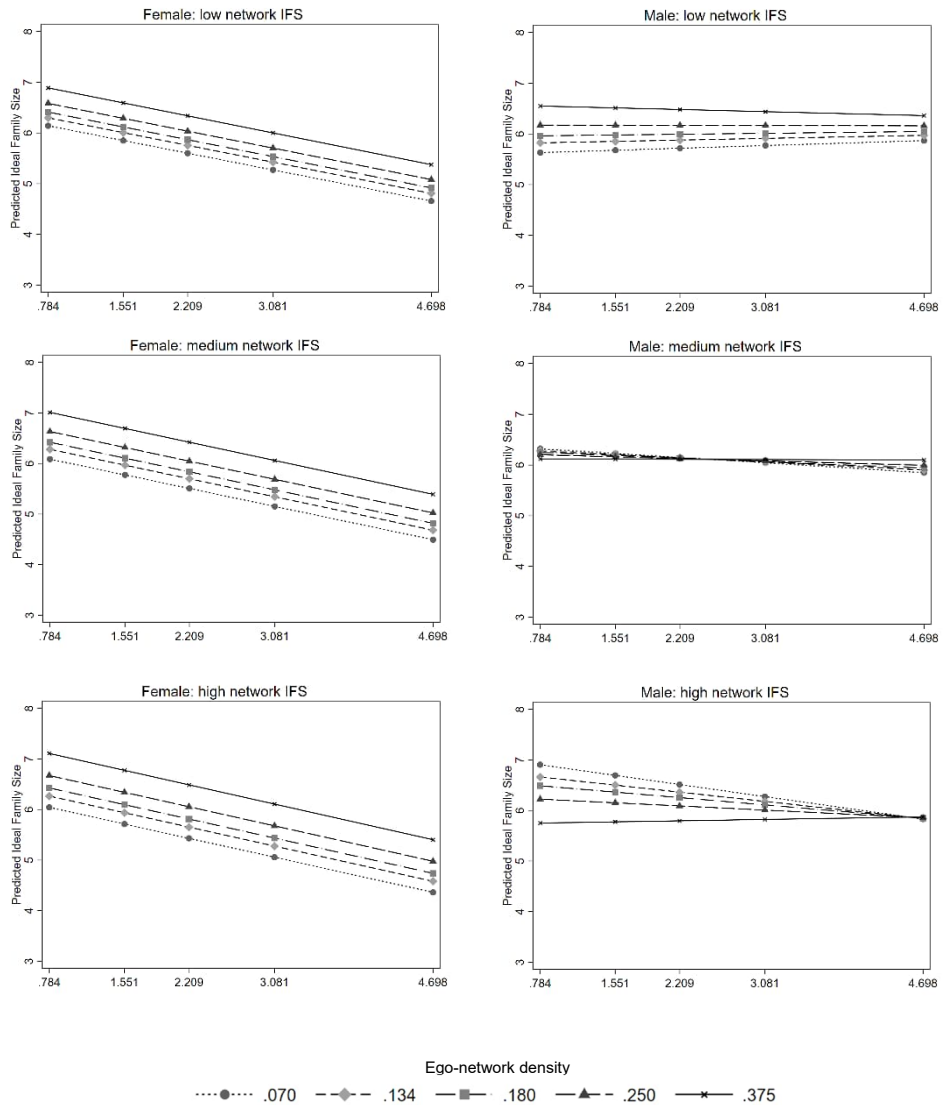
For numeric ideal family size there appears to be no interaction between network density and average alter years of migration for women, as shown in Figure 3. The strong main effect of alter average migration years remains at low (4.5) through medium (5.73) and high (7.2) levels of network ideal family size, supportive of a strong learning effect.

Figure 2: Contraceptive acceptability on individual controls and interaction between sex, average network migration years, ego network density, and network acceptability prevalence, Yandé, Senegal, 2014



Source: Compiled by the authors from the main panel of NSNHP.

Figure 3: Numeric ideal family size on individual controls and interaction between sex, average network migration years, ego network density, and average ideal family size, Yandé, Senegal, 2014



For males, there appears to be no evidence for either learning or influence effects associated with migrant alter exposure at low or medium levels of network ideal family size. At the highest network ideal family sizes, we estimate a negative association in the least dense networks, suggesting a social learning effect, decreasing in magnitude with increasing network density, as suggested in the learning-versus-influence framework forwarded by Kohler, Behrman, and Watkins (2001).

5. Summary and discussion

The hypothesis that fertility ideation and behavior diffuse from urban to rural areas through interpersonal channels has found support through evidence at the aggregate level in both historical and contemporary fertility transitions. Except for a few limited examples, individual-level mechanisms by which this may take place have previously resisted identification. This paper has presented evidence using detailed social network data supporting such mechanisms related to numeric (versus nonnumeric) response concerning ideal family size, the moral acceptability of contraceptive use, and numeric ideal family size. As discussed in the introduction, the first of these is potentially indicative of fertility limitation as a culturally and cognitively available option or of decreasing uncertainty about the future, particularly concerning adult or child survival. The second has been seen as a major factor limiting contraceptive uptake in sub-Saharan Africa, and the third is strongly related, though not deterministically, to levels of achieved fertility in the region.

Our main results concern exposure to urban migrants and urban residents in respondents' networks. In the first part of the analysis, we saw that the probability of numeric response and contraceptive acceptability were strongly associated with both measures of migrant alter exposure in men's social networks but not in women's. We also saw that migrant alter exposure is associated with lower ideal family sizes for both men and women, though most strongly for women.

Our hypotheses concerning potential mediating mechanisms through which migrant exposure could influence these outcomes yielded mixed but largely negative results. In general, the vast majority of identified migrant exposure effects on our outcomes remained unexplained. For men, however, a small but not insubstantial part of identified exposure effects could be explained by the mediation candidates when specified jointly. These effects were strongest in the analyses of numeric response and contraceptive acceptability. The strongest effects were associated with the endogeneity variables – the average prevalence of each outcome among migrant alters. This could in part be due to measurement error or unobserved homophilous effects, but at least in the latter case we believe our conditioning strategy minimized that possible explanation. If this potential

mediation is not artifactual, we believe our results provide some tentative support for the idea that one of the mechanisms by which migrant alters influence those in their network is directly through their own ideation.

A further contribution of this paper is to assess the association between our outcomes and exposure to non-migrant urban residents. The influence of this type of individual in rural residents' social networks has conventionally been ignored in analyses of the urban–rural diffusion of fertility. In contexts across the world like the one studied here, communication and transport technology has made such individuals potentially important sources of information concerning urban ideals, norms, and behavior. Controlling for migrant exposure, we saw only a small effect associated with having Dakar residents in their network for women in the analysis of numeric response and saw a large effect for men in the analysis of contraceptive acceptability. In the analysis of numeric family size, we saw a small effect for women but a large effect for men.

In the density interaction models, we saw the likely reason for the disparity in migrant exposure between men and women in the analyses of numeric response and contraceptive acceptability. This appears to be attributable in part to the fact that for both men and women, response to migrant exposure for these variables is to some degree conditional on how prevalent these beliefs are in their network, as well as on the density of the network.

Response to migrant exposure in both cases was strongest in the densest networks and stronger when the prevalence of numeric response and contraceptive acceptability in networks was lower – that is, where numeric response and contraceptive acceptability are less frequent in respondents' social circles. At lower levels of prevalence and in the densest networks, the effects estimated for migrant exposure for both variables were very large for men and women. For women, this effect diminishes somewhat in medium-prevalence networks, while it remains strong in these networks for men. Though there appears to be a slight social learning effect among both men and women, with low proportions of their networks believing contraception to be an acceptable practice for married women, overall, the analysis of numeric response and contraceptive acceptability strongly supports the predominance of social influence effects, where denser networks serve to reinforce conformity to some aggregate of views held within networks.

At least for women, the predominant migrant exposure effect associated with numeric ideal family size appears to occur through social learning. The main effects for women were undeniably strong across different levels of average network ideal family size (although still greatly above replacement). Those for men, in contrast, were substantially smaller and were primarily restricted to networks with higher average numeric ideal family sizes and likely urban residents – though this is not addressed in this analysis – as seen in the main effects analysis.

The results presented here have revealed a few substantive differences between men and women in their response to both migrant alters and urban residents in their networks. We can only speculate broadly concerning potential explanations for these differences. Regarding ideal family size, women may be more receptive to new information from migrants concerning the desirability of smaller families, as childbirth is solely, and child care predominantly, their responsibility. One might also speculate that the weaker influence effects regarding numeric response and contraceptive acceptability seen among women in the density interaction models may be associated with gendered differentials in the normative acceptability of iconoclastic or novel viewpoints, potentially indicating greater tolerance among women for divergent views concerning reproduction (Rutenberg and Watkins 1997; Watkins and Danzi 1995). More simply, these and other gendered differences may partially be explained by differences in the structures of men's and women's networks not addressed here (for example, gender composition), either alone or in interaction with other factors. Investigating whether and to what degree these explanations or others may be empirically supportable, however, is beyond the scope of this paper.

In general, while the social influence effects seen in the density interaction models are prominent for both sexes, they appear to be stronger for men.

A number of limitations should be kept in mind when interpreting the results of the analyses presented here. Though the data identify much larger and more extensive networks than were known previously, it is certain that these networks are censored subsets of still much larger networks and tend to be reflective of stronger, more affectively close, or more instrumentally valuable ties (Marin 2004). It is likely that these networks are biased against weaker ties, long thought to be an important source of novel information and social capital (Burt 1995; Granovetter 1973).

It is also possible that our estimates are biased through residual confounding or reverse causation due to homophily. In the former case, the structure of respondents' migrant exposure and fertility ideation would be caused by some third factor. In the latter, fertility ideation would cause migrant exposure, with individuals seeking out others with similar beliefs, who would *ceteris paribus* tend to more likely be migrants. We believe the potential for both is mitigated by our conditioning strategy. Any such bias would have to be independent of the individual-, network-, and compound-level factors we control for here as well as the neighborhood fixed effects. In a prior paper using the same data and a nearly identical set of controls, we showed that individuals who had not migrated at the time of the survey but would in the next four years (future migrants) were estimated to have identical or only minimal differences in terms of ideal family size and contraceptive acceptability relative to non-migrants (Boujija, Bignami, and Sandberg 2024). This suggests that these ideational measures might not be strongly associated with the propensity to migrate, and because migration in this population itself is driven by

social effects (Boujija et al. 2022), differential selection of future migrants into networks might not be either.

Our operationalizations of migrant exposure also present some limitations. While duration in the destination is a common method for operationalizing adaptation of migrants to urban environments, migrants' experiences and levels of integration are likely to vary considerably regardless of the duration of their stay (Cassarino 2004). This will introduce unknown, likely random errors into this measure. Further, neither measure of migrant exposure makes a distinction between current migrants, recently returned migrants, and migrants who returned to the village further in the past. While it has been shown that both categories of returned migrants in this population maintain fertility ideation closer to that of current migrants than to that of non-migrant residents (Boujija et al. 2024), it would be worthwhile to consider their potentially differential relative influence. That work, however, is beyond the scope of this paper.

Lastly, these results pertain to one small rural Senegalese village with a long history of temporary and circular urban migration and cannot be generalized statistically to any larger population. While the same research conducted in different areas with different migration characteristics and cultural contexts would undoubtedly yield different estimates, we would argue that the fundamental mechanisms behind the social effects found here are likely operative in some way in other rural African populations.

Despite these limitations, we believe this analysis has potentially important implications for family planning efforts in the region. As discussed in the introduction, the high demand for children and concerns about the side effects or moral acceptability of contraception are likely major elements behind continued high fertility and stalled fertility transitions in sub-Saharan Africa. It has long been known that interpersonal communication may in some cases be more effective in disseminating family planning information and motivating behavior change than (or act as a multiplier for) public health programming disseminated through other channels (Rutenberg and Watkins 1997; Watkins and Danzi 1995).

While recent research has shown that it may be possible to motivate this type of communication through network interventions (Kim et al. 2022), such efforts – particularly where they involve changing the structure of networks – will be expensive, labor-intensive, and difficult to scale. Given the results in this paper, an alternative programmatic approach might attempt to increase discussion of family planning through existing network connections of strong ties between rural residents and urban migrants (or non-migrant residents) already holding, on average, beliefs and ideals conducive to lower fertility and increased contraceptive use. Modifying existing programmatic efforts in urban areas to encourage discussion of the advantages, safety, and acceptability of family planning and contraception with rural relatives and friends, for example, would be relatively easy to accomplish and inexpensive. Additionally, since large urban areas

attract migrants from multiple regions within a country and often from other countries as well, any effects of such efforts would potentially extend further than those associated with isolated intervention efforts. While funders and advocates of family planning programming have rightfully focused on programmatic efforts in rural areas, where fertility is higher, an additional effort to leverage network ties may yield substantial added value at minimal cost.

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Appendix

Table A-1: Differences in estimated marginal probability of using and intending to use a modern contraceptive method, numeric responses to ideal family size, and numeric ideal family sizes between urban and rural residents and between residents of Dakar and the Fatick regions, Senegal DHS, 2014

	Urban (N = 3406)	Rural (N = 5082)	Urban – Rural (95% CI)
Currently using modern contraception	.183 (.161, .204)	.107 (.091, .123)	+.076 (+.049, +.103)
Intend to use modern contraception	.380 (.353, .407)	.274 (.247, .300)	+.106 (+.068, +.144)
Numeric response to ideal family size	.882 (.856, .909)	.811 (.784, .839)	+.071 (+.033, +.110)
Numeric ideal family size	4.73 (4.61, 4.86)	5.88 (5.70, 6.05)	-1.14 (-1.36, -0.93)
	Dakar (n = 593)	Fatick (n = 570)	Dakar – Fatick (95% CI)
Currently using modern contraception	.207 (.167, .247)	.122 (.086, .158)	+.085 (+.031, +.139)
Intend to use modern contraception	.405 (.356, .453)	.333 (.266, .400)	+.072 (-.012, +.155)
Numeric response to ideal family size	.895 (.864, .925)	.900 (.860, .939)	-.005 (-.055, +.045)
Numeric ideal family size	4.54 (4.38, 4.70)	5.50 (5.14, 5.85)	-0.96 (-1.35, -0.57)

Notes: Estimates adjusted for complex survey design. Confidence intervals (in parentheses) are delta method 95% intervals. The third column reports the difference between the two groups (first column minus second) with its delta method 95% confidence intervals.

Source: Compiled by the authors.

Table A-2: Descriptive statistics for all analyses, Yandé, Senegal

	Numeric response N = 1075		Numeric ideal family size N = 521		Contraceptive acceptability N = 1014	
	Mean/prop (N = 495)	Standard deviation	Mean/prop (N = 240)	Standard deviation	Mean/prop (N = 473)	Standard deviation
<i>Males</i>						
Dependent variable	0.483	0.500	6.154	2.652	0.482	0.500
Network average migration years	2.183	1.310	2.302	1.375	2.198	1.337
Network proportion migrants	0.501	0.161	0.533	0.164	0.500	0.164
Network proportion Dakar residents	0.265	0.442	0.317	0.466	0.271	0.445
Ego network density	0.196	0.113	0.196	0.120	0.197	0.108
<i>Females</i>	(N=580)		(N=281)		(N=541)	
Dependent variable	0.484	0.500	5.911	2.227	0.584	0.493
Network average migration years	2.374	1.202	2.536	1.190	2.381	1.208
Network proportion migrants	0.562	0.154	0.582	0.146	0.565	0.155
Network proportion Dakar residents	0.380	0.486	0.420	0.494	0.390	0.488
Ego network density	0.206	0.109	0.213	0.121	0.203	0.107
<i>Mediation candidates</i>						
Network average residual children ever born	2.793	1.436	2.566	1.393	2.750	1.429
Network average agricultural wealth	0.142	0.420	0.113	0.437	0.141	0.413
Network average material wealth	0.408	0.587	0.448	0.627	0.413	0.577
Network traditional health ideation	0.266	0.193	0.240	0.186	0.263	0.192
Network endogeneity	0.527	0.268	5.629	1.217	0.584	0.259
<i>Controls</i>						
Age	36.790	16.604	32.261	14.387	36.004	16.016
Female (0 = male)	0.540	0.499	0.539	0.499	0.534	0.499
Children ever born	3.059	3.408	2.464	3.168	3.054	3.438
Education (0 = none)						
Primary	0.178	0.382	0.190	0.393	0.189	0.392
Secondary	0.161	0.368	0.217	0.413	0.162	0.368
High school+	0.098	0.297	0.157	0.365	0.104	0.305
Household agricultural wealth	0.039	0.957	-0.044	0.997	0.058	0.920
Household material wealth	-0.001	0.978	0.071	1.040	-0.005	0.960
Religion (0 = Muslim)						
Catholic/other	0.113	0.317	0.125	0.331	0.112	0.316
Traditional	0.025	0.157	0.027	0.162	0.026	0.158
Traditional health ideation	0.311	0.368	0.270	0.345	0.307	0.365
Years migration to Dakar	1.627	2.936	1.927	3.189	1.668	2.973
Household average years migration to Dakar	1.942	1.287	2.055	1.166	1.918	1.241
Number of alters	24.055	8.399	24.624	8.961	24.254	8.340

Notes: Compiled by the authors from the main panel of NSNHP.

Table A-3: Conditional logit models of numeric response concerning ideal family size on proportion of migrants and presence of urban residents in network by sex, network residual children ever born, traditional health ideation, wealth, proportion finding contraceptive use acceptable, and controls; discrete and marginal change in probability; Yandé, Senegal

	Zero	M1	M2	M3	M4	M5	M6	M7
Proportion migrant alters (women)	0.300**		-0.044‡	-0.047‡	-0.041‡	-0.050‡	-0.046‡	-0.051‡
Proportion migrant alters (men)	0.405***		0.299***	0.297**	0.289***	0.304***	0.260***	0.256***
Any Dakar residents (ref = no: women)	0.073		0.018	0.018	0.019	0.019	0.018	0.017
Any Dakar residents (ref = no: men)	0.095		0.002	0.002	0.002	0.002	0.000	0.003
Sex (0 = male)		0.051*						
Migrant alter residual children ever born	-0.004			-0.007				-0.008
Migrant alter agricultural wealth	0.018				0.054			0.057
Migrant alter material wealth	0.068*				0.029			0.023
Migrant alter traditional health ideation	-0.260***					-0.108‡		-0.079
Migrant alter numeric response	0.226***						0.079*	0.072‡
Respondent's age		-0.005***	-0.005***	-0.005***	-0.004***	-0.005***	-0.004***	-0.004***
Children ever born		0.001	0.002	0.002	0.002	0.002	0.002	0.002
Education (ref = none)								
Primary		0.074*	0.060*	0.058‡	0.059*	0.060‡	0.053‡	0.051‡
Secondary		0.170***	0.141***	0.140***	0.135***	0.144***	0.120***	0.117***
High school+		0.296***	0.217***	0.215***	0.204***	0.225***	0.191***	0.187***
Household agricultural wealth		-0.004	-0.003	-0.002	-0.012	-0.003	-0.001	-0.011
Household material wealth		0.022	0.022	0.021	0.012	0.021	0.020	0.012
Religion (ref = Muslim)								
Catholic/other		0.023	0.014	0.014	0.01	0.014	0.012	0.009
Traditional		0.096	0.08	0.08	0.072	0.082	0.079	0.074
Traditional health ideation		-0.001	0.007	0.007	0.006	0.017	0.008	0.014
Years migration to Dakar		0.012**	0.009*	0.009*	0.008*	0.009*	0.008*	0.008*
Household average years migration		0.022*	0.016‡	0.016‡	0.016‡	0.018*	0.014‡	0.015‡
Number of alters		0.003**	0.003**	0.003*	0.003*	0.003**	0.003**	0.003**
ll		-636.55	-633.13	-632.95	-632.26	-632.07	-631.71	-629.86
Wald		132.39	139.23	139.89	140.97	141.33	142.07	145.97
aic		1301.091	1302.25	1303.595	1304.517	1302.148	1301.411	1305.514
bic		1370.81	1391.89	1398.22	1404.12	1396.77	1396.03	1420.06

Notes: N = 1,075; p < ‡ 0.1 (one-tailed), *0.1, **0.05, ***0.01; ‡ significant difference between males and females at p < 0.05.

Source: Compiled by the authors from the main panel of NSNHP.

Table A-4: Conditional logit models of numeric response concerning ideal family size on average network years of migration and presence of urban residents in network by sex, network residual children ever born, traditional health ideation, wealth, proportion finding contraceptive use acceptable, and controls; discrete and marginal change in probability; Yandé, Senegal

	Zero	M1	M2	M3	M4	M5	M6	M7
Average network migration years (women)	0.049***		0.006	0.004	0.008	0.004	0.004	0.003
Average network migration years (men)	0.028†		0.018	0.017	0.020	0.018	0.016	0.016
Any Dakar residents (ref = no: women)	0.073*†		0.023	0.023	0.022	0.023	0.023	0.023
Any Dakar residents (ref = no: men)	0.095*		0.014	0.014	0.016	0.014	0.011	0.014
Sex (0 = male)		0.051*						
Migrant alter residual children ever born	-0.004			-0.006				-0.007
Migrant alter agricultural wealth	0.018				0.070			0.070
Migrant alter material wealth	0.068*				0.035			0.026
Migrant alter traditional health ideation	-0.260***					-0.124†		-0.097
Migrant alter numeric response	0.226***						0.104*	0.096*
Respondent's age		-0.005***	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***	-0.005***
Children ever born		0.001	0.001	0.001	0.001	0.001	0.002	0.002
Education (ref = none)								
Primary		0.074*	0.071*	0.069†	0.071*	0.068†	0.065†	0.063†
Secondary		0.170***	0.164***	0.164***	0.161***	0.162***	0.143***	0.140***
High school+		0.296***	0.281***	0.280***	0.270***	0.283***	0.252***	0.247***
Household agricultural wealth		-0.004	-0.003	-0.002	-0.016	-0.003	-0.002	-0.014
Household material wealth		0.022	0.022	0.022	0.011	0.021	0.021	0.012
Religion (ref = Muslim)								
Catholic/other		0.023	0.021	0.021	0.016	0.02	0.019	0.015
Traditional		0.096	0.092	0.093	0.084	0.091	0.096	0.090
Traditional health ideation		-0.001	0.003	0.004	0.003	0.015	0.005	0.014
Years migration to Dakar		0.012**	0.011**	0.011**	0.010**	0.010**	0.010**	0.010**
Household average years migration		0.022*	0.019†	0.020*	0.019†	0.021*	0.017†	0.019*
Number of alters		0.003**	0.003*	0.003*	0.003*	0.003*	0.003**	0.003*
ll		-636.55	-635.81	-635.72	-634.86	-634.73	-634.14	-632.33
Wald		132.39	133.87	134.34	135.77	136.01	137.21	141.03
aic		1301.091	1307.612	1309.146	1309.713	1307.469	1306.275	1310.451
bic		1370.81	1397.25	1403.77	1409.31	1402.09	1400.9	1424.99

Notes: N = 1,075; p <: † 0.1 (one-tailed), *0.1, **0.05, ***0.01; ‡ significant difference between males and females at p < 0.05.
Source: Compiled by the authors from the main panel of NSNHP.

Table A-5: Conditional logit models of moral acceptability of contraceptive use for married women on proportion of migrants and presence of urban residents in network by sex, network residual children ever born, traditional health ideation, wealth, proportion finding contraceptive use acceptable, and controls; discrete and marginal change in probability; Yandé, Senegal

	Zero	M1	M2	M3	M4	M5	M6	M7
Proportion migrant alters (women)	0.023‡		-0.055‡	-0.052‡	-0.051‡	-0.059‡	-0.044‡	-0.042*‡
Proportion migrant alters (men)	0.263**		0.239**	0.242**	0.238**	0.244**	0.212**	0.218**
Any Dakar residents (ref = no: women)	-0.013‡		-0.029‡	-0.028‡	-0.025‡	-0.031‡	-0.024‡	-0.022‡
Any Dakar residents (ref = no: men)	0.092*		0.044	0.043	0.045	0.045	0.043	0.044
Sex (0 = male)		0.091***						
Migrant alter residual children ever born	0.025‡			0.008				0.004
Migrant alter agricultural wealth	0.078‡				0.075*			0.065
Migrant alter material wealth	0.057*				0.003			-0.000
Migrant alter traditional health ideation	-0.132					-0.076		-0.047
Migrant alter contraceptive acceptability	0.167***						0.088**	0.082*
Respondent's age		-0.002‡	-0.002‡	-0.002‡	-0.001‡	-0.002‡	-0.002‡	-0.001
Children ever born		0.021***	0.018***	0.018***	0.017***	0.019***	0.016***	0.015***
Education (ref = none)								
Primary		0.016	0.01	0.013	0.015	0.009	0.008	0.012
Secondary		0.071‡	0.061*	0.062*	0.061*	0.060‡	0.052‡	0.053*
High school+		0.085‡	0.065‡	0.067‡	0.068*	0.062‡	0.053‡	0.057‡
Household agricultural wealth		0.002	0.003	0.002	-0.012	0.003	0.004	-0.01
Household material wealth		0.032*	0.028*	0.029*	0.028+	0.029*	0.025*	0.026+
Religion (ref = Muslim)								
Catholic/other		0.049	0.031	0.031	0.028	0.032	0.029	0.026
Traditional		0.152*	0.123**	0.122**	0.114**	0.125**	0.100*	0.095*
Traditional health ideation		-0.083*	-0.064‡	-0.065‡	-0.062‡	-0.060‡	-0.056‡	-0.052‡
Years migration to Dakar		0.008	0.005	0.005	0.005	0.005	0.004	0.004
Household average years migration to Dakar		0.01	0.006	0.006	0.006	0.007	0.005	0.005
Number of alters		0.001	0.001	0.001	0.001	0.001	0.001	0.001
ll		-631.95	-628.91	-628.73	-627.43	-628.4	-626.92	-625.06
Wald		43.74	49.82	51.39	52.77	50.84	53.80	58.62
aic		1291.893	1293.817	1294.25	1294.866	1294.801	1291.836	1295.02
bic		1360.8	1382.41	1387.76	1393.3	1388.31	1385.35	1408.22

Notes: N = 1,014; p < ‡ 0.1 (one-tailed), *0.1, ** 0.05, ***0.01; ‡ significant difference between males and females at p < 0.05.

Source: Compiled by the authors from the main panel of NSNHP.

Table A-6: Conditional logit models of moral acceptability of contraceptive use for married women on average network years of migration and presence of urban residents in network by sex, network residual children ever born, traditional health ideation, wealth, proportion finding contraceptive use acceptable, and controls; discrete and marginal change in probability; Yandé, Senegal

	Zero	M1	M2	M3	M4	M5	M6	M7
Average network migration years (women)	0.023†		0.014	0.017	0.016	0.013	0.010	0.014
Average network migration years (men)	0.038**		0.031†	0.035**	0.034**	0.031*	0.027†	0.033**
Any Dakar residents (ref = no: women)	-0.013		-0.034	-0.032	-0.030	-0.036	-0.030	-0.028
Any Dakar residents (ref = no: men)	0.092*		0.056	0.058	0.059	0.057	0.057	0.059
Sex (0 = male)		.091***						
Migrant alter residual children ever born	0.025†			0.016				0.011
Migrant alter agricultural wealth	0.078				0.098*			0.085*
Migrant alter material wealth	0.057				0.003			-0.000
Migrant alter traditional health ideation	-0.132†					-0.08		-0.054
Migrant alter contraceptive acceptability	0.167***						0.098**	0.091*
Respondent's age		-0.002†	-0.002†	-0.002†	-0.002†	-0.002*	-0.002†	-0.001
Children ever born		0.021***	0.020***	0.019***	0.019***	0.020***	0.018***	0.017***
Education (ref = none)								
Primary		0.016	0.009	0.013	0.014	0.007	0.008	0.014
Secondary		0.071†	0.060†	0.061†	0.060†	0.058†	0.054†	0.054†
High school+		0.085†	0.064	0.067†	0.069†	0.061	0.055	0.061†
Household agricultural wealth		0.002	0.004	0.002	-0.016	0.004	0.005	-0.013
Household material wealth		0.032*	0.030*	0.030*	0.030†	0.030*	0.027*	0.029†
Religion (ref = Muslim)								
Catholic/other		0.049	0.039	0.037	0.035	0.038	0.037	0.033
Traditional		0.152*	0.139*	0.137*	0.130*	0.140*	0.118*	0.112*
Traditional health ideation		-0.083*	-0.074*	-0.075*	-0.072*	-0.069†	-0.068†	-0.064†
Years migration to Dakar		0.008†	0.005	0.004	0.004	0.005	0.004	0.003
Household average years migration to Dakar		0.010	0.003	0.002	0.002	0.004	0.003	0.002
Number of alters		0.001	0.001	0.001	0.001	0.001	0.001	0.001
ll		-631.95	-629.15	-628.59	-627.29	-628.7	-627.41	-625.00
Wald		43.74	49.34	52.33	53.05	50.23	52.81	59.40
aic		1291.893	1294.296	1293.304	1294.584	1295.406	1292.827	1294.238
bic		1360.8	1382.89	1386.82	1393.02	1388.92	1386.34	1407.44

Notes: N = 1,014; p < † 0.1 (one-tailed), *0.1, ** 0.05, ***0.01; † significant difference between males and females at p < 0.05.
Source: Compiled by the authors from the main panel of NSNHP.

Table A-7: OLS models of numeric ideal family size on proportion of migrants and presence of urban residents in network by sex, network residual children ever born, traditional health ideation, wealth, proportion finding contraceptive use acceptable, and controls; Yandé, Senegal

	Zero	M1	M2	M3	M4	M5	M6	M7
Proportion migrant alters (women)	-4.103***†		-2.884***	-2.941***	-2.875***	-2.844***	-2.798**	-2.824**
Proportion migrant alters (men)	-1.621*		-0.987	-0.936	-1.133	-0.987	-1.000	-1.048
Any Dakar residents (ref = no: women)	-0.418†		-0.223	-0.210	-0.231	-0.221	-0.272	-0.231
Any Dakar residents (ref = no: men)	-0.889***		-0.508†	-0.502†	-0.524†	-0.514†	-0.506†	-0.524†
Sex (0 = male)		-0.438**						
Migrant alter residual children ever born	0.184*			0.175†				0.190†
Migrant alter agricultural wealth	0.248				-0.179			-0.365
Migrant alter material wealth	-0.435*				-0.484*			-0.503*
Migrant alter traditional health ideation	0.937†					0.297		0.004
Migrant alter ideal family size	0.177*						0.113	0.086
Valid network numeric ideal family size (0 = yes)	0.709						0.155	0.238
Respondent's age	0.017*	0.01	0.006	0.009	0.007	0.006	0.006	0.011
Children ever born	0.045†	-0.036	-0.044	-0.055	-0.048	-0.045	-0.045	-0.060
Education (ref = none)								
Primary	-0.130	-0.172	-0.158	-0.111	-0.152	-0.149	-0.181	-0.128
Secondary	-0.657*	-0.622*	-0.565*	-0.547*	-0.600*	-0.561*	-0.580*	-0.593*
High school+	-1.290***	-1.243***	-1.090***	-1.027***	-1.050***	-1.074***	-1.082***	-0.993***
Household agricultural wealth	0.184++	0.085	0.109	0.083	0.132	0.107	0.088	0.124
Household material wealth	-0.232*	-0.124	-0.124	-0.114	0.045	-0.12	-0.114	0.067
Religion (ref = Muslim)								
Catholic/other		0.444	0.463†	0.465†	0.519†	0.470†	0.449	0.513†
Traditional		0.898†	0.726	0.71	0.802	0.725	0.719	0.797
Traditional health ideation	1.315***	0.965***	0.806**	0.791**	0.790**	0.790**	0.780**	0.760**
Years migration to Dakar	-0.063†	-0.059*	-0.032	-0.030	-0.034	-0.032	-0.031	-0.031
Household average years migration to Dakar	-0.060	-0.003	0.029	0.024	0.025	0.026	0.035	0.026
Number of alters		-0.017+	-0.013	-0.011	-0.01	-0.013	-0.012	-0.008
Constant	5.668	6.605***	7.195***	7.196***	7.428***	7.148***	6.556***	6.947***
R2	0.01	0.09	0.11	0.11	0.11	0.11	0.11	0.12
RMSE	2.39	2.31	2.3	2.3	2.3	2.3	2.3	2.3
F	3.28	3.53	3.35	3.31	3.16	3.18	3.09	2.80

Notes: N = 521; p <: † 0.1 (one-tailed), *0.1, **0.05, ***0.01; ‡ significant difference between males and females at p < 0.05.

Source: Compiled by the authors from the main panel of NSNHP.

Table A-8: OLS models of numeric ideal family size on average network years of migration and presence of urban residents in network by sex, network residual children ever born, traditional health ideation, wealth, proportion finding contraceptive use acceptable, and controls; Yandé, Senegal

	Zero	M1	M2	M3	M4	M5	M6	M7
Average network migration years (women)	-0.485***‡		-0.360***‡	-0.336***‡	-0.362***	-0.355***	-0.346***	-0.324**
Average network migration years (men)	-0.163‡		-0.086	-0.062	-0.091	-0.083	-0.082	-0.061
Any Dakar residents (ref = no: women)	-0.418‡		-0.205	-0.198	-0.214	-0.203	-0.252	-0.249
Any Dakar residents (ref = no: men)	-0.889***		-0.534‡	-0.530‡	-0.558*	-0.538	-0.535	-0.561
Sex (0 = male)		-0.438**						
Migrant alter residual children ever born	0.184*			0.107				0.130
Migrant alter agricultural wealth	0.248				-0.272			-0.398
Migrant alter material wealth	-0.435**				-0.473‡			-0.486*
Migrant alter traditional health ideation	0.937‡					0.188		-0.048
Migrant alter ideal family size	0.177*						0.099	0.082
Valid network numeric ideal family size (0 = yes)	0.709						0.285	0.365
Respondent's age		0.01	0.009	0.011	0.01	0.009	0.009	0.012
Children ever born		-0.036	-0.045	-0.051	-0.048	-0.045	-0.045	-0.055
Education (ref = none)								
Primary		-0.172	-0.102	-0.080	-0.102	-0.098	-0.122	-0.097
Secondary		-0.622*	-0.540*	-0.536*	-0.574*	-0.538*	-0.548*	-0.575*
High school+		-1.243***	-1.080***	-1.057***	-1.054***	-1.072***	-1.071***	-1.027***
Household agricultural wealth		0.085	0.085	0.070	0.126	0.084	0.067	0.118
Household material wealth		-0.124	-0.091	-0.085	0.074	-0.088	-0.083	0.089
Religion (ref = Muslim)								
Catholic/other		0.444	0.463‡	0.459‡	0.517‡	0.466‡	0.449‡	0.505‡
Traditional		0.898‡	0.916‡	0.903‡	0.999‡	0.914‡	0.902‡	0.979‡
Traditional health ideation		0.965***	0.834**	0.833**	0.826**	0.824**	0.810**	0.808**
Years migration to Dakar		-0.059*	-0.031	-0.032	-0.033	-0.031	-0.03	-0.033
Household average years migration to Dakar		-0.003	0.045	0.034	0.041	0.042	0.051	0.037
Number of alters		-0.017+	-0.012	-0.012	-0.01	-0.013	-0.012	-0.008
Constant		6.605	6.713	6.699	6.896	6.681	6.122	6.407
R2		0.09	0.11	0.11	0.11	0.11	0.11	0.12
RMSE		2.31	2.3	2.3	2.29	2.3	2.3	2.3
F		3.53	3.39	3.25	3.19	3.21	3.11	2.75

Notes: N = 521; p < † 0.1 (one-tailed), *0.1, **0.05, ***0.01; ‡ significant difference between males and females at p < 0.05.

Source: Compiled by the authors from the main panel of NSNHP.

Table A-9: Name generators used to elicit network alters in English translation from Sereer (language of interview)

Affective ties

Q1: Could you give me the name of the people that are closest to you (in your heart). This could be anyone, including your parents, friends, fellow students, colleagues at work, or neighbors.

Q2: Would you please tell me the name of the people that are close to you and that do not live in your area. For example, this could be people living in Dakar, Koumpentoum, St. Louis, or abroad, or even those that stayed in their birthplace, as long as they are in a place away from here.

Q3: I'd like you to tell me the name of the people that are close to you in terms of kin or those you consider as kin.

Q4: I'd like you to tell me the names of the people that are close to you and that are of the same age or in the same generation as you are.

Instrumental ties

Q5: Would you please give me the name of people that you ask for help when you are in a "tight situation" – when you are struggling.

Q6: Now I would like you to tell me the names of the people that help you do work around the house.

Q7: I would like you to tell me the names of the people that gave you help when you or a relative was ill. This could be any kind of help, for example, by giving advice on what to do, giving financial aid, help with household duties, help with transport money, help with treatment, help with ethnomedical protection – all kinds of help.

Q8: I would like you to tell me the names of the people you helped when they or the people close to them were ill. This could include all kinds of help, for example, advice given on what to do, financial help, help with household duties, help in terms of transport money, help with treatment, help in terms of ethnomedical protection – all kinds of help.

Ties based on frequency of interaction

Q9: I'd like you to tell me about the people you meet up with regularly during your free time.

Q10: Please tell me the names of the people with whom you speak on the telephone.

Q11: Please tell me the names of the people with whom you talk or chat most frequently.

Q12: Please tell me the names of the people you know when you go to the market.

Q13: Please tell me the names of the people you meet most often when you go fetching water at the well or the communal water tap.

Role relational ties

Q14: Please tell me the names of the people whose way of living appeals most to you.

Q15: Please tell me the names of the people with whom you talk most frequently in traditional or religious groups or meetings.

Residual ties

Q16: To conclude, please tell me if you forgot to mention anyone among the people you just mentioned to me.

Source: NSNHP Panel I survey instrument.

