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Does grandparental help mediate the relationship between kin presence and fertility?

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Abstract

BACKGROUND
Previous research suggests that kin availability may be correlated with reproductive outcomes, but it is not clear that a causal relationship underlies these findings. Further, there is substantial variation in how kin availability is measured.

OBJECTIVE
We attempt to identify whether different measures of kin availability influence how kin affect reproductive outcomes and whether the effect of kin on reproductive outcomes is driven by the help that they provide.

METHODS
Using data from the Indonesia Family Life Survey (1993, 1997, 2000, 2007), we compare the survival of parents and parents-in-law, their co-residence, geographic proximity, contact frequency, and helping behavior in predicting fertility outcomes, and test a hypothesized causal pathway linking kin availability to reproduction via helping behavior.

RESULTS
We find different results if we operationalize parental availability as survival or co-residence, suggesting that these measures cannot be used interchangeably. Receiving help from parents or parents-in-law has a positive effect on progression to birth when women have fewer than three living children. Path analyses show that geographic proximity is associated with contact frequency, which in turn influences helping behavior. Kin help has a positive effect on progression to giving birth for all parental categories, but the effects are strongest for mothers-in-law.

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CONCLUSION

In Indonesia, kin availability has a positive effect on fertility *only* when kin provide help, suggesting that there is a causal relationship between kin availability and fertility which is mediated via the provision of help.

1. Introduction

There is a growing literature on the effect of kin on fitness outcomes, which demonstrates associations between kin availability and reproductive outcomes in many different contexts (see reviews in Sear and Mace 2008; Sear and Coall 2011). This evidence largely takes the form of associations between the presence of kin and child survival or fertility rates. Reviews of this literature show that although such correlations have been demonstrated in a number of populations, the existence and direction of these effects can vary substantially between populations and among different family members. Broadly speaking, the presence of husband's parents is more likely to be correlated with increased fertility than that of the woman's own parents (Sear and Coall 2011), while the presence of the woman's parents is more likely to be associated with improved survival of offspring than the presence of the husband's parents (Sear and Mace 2008).

There are two problems with this literature. First, kin presence is measured in many different ways in previous research, depending on data availability. The survival status of family members is sometimes used as a proxy for kin availability (i.e., simply whether the relative is alive or dead, based on the assumption that living kin will be more able to influence fertility than those who are dead) (see examples: Beise and Voland 2002; Tymicki 2004; Beise 2005; Kemkes-Grottenthalef 2005; Sear, Mace, and McGregor 2003; Hadley 2004; Hill and Hurtado 1996). Survival status may overestimate any effects of kin if kin survival is confounded by other variables (such as wealth or genes for disease resistance, which may be associated with survival and fertility outcomes). It may, conversely, underestimate kin effects if after a death, other kin step in to provide necessary help. A popular alternative measure of kin availability is co-residence with kin, sometimes measured by postnuptial residence (see examples: Snopkowski and Sear 2013; Thornton et al. 1986; Skinner 2004; Jamison et al. 2002; Tsay and Chu 2005). This measure may be biased if individuals who live with kin after marriage are systematically different from those who do not. For example, if those who are more family orientated are more likely to co-reside with kin, the effects of kin may be overestimated (although this leads to further questions of why some individuals are more family-orientated and whether living with kin simply provides the help needed to

attain desired family size). In contrast, if individuals with fewer resources are constrained to live with kin, the effects may be underestimated, assuming that lack of resources is associated with lower fitness. These biases may be reduced, however, if co-residence is dictated by social norms. For example, in a given society, the eldest daughter may be expected to reside with parents and take over the family household, in which case individuals are less likely to self-select into co-residence with kin. Finally, some authors have compared levels of contact with kin or geographic proximity (for example: kin living in the same village vs. living in another village), with the assumption that kin are more able to help if they have more contact or live nearby (see examples: Lahdenperä et al. 2004; Gibson and Mace 2005; Johow and Voland 2012). These outcomes may also be biased since geographic proximity and contact frequency allow for self-selection (those with kin nearby may need the most help or may be the most family orientated). While the authors of the studies cited above typically do as much as they can to reduce the possibility of such confounding factors, the different measures of kin availability adversely affect the comparability of existing research. Here we directly compare the effects of different measures of kin availability in our dataset to determine whether these measures of kin availability influence fertility in the same way.

The second problem with the existing literature is that we do not yet fully understand the mechanism(s) by which kin availability influences fertility outcomes. Cooperative breeding models of human reproductive behavior propose that alloparenting by kin is common in our species, and these models make the general assumption that kin provide some kind of help (e.g., with childcare or food production) which enhances one another's reproduction, as predicted by kin selection (Hamilton 1966; Hrdy 2005). However, the large-scale datasets often used to demonstrate associations between kin availability and fitness outcomes are typically not suitable for testing whether such associations are driven by help from kin: usually an association between some measure of kin presence and a fitness outcome is all that is demonstrated (see exceptions: Waynforth 2012; Mathews and Sear 2013; Kaptijn et al. 2010). There is a parallel literature, from anthropologists working in small-scale subsistence societies, which has clearly demonstrated that kin do provide alloparenting and other forms of help for one another (Gibson and Mace 2005; Hawkes, O'Connell, and Blurton Jones 1997; Ivey 2000; Kramer 2010; Meehan, Quinlan, and Malcom 2013). This supports the argument that kin help may be the cause of associations between kin and reproductive outcomes, but sufficiently detailed time−budget data are difficult to collect, so that it is rare to find datasets detailed enough to directly test whether kin help influences fitness outcomes. Further, while some researchers have proposed that kin help is the mechanism by which kin influence fertility outcomes, other researchers have argued that kin influence fertility through mechanisms other than (or in addition to) the

help they provide; such as interactions with kin that propagate pro-natal norms (Newson et al. 2005), competition for resources among kin that outweigh the positive effects of cooperation (Sear 2008; Strassmann 2011), and sexual or in-law conflict that may alter a woman's ideal fertility strategy (Borgerhoff, Mulder, and Rauch 2009; Leonetti, Nath, and Hemam 2007). To better understand these kin effects, we have developed a simple hypothesized causal pathway to test the mechanisms by which parents and in-laws are likely to influence fertility outcomes.

1.1 Hypothesized causal pathway of kin influence

As described in cooperative breeding models, one route by which kin influence fertility is by the help they provide to a reproducing woman. Figure 1 presents a hypothesized causal pathway by which parental availability influences fertility outcomes, with physical help as the main link between kin presence and reproduction. We incorporate geographical proximity, face-to-face contact, and help received to understand the pathway by which kin may affect fertility. Our hypothesized causal pathway predicts that geographical proximity influences face-to-face contact frequency, as face-to-face contact is likely to occur more often for kin who live nearby. This, in turn, affects the help women receive from kin, and results in decisions about whether to reproduce. There are several ways that kin may influence fertility outcomes. It is possible that they provide physical help, such as financial help or childcare help (as shown in our hypothesized causal pathway). Kin may also provide other types of non-physical help, such as emotional support, informational help, or emergency support. Research has shown that social support is important for good health and well-being (Berkman 1984; Sosa et al. 1980), and we might expect that social or emotional support has an effect on fertility, potentially through the decision to have more children, or because pregnancies are more likely to result in live births and healthy children (Scelza 2011). Informational help may include the information kin provide about how best to raise children or when to seek medical care. Emergency support may not occur regularly, but parents know that they can call on kin if a situation occurs in which they require assistance (Waynforth 2012). This may allow the couple to have more children than they would have if they had no source of emergency support. If there is still a direct effect of geographic proximity or contact frequency on the likelihood of having a birth that cannot be explained through physical help, this may provide evidence that the help kin provide may be emotional, informational or emergency support. Additionally, it may suggest that women are experiencing influence or pressure from kin to reproduce more rapidly(Newson et al. 2005, 2007), as it has been proposed that in-laws may be particularly keen for women to produce children at a faster rate, because of sexual

conflict between men and women over ideal family size (Leonetti, Nath, and Hemam 2007; Penn 1999; Sear, Mace, and McGregor 2003, but see Moya, Snopkowski, and Sear 2016). While we might expect such conflict to result in long-term reductions in reproductive success, over short time spans, conflict may result in higher fertility for women. Finally, it is possible that direct effects of kin proximity and contact frequency may have a negative effect on fertility rates. For instance, a woman of reproductive age may provide help *to* her kin, acting as helper-at-the-nest (Kramer 2005); resulting in close kin more effectively reproducing, but the woman herself suffering a reduction in fertility. This may occur because of reproductive competition between generations (Cant and Johnstone 2008; Moya and Sear 2014).

Figure 1:   Hypothesized causal pathway of kin influence
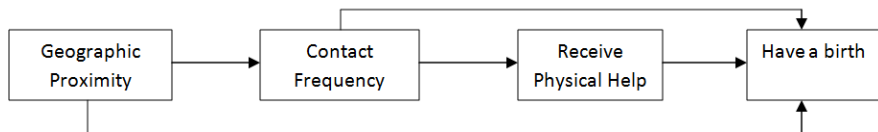
Given the profound interest of policy makers to influence fertility (with a goal, in different parts of the world, of either decreasing or increasing it), understanding which factors influence reproductive decision-making is of critical importance. As couples reside further from kin, possibly due to labor markets that make people more geographically mobile, this may have a direct effect on people's reproductive decisions.

Our aims are as follows: 1) to directly compare the effects of kin survival status, co-residence, proximity, and contact frequency, as these are the most commonly used proxies for kin availability and 2) to test the hypothesized casual pathway by which we expect kin to influence fertility outcomes, by exploring whether kin survival status acts on fertility through geographic proximity, contact frequency, and help received.

2. Methods

Data are derived from the four waves (1993, 1997, 2000, 2007) of the Indonesia Family Life Survey (IFLS), which provide information at the individual and family level on fertility, health, education, migration, and employment (Frankenberg and Karoly 1995; Frankenberg and Thomas 2000; Strauss et al. 2004, 2009). The survey represents an area that includes 83% of Indonesia's population (specifically, 13 provinces found on the islands of Java, Sumatra, Bali, West Nusa Tenggara, Kalimantan, and Sulawesi).

Small provinces and the provinces that were politically unstable at the time of first interview were not sampled. A total of 7,224 households were surveyed in 1993. In the first wave, the head of household and their spouse were interviewed (in addition to two randomly selected children and individuals over the age of 50); which generally meant the oldest couple in the household was interviewed, and then in 25% of households another couple (aged 15−49) was also sampled (if there was another couple living in the household). In subsequent waves, additional individuals from the original households were added to the survey (for example, in wave 2, all household members aged 30 or older were added). This sampling strategy results in a higher proportion of married women living with parents or in-laws in later waves. We have data on 6,536 ever-married women (aged 15−45) who were sampled in at least two waves. Given that some women were interviewed in several waves, we have a total of 12,505 cases. To be included in the analysis, women had to be married, aged 15−45, remain married to the same individual by the next wave, and have information on whether they progressed to a birth by the next wave. Women were only included up to age 45 as women over 45 were unlikely to have additional births. Only married women were included because: 1) married women are most likely to reproduce by the next wave (only 1% of female respondents reported having sex before marriage in the Indonesian Young Adult Reproductive Health Survey (BPS Statistics Indonesia and Macro International 2008)) and 2) women only have in-laws if they are married. This survey has the advantage of including information on survival of respondent's parents and parents-in-law, including year of death and residence at each year of the survey, which allows us to compare the effect of survival and residence of parents and in-laws on progression to a birth by the next wave.

A benefit of this panel dataset is that we can use information collected at one interview to predict future fertility outcomes. Most datasets use retrospective information, which suffers from recall bias which may become more pronounced for events further in the past, and may result in using current information to predict past events (for example, using current socioeconomic status to predict previous fertility, even though the causal arrow may point in the opposite direction (Havanan, Knodel, and Sittitrai 1992)). Panel data provides more power to infer the direction of causality.

2.1 Study site

Indonesia is an archipelago consisting of thousands of islands, and is the fourth most populous country in the world, with a population of approximately 239 million people (United Nations 2011). Indonesia has more than 300 ethnic groups with a wide range of marriage norms, from the Minangkabau tribe of West Sumatra, which is the largest matrilineal kinship system in the world (Rammohan and Johar 2009) to the Balinese

people, the predominant group on the island of Bali, who are overwhelmingly Hindu and tend to be virilocal (living with or near the husband's kin) after marriage (Jensen and Suryani 1992). In 1993, the total fertility rate (TFR) of Indonesia was 2.90 and by 2007 it had dropped to 2.21, but many older women in this sample began their reproductive careers in the 1960s, when the TFR was approximately 5.60 (United Nations 2011). In the decades preceding this survey, Indonesia experienced a rapid reduction in fertility and infant mortality, a dramatic increase in primary school attendance, and a state-sponsored family planning program (Molyneaux and Gertler 2000). The National Family Planning Coordinating Board (BKKBN), Indonesia's family planning program, was established in 1970 and has been used as a model for other countries attempting to reduce their fertility rates (Gertler and Molyneaux 1994). This program promotes a two-child family by encouraging later age at marriage and contraceptive use to limit higher order births. Indonesia has nearly universal marriage (97% of women in the IFLS are married by age 30) and essentially no non-marital fertility. Child mortality in Indonesia has dropped quite dramatically in the past 50 years. In 1960, approximately 22% of children born died before their 5th birthday (UNICEF 2000). Today, that proportion has fallen to 3% (UNICEF 2013).

2.2 Data analysis

We used random effects logistic regression to model the probability of a birth before the next wave of survey data, according to measures of kin availability in the previous wave. Some women were interviewed in several waves, so the random effect controls for repeated measurements. We included a number of potentially confounding variables, described in Section 2.2.6. Our measures of kin availability are described below.

2.2.1 Comparing kin availability measures

The most basic comparison can be made by using those kin availability measures that have been used previously in the literature, specifically: survival status (either alive or dead), residence status (either co-resident or not), village residence (either lives in the village or does not) or frequent contact (either has weekly face-to-face contact or does not) to predict progression to another birth before the next wave. These dichotomous variables allow for comparison of different measures of kin availability used in the literature. These measures also combine categories of kin who have died with kin who may live elsewhere or have infrequent contact. To explore kin availability categories in more detail, we re-categorize these variables in more informative ways in the following sections.

2.2.2 Comparing residence and survival status of kin

To compare residence and survival status for the respondent's parents and parents-in-law, we included each parent's status (co-resident; alive, but not co-resident; and dead) in the model. Information from one wave was used to predict a birth before the next wave using a random effects logistic regression analysis. All parents and in-laws were included in the same model.

2.2.3 Geographic proximity and contact frequency

We ran additional models to test two other measures of kin availability; geographic proximity and contact frequency for non-resident kin. Geographic proximity of parents and parents-in-law was not collected in 1997. Geographic proximity is categorized as follows: living out of the province, in the province but in a different district, in the district but in a different village, or in the village. Frequency of contact with kin is collected at each interview for parents. In-law contact information was extrapolated from a husband's contact with his parents, which is likely to be correlated with a woman's frequency of contact with her in-laws. Contact with a kin member was defined as the frequency with which one meets face-to-face with him or her during the past year. Frequency of contact was categorized as follows: never, at least once per year, at least once per month, or at least once per week. We conducted random effects logistic regression analyses to determine whether kin proximity and kin contact in one interview predicts the respondent progressing to a birth before the next interview. Because kin could only be included in the model when they were alive, but not co-resident, models were run separately for each kin member. We exclude co-resident kin because they were already modeled in the previous section; 'Comparing residence and survival status of kin.'

2.2.4 Help received from kin

Finally, a dichotomous variable of whether kin provided help in the 12-months prior to the interview was used as an independent variable in a random effects model to predict the progression to a birth (for more details on kin help, see Snopkowski and Sear 2015). Help could include any form of money, goods or service. Information on the help respondents received from kin was only collected for parents who were alive, *but not resident* (we do not have information on helping behavior of co-resident kin). Helping behavior was collected on the respondent's parents together if they were both still living and married, and separately otherwise. As before, information on a woman's in-laws was extrapolated from her husband's report of help received from his parents. We

conducted random effects logistic regression analyses to test whether receiving help from kin is associated with the respondent having abirth before the next interview. Again, because this information was only available for kin who were still alive and not co-resident, we ran separate models for each kin member.

2.2.5 Testing the hypothesized causal pathway

We used generalized structural equation modeling to explore the pathways by which we expect kin availability to influence reproductive outcomes. This method allows us to set up and test a plausible path model through which kin availability is linked to fertility: we test whether kin proximity influences kin contact, transfers of help, and ultimately, reproductive outcomes (see Figure 1). This allows us to determine if proxies for kin availability are working through expected pathways or if any associations may be due to other types of help or confounding effects. We use the "gsem" command in STATA (v. 13), which fits generalized structural equation models to simultaneously estimate the direct and indirect effects of kin availability and kin help on reproductive outcomes (Rabe-Hesketh, Skrondal, and Pickles 2004). All variables included in our model are observed variables (none are calculated as latent). Structural equation modeling allows us to create a visual representation of our model and estimate a series of models to obtain direct, indirect, and total effects of independent variables on the outcome of interest. Generalized structural equation modeling relaxes the constraints of structural equation models by allowing for continuous, binary, ordinal, count, and multinomial modeling of dependent variables and allows for interactions between independent variables. SEM cannot demonstrate causality, and our results should be interpreted as correlations; however, it does allow us to determine whether our hypothesized causal pathway is plausible or not.

2.2.6 Controls

Many controls were included in the analyses as they are known correlates of fertility. In all analyses, we controlled for religion and region. In the random effects logistic regression analyses we also included the following controls; completed educational level of respondent, urban or rural context, age of respondent, number of living children, age at marriage, whether the respondent had been married multiple times, a wealth indicator, and wave of interview.

Education is categorized as follows: no schooling, primary schooling (1−6 years), junior secondary schooling (7−9 years), senior secondary schooling (10−12 years), and tertiary schooling (13 or more years). In the structural equation model, education is entered as a continuous variable. Women classified each place of residence as an urban

or rural area. A wealth variable was constructed as a factor of number of rooms in the house, floor type, whether the house has electricity type of outer wall, and whether the house has a telephone (in 1993) or a television (in 1997, 2000, 2007). This variable has a mean of approximately zero and a standard deviation of one, where values greater than zero represent an above average amount of household wealth. For the random effects logistic regression analyses, age is measured in 5-year age categories; for the structural equation model, age is included as a continuous variable. Whether the respondent has been married multiple times is included as a binary variable defined as married once or married more than once. Number of living children ranges from 0 to 14 and is included in all models with its square term (which allows for a curvilinear effect). It is necessary to control for individual survey wave, as there were different lengths of time between waves, making progression to a birth more likely between certain waves.

In all models, we also included interactions between number of living children, its square term, and a wealth indicator as likelihood of progression to a birth depends on current number of living children and wealth; wealthier families are less likely to progress at higher numbers of children, and poorer families are more likely to progress at higher numbers of children.

3. Results

The descriptive statistics of the control variables are included in Table 1, including the percent of values which are missing. Figure 2 displays the mean z-score for age, household wealth, age at first marriage, number of living children, and education by status of each parent and parent-in-law. These variables are correlated with survival status and residence status of kin (dead parents are represented in shades of black; living − but non-resident parents are represented in shades of blue with a diagonal pattern; and co-resident parents are represented in shades of orange with a checker pattern). Respondents whose parents or parents-in-law are dead are, on average, older, have more living children, have less education, and married at a younger age. In contrast, individuals who have their parents or in-laws alive are younger, have fewer children, and higher levels of completed education. We observe that respondents who are residing with parents or in-laws are the youngest on average, with the highest level of education, the largest amount of household wealth, and the fewest number of living children. This suggests that lack of resources may not be driving co-residence with parents in this context.

Table 1: **Descriptive statistics of variables**

Continuous variables	mean	sd	n	% missing
age	31.91	7.29	12505	0.00%
wealth factor	0.027	0.96	12383	0.98%
age at first marriage	19.05	4.57	12390	0.92%
number of living children	2.50	1.75	12457	0.38%
Binary variables	**Yes**	**No**	**n**	**% missing**
married more than once	1348	11156	12504	0.01%
urban	5627	6877	12504	0.01%
had child before next wave	7501	5004	12505	0.00%
Categorical variables	**n**		**total n**	**% missing**
education			12482	0.18%
None	1251	10.02%		
Primary	6649	53.27%		
Jr. Secondary	1975	15.82%		
Sr. Secondary	2053	16.45%		
Tertiary	554	4.44%		
region			12505	0.00%
Sumatra	2581	20.64%		
Java	7247	57.95%		
Bali/Nusa Tenggara	1449	11.59%		
Kalimantan	618	4.94%		
Sulawesi	610	4.88%		
religion			12493	0.10%
Muslim	11,155	89.29%		
Hindu	661	5.29%		
Catholic	165	1.32%		
Protestant	441	3.53%		
Buddhist	54	0.43%		
Other	17	0.14%		
wave			12505	0.00%
1993	3608	28.85%		
1997	4074	32.58%		
2000	4823	38.57%		

Note: sd represents standard deviation; n represents number of cases (some individuals may be represented multiple times if they were sampled in multiple waves). If we only include individuals in the first wave in which they were sampled, the distribution of variables is quite consistent, with the exception of age (which is 2 years younger), having a child by the next wave (where only 52.9% of women progressed compared to 60.0% across all waves) and number of living children (which is 0.34 fewer children).

Figure 2: **Average z-score of age, wealth, age at first marriage, number of living children, and education as it is correlated with mother, father, mother-in-law, and father-in-law status**
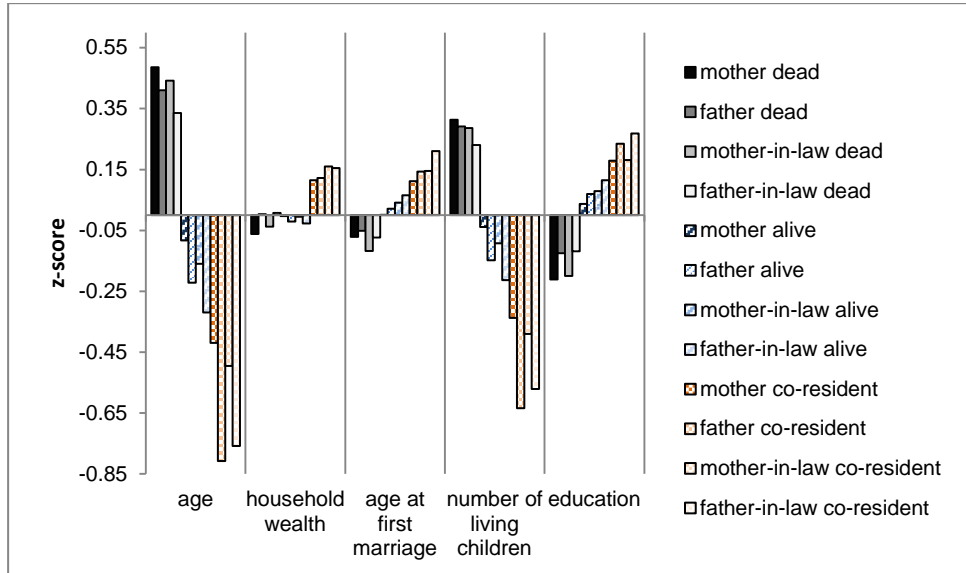
Note: Dead parents in shades of black, living but non-resident parents in shades of blue with a diagonal pattern, and co-resident parents in shades of orange with a checkered pattern.

3.1 Comparing kin availability measures

If we had limited data, for instance only survival status, village co-residence, household co-residence, or contact frequency, we might simply test whether our one measure of kin availability was correlated with the probability of birth, and draw conclusions on the results of this analysis. Table 2 presents the output from a series of models in which we have tested whether each of our four measures of kin availability, coded dichotomously, is correlated with the probability of progressing to a birth (controlling for potentially confounding variables) in order to compare across these different measures of kin availability in a single population. The results demonstrate some differences across kin availability measures, suggesting we would have drawn somewhat different conclusions had we only had access to a single kin availability measure. We find that mother's survival status and in-village residence positively predicts a progression to giving birth, but no other parent or in-law has a significant effect. Frequent contact with kin,

measured as at least weekly contact, is not associated with the progression to giving birth. However, if we compare co-resident kin with non-resident kin, we see that mothers-in-law have a significantly positive effect on progression, though only when women do not have living offspring (see Supplementary Material Figure 1 for the graph of the predicted probabilities of progression to birth by number of living children for mothers-in-law). In the following sections, we explore these different types of kin availability measures in more detail, in order to fully understand how each measure of kin availability may be correlated with the progression to birth, and to build our causal pathway model.

Table 2: **Random effects logistic regression analyses predicting progression to a birth before the next wave by a) kin survivorship, b) village co-residence, c) frequent contact with kin, and d) household co-residence**

	a) Alive v. Dead		b) In Village v. Not		c) Frequent Contact v. Not		d) Co-resident v. Not	
	OR	SE	OR	SE	OR	SE	OR	SE
Mother	1.111^	0.071	1.174*	0.085	0.998	0.060	0.995	0.089
Father	1.028	0.055	0.976	0.076	1.052	0.066	0.992	0.113
Mother-in-law	1.069	0.062	0.901	0.066	0.993	0.059	1.562*	0.316
Father-in-law	1.000	0.053	1.081	0.087	0.957	0.061	0.871	0.120
Mother-in-law * Number of children							0.667**	0.098
Mother-in-law * Number of children2							1.078**	0.026

Note: ^ p < 0.10, * p < .05, ** p < .01, OR = odds ratio, SE = standard error. Coefficients for kin refer to the odds ratios of progression to a birth for having the kin member a) being alive compared with being dead, b) living in the same village compared with living elsewhere or being dead c) having at least weekly contact compared with having less frequent contact or being dead, and d) living in the same household compared with living elsewhere or being dead. Models control for region, religion, urban/rural residence, education, age category, age at marriage, married more than once, wave, number of living children, number of living children squared, wealth and the interactions between wealth, number of living children and number of living children squared,.

3.2 Comparing residence and survival status of kin

To explore the effect of kin survivorship and co-residence in more detail, we split up our kin categories into: co-resident, alive (but not co-resident) and dead. Table 3a presents the proportion of cases according to this categorization (note that some women may be represented multiple times in this table if they were interviewed in multiple waves). We can see that women are most likely to have dead fathers-in-law and least likely to have dead mothers, as expected, given typical age differences between men and women at marriage. Figure 3 (see Supplementary Material Table 1 for full model) presents the predicted probabilities of the random effects logistic regression analysis examining the effect of parental co-residence and survival on progression to a birth.

There is a significant interaction between parental status, number of living children, and number of living children squared; where the negative linear and the positive quadratic terms indicate progression to next birth decreases with number of children, but at a decreasing rate. To visualize this interaction, we include charts for women with differing numbers of living children. The results show that when a married woman has no living children, co-residence with her mother, father or mother-in-law has a positive effect on the likelihood of her progressing to her first birth. Additionally, father-in-law and mother's survival (but not co-residence) has a significant positive effect on progression to first birth.

Table 3: **Number (and %) of respondents with parents in the following categories: a) survival/co-resident status, b) geographic proximity, c) face-to-face contact and d) receiving help**

	Mother	Father	Mother-in-law	Father-in-law
a. Survival/Co-resident				
Co-resident	1738 (13.9%)	967 (7.7 %)	1162 (9.3%)	650 (5.2%)
Alive (not co-resident)	7912 (63.3%)	6251 (50.0%)	7367 (59.0%)	5311 (42.5%)
Dead	2852 (22.8%)	5283 (42.3%)	3969 (31.8%)	6537 (52.3%)
b. Geographic Proximity				
In village	2514 (47.8%)	1896 (45.7%)	2171 (48.8%)	1561 (48.3%)
In district	1330 (25.3%)	1098 (26.5%)	1054 (23.7%)	802 (24.8%)
In province	718 (13.7%)	609 (14.7%)	596 (13.4%)	433 (13.4%)
Out of province	693 (13.2%)	545 (13.1%)	628 (14.1%)	436 (13.5%)
c. Face-to-face contact				
At least weekly	4664 (60.3%)	3495 (57.9%)	4182 (63.8%)	2987 (63.6%)
At least monthly	1439 (18.6%)	1132 (18.8%)	1038 (15.8%)	710 (15.1%)
At least yearly	1373 (17.7%)	1122 (18.6%)	1074 (16.4%)	800 (17.0%)
Never	264 (3.4%)	288 (4.8%)	258 (3.9%)	200 (4.3%)
d. Receiving help				
No help received	4122 (53.6%)	3241 (53.8%)	4155 (63.8%)	2898 (61.8%)
Help received	3572 (46.4%)	2784 (46.2%)	2361 (36.2%)	1793 (38.2%)

Note: Some women have been included multiple times if they were interviewed in multiple waves. Individuals included in b,c,d report information (geographic proximity, face-to-face contact, and receiving help) from non-resident, surviving kin.

The effect of co-residence changes after the first birth. Once a woman already has a child, co-residence with her mother does not have a significant effect on progression to a birth, while co-residence with her mother-in-law has a marginally significant positive effect. Additionally, the results show a significant positive effect of both mother and father-in-law's survivorship (but not co-residence) compared with the reference category of 'dead' on progression to a second birth. For women with two children, parental status (dead, alive, co-resident) across all parents and in-laws has no significant effect on progression to third birth. For women with three children, co-

residence with one's father and survival (but not co-residence) of one's father-in-law has a negative effect on progression to fourth child (as compared with having a dead father or father-in-law), while for mothers and mothers-in-law there is no significant effect.

Figure 3: **Predicted probability of progressing to a birth by the next wave by parent and parent-in-law status (dead, alive, co-resident) based on number of living children**
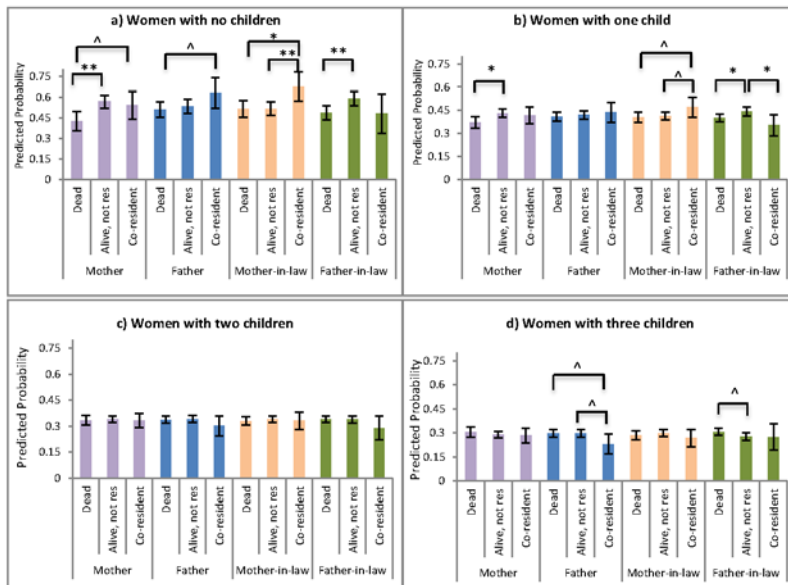
Note: ^ p < .10, * p < .05, ** p < .01. Error bars represent 95% confidence intervals. Model controls for: region, religion, urban/rural residence, education, age (categorized in 5-year age groups), age at first marriage, whether respondent has been married more than once, wave, number of living children, number of living children squared, a wealth indicator, and interactions between wealth, number of living children, and number of living children squared.

These results show that a parent's status affects a woman's fertility differently depending on number of living children she already has. Co-residence with one's mother, father or mother-in-law has a positive effect on fertility when women have few offspring. The effect of survival status (excluding co-resident kin) is only significant for mothers and fathers-in-law at zero and one living offspring; where the survivorship of a mother or father-in-law has a positive effect on progression to a birth. After several children, the effect of kin, particularly fathers and fathers-in-law tends to be more

negative, where women with co-resident fathers and those with a living (but not co-resident) father-in-law are less likely to progress to a birth. This suggests that the positive effect of kin occurs more frequently at low parities, while the negative effect of male kin is more likely to occur at higher parities.

3.3 Geographical proximity

Survival status is a crude proxy for kin availability, since just knowing that parents or in-laws are alive does not tell us if they are living near their adult children or are in contact with them. In this section and the next, we explicitly model the influence of geographical proximity and contact frequency of non-resident parents and in-laws on fertility (for those parents/in-laws who are still alive but not co-resident with the index woman), to determine whether correlations are more likely to be seen for those kin who are more accessible to women and therefore more likely to provide physical help and emotional support.

In all models in both this section and the next, each parent is analyzed in a separate model because women have different combinations of co-resident parents and in-laws. If we include all kin in one model, we eliminate all women who were co-resident with any other kin (although the results of a single model with all kin included are substantively similar, not shown).

Table 3b presents the distribution of geographic proximities of parents and in-laws (note that the sample sizes are smaller than Table 3a because geographic proximity was not collected in 1997). Having kin in the same village is most frequent, and accounts for about half of surviving, non-resident kin; the remaining kin are roughly equally divided between those that live in the woman's district (but not village) and those that live out of the district (either in the same province or another province). These proportions are similar for all types of kin.

Figure 4 presents the predicted probabilities of the random effects logistic regression model of parent's geographic proximity on progression to a birth before the next wave, categorized as same village, same district (but different village), same province (but different district), and out of province (see Supplementary Material Table 2 for the full model). No interactions with number of living children were significant in this model. For mother's and father's location, there is no significant effect of geographic proximity on the progression to giving birth. In contrast, the results for mothers-in-law and fathers-in-law are significant, but they are not in the predicted direction. Mothers-in-law and fathers-in-law living outside the province are associated with an increased likelihood of progression to a birth before the next wave, as compared to in-laws living in the same village.

Figure 4: **Predicted probability of progressing to a birth by geographic proximity of kin**
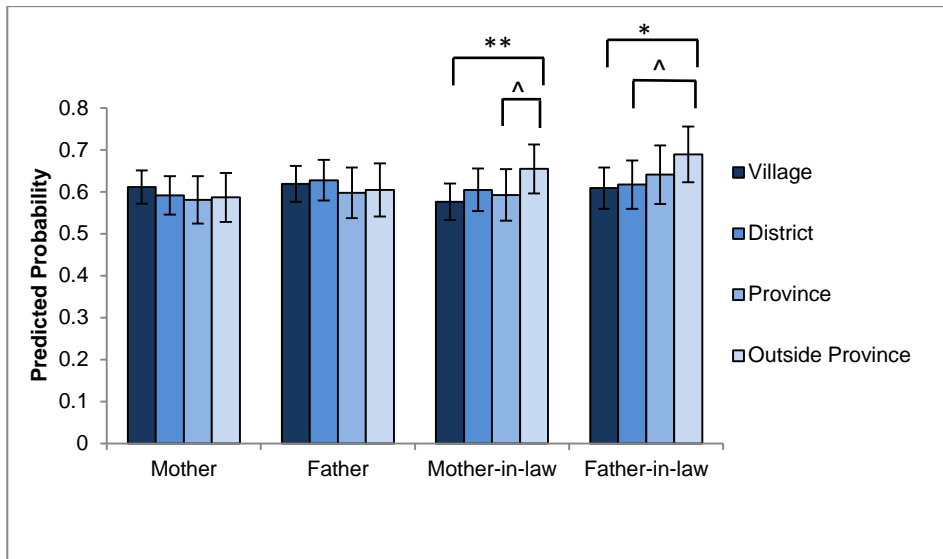
Note: ^ p < .10, * p < 0.05, ** p < 0.01; Error bars represent 95% confidence intervals. Predicted probability based on random effects logistic model controlling for: region, religion, urban/rural, education, age (in 5-year age categories), age at first marriage, whether respondent has been married more than once, wave, wealth indicator, number of living children, number of living children squared, and interactions between wealth, number of living children, and number of living children squared. Predicted probabilities are based on the means of covariates in the model, except for the age category, which was calculated for the 25−29 age group.

3.4 Contact frequency

Table 3c presents parents' and parents-in-law's distribution of face-to-face contact frequencies. When reporting their contact frequency with kin, approximately 60% of women report at least weekly contact with kin (of kin who are not co-resident, but alive). The proportion of women seeing kin monthly or yearly is much less, with about 15−20% for each kin category. Finally, less than 5% of women report never seeing their kin.

Figure 5 presents the predicted probability of progression to a birth based on parental contact frequency from the random effects logistic model (which can be found in Supplementary Material Table 3). As in the geographic proximity models, each parent is entered into a separate model. The results show that there are no significant differences between amount of face-to-face contact and the likelihood of progressing to

a birth for mothers-in-law and fathers-in-law. Monthly contact with mothers and fathers results in a positive effect in comparison to individuals with weekly or yearly contact with parents. Again, these results were not as expected, as we have no a priori reason to predict that monthly contact should be greater than both weekly and yearly contact.

**Figure 5:   Predicted probability of progressing to a birth by contact frequency**
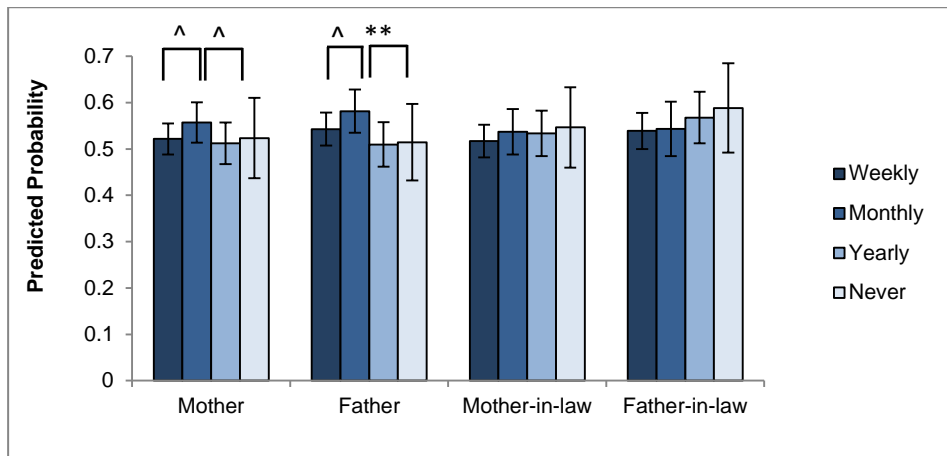
Note: ^ p < 0.10, ** p < 0.01. Error bars represent 95% confidence intervals. Predicted probability based on random effects logistic model controlling for: region, religion, urban/rural, education, age (in 5-year age categories), age at first marriage, whether respondent has been married more than once, wave, wealth indicator, number of living children, number of living children squared, and interactions between wealth, number of living children, and number of living children squared. Predicted probabilities are based on the means of covariates in the model, except for the age category, which was calculated for the 25−29 age group.

3.5 Receiving help

Based on our hypothesized causal model from Figure 1, we expect that one route by which kin influence fertility is by the help they provide. In this case, we expect that women who receive help can more easily progress to a birth. The proportion of help received by parents and in-laws is presented in Table 3d. Parents are more likely to provide help than parents-in-law, although more than half of respondents with surviving, non-resident kin report not receiving help from parents (approximately 53%) and even more reported not receiving help from parents-in-law (approximately 62%).

The predicted probability of giving birth based on parental help is shown in Figure 6 (for full model see Supplementary Material Table 4). There is a significant interaction between receiving help and number of living children for mothers, mothers-in-law and

fathers-in-law, while this interaction is not significant for fathers, we have included the interaction to plot the effect of help by number of living children across all parental categories. For women with fewer than three children, receiving help from one's mother or mother-in-law has a significantly positive effect on progression to giving birth. For fathers and fathers-in-law the effect is also positive, but tends to be only marginally significant. With increasing numbers of children, though, this effect is reduced, and once women have three living children, the effect of kin is no longer significant.

Figure 6:   Predicted probability of progressing to a birth based on whether the respondent is receiving help from parents and parents-in-law
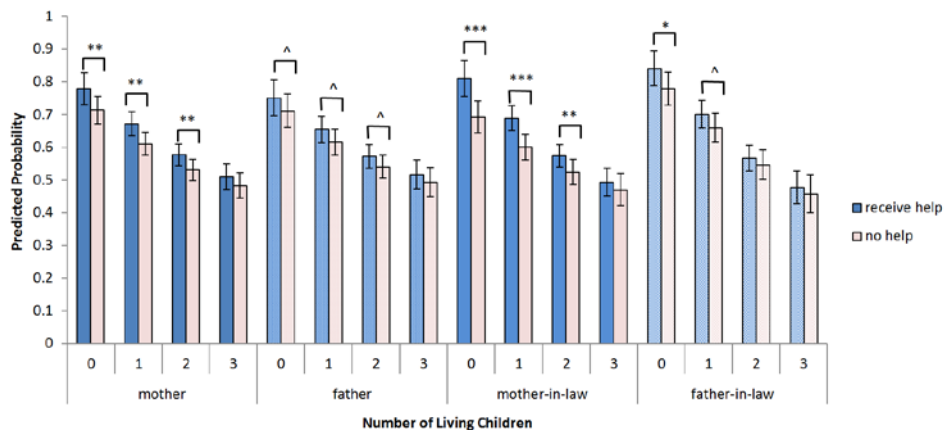
Note: ^ p < 0.10, * p < .05, ** p < 0.01, *** p < 0.001 Error bars represent 95% confidence intervals. Predicted probabilities are based on the random effects logistic regression presented in Supplementary Material Table 4 which controls for region, religion, urban/rural, education, age (in 5-year age categories), age at first marriage, whether respondent has been married more than once, wave, wealth indicator, number of living children, number of living children squared, and interactions between wealth, number of living children, and number of living children squared. Predicted probabilities are based on the means of covariates in the model, except for the age category, which was calculated for the 25−29 age group.

3.6 Testing the hypothesized causal pathway

After exploring how the measures of parental availability influence fertility, we want to test the hypothesized causal pathway − that kin influences on fertility act through geographical proximity, contact frequency, and help received. Our structural equation model tests the pathway presented in Figure 1. Figure 7 presents the path analyses for mothers, fathers, mothers-in-law, and fathers-in-law (all analyses conducted separately). Across all parental types, geographic proximity is a significantly positive predictor of

face-to-face contact frequency, and contact frequency is a significantly positive predictor of receiving help. Geographic proximity also has a significant (or marginally significant) effect on receiving help, even after the effect through contact frequency is controlled for, where closer geographic proximity predicts receiving help. The effect of receiving help on progressing to a birth is less consistent. It is significant for mothers-in-law, fathers-in-law, and mothers, where in all cases receiving help is associated with an increased probability of progressing to a birth. The effect of fathers is not significant, although still positive. These results slightly contrast those from the 'receiving help' section above, because when we include geographic proximity – which was not reported in 1997 − into the model, our sample size decreases by one-third. This reduction in sample size is enough to increase the standard error of helping behavior on births from the previous analyses to non-significant effects found in the path model for fathers.

For parents (both mothers and fathers), there is not a significant effect of geographic proximity and contact frequency on having a birth after the pathway through helping behavior is controlled for. However, this is not the case for in-laws: in the case of mothers-in-law and fathers-in-law geographic proximity has a significant negative effect on progression to a birth. This suggests that when controlling for contact frequency and helping behavior, close geographic proximity actually has a negative effect on birth progression. These effects are relatively consistent with the results we found in the previous sections, where geographic proximity has a significant negative effect on progression to birth, but receiving help has a significant positive effect on birth progression.

Overall, our path models broadly support our hypothesis that kin availability influences progression to births through helping behavior. For all four types of kin, greater geographic proximity and contact frequency are correlated with more helping behavior, and more help is associated with a higher probability of a birth. This last pathway, however, is not significant for fathers. Examining effect sizes suggests that help from mothers-in-law has the largest impact on fertility (compared to mothers, fathers and fathers-in-law) and that help is the main pathway by which kin positively influence fertility.

Finally, we also conduct a random effects regression analysis predicting progression to a birth, including the three measures of kin availability − receiving help, geographic proximity and face-to-face contact – to allow for a comparison with the SEM model (see Supplementary Material Table 5). These results are substantively the same as the SEM model; help from one's mother-in-law, father-in-law, or mother is a significant predictor of progression to a birth after controlling for all other kin availability measures and geographic proximity of mothers-in-law and fathers-in-law is negative after controlling for other kin availability measures.

Figure 7: **Generalized structural equation model of the effect of kin proximity, contact, and help on progression to a birth for the following kin: a) mothers b) fathers c) mothers-in-law and d) fathers-in-law**
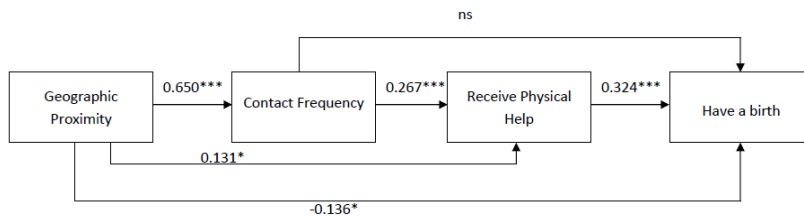
a) Mother
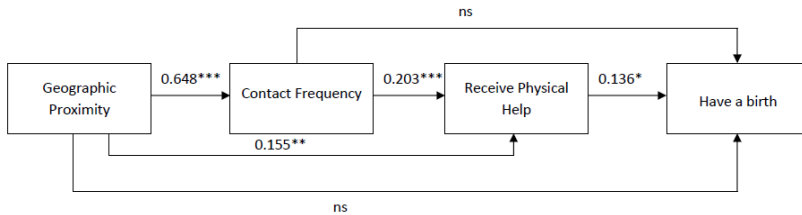
b) Father
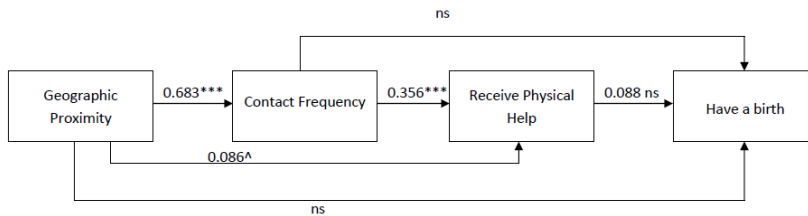
c) Mother in-law

d) Father in-law
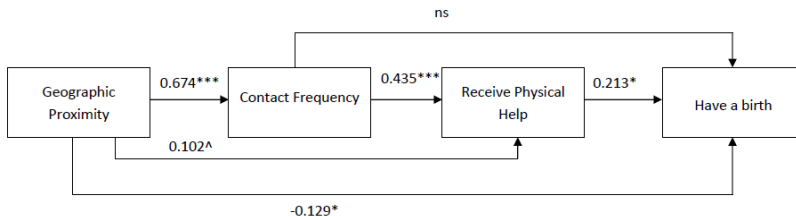
Note: ^ p < 0.10, * p < 0.05, ** p< 0.01, ***p < 0.001, ns represents p > 0.10. All generalized structural equation models control for region, religion, urban/rural, education, age, age at first marriage, whether respondent has been married more than once, wave, wealth indicator, number of living children, number of living children squared, and interactions between number of living children, living children squared, and wealth.

Table 4:   Summary of results: predicting progression to a birth before next wave

	Co-residence	Survival	Close Geographic Proximity	Frequent Contact	Help	Path Analysis provides support for hypothesis that help mediates kin effects?
Mother	+ (ms) NLC= 0	+ NLC <= 1	ns	- (ms) compared to monthly	+ NLC <= 2	Yes
Father	+ (ms) NLC = 0, - (ms) NLC = 3	ns	ns	- (ms) compared to monthly	+ (ms) NLC <= 2	No
Mother-in-law	+ NLC = 0, + (ms) NLC = 1	ns	-	ns	+ NLC <= 2	Yes
Father-in-law	ns	+ NLC <= 1, - NLC = 3	-	ns	+ NLC <= 1	Yes

Note: NLC = number of living children, ns = not significant (p-value > 0.10), ms = marginally significant (.05 < p-value < .10), + represents an increase in the probability of progression to a birth, - represents a decrease in the probability of progression to a birth. 'Co-residence' is compared to a reference category of dead parents and 'Survival' only includes non-resident parents.

4. Discussion

Our first aim was to directly compare the effects of kin survival status, co-residence, proximity, and contact frequency as these are common proxies for kin availability. We have summarized these results in Table 2, which presents the simplest analysis of each kin availability measure, where each measure is coded dichotomously, and Table 4, which summarizes our more nuanced analyses, where we distinguished between different categories of each variable, e.g., proximity is coded according to distance. The first conclusion that can be drawn from these tables is that, when correlations are seen between kin and fertility, these correlations are generally positive, particularly at low parties, suggesting the presence of kin may increase fertility (exceptions are a negative effect of village contact compared to living out of the province for in-laws and a negative effect of weekly contact compared to monthly contact for parents). While we expect parents and in-laws to have greater effects at low parties, as by the time women reach greater numbers of offspring their parents and parents-in-law will be older and less able to help, and women may also have alternative helpers in their early born children, this result has not received much attention in the existing literature as it requires relatively large sample sizes to demonstrate. We also observe the way in which kin availability is measured does affect the conclusions one would make. For instance, co-residence with mothers-in-law tends to have a more positive effect on progression to births than survival status, geographic proximity or contact frequency, while survival

status of mothers tends to have a more positive effect on progression to births than co-residence, geographic proximity or contact frequency. Further, the positive effects of co-residence are strongest when women have few surviving children, which implies that positive kin influences on fertility may be particularly noticeable if kin availability is measured as postnuptial residence (i.e., co-residence immediately after marriage). We can actually examine the effect of post-marital residence on number of living children in the Indonesia Family Life Survey. The results of a Poisson regression show that both matrilocal and patrilocal post-marital residence has a positive effect on number of living children (after controlling for likely confounding factors), but the effect of patrilocality is about 50% larger than that of matrilocality (see Supplementary Material Table 6 for full results).

These tables also suggest that if we had limited data, for instance, only survival status, village co-residence, or contact frequency, we might have concluded, given that most of our results were not significant (see Table 2), that kin have little or no effect on fertility in this context. When we are directly able to analyze the effects of helping behavior from kin, however, we find that this is the only measure which is positively correlated with progression to births across all four kin categories, though the correlations are strongest when women have fewer than three children. This suggests that it is only when we actually explore the pathway of kin effects - separating the kin who provide help from those who do not – that we can see the positive effect of kin on progression to births.

Our second aim was to test the hypothesized causal pathway by which we expect kin to influence fertility outcomes, and the results of our path analyses are also summarized in Table 4. Our path analyses provide some support for our hypothesized causal pathway across all parental types; in all models geographic proximity predicts contact frequency, and contact frequency predicts helping behavior. Helping behavior only significantly predicts births in the case of mothers, mothers-in-law, and fathers-in-law, but the effects are consistently positive across all parental groups. This suggests that helping behavior does increase the likelihood of birth progression – although the effect is strongest for mothers-in-law. The effect of helping behavior on births is actually smallest for fathers and then mothers, which is somewhat surprising given that mothers are most likely to provide help. While help has a positive effect on birth progression for both mothers-in-law and fathers-in-law, geographic proximity instead has a negative effect on birth progression (counter to predictions; see Figure 4), which remains even after controlling for contact frequency and help (see Figure 7). This suggests that when in-laws live nearby, but do not have much contact nor provide help, their presence actually reduces fertility outcomes. A similar result was found in Puerto Rico, where women who lived geographically close to their mothers, but did not receive support from them actually had increased odds of infant death and low birth weight

offspring (Scelza 2011). For women who have geographically close kin, but have poor relationships with them, their fertility may actually be reduced.

Why would parents (mothers and fathers) provide help if their help has a small effect on reproductive success? It is possible that most of parent's help is converted into improved health outcomes for children. This effect is consistent with the literature showing that the presence of parents-in-law is associated more with increased fertility than parental presence (Snopkowski and Sear 2013; Sear and Coall 2011). There is substantial evidence suggesting that the availability of mothers is associated with improved child survival (Sear and Mace 2008). This would explain why parents' help has less of a direct effect on progression to a birth than parents-in-law. In contrast, parents-in-law, particularly mothers-in-law, are consistently found to be associated with increased fertility rates (Sear, Mace, and McGregor 2003; Snopkowski and Sear 2013; Tymicki 2004). Some have argued that this may be a manipulative strategy by in-laws to increase an unrelated daughter-in-law's fertility (Leonetti et al. 2007), while others suggest that it may be adaptive for women to increase their fertility in contexts where they have few kin around to help (such as patrilocal contexts, where most household members will not be related kin) (Johnstone and Cant 2010; Moya, Snopkowski, and Sear 2016).

While previous research has mostly found correlations between parental presence and fertility outcomes, we actually test a hypothesized causal pathway of how kin presence may influence fertility outcomes. The results show positive kin effects on fertility occur *when kin provide physical help*. Contact frequency does not have a significant effect on births (after controlling for the path through help), which suggests that non-physical help or pressure is *not* the main route by which kin influence fertility in this context. Overall, these results provide evidence in support of cooperative breeding and inclusive fitness models – that kin presence influences fertility outcomes when kin provide help to reproducing women.

A large percentage of women in this survey did not report receiving help from kin – over 50% for each kin category, although this excludes co-resident kin, who may provide more help than non-resident kin (for example, with childcare (Chen, Short, and Entwisle 2000; Vandell et al. 2003)). Perhaps kin who do not provide help are in need of help themselves. However, we did attempt to test this possibility by re-running all of our analyses including variables which controlled for help *provided to* kin, and these control variables did not alter our results (results not shown). It is possible that the relatively large proportions of women not receiving help might be the reason why we see relatively few correlations between fertility and our kin measures of survival status, proximity and contact frequency in our initial models. We might expect that in contexts where we have larger proportions of kin providing help, survival status, geographic proximity, and contact frequency may have a larger positive effect on birth progression.

Indonesia has considerable ethnic and regional variation, which may mask kin influences because of different patterns of kin interactions in different groups within the country, or may result in conclusions being generalized to the whole country, when results are actually driven by particular groups within the country. In the analyses described above, we tried to account for these differences by controlling for region in our analyses; we have also run analyses to determine whether our results are robust to variations across regions. In Supplementary Material Figure 2, we re-analyzed parental survival and co-residence using a random effects logistic regression, where we ran each analysis separately by region (we excluded Kalimantan because the sample size was too small for the model to converge). The effect of mothers is quite similar across regions, where having a co-resident or surviving mother tends to have a positive effect on the progression to a birth (compared to having a dead mother) when women have few living children. The only exception occurs in Bali/Nusa Tenggara, where women who report living with their mothers have a lower likelihood of birth progression, particularly at low parities. Bali/Nusa Tenggara is patrilocal, which suggests that in contexts where it is non-normative to live with one's mother, actually doing so results in fitness consequences. Across all regions, co-residence with one's mother-in-law (compared to having a dead mother-in-law) has a positive effect on progression to a birth for women who have no or few living offspring. Fathers tend to have a positive effect on progression to a birth if they are co-resident at low-parities, with the exception of Sulawesi, where co-residence at high parities has a positive effect. The effect of fathers-in-law is quite variable across contexts; in some regions the effect of living with one's father-in-law is negative while in others it is positive. We might not expect the effects of fathers and fathers-in-law to be as consistent due to the possible option for men to marry additional wives (polygyny is legal under strict circumstances in Indonesia), which may cause men to invest in mating effort over parenting (or grandparenting) effort. Additionally, given that men tend to be older at marriage, women are less likely to have their fathers or fathers-in-law still alive, reducing our sample size for these analyses. Our main conclusion from this analysis is that co-residence with one's mother or mother-in-law has a positive effect for women with few living offspring in most regions (with the exception of Bali/Nusa Tenggara for mothers).

In Supplementary Material Table 7, we look at the direction of the effects for the structural equation model for each region. The effects of geographic proximity on contact frequency and contact frequency on help are consistently positive across all regions. The effect of helping behavior on progression to a birth is consistently positive across Sumatra, Java, Bali/Nusa Tenggara, and Kalimantan, except for mothers in Sumatra, which have a negative effect. In Sulawesi, receiving help from kin (mothers, fathers, mothers-in-law, or fathers-in-law) always has a negative effect on progression

to birth. This is surprising and suggests that the role of kin help may be inherently different in Sulawesi than in other parts of the country. Our other main conclusions, that mother-in-law's and father-in-law's geographic proximity has a negative effect on progression to a birth when controlling for contact frequency and help is consistent in Sumatra, Java, and Bali/Nusa Tengarra. In Sulawesi, the negative effect only occurs for mothers-in-law and in Kalimantan, the effect is positive for both mothers-in-law and fathers-in-law. Unfortunately, because the sample sizes become quite small for some regions, we may not expect to find significant results. Fortunately, the strongest result – that kin help is the main route by which kin influence fertility outcomes − is generally consistent across all regions, with the exception of Sulawesi, a region where less than 5% of the sample resides.

While our study takes a large step forward in understanding how kin influence fertility outcomes, there are several limitations to this study. First, we have no information on help from co-resident kin. This likely indicates that we are underestimating the amount of help that respondents receive, and we are unable to analyze the hypothesized causal pathway using co-resident kin. Second, we have no information on non-physical help or pro-natalist pressure from kin to reproduce. Third, all of our measures are based on self-report, which are subject to recall-bias and cannot be confirmed by interviewers.

This research suggests that the way kin presence is measured can alter one's conclusions. Therefore, it is important for researchers to determine the best operationalization of kin availability for their context, as it is likely to vary depending on cultural and ecological factors, and be explicit about which measure of kin availability is being used and why (including potential limitations of that particular measure). It is also important to conduct mediation analyses to understand the pathways of kin influence to disentangle direct and indirect effects, which may obscure the effect of kin on fertility. In conclusion, we need to move from a basic presence/absence model to understanding the mechanisms by which kin are influencing fertility, and be more explicit regarding the time at which we expect certain outcomes.

5. Acknowledgements

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