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Is there an adverse effect of sons on maternal longevity?

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Recent years have witnessed the emergence of a literature examining the effects of giving birth to sons on postmenopausal longevity in pre-industrial mothers. The original paper in this lineage used a sample ($n=375$) of Sami mothers from northern Finland and found that, relative to daughters, giving birth to sons substantially reduced maternal longevity. We examine this hypothesis using a similar and a much larger sample ($n=930$) of pre-industrial Sami women from northern Sweden, who in terms of their demographic, sociocultural and biological conditions, closely resemble the original study population. In contrast to the previously reported results for the Sami, we find no evidence of a negative effect of sons on maternal longevity. Thus, we provide the most compelling evidence to date that the leading result in the literature must be approached with scepticism.

Keywords: maternal longevity; sons; parity

1. INTRODUCTION

Did giving birth to sons reduce maternal old-age longevity in pre-industrial humans? This question was posed, and answered in the affirmative, by Helle, Lummaa and Jokela (henceforth HLJ; Helle *et al.* 2002*a*,*b*) who used a sample of 375 pre-industrial Sami women from northern Finland. Restricting the sample to mothers who reached an age of at least 50, and regressing the longevity of these mothers on the number of sons and daughters produced, the authors found that maternal longevity decreased by 0.65 years for each son born while it increased by 0.44 years for each daughter.

These results, and their interpretation as evidence in favour of negative 'effects' of sons on maternal longevity, drew criticism almost immediately. In a rejoinder to HLJ, Beise & Voland (2002) reported no evidence for an association between the number of sons born and maternal longevity in neither Canadian nor German pre-industrial populations. Helle *et al.* (2002b, p. 317) retorted that Beise and Voland had made a 'disputable attempt to refute our conclusions', citing the unique demographic, sociocultural and ecological conditions of the Sami. Since the original HLJ paper made a general claim about sons reducing longevity in pre-industrial mothers, and not just in their Sami study population, this response is not fully satisfactory. Yet, the HLJ reply did make the valid point that, in principle, it is possible that the relationship between the number of sons born and old-age maternal longevity varies considerably depending on cultural and biological conditions that may be idiosyncratic to each population studied.

Additional fuel to Beise and Voland's scepticism has been offered by a number of recent attempts to replicate HLJ's findings in other populations. For instance, Van de Putte *et al.* (2004) studied women in a Flemish agricultural village, born between 1700 and 1870. In their baseline regression, there was only weak evidence for a negative correlation between number of sons and maternal longevity, although the association did become statistically significant when the sample was restricted to women born before 1815 married to 'ordinary labourers'. Furthermore, no evidence for differential effects on longevity by the sex of offspring was found by Jasienska *et al.* (2006) in a study of mothers in rural Poland. Similarly, Hurt *et al.* (2006) failed to find any association between the number of sons and maternal mortality in a sample from modern-day Bangladesh. Finally, Cesarini *et al.* (2007) reported null results for a large sample of eighteenth and nineteenth century women from northern Sweden. A recent paper by Harrell *et al.* (2008) did, however, find some evidence of a relationship between the sex composition of offspring and maternal longevity, but the estimated coefficients were small. Taken together, these papers uniformly find much weaker associations between the number of sons born and maternal longevity than the original HLJ paper did. In fact, a majority of published papers fail to find a stable and significant relationship.

The hypothesis that the sex of offspring might have adverse long-term effects on maternal longevity is not unreasonable, *a priori*. A distinction can be made between biological and environmental mechanisms through which the sex composition of a mother's children might matter (Van de Putte *et al.* 2004; Harrell *et al.* 2008). It is well known that the physiological costs of childbearing are higher for sons, as evidenced by their higher intrauterine growth rates, birth weights (Marsal *et al.* 1996; de Zegher *et al.* 1999) and the greater maternal energy intake during male pregnancies (Tamimi *et al.* 2003). Furthermore, women carrying male foetuses have elevated levels of testosterone (Meulenberg & Hofman 1991), a known immunosuppressant (Folstad & Karter 1992). In addition to biological channels, it has been proposed that daughters

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may relieve the burden on their mothers to carry out domestic tasks (e.g. Turke 1988; Hames & Draper 2004). However, what is at stake is not whether these theoretical channels are plausible, but whether they are consistent with the body of empirical evidence.

In this paper, we ask whether there is merit to HLJ's claim that the unique demographic, sociocultural and biological conditions that characterize their Sami study population can explain the inconsistencies between their findings and the subsequent replication attempts. We test the hypothesis that the sex composition of offspring affects postmenopausal longevity using a sample of Sami women almost three times larger than that in HLJ. While there is some cultural and genetic heterogeneity among different Sami populations, this heterogeneity is comparatively small. As a group, the Sami can be culturally and genetically distinguished from other European populations, and they are often thought of as an outlier (Roung 1969; Nickul 1977; Tambets *et al.* 2004). This cultural and genetic uniqueness shared by our and HLJ's sample populations, combined with the fact that the border between Sweden and Finland is a recent construction that never actually hindered contact, arguably makes the Sami of northern Sweden ideal for replicating HLJ.

As we have indicated elsewhere, we have misgivings about the methodological approach taken by HLJ (Cesarini *et al.* 2007), but we will suppress these concerns here as far as possible and focus primarily on the issue of replicability. To preview our results, we find no evidence in favour of the hypothesis that sons had a negative impact, relative to daughters, on maternal longevity. That is, holding parity constant, there is no evidence that mothers with more sons had a shorter postmenopausal longevity in our Sami population.

2. MATERIAL AND METHODS

The regression run by HLJ is of the form,

$$Y_i = \beta_0 + \beta_1 x_i + \beta_2 z_i + \beta_3 d_i + \epsilon_i, \tag{2.1}$$

where Y_i is the longevity of mother i; x_i is the longevity of the husband of mother i; z_i is the number of sons of mother i; and d_i is the number of daughters of mother i. Note that if parity (z_i+d_i) is correlated with unobserved variables that affect old-age longevity, such as health or wealth, then the estimates will be biased due to omitted variable bias. Indeed, evidence from both hunter–gatherer and agro-pastoralist, as well modern industrial, societies suggests that family size is correlated with health, wealth and other indicators of longevity, although the strength and direction of this correlation may vary (see, for instance, Kaplan 1996; Dolbhammer & Oeppen 2003). If this is true also in our population, the results in HLJ tell us only whether giving birth to sons is a predictor of longevity, but do not speak about the issue of causality, contrary to what is implied by the title of HLJ's paper. Under less restrictive assumptions, however, any significant difference in the regression coefficients such that $\hat{\beta}_2 - \hat{\beta}_3 \lesssim 0$ can be interpreted as reflecting a difference in the relative cost of producing a son or a daughter (Cesarini *et al.* 2007). Consider a simple rearrangement of equation (2.1) as follows:

$$Y_i = \alpha_0 + \alpha_1 x_i + \alpha_2 z_i + \alpha_3 n_i + \epsilon_i, \tag{2.2}$$

where n_i is the parity of mother i (i.e. $n_i = z_i + d_i$). This is equivalent to the regression in HLJ with $\alpha_0 = \beta_0$, $\alpha_1 = \beta_1$ and $\alpha_2 = \beta_2 - \beta_3$. If α_2 is negative, this means that giving birth to sons is costlier relative to daughters. Note that α_2 can be negative even if both boys and girls have a positive causal effect on longevity (i.e. if $\beta_3 > \beta_2 > 0$). The more general issue of how parity is associated with parental longevity is reviewed in Le Bourg (2007).

The rearrangement in equation (2.2) is only for expositional convenience. The estimated α_2 in equation (2.2) is mathematically equivalent to the estimate of $\beta_2 - \beta_3$ in equation (2.1). Cesarini *et al.* (2007) provided a more thorough discussion on this point.

Table 1. Sample parishes.

parish	number of women
Frostvikens lappförsamling	13
Föllinge	4
Föllinge lappförsamling	21
Gällivare	286
Hede lappförsamling	3
Hotagen	12
Hotagens lappförsampling	7
Jokkmokk	153
Jukkasjärvi	164
Karesuando	212
Kvikkjokk	41
Undersåkers lappförsamling	14
Σ	930

3. DATA

Our dataset was constructed by the staff at the Demographic Database at Umeå University, Sweden specifically for the purpose of this paper. The sample consists of Sami women whose reproductive history is known, and who were born between 1698 and 1840 in either one of the 12 studied parishes (table 1) belonging to the counties Jämtland and Norrbotten. The sample is restricted to women who reached the age of 50 and had at least one child. These selection criteria are equivalent to those used by HLJ.

The data sources are separate registers of catechetical examinations, births and baptisms, banns and marriages, migration, deaths and burials. There are, of course, uncertainties concerning the completeness of the data. However, there is no reason to believe that faulty or missing information has affected the data in any way that will introduce a systematic bias. Importantly, our original sources are fully comparable to those used by HLJ as the laws governing the keeping of parochial records were identical in the two countries for the vast majority of the sample period.

Our classification of Sami ethnicity is based on unpublished research at Umeå University by Peter Sköld, Per Axelsson and Gabriella Nordin. The staff at the Demographic Database created six different indicator variables for Sami ethnicity. The two most informative indicators are based on an individual's place of residence and notes about relatives' (siblings and parents) ethnic affiliation. Several villages and areas are known to have been populated almost exclusively by the Sami during our sample period. Additionally, there are Sami indicator variables based on miscellaneous remarks made by the priest, occupational status, surnames or whether a death

Table 2. Sons and maternal longevity. (Heteroskedasticity robust standard errors (White 1980) in parentheses. Significant at *5%, **1%.)

	dependent variable: maternal longevity					
	(1)	(2)	(3)	(4)	(5)	(6)
constant	66.999** (1.984)	41.051** (2.600)	66.178** (2.359)	66.707** (3.276)	66.117** (2.091)	67.035** (2.507)
number of sons	0.230 (0.278)	0.410 (0.383)	−0.048 (0.348)	0.091 (0.482)	0.263 (0.313)	−0.015 (0.391)
parity	0.009 (0.184)	0.974** (0.258)	0.373 (0.231)	−0.113 (0.351)	0.097 (0.207)	0.259 (0.268)
husband's longevity	0.068* (0.028)	0.247** (0.038)	0.053 (0.035)	0.095 (0.050)	0.067* (0.030)	0.049 (0.037)
observations	930	1221	582	304	802	497
Sami indicator: mother	one or more	one or more	two or more	three or more	one or more	two or more
Sami indicator: husband	–	–	–	–	one or more	two or more
longevity restriction	≥50	–	≥50	≥50	≥50	≥50
R^2	0.009	0.092	0.015	0.014	0.013	0.010

occurred in the Alpine region. All six indicator variables take the value 1 if a piece of information indicates Sami ethnicity, and 0 if this is not the case. For example, the occupational variable takes the value 1 if the parish record indicates an occupation specific to the Sami population (e.g. reindeer herder), and 0 if the registered occupation does not indicate Sami ethnicity or if there is no record on occupation at all. Hence, the fact that an indicator variable is 0 does not imply that the person is not of Sami ethnicity.

The Pearson correlation between the number of Sami indicators of a wife and the number of Sami indicators for her husband is 0.81. To select our sample, we calculate the number of Sami indicators (i.e. indicator variables equal to 1) for the wife and the husband of each couple. In our basic sample, we consider couples where there is at least one Sami indicator for the mother. This sample consists of 930 married couples and their 5741 children. We then perform robustness checks with subsamples selected under more restrictive criteria.

4. RESULTS

The results from regression (2.2) are displayed in table 2. In contrast to HLJ, our estimates imply a small positive, but statistically insignificant, association between maternal old-age longevity and giving birth to a son instead of a daughter. The coefficient on parity is close to zero and statistically insignificant, implying that there is no association between parity and postmenopausal longevity. Our data allow us to reject much smaller relative effects of boys on maternal old-age longevity than those implied by HLJ. The point estimate of α_2 implied by HLJ's results (−1.09) is thus firmly rejected in our data ($F=20.41$; $p<0.00001$). The 95% confidence interval for the coefficient α_2 ranges from −0.32 to 0.78, hence the null hypothesis that the two coefficients β_2 and β_3 are equal cannot be rejected. These results remain essentially unchanged if women with a longevity shorter than 50 are also included in the sample (column 2). The only difference is that the coefficient on parity is now large and statistically significant, reflecting the reverse causality from (premenopausal) longevity to parity. The results do not change appreciably if we use more restrictive definitions of Sami ethnicity (columns 3–6).

In additional analyses not reported here, we find that the results are similar also when stillborn children are excluded, when survival models (Cox and Weibull) are estimated instead of least squares, or when standard errors are clustered at the parish level (available on request from the authors).

5. CONCLUSION

This paper has attempted to replicate the findings in HLJ for a sample that strongly resembles the original study population in terms of their genetic, demographic, socio-cultural and ecological conditions. Our failure to find any evidence in support of the hypothesis that sons reduce old-age maternal longevity, in a sample approximately three times larger than that used by HLJ, provides the most compelling evidence to date that the results reported in HLJ ought to be interpreted with great caution. In our previous work, we concluded our review of the cumulative evidence by noting that, on balance, 'it is the Sami population (in HLJ) which is an outlier in need of an explanation' (Cesarini *et al.* 2007, p. 544). The results reported here reinforce this conclusion. The original HLJ paper made the strong general claim that sons reduced longevity in pre-industrial humans. This general claim has received little support in subsequent research.

Modest adverse relative effects of sons cannot be ruled out, but the suggestion that giving birth to a son as opposed to a daughter reduced life expectancy by over a year, an extraordinary finding if true, seems to be an anomaly found in only one small sample.

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