Evolution and Human Behavior 34 (2013) 130–138

Contents lists available at SciVerse ScienceDirect

Evolution and Human Behavior

journal homepage: www.ehbonline.org

Original Article

# Kin influences on fertility in Thailand: Effects and mechanisms ☆

Kristin Snopkowski *, Rebecca Sear

*Department of Population Health, London School of Hygiene and Tropical Medicine*

ARTICLE INFO

*Article history:*
Initial receipt 20 July 2012
Final revision received 13 November 2012

*Keywords:*
Postnuptial residence
Kin
Cooperative breeding
Thailand
Fertility

ABSTRACT

It has been suggested that human mothers are cooperative breeders, as they need help from others to successfully raise offspring. Studies working under this framework have found correlations between the presence of kin and both child survival and female fertility rates. This study seeks to understand the proximate mechanisms by which kin influence fertility using data from the 1987 Thailand Demographic and Health Survey (DHS), a nationally representative sample of 6775 women. Kin influence is measured by the length of time couples live with the husband's or wife's parents after marriage. Event history analysis, multilevel modeling and structural equation modeling are used to investigate both fertility outcomes and potential pathways through which postnuptial residence may influence fertility outcomes, including employment status, maternal and child outcomes, contraceptive use, breastfeeding duration, and age at marriage. We show that living virilocally (with husband's kin after marriage) increases total fertility by shortening time from marriage to first birth, and increasing the likelihood of progression to each subsequent birth. These effects are mediated through correlations between virilocal residence and earlier age at marriage as well as delayed initiation of contraceptive use. We find no influence of husband's kin on maternal or child outcomes. Living uxorilocally (with wife's kin after marriage) also reduces age at marriage, shortens time from marriage to first birth and (marginally) improves child survivorship, but has no effect on other child and maternal outcomes or progression to subsequent births and results in a similar number of living children as women living neolocally.


## 1. Introduction

Human reproduction is unique compared to our closest living relatives because of short birth intervals and an extended period of offspring dependence, which lead to multiple dependent offspring of differing ages (Galdikas & Wood, 1990; Kramer, 2005). While non-human primates typically do not begin another bout of reproduction until the previous offspring is an independent food producer, human females supplement the needs of many offspring. To support many dependent offspring, humans may breed cooperatively, allowing females to receive help from other individuals (Hrdy, 1999). Evidence suggests that helpers include partners (Kaplan et al., 2000), unrelated adult males (Hill & Hurtado, 2009), parents (Sear et al., 2003; Tymicki, 2004), older children (Kramer, 2005) and other kin (reviewed by Sear & Mace, 2008). This evidence largely takes the form of correlations between the presence of potential helpers and either child survival rates or fertility rates (Sear & Coall, 2011). However, such analyses frequently do not attempt to determine *how* helpers influence these components of reproductive success (with some exceptions, see e.g. Gibson & Mace, 2005). Here we use a rich source of data, a Demographic and Health Survey, to investigate not just whether there is an association between the presence of potential helpers and female fertility, but also the pathways through which such an association might be brought about.

Kin may influence female fertility, including age at first birth, total number of children born, and length of birth intervals, but it is likely that different relatives have distinct effects on fertility, which may vary further under different ecological conditions. While the cooperative breeding hypothesis and inclusive fitness considerations suggest that kin will broadly support one another's reproductive success (Hamilton, 1966; Hrdy, 2005), under conditions of resource stress, local resource competition may become important, resulting in the presence of kin reducing reproductive success (Sear, 2008; Strassmann, 2011). Further, even if the reproductive goals of women and their kin are in harmony, there is the opportunity for sexual conflict between partners which may result in a woman's fertility reflecting her partner's optimum fertility rather than her own (Leonetti et al., 2007; Sear et al., 2003). Some research has shown that men may want more children than their wives do (Ratcliffe et al., 2000; Bankole & Singh, 1996) since the potential costs of reproduction are greater for women. Kin may try to support the reproductive desires of the individual they are genetically related to: for example, the husband's kin may encourage the reproductive desires of the husband (which would promote higher fertility) while the wife's kin may try to encourage the wife's desired fertility. A review of kin effects on fertility shows that correlations between the availability of kin and

☆ This research was funded by the European Research Council.
* Corresponding author. LSHTM Keppel Street London WC1E 7HT.
*E-mail address:* Kristin.Snopkowski@lshtm.ac.uk (K. Snopkowski).

1090-5138/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.evolhumbehav.2012.11.004

fertility can vary substantially between populations, though broadly the presence of husband's kin is more likely to be correlated with increased fertility than that of the woman's own kin (Sear & Coall, 2011). Both theory and empirical observation therefore reinforce the need for research on the mechanisms through which kin influence fertility, in order to understand exactly why such kin influences exist. Below we describe the hypotheses for pathways of kin influence which we are able to test on our data.

### *1.1. Hypothesis 1: Kin reduce the costs of reproduction*

This is the assumption behind the 'humans are cooperative breeders' hypothesis: that alloparents are critically important for parents to obtain the necessary resources and care required for their growing brood of children. We test the hypothesis that kin reduce the costs of reproduction in two ways: 1) kin affect a woman's time allocation and 2) kin influence maternal and child outcomes.

In both traditional and modern societies, the presence of helpful kin may allow mothers with young children to optimize their time allocation. In many societies today, childcare is incompatible with work, so when kin members provide childcare, women may be able to achieve higher fertility (Bereczkei, 1998; Thompson, 1965). Alternatively, having additional resources may allow a woman to forgo employment and focus on providing childcare for her offspring. Even in traditional societies, there will be some trade-off between food-producing work, domestic work and childcare. Helpful kin may alleviate some of the burden of this workload (see e.g. Gibson & Mace, 2005).

One way that relatives can help mothers is by improving the likelihood of survival for her children. Since mortality is quite low in post-demographic transition societies, most studies on kin availability and child survival have been conducted in pre-transitional societies. Positive correlations between the presence of kin and child survival rates are now well established (see Sear & Mace, 2008). Such correlations may potentially be brought about by the provision of resources and high quality childcare by these available kin. Additional resources may improve the health of offspring, as well as their survival rates, and in food stressed environments, additional resources can lead to beneficial effects on child weight, height, and other indicators of health. Evidence has shown that maternal grandmothers may have a beneficial effect on child height (Sear & Mace, 2008; Sear et al., 2000) and improve nutrient intake (Sharma & Kanani, 2006). Kin may improve maternal outcomes as well. If individuals are providing calories to supplement mothers, we may see an increase in mother's body mass index (BMI).

### *1.2. Hypothesis 2: Kin influence contraceptive uptake*

The hypothesis above is an indirect mechanism by which kin may influence fertility: by changing the costs of reproduction. But kin may have interests in directly influencing a woman's fertility, because they actively desire her to produce more children, or perhaps to protect her own well-being by slowing her rate of reproduction. In controlled fertility populations, individuals commonly control their fertility through the use of contraceptives. There is some evidence that kin may influence contraceptive use (Madhavan et al., 2003, but see Mace & Colleran, 2009) or its' effectiveness (Borgerhoff Mulder, 2009).

### *1.3. Hypothesis 3: Kin influence breastfeeding duration*

Breastfeeding duration is correlated with birth interval length among natural fertility populations (Ellison, 2001). One route by which kin may impact birth intervals is by promoting the extension or cessation of breastfeeding. Kin effects may either be direct, the influence of older women on the nutrition of young children and nursing mothers may directly contribute to breastfeeding cessation (Hawkes et al., 1997; Sear et al., 2000) or indirect, when help allows women the time to continue breastfeeding a child they might have to wean without such help.

### *1.4. Hypothesis 4: Living with kin allows couples to marry at younger ages*

A fourth hypothesis is that individuals can marry at a younger age if they live with family postnuptially. Age at marriage has a direct effect on fertility if there is little sexual activity outside of marriage. Following Morgan and Rindfuss (1984), anticipated post-nuptial residence may influence one's ability to marry. There is some evidence that having available kin correlates with earlier age at marriage, particularly in low socio-economic status contexts (Johow & Voland, 2012) or when couples live with the husband's kin postnuptially (Morgan & Rindfuss, 1984).

### *1.5. Hypothesis 5: Individuals with high desired fertility live with kin*

Finally, we aim to test whether desired family size is correlated with kin presence. It is possible that individuals who desire high fertility are more likely to maintain close ties with family members in order to utilize their help to achieve their reproductive goals. If this hypothesis is true, then kin do not influence fertility, but instead fertility goals influence individuals' proximity to kin. Regardless of the causal arrow, if individuals choose to live with kin because of higher desired family size, we can still understand their choice as needing help from kin to successfully raise offspring.

This paper aims to answer two questions. First, do kin influence fertility in Thailand? If yes, in which ways do kin influence fertility? This research focuses on understanding the proximate mechanisms by which kin affect fertility in a nationally representative survey where there is large variation in postnuptial residences. This allows for different potential mechanisms to be compared.

## 2. Data and methods

Data are derived from the Thailand Demographic and Health Survey (DHS), a nationally representative household survey which includes data on a wide range of topics including fertility, health and contraceptive use. Interviews were conducted in 1987 with 6775 ever-married women between 15 and 49 years old. While the DHS dataset is constrained by the sampling criteria (only ever-married women), it has the advantage of sampling a large number of women across Thailand. The dataset contains questions regarding which set of parents the couple resided with after marriage, and for how long that residence lasted. This allows us to investigate the potential differing effects of wife's kin and husband's kin on fertility outcomes. In the analyses that follow, we use uxorilocal and virilocal residence to refer to postmarital residence with the wife's or husband's parents (respectively); and neolocal to refer to couples that lived with neither set of parents after marriage.

Thailand has experienced a significant fertility decline over the past 50 years. Data show that the total fertility rate for Thailand in the early 1960s was approximately seven births per woman (Hirschman et al., 1994), but dropped to 2.3 between 1985 and 1990 (United Nations, 2011). At the same time, Thailand experienced rapid economic growth (Chayovan et al., 1988) and declining infant mortality rates (United Nations, 2011). Most respondents were currently married at the time of the survey and had only been married once (90%). About 65% of women sampled resided in rural areas. The majority of reproduction occurs within marriage, as only 15 women (0.2%) reported the birth of their first child before marriage.

Variables recorded in the DHS include a reproductive history, with information on children's birth dates, gender, survival status, and for children under three years old, height and weight. Information on the respondent's age at marriage, desired fertility, contraceptive use, education, wealth indicators, employment history and her own height and weight were also collected.

Kin availability, while always defined as postnuptial residence, was measured in different ways depending on the type of analysis. For event history analyses, we created time-varying categorical variables of uxorilocal and virilocal residence for each year. For multiple regression, we created categorical variables for living with each set of kin after marriage (separate variables for husband's kin and wife's kin). These categories include: (1) women who did not live with either set of kin, (2) women who lived with a set of kin for up to 5 years after marriage and finally, (3) women who lived with a set of kin for more than 5 years after marriage. The advantage of these categorical variables is that it combines individuals into groups with sample sizes large enough for statistical analysis.

In Thailand, there are a substantial number of individuals in each of the possible postmarital residence patterns. The largest proportion of couples live uxorilocally at 40.1%, while 34.5% live neolocally and the remaining 25.3% live virilocally. While many couples choose to live with parents after marriage, this residence typically lasts less than five years (see Table S1 in Supplementary Material for the distribution of couples that lived in virilocal and uxorilocal postnuptial arrangements by length of residence, available on the journal's website at www.ehbonline.org). Couples who choose each residence pattern may differ systematically from one another. Limanonda (1989) found that region, rural–urban residence, religio-linguistic ethnicity, education and women's work experience affect postnuptial residence patterns in Thailand. Postmarital residence varies with region, with higher rates of uxorilocal residence in the rural northern regions, a preference for virilocal residence in the central and southern regions, and higher rates of neolocal residence in urban areas. Women with higher levels of education are more likely to live neolocally. Given the relationship between these variables and postnuptial residence, we included appropriate control variables in all models. These typically included: urban–rural residence, language spoken in the home (which is highly correlated with region), educational level attained, and a wealth indicator. Since income was not reported in the survey, a wealth indicator was created as a factor of floor type, toilet type, mode of transportation and electrical goods owned. The resulting wealth variable has a mean of 0.0 and a standard deviation of 1.0, where positive values refer to a family with above average wealth. Given that data were collected from women who were reproducing during a shift in demographic regime, we also control for birth cohort (typically included as age). Interaction terms were analyzed and included in the results if they had significant effects on the model. Occasionally we used additional control variables and these are described in the corresponding tables. In some analyses, only women over the age of 29 were included because young women in this sample are not representative of all young women in Thailand. Since only married women were included, this likely means that the sample of young women is biased towards women with lower educational achievement. All supplementary material can be found on the journal's website at www.ehbonline.org.

Table 1 presents a brief overview of all of the analyses performed and their results. Below we discuss each hypothesis, how we tested it, and describe the results found.

**Table 1**
Overview of results.

| Hypothesis | Does residence with kin affect… | Virilocal | Uxorilocal |
|---|---|---|---|
| | progression to each birth? | + | + (for first birth only) |
| | total children born? | + | n.s. |
| | number of living children? | + | n.s. |
| 1a | labor force participation after marriage? | − (for women 25+) | − (for women 25+) |
| | current employment? | n.s. | − (marginally significant) |
| 1b | child survivorship? | n.s. | + (marginally significant) |
| | child height? | n.s. | n.s. |
| | child weight? | n.s. | n.s. |
| | maternal BMI? | n.s. | n.s. |
| | respondent's likelihood of being underweight? | n.s. | n.s. |
| 2 | contraceptive uptake? | − | − |
| | number of children born before contraceptive use begins? | + | + |
| 3 | breastfeeding termination? | + (marginally significant compared to uxorilocal) | − (marginally significantly compared to virilocal) |
| 4 | age at marriage? | − | − |
| 5 | desired fertility? | + | + |
| SEM | the pathways of fertility? | Earlier age at marriage, earlier age at first birth, shorter average birth intervals, higher fertility at time of first contraceptive use, increased number of children born | Earlier age at marriage (in 2 of 3 models), higher fertility at time of first contraceptive use, a reduction in number of children born |

+ represents a significant positive effect, − represents a significant negative effect, n.s. represents a non-significant effect.

## 3. Do kin influence fertility?

### 3.1. Methods

We first tested whether there was an association between postmarital residence and fertility. We used discrete-time event history analysis to determine the likelihood of progressing to each birth. Event history analysis models the time until an event occurs and is able to accommodate censored and time-dependent variables. We used each year since the previous event (progression to first birth was measured from marriage, progression to second and higher order births was measured from the previous birth) as our time variable, up to nine years. A cutoff was used because the majority of women progressed to each event within nine years. Analyses were conducted for each birth interval separately up to the fifth birth, at which point all subsequent births were analyzed together and a control variable indicating the number of children previously born was included.

The respondent's residence pattern is a time-varying categorical variable, time lagged by one year. If a birth occurs in a given year, the time-lagged kin residence variable indicates the living situation at the time of conception (and the time of reproductive decision making). Many couples move out of their parent's home just before the birth of their first child (Limanonda, 1989), so using the living arrangement from the year prior to birth allows us to investigate how kin availability influences the decision to reproduce.

We then ran two multiple regression models to investigate the effect of postnuptial residence on total number of children born and number of living children at the time of the survey. Only women over the age of 29 were included in the analysis.

### 3.2. Results

The results of the discrete-time event history analysis of the progression to each birth show that women are significant more likely to progress to their first birth (from marriage) if they are living either

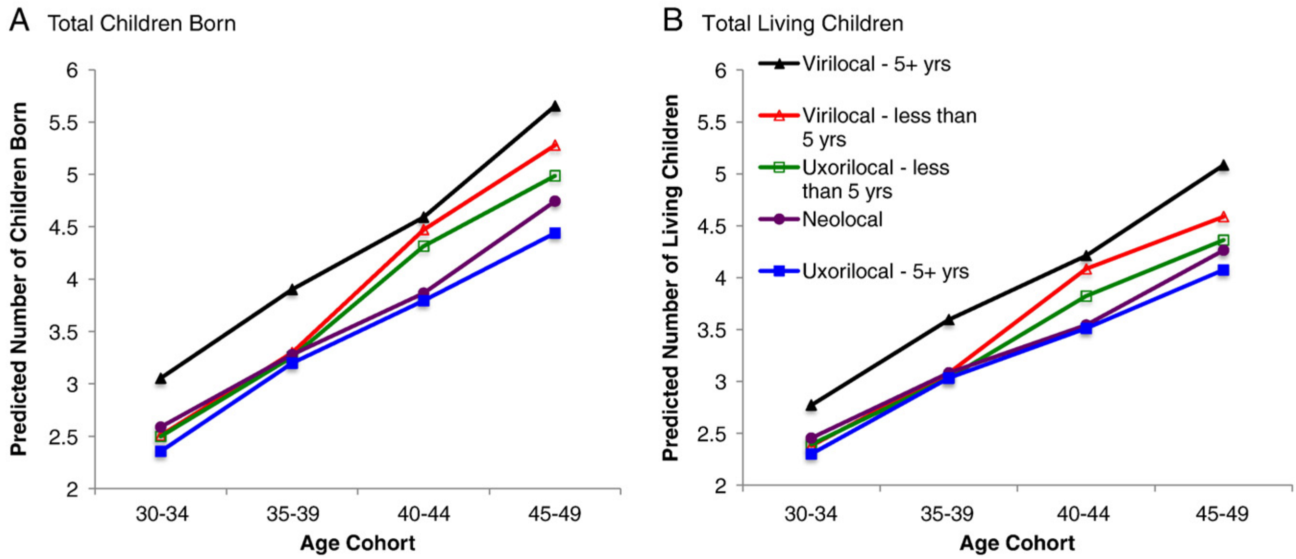


**Fig. 1.** Predicted (A) number of children born and (B) number of living children based on multiple regression analyses presented in Supplementary Material Table S3 (available on the journal's website at www.ehbonline.org). Predicts the fertility output of a woman who married at age 20, speaks Central Thai, lives in a rural part of the country, has an average amount of wealth, and has achieved primary school education. Filled squares represent women who lived uxorilocally for more than five years after marriage. Filled circles represent women who lived neolocally after marriage and open squares represent women who lived uxorilocally for less than five years after marriage. Open triangles represent women who lived virilocally for less than five years after marriage and filled triangles represent women who lived virilocally for more than five years after marriage.

virilocally or uxorilocally at the time of conception (see Table S2 in Supplementary Material). Living virilocally significantly increases the likelihood of progressing to second, third, fourth and higher births (as compared with neolocal residence). This means that respondents are more likely to have children when living with the husband's kin and therefore have, on average, shorter birth intervals. In contrast, living uxorilocally has no significant impact on progression to any birth other than the first.

Fig. 1 displays the predicted number of children born (in plot A) and number of living children (in plot B) for a given woman (at the mean value of covariates) based on the multiple regression analysis of children born and living children (see Table S3 in Supplementary Material). There is a significant interaction with postnuptial residence and age. For individuals over 40 years old, women bear more children and have more living children if they live virilocally, regardless of duration. In contrast, living uxorilocally for more than five years results in marginally fewer offspring born for women over 45 and no significant difference in the number of living offspring. For the other cohorts (ages 30–34 and 35–39), there is no significant difference between groups, except for those who lived virilocally for more than five years. This result shows that living virilocally for an extended period of time has a positive effect on fertility (both in terms of children born and currently living).

## 4. How do kin influence fertility? Potential pathways

### *4.1. Hypothesis 1: Kin reduce the cost of reproduction*

#### *4.1.1. Methods*

Logistic regression was used to analyze whether the respondent engaged in wage labor after marriage and whether a respondent was working at the time of interview based on her postnuptial and current residence with kin (respectively).

Multilevel discrete-time event history modeling was used to test the effects of residence on offspring survivorship (Rasbash et al., 2011). A multilevel model is needed because of the likely correlation in offspring mortality for children of the same mother, since these offspring share genetic, behavioral, and socioeconomic factors. Event history analysis was used because of right-censored observations (children were included in the model until death or age five, whichever came first), and so that time-varying covariates, uxorilocal and virilocal residence for each year, could be included. The time variable for the analysis was measured in one-year increments until age two and then, two-year increments up to age five. Multilevel models were analyzed in MLwiN 2.24. The penalized quasi-likelihood (PQL) approximate estimation procedure was used to model the binary response of the multilevel model.

Based on the data collected in the DHS it is not possible to see the flow of caloric or monetary transfers from grandparents to mothers and grandchildren, but it is possible to look at the height and weight of grandoffspring and mothers. Grandparents who provide resources, particularly in a nutritionally stressed environment, are likely to increase the height and weight of their grandoffspring. The DHS data compare the heights and weights of children 3 to 60 months old to the Center for Disease Control (CDC) standard deviation-derived growth references curves based on age and sex. In Thailand, 17% of children were at least 2 standard deviations below the median in their weight for age and 25% were below this threshold in their height for age. This may provide an opportunity for kin members to influence offspring size. We used multiple regression analysis to model the association between residence and anthropometric status of the youngest child. Height (or weight) for age (calculated as the standard deviation from the median) was used as the dependent variable. A negative value indicates a child who is below the standard growth curve median for their sex and age. The residence pattern at the time of interview is used as an indicator of grandparental availability.

Kin may also improve the nutritional status of mothers. Multiple regression was used to analyze the influence of postmarital residence on the body mass index (BMI) of the respondent. Kin may be protective against the effects of under-nutrition, so we also tested this possibility by using binary logistic regression to analyze the likelihood of a mother being underweight (defined as a BMI less than 18.5) based on her residence pattern at time of interview.

#### *4.1.2. Results*

Living with kin may allow a woman to reduce time engaged in labor force participation and provide her the opportunity to spend more time with her children in direct childcare. Approximately 56% of women worked after marriage if they lived in a neolocal residence pattern, but only 34% and 43% of women worked if their postnuptial residence was uxorilocal or virilocal (respectively). There is a significant interaction between age category and postnuptial residence in the logistic regression model predicting labor force participation (see Table S4a in Supplementary Material available on the journal's website at www.ehbonline.org). Analyses show that, for women over the age of 24, living with kin postnuptially reduced the likelihood of participation in wage labor compared with women living neolocally (see Fig. S1a in Supplementary Material available on the journal's website at www.ehbonline.org). For younger women, no significant differences across residence groups existed, likely because of low rates of employment for young women. Women not engaged in wage labor may have the opportunity to increase time in direct childcare and possibly start another bout of reproduction sooner than would be possible with work obligations. Alternatively, it is possible that women who do not want to work choose to live with kin. Unfortunately, we do not have any information regarding the reasons women choose to, or refrain from, work.

Living uxorilocally at the time of interview has a marginally significant negative effect on likelihood of current employment, while living virilocally does not have a significant effect (see Fig. S1b and Table S4b in Supplementary Material). The association between working in wage labor and current postnuptial residence does not interact with age.

Of those women sampled in Thailand, approximately 7.3% of their 17,803 children died prior to the survey. Of those, 72% died within the first year. Results of the multilevel analysis of child mortality show that living uxorilocally has a marginally negative effect on offspring mortality, while living virilocally has no significant effect (see Table S5 in Supplementary Material available on the journal's website at www.ehbonline.org). Children living with maternal grandparents were 15% less likely to die after controlling for confounding variables.

Residence with grandparents has no significant effect on the height or weight of grandchildren (see Table S6a, b in Supplementary Material available on the journal's website at www.ehbonline.org). The investigation into maternal outcomes shows that body mass index (BMI) is not associated with kin residence (see Table S6c in Supplementary Material available on the journal's website at www.ehbonline.org). Analyzed differently, there is no significant effect of living with kin on likelihood of being underweight (defined as a BMI less than 18.5) (see Table S6d in Supplementary Material available on the journal's website at www.ehbonline.org).

In conclusion, our tests of hypothesis one suggest that living with kin postnuptially may affect some of the costs of reproduction as it is associated with a reduced likelihood of working in wage labor after marriage for women over age 24. There is also marginal evidence that living uxorilocally improves survival rates of offspring, though living virilocally has no effect on child survival. There were no discernible effects of living with kin on nutritional outcomes for children or mothers.

### *4.2. Hypothesis 2: Kin influence contraceptive uptake*

#### *4.2.1. Methods*

The advent of modern contraceptives has made it easier for individuals to control reproduction. Discrete-time event history analysis was conducted to investigate the effect of time-varying residence with kin on contraceptive uptake. The unit of time is the number of years since marriage (since this is when individuals enter the analysis).

As an alternative way of testing whether kin influence contraceptive uptake, multinomial logistic regression was used to model the number of children born before the start of contraceptive use. In the Gambia, contraceptive use is dependent on the number of children already born where greater parity is associated with an increased likelihood of contraceptive uptake (Mace et al., 2006).Our dependent variable (the number of children born before the start of contraceptive use) was censored at four children since over 92% of women who used contraceptives did so before their fifth birth. Violation of the proportional hazards assumption led us to conduct a multinomial logistic regression instead of an ordinal logistic regression.

#### *4.2.2. Results*

The discrete-time event history analysis modeling the start of contraceptive use shows that women who live virilocally or uxorilocally are significantly less likely to begin using contraceptives per unit time than women living neolocally (see Table S7 in Supplementary Material available on the journal's website at www.ehbonline.org).

Calculating the proportion of individuals who begin using contraceptives after each birth (censored at four births) suggests that individuals living neolocally are most likely to use contraceptives before reproducing (see Fig. S2 in Supplementary Material available on the journal's website at www.ehbonline.org). Individuals who live with kin for a short period of time are most likely to start using contraceptives after their first child is born. Women who live with kin for longer periods of time are more likely to further delay contraceptive use. This suggests that living with kin is correlated with higher fertility before contraceptive use begins.

The results from the multinomial logistic regression of kin influence on timing of contraceptive uptake show that virilocal residence (regardless of length) significantly increases the likelihood of a woman having more children when contraceptive use begins compared with neolocal residence (see Table S8 in Supplementary Material available on the journal's website at www.ehbonline.org). Uxorilocal residence is significantly positive for some parity categories, but not others. These results suggest that living virilocally has a strong effect on delaying contraceptive use until higher parities, while living uxorilocally has a weaker effect in delaying contraceptive use.

### *4.3. Hypothesis 3: Kin influence breastfeeding duration*

#### *4.3.1. Methods*

Data were collected from 2675 mothers of children aged 3 to 48 months old to obtain information on breastfeeding duration of their youngest child. All women who were currently pregnant were removed to eliminate the possibility that pregnancy led to the cessation of breastfeeding. The median length of breastfeeding was 12 months, and only six percent of mothers stated they did not breastfeed their most recent child. Breastfeeding duration was modeled using discrete-time event history analysis. Months since the birth of the child were used as the unit of time. The DHS data also allow us to run the same analysis on the length of self-reported postpartum amenorrhea, which should be correlated with the length of breastfeeding, and postpartum sexual abstinence, which may be affected by kin influence (Achana et al., 2010).

#### *4.3.2. Results*

The analysis of breastfeeding duration shows that those women who lived with their husband's parents after the birth of their most recent child breastfed for a (marginally) shorter length of time than those women who lived with their own parents (see Table S9 in Supplementary Material available on the journal's website at www.ehbonline.org). The predicted rates of breastfeeding termination by residence pattern show that at birth, the majority of mothers breastfeed, but as time progresses, the rate of mothers who continue to breastfeed declines. The rate of breastfeeding termination is marginally faster for women living virilocally than uxorilocally (see Fig. S3 in Supplementary Material available on the journal's website at www.ehbonline.org). The pattern of breastfeeding termination for women living neolocally is not significantly different from either uxorilocal or virilocal residence. The reported duration of lactational amenorrhea is in the same direction as breastfeeding duration (those living virilocally experience shorter periods of lactational amenorrhea while those living uxorilocally have longer periods of amenorrhea) but the effects are not statistically significant. Further, there is no significant difference in the duration of postpartum sexual abstinence based on residence patterns. Results of the latter two models are not shown but can be provided on request.

### 4.4. Hypothesis 4: Living with kin allows couples to marry at younger ages

#### 4.4.1. Methods

Multiple regression was conducted to look at the effect of kin on age at marriage for women over the age of 29. Since never-married women were not included in the sample, the effect of kin on likelihood of progression to marriage cannot be calculated and our results can only show correlations between age at marriage and postmarital residence patterns.

#### 4.4.2. Results

The difference in the average age at marriage between postmarital residence groups is slightly more than one year, with individuals in a neolocal residence pattern marrying at an average age of 21.35 ($n = 1415$), and those in virilocal and uxorilocal residence marrying at an average age of 19.80 ($n = 994$) and 19.97 ($n = 1706$) years old, respectively. The results of the multiple regression model predicting age at marriage show that a woman is expected to marry 0.557 year earlier if she lives with her own parents and 0.952 year earlier if she lives with her husband's parents as compared with living neolocally (Table S10 in Supplementary Material available on the journal's website at www.ehbonline.org). This provides evidence to support the hypothesis that living with kin postnuptially is correlated with couples marrying at younger ages.

### 4.5. Hypothesis 5: Individuals with high desired fertility live with kin

#### 4.5.1. Methods

If individuals are aware that living with paternal kin may result in more living children, then those women who have higher desired fertility may choose to live with paternal kin. In the DHS survey, women were asked: "What is the ideal number of children you would like to have irrespective of how many children you already have?" One's ideal number of children may be both a cause and a result of their actual fertility behavior but unfortunately, since the sample is cross-sectional, we do not have time-varying information on one's ideal number of children before reproduction begins. We conducted t-tests to investigate women's desired fertility and their postmarital residence by age (since younger women may have different fertility intentions than women born decades before them).

#### 4.5.2. Results

The average ideal family size by postnuptial residences for women of different age categories generally shows that there are significant differences between neolocal residence and residence with kin (see Fig. S4 in Supplementary Material available on the journal's website at www.ehbonline.org). For women under 25, there is a significant difference between neolocal and uxorilocal residence ($t_{966} = 2.869$, $p < 0.01$), but not between neolocal and virilocal ($t_{829} = 0.944$, $p > 0.05$) residence. For women aged 25–39, there is a significant difference between neolocal and both uxorilocal ($t_{2809} = 3.976$, $p < 0.001$) and virilocal residence ($t_{2232} = 3.484$, $p < 0.01$). For the oldest group of women (aged 40–49), respondents who lived neolocally immediately after marriage have a significantly lower average ideal family size compared with virilocal residence ($t_{938} = 2.065$, $p < 0.05$) and a marginally lower average ideal family size

**Table 2**
Comparison of standardized coefficients of virilocal and uxorilocal residence on total living children across multiple SEM models.

| | Relationship | Models | | |
|---|---|---|---|---|
| | | a) Women who used contraceptives | b) All women – excludes contraceptive variable | c) All women. Those who have not used contraceptives have the number of living children as a proxy |
| Virilocal | Age at marriage | −0.0511** | −0.0580** | −0.0507** |
| | Age at first birth | −0.0138** | −0.0131* | −0.0130* |
| | Number of children when contraceptive use begins | 0.0194** | NA | 0.0163** |
| | Average birth intervals | −0.0305^ | −0.0548** | −0.1769* |
| | Total children born | 0.0230** | 0.0643** | 0.1340** |
| | Offspring survivorship | NS | NS | NS |
| Uxorilocal | Age at marriage | NS | −0.0330* | −0.0237* |
| | Age at first birth | NS | NS | NS |
| | Number of children when contraceptive use begins | 0.1280** | NA | 0.0081^ |
| | Average birth intervals | NS | NS | NS |
| | Total children born | −0.1624** | −0.0533** | −0.0170** |
| | Offspring survivorship | NS | NS | NS |
| | RMSEA | 0.055 | 0.037 | 0.063 |
| | CFI | 0.976 | 0.99 | 0.969 |
| | Sample size (n) | 3000 | 3476 | 3476 |

^p<0.10, *p<0.05, **p<0.01, NS = Not significant, NA = Not Applicable (variable is not included in the model).
All models include controls for age, education and a latent variable, wealth. Includes co-variation among independent variables.
See Fig. 2 for visual representation of Model a.

compared with uxorilocal residence ($t_{1233} = 1.875$, $p < 0.10$). While it is possible that those women with higher desired fertility choose to live with kin, it is also possible (since data were collected retrospectively) that living with kin influences a woman's ideal family size. Those women who live virilocally after marriage appear to have higher desired family size (although it is impossible to determine if women who had large families have changed their ideal family size to reflect their experienced fertility), but it is perhaps surprising that women living uxorilocally also have higher desired family size even though they do not have higher fertility.

One might predict that if women are having more children in a virilocal residence pattern, they are having unwanted children. The data on desired fertility above suggest this may not be the case since virilocally resident women state a desire for relatively large family size, but it is possible these fertility desires are influenced by living with kin. An alternative test of whether women are being encouraged to have more children than they consider ideal is to examine data on whether the most recent child (born within five years of the interview) was wanted: possible responses to this question were "was wanted at that time", "was wanted, but at a later time" and "not wanted at all". Women living neolocally were more likely to state that they did not want the child at all (17.7%), compared to 9.2% of women living uxorilocally and 10.0% of women living virilocally ($X^2 = 5.987$, $df = 2$, $p < 0.001$), supporting the previous analysis that the higher fertility of women living with kin is desired. There were no statistically significant differences between the proportions of individuals who stated they wanted the child at a later time based on postnuptial residence.

### 4.6. Structural equation modeling

#### 4.6.1. Methods

Finally, structural equation modeling (SEM) was conducted (Stata v.12) to simultaneously estimate the direct and indirect effects of kin availability, proximate mechanisms and control variables on fertility outcomes (Kline, 2005). SEM allows us to create a visual representation of our model and estimate a series of regression models to obtain direct, indirect, and total effects of independent variables on the outcome of interest. While SEM is limited in its ability to deal with censored variables, binary dependent variables, and non-linear analyses, it does allow for several linear relationships to be modeled simultaneously and allows the strengths of different relationships to be compared among a set of variables. We use SEM to investigate the possible opposing effects of kin on different fertility outcomes and through different pathways in one model to understand the overall effect of kin on total fertility. The potential pathways through which kin may influence fertility are not necessarily mutually exclusive. Our SEM allows us to include multiple pathways in the same model in order to explore relationships between the pathways and evaluate each pathway's relative importance.

Given the constraints of SEM, some of our variables are defined differently for this model. Postmarital residence is measured as the years living in a particular postmarital residence after marriage. Given that many women were censored for breastfeeding duration, this variable was excluded. Individuals who progress more rapidly to each parity have shorter birth intervals, so average birth interval was used as a proxy for progression to higher parities. Contraceptive use is defined as the number of children a woman has when contraceptive uptake begins. Women who have never used contraceptives are censored and do not have a value for this variable. To account for this, we ran the model three times: first, only including women who had used contraceptives; second, a model without the contraceptive use variable; and third, a model with current number of living children as the value for women who have never used contraceptives. This allows for a comparison between the three approximate models, since none of them can incorporate the censored contraceptive use variable. All models only used women over the age of 29.

#### 4.6.2. Results

Table 2 displays the standardized coefficients of the effects of uxorilocal and virilocal residence on fertility variables for our three SEM models: a) only women who have used contraceptives, b) all women without the contraceptive uptake variable, c) all women where number of living children is used as a proxy for women who never used contraceptives. As we compare the models, we generally see agreement across them.

Fig. 2 displays results of the SEM analysis from Table 2a. This model is similar to the other two and was chosen as an example to provide the visual representation of the model. Previous literature has shown that goodness of fit tests with combined values of CFI (comparative fit index) >= .0.95 and RMSEA (root mean square error of approximation) <= 0.06 represent a good fit of the data (Hu & Bentler, 1999). The model presented in Fig. 2 fits the data well with a CFI = 0.976 and a RMSEA = 0.055. This model fits the data better than a sub-model which excludes kin variables (CFI = 0.976 and RMSEA = 0.06). The model suggests that living virilocally does not influence just one part of the fertility pathway, but has influence throughout the causal pathway. Living virilocally reduces age at marriage, accelerates the time between marriage and first birth, reduces birth interval length, delays contraceptive uptake until higher parities and finally, increases total children born. These are the same results we found from the previous analyses described above.

Living uxorilocally impacts fertility by delaying contraceptive uptake until higher parities and reducing overall number of children born, but there is no separate effect on age at marriage, age at first birth, birth intervals, or offspring survivorship. These results slightly

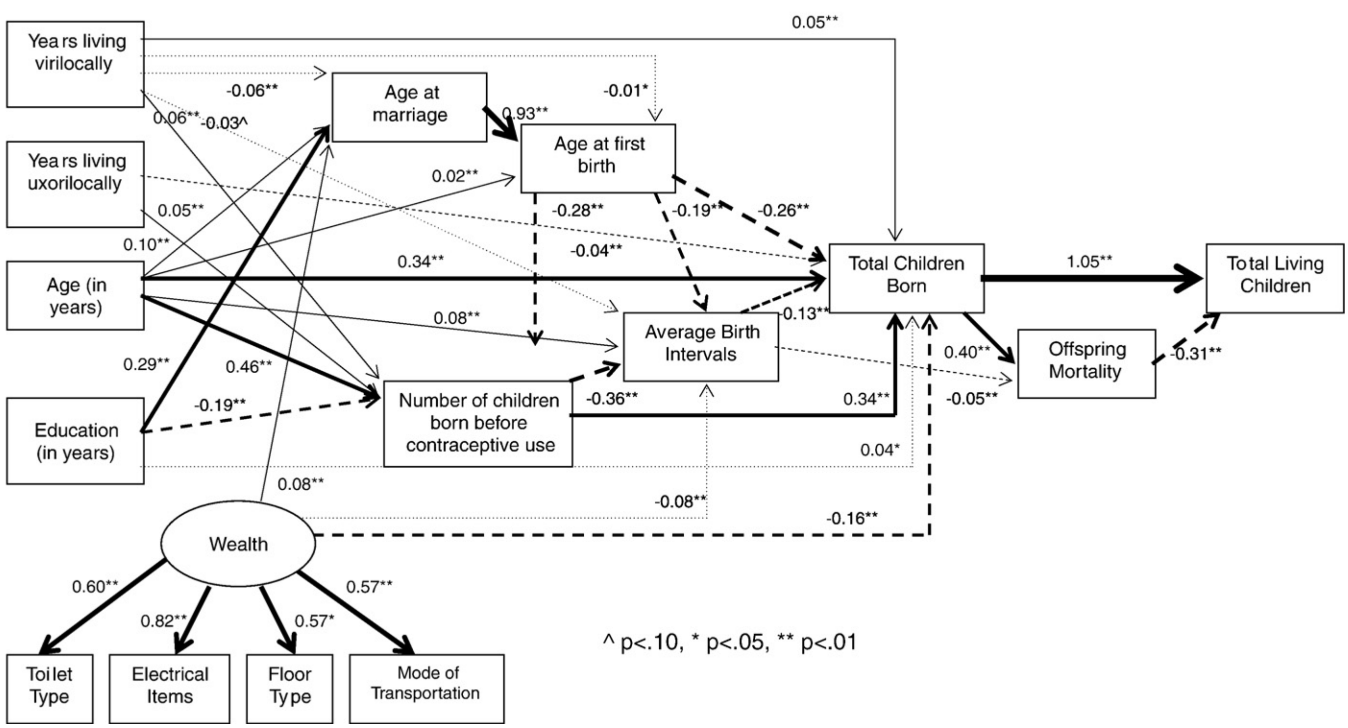


**Fig. 2.** Structural Equation Model (SEM) of the pathways of influence of living with kin on total living children. Values represent standardized coefficients. Solid lines represent positive effects and dotted lines represent negative effects. The strength of the effect is represented by the width of the line. Covariances are included (but are not shown) for all independent variables: education, age, wealth, uxorilocal and virilocal residence.

contrast results from prior sections. Previously, we found that living uxorilocally was associated with an earlier age at marriage. This was not significant in model a, but was significant in the other two versions of the model, suggesting that excluding women who never used contraceptives in our analyses reduces the sample size and makes significant differences harder to detect. Other dissimilarities may result from the difference in the power of individual analyses. Discrete-time event history analyses allow for an indicator of postnuptial residence in a given year, which is more powerful than length of postmarital residence and likely explains the lack of an effect on age at first birth and childhood mortality. Finally, the SEM finds a negative effect on overall number of children born, while the regression analyses found no significant difference between uxorilocal and neolocal residence. This is likely the result of having all the analyses combined. In the SEM, a significant delay in contraceptive use predicts an increased number of births. Since couples living uxorilocally do not have higher fertility, even though they delay contraceptive use, there must be a fertility suppressive effect that is not accounted for elsewhere in the model.

The total effect (defined as the sum of the indirect and direct standardized effects) of living virilocally on number of living children is 0.091 as compared with −0.02 for living uxorilocally. This means that there is about a 9% increase in total living children for each additional 3.5 years that a couple lives virilocally, compared to a 2% decrease in total living children for the equivalent uxorilocal residence.

## 5. Discussion

These data come from a country going through transition. The fertility outcomes of women aged 40–49 are significantly different from younger women. Throughout these analyses, care was taken to understand how postnuptial residence effects fertility by cohort. Evidence from Fig. 1 shows that differences in overall fertility by residence pattern are largest among women between ages 40 and 49. The smaller effect sizes for younger women may reflect a reduction in fertility variance (due to fertility reduction across the population) or that the effects of kin are cumulative over many birth intervals and become most obvious towards the end of a woman's reproductive life. While fertility rates have decreased (both in the number born and living children) for younger couples, the number of women living virilocally or uxorilocally is quite consistent across cohorts (see Table S11 in Supplementary Material for descriptive statistics by age cohort available on the journal's website at www.ehbonline.org). We also found relatively few interactions between residence patterns and cohort in our more detailed analyses of kin influences on fertility and proximate mechanisms, so it seems that the impact of kin on fertility has not changed much over time.

While this research takes a step in the direction of trying to understand the different ways that kin influence fertility, there are still some unanswered questions and limitations of the data. First, although we controlled for a number of confounding factors, people who live with a particular set of kin postnuptially may be systematically different from other individuals in ways that have not been accounted for in this analysis. While we would like to determine if unmeasured factors influence both kin residence and fertility decisions, this DHS dataset does not have suitable information that would allow us to explore that possibility. Second, our postnuptial residence variables only indicate which set of parents a couple lived with and cannot separate out the effects of each individual parent or parent-in-law. A more detailed study investigating the role of each parent separately would be more effective.

Additional limitations relate to the problem that, though the DHS is incredibly rich in data, it does lack some variables that would help elucidate pathways of kin influence on fertility. For example, it is impossible to tell if grandparents are helping out with childcare, which many authors have suggested is an important mechanism by which kin can influence fertility (Bereczkei, 1998; Thompson, 1965; Turke, 1989). Further, it is likely that parents influence educational achievements of their children (which, in turn, influences fertility outcomes), but since we only have data about postnuptial residence; it is impossible to determine how kin influence educational achievements. It would also be useful to explore in more detail exactly how kin influence contraceptive use or breastfeeding duration. For example, advice from kin may influence fertility decisions (Newson et al., 2007); similarly advice on the appropriate way to feed children or information on contraception might affect these correlates of fertility. Future work should continue to look at how kin can influence contraceptive usage, breastfeeding duration, and progression to subsequent births.

In conclusion, we have found evidence that in Thailand living virilocally increases fertility by decreasing age of marriage, shortening the duration between marriage and first birth, shortening birth intervals and delaying contraceptive use until higher parities. Additionally, living virilocally decreases the likelihood of engaging in wage labor, which may allow women the opportunity to devote more time to reproduction, and may reduce breastfeeding duration, which may account for the shorter birth intervals. These contributions lead to an increased number of living children. There is no evidence that living virilocally affects maternal or child outcomes, based on our measures of child survivorship and health or maternal under-nutrition. Living uxorilocally allows couples to marry younger, progress to their first child more quickly, affects work patterns, and may improve offspring survivorship (but not other indicators of child or maternal health), but does not result in an increase in number of living children. A weak test of the hypothesis that the husband's kin might be manipulating women into having more children than they desire returns null results (there is not an increased rate of virilocally-resident women who wished they did not have their most recent child).

Our results provide some support for the cooperative breeding hypothesis. First, older women who lived with kin after marriage are less likely to work, which may allow them the opportunity to invest more in reproduction and childcare. Second, living with maternal kin appears to be associated with reduced mortality for offspring. However, they also provide further evidence that husband's kin tend to have a greater influence on fertility than a woman's own kin. While we suggest some potential pathways through which this kin influence may be brought about, the functional explanation for this pattern requires further investigation. Our data do not support the hypothesis that the husband's kin are encouraging higher fertility than the woman considers ideal, but more detailed qualitative data may be needed to explore this possibility fully.

## Supplementary Materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2012.11.004.

## Acknowledgments

Thanks to Sandra Virgo, Paula Sheppard, Susie Schaffnit, Cristina Moya, Paul Mathews, and two anonymous reviewers for helpful comments.

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