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On the number of sons born and shorter lifespan in historical Sami mothers

A recent paper by Cesarini *et al.* (2009) published in *Proceedings B* aimed at replicating our previous finding showing that in historical Sami mothers from Northern Scandinavia (mainly from Finland), each son born was associated with a reduction of 0.65 years of a mother's post-menopausal lifespan (Helle *et al.* 2002). This finding supports the hypothesis that energetic resources invested in reproduction by the mothers may compromise those resources available for longevity (Kirkwood & Rose 1991). Using similar but a larger dataset of Sami mothers from Sweden, a neighbouring country of Finland, Cesarini *et al.* (2009) found no evidence for the association between sons born and the mothers' post-menopausal lifespan. The authors made two main conclusions: (i) our results were likely to be false-positive because of smaller sample size and (ii) that current evidence for the association between offspring sex and maternal longevity is rare and restricted to these Finnish Sami only. We disagree with both conclusions.

First, our original analysis was based on 375 post-menopausal Finnish Sami mothers (Helle *et al.* 2002), whereas the analysis of Cesarini *et al.* (2009) included, at maximum, 930 Swedish Sami mothers (ranging from 304 to 930, depending on how confident they were on the ethnicity of the mothers). Based on their larger sample size and non-significant results, Cesarini *et al.* (2009) seem to suggest that our findings were false-positive. Our original publication was based on all Sami women resident in three Finnish Sami populations between 1640 and 1870, but we were unable to include all these women in our analysis because of missing records on their age at death. Since the study of Helle *et al.* (2002), we have supplemented our database on these Sami using additional historical records available to fill in missing information. Now, this enables us to repeat our original analysis with 481 post-menopausal mothers. Using this larger sample and the same statistical model as previously (i.e. controlling for the number of daughters born and spouse's lifespan), we find a similar association between the number of sons born and maternal longevity as reported previously ($\beta(95\% \text{ CIs}) = -0.65(-1.17, -0.12)$, $p = 0.016$). In this model, the regression coefficient of sons statistically differs from that of daughters (-0.65 versus 0.40 , $F_{1,477} = 6.73$, $p = 0.0098$). To further increase our sample size, we applied multiple imputation to account for the missing values (96 cases, 16.6%) of spouse's lifespan (a predictor of the wife's post-reproductive survival; see Helle *et al.* 2005) that originally led to the exclusion of these women from the sample. These women had a 3.7 years lower mean

lifespan ($F_{1,575} = 9.79$, $p = 0.002$) and gave birth to 0.6 sons less ($F_{1,575} = 8.54$, $p = 0.004$), but did not have a differing number of daughters born ($F_{1,575} = 2.47$, $p = 0.12$) than women with no missing data. Owing to the monotone pattern of missing data, we imputed five datasets using a regression method where the number of sons and daughters born and the wife's lifespan were used to impute missing values of spouse's lifespan (Allison 2002). Conducting the corresponding analysis now with a total of 577 mothers using multiple imputed datasets still showed a significant negative association between the number of sons born and maternal post-menopausal lifespan ($\beta(95\% \text{ CIs}) = -0.58(-1.08, -0.08)$, $t = -2.28$, $p = 0.023$). These results confirm that our original findings were not owing to sampling variation.

In addition, during the process of updating our database, conducted by a professional historian himself a Sami, we discovered that not all mothers included in our original analysis were Sami, but instead of Finnish ethnic origin in one of our three study populations, Enontekiö. These Finns mainly practised farming (periodically also hunting and fishing) and had almost entirely populated Enontekiö towards the end of the nineteenth century, by which time only 10 per cent of the population were Sami (Itkonen 1948). Co-residing Sami and Finns gives us an opportunity to examine whether the number of sons born had a differing association with maternal longevity among the sympatric Sami and Finns (72 mothers), who markedly differed in their lifestyle and genetic background (Norio 2000). We found no evidence that the association between sons born and maternal lifespan differed between Sami and Finnish mothers either using raw ($\beta(95\% \text{ CIs}) = -0.52(-1.83, 0.79)$, $F_{1,457} = 0.62$, $p = 0.43$) or multiple-imputed data (79 Finnish mothers, $\beta(95\% \text{ CIs}) = -0.43(-1.72, 0.85)$, $t = -0.63$, $p = 0.53$). These models also controlled for the spatio-temporal variation of maternal lifespan by including study population and birth cohort (as a random factor), respectively. The result that Sami and Finnish mothers did not show a different association according to the number of sons born suggests that our findings may not be endogamous to resident Sami only. However, this result should be interpreted with caution owing to the small number of Finnish mothers included in the analysis.

One of the main points emphasized in our original contribution but untested by Cesarini *et al.* (2009) was that children may not have an adverse association on their mother's lifespan only, but also have positive influence on maternal survival, as found among the Finnish Sami where the number of daughters raised to adulthood

was positively associated with maternal post-menopausal lifespan (Helle *et al.* 2002). This association was suggested to be owing to the family system of Sami, where mainly daughters helped their mother in everyday household tasks (Helle *et al.* 2002). This argument thus states that in mothers the lifespan-related effects of child-bearing are not restricted to gestation only, but also that post-partum effects may play an important role. Raising children is also probably resource-demanding for both the parents and in some cultures mothers may, for example, breastfeed their sons longer than daughters (Quinlan *et al.* 2005). Such practises have thus also the capability of pronouncing the potential negative association between the number of sons born and maternal longevity.

Corresponding conclusions can also be drawn from our updated data, as the number of adult daughters was associated with the improved survival of post-menopausal mothers ($\beta(95\% \text{ CIs}) = 0.70(0.09, 1.30)$, $p = 0.024$). Again, this association did not vary among Sami and Finnish mothers ($F_{1,473} = 0.98$, $p = 0.32$). As discussed above, these kinds of results might be culture-dependent. In some societies, males are the gender co-habiting with the ageing parents and thus primarily responsible for the well-being of the elderly, resulting in the more sons surviving, the better is the late-life survival of their parents (Omar Rahman 1999). Since Cesarini *et al.* (2009) do not provide any analysis to this respect, they are incapable of contrasting the potential biological and socio-cultural correlates of maternal longevity. Consequently, they fall short of replicating our previous findings on the Sami people.

Second, we disagree with Cesarini *et al.*'s (2009) interpretation of the current state of the evidence for the negative association between the number of sons born and maternal longevity (and offspring sex-specific effects in general) and regard their literature review on the issue somewhat incomplete and partly misleading. For example, the paper by Hurt *et al.* (2006) clearly showed that, after controlling for the effects of surviving sons, the number of sons born had a life-shortening influence on their mothers. It thus seems imprecise that Cesarini *et al.* (2009) wrote that: '... Hurt *et al.* (2006) failed to find any association between the number of sons and maternal mortality in a sample of modern-day Bangladesh'. Likewise, the paper by Jasienska *et al.* (2006) demonstrated that in a rural Polish population mothers with many sons were short-lived but also that daughters born had a similar association with maternal mortality. Although in this population, daughters help with household tasks, their beneficial effect was reflected only on the lifespan of fathers. Among mothers, the physiological costs of reproduction may have thus outweighed the help provided by the daughters (Jasienska *et al.* 2006). However, unlike the case of our sample size, Cesarini *et al.* (2009) did not question the findings of Jasienska *et al.* (2006) based on a sample size of 102 post-menopausal mothers and seem to take these results as evidence against the potential negative association between sons and maternal longevity.

The literature review of Cesarini *et al.* (2009) on whether the number of sons born was related to their mother's lifespan is incomplete because there are more studies on this issue than is evident from their list of publications. For example, using historical Canadian women,

Carey (2003, p. 194) reported that: 'The number of sons born during the reproductive period was weakly negatively related to post-menopausal longevity'. On the other hand, McArdle *et al.* (2006) found no indication on the differential associations of sons and daughters born on maternal post-reproductive lifespan among Amish women. Taken together, the studies that have so far found evidence that the number of sons born may be related to their mother's survival during the post-menopausal period include Helle *et al.* (2002), Carey (2003), Van De Putte *et al.* (2004), Hurt *et al.* (2006), Jasienska *et al.* (2006) and Harrell *et al.* (2008). Corresponding association was not found in Beise & Volland (2002), McArdle *et al.* (2006) and Cesarini *et al.* (2007, 2009). It thus seems that there is no convincing evidence that the number of sons would *not* be related to maternal post-menopausal lifespan as concluded by Cesarini *et al.* (2009). We do, however, acknowledge that the Sami stand out when we consider the effect size of the reported associations between sons born and maternal longevity. We welcome further comprehensive and theory-driven studies to investigate how childbearing and offspring sex composition in particular relates to parental long-term survival, and hypothesis-based investigations on the reasons underlying discrepancies between the detected associations in different populations.

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