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Dimensions of Rational Decision-Making during the Demographic Transition; Aranjuez (Spain) Revisited

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ABSTRACT

A set of linked reproductive histories taken from the Spanish town of Aranjuez during the demographic transition is used to address key issues regarding reproductive change and reproductive choice. This paper builds on the existing literature and especially on the findings first shown in Reher & Sanz-Gimeno (2007) and in Van Poppel et al. (2012) where the links between childhood survival and reproductive decision-making were specified. This paper goes beyond the original ones in two important ways: (a) the sex composition of the surviving sibset is included in the analysis and (b) behavior is modeled by means of event history analysis. In these models, controls for the survival status of the previous child are introduced so as to distinguish between biological factors related to the cessation of breastfeeding and both short term (child replacement) and more long-term reproductive strategies. The results offer convincing proof that couples were continually regulating their fertility in order to achieve reproductive goals both in terms of net fertility and of the sex composition of the resulting sibset. Here results show that both sexes were desired by parents but that lack of surviving males had greater influence on fertility behavior. As expected, controls for the survival status of the previous-born child were important though they did not diminish appreciably the overall effect of the number of surviving offspring. This article offers strong proof for the existence of active decision-making during the demographic transition and applies a method to model these behaviors over the full reproductive history of the couple.

Keywords: Fertility Transition, Child Mortality, Sex-Composition, Rational Decision Making, Spain

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1 INTRODUCTION

This paper addresses the issue of rational decision-making and human agency in historical contexts and aims to evaluate empirically how it worked during the demographic transition. A central part of the demographic transition is that reproduction began to be determined more by rational decisions than by cultural constraints (Johnson-Hanks 2008; Reher 2011). As the story goes, before the transition reproductive decisions tended to be made at a societal or group level often by means of changes in marriage timing and intensity, but as it proceeded these decisions became increasingly individual and family-based, responding to concrete conditions of individual families more than to accepted societal norms. Proving the existence of rational decision-making during the demographic transition empirically, however, has not been straightforward and until fairly recently was more a basic postulate than a proven cornerstone of transition theory.

When addressing this issue, the role of mortality is difficult to avoid because of the major changes it underwent as part of the transition itself. Inherent in Notestein's (1945) original formulation of demographic transition theory, especially as subsequently modified by Kingsley Davis (1963), mortality change was seen as the key factor —or a key factor— triggering fertility decline in the late nineteenth century, both at a societal and a familial level (Reher 2004). Underlying this argument is the supposition that couples generally desired a given number of surviving children that, judging from prevailing growth rates prior to the demographic transition, tended to be small. This cornerstone of transition theory subsequently came under severe criticism, especially within the context of the Princeton European Fertility Project (Knodel 1974; Knodel 1978; Lesthaeghe 1977; Livi Bacci 1977; Matthiessen & McCann 1978; Van de Walle 1986; Rosero-Bixby 1998; Palloni & Rafalimanana 1999). Many other scholars, however, have insisted on its validity (Chesnais 1986; Knodel 1988; Kirk 1996; Haines 1997; Bhat 1998; Galloway, Lee & Hammel 1998). An important reason for this difference of opinion in the field is that the mechanisms whereby mortality change intervened in reproductive decisions are not well understood because of a lack of requisite individual level data. More recently this situation has changed as a number of studies have made use of longitudinal data to deal with rational reproductive decision-making during or even before the demographic transition (Van Bavel 2003, 2004; Van Bavel & Kok 2010; Bengtsson & Dribe 2006; Alter 1988; Knodel 1988). Yamaguchi and Ferguson (1995) used a similar perspective for their paper on spacing, stopping, rational choice and sex composition in a contemporary population.

This paper follows this line of research and builds directly on the results of two recent publications that have addressed this issue specifically by making use of longitudinal micro data (Reher & Sanz-Gimeno 2007; Van Poppel et al. 2012). The initial article used linked reproductive histories over the period of the demographic transition for the Spanish town of Aranjuez in order to study the extent to which mortality and mortality change was a factor for fertility limitation. In response to rapidly declining childhood mortality, families made increasing use of family limitation within marriage. At the outset, this was achieved almost entirely by stopping behavior while both stopping and spacing were used at a more advanced stage of transition. Throughout the period studied, families appear to have been increasingly aware of the implications of the number of surviving children, though they may not always have been successful in meeting their goal. The second paper was based on similar data from the Netherlands during the same period. Adopting similar analytical strategies, as in Reher & Sanz-Gimeno (2007), the authors found that mortality exercised important constraints on fertility by means of the way the probability of having an additional child was contingent on the number of surviving offspring at the time when reproductive decisions were made. In both papers the authors found that at any given parity the probability of having another child was closely linked to the number of surviving children present in the family. Thanks to the quality of the Dutch data, the authors were able to address certain issues beyond the scope of the original paper, exploring differences by urban/rural status, religion and specifying changes over time more precisely. The authors made use of detailed descriptive data in order to make their cases. In both papers, reproductive decisions based on the actual numbers of surviving offspring were considered indications of rational decision-making, though neither paper attempted to disentangle the different types of interaction that can actually exist between childhood survival and reproductive goals.

When addressing the role of declining child mortality for fertility outcomes it is important to differentiate between several possible mechanisms by which declining mortality can influence fertility. Previous literature has often highlighted three different types of factors (see e.g. Pebley, Delgado & Brinemann 1979; see e.g. Knodel 1988 ; Palloni & Rafalimanana 1999). Firstly, there is an *individual level biological effect* of increased child survival in terms of longer periods of breastfeeding when infants survive. If lactation is not interrupted due to infant fatalities the postpartum infecundity is prolonged and thus tends to delay conception even in the absence of active contraception (Knodel & Van de Walle 1967). This effect would exist independent of any desire for fertility limitation.

Secondly, *individual level behavioral effects* will come in to play wherever couples have preferences regarding family size and at least partially effective means of adjusting fertility. These preferences are a response to the number of surviving children rather than to the number of children ever born. If such preferences exist, childhood fatalities will result in replacement behavior of the deceased child. Scholars have interpreted the custom to give a newborn the same name as his or her deceased sibling as qualitative evidence for the existence of such a replacement strategy (Reher, González-Quiñones & Sanz-Gimeno 2004). Beyond this immediate child replacement effect, if couples had clear fertility goals and the ability to implement them their fertility decisions would be based on the overall survival status of their sibset rather than on the outcome of the previous birth. Both child replacement and reactions to the overall number of surviving children are indicators of the existence of fertility goals. However, in the first case the observed effects would be in response to short-term goals together with the biological effects mentioned above. It is important to distinguish wherever possible between these different effects of childhood mortality. We can also expect that that the ability of people to influence their reproductive outcomes efficiently tended to be more pronounced as the demographic transition progressed and stopping behavior became widely adopted and more successful. Another related mechanism of rational choice is an insurance or hoarding effect (Preston 1978; see also Alter 1988). Whenever mortality is high and variable it will be prudent for the couple to try to overshoot their actual target family size to ensure a minimum number of surviving children that eventually reach adulthood. When levels of child mortality decrease sufficiently, the need for this type of insurance behavior decreases and couples can choose to both stop and space their births at lower parities, as they are confident that most, or all, of their children will survive to adulthood.

Thirdly, *community level effects* that operate indirectly are another possible link between mortality reduction and fertility. Institutional mechanisms such as housing conditions and inheritance systems adapted for low levels of child survival could plausibly work to change fertility norms towards greater acceptance of fertility control as an adaptation strategy to increased childhood survival. In this paper we will focus on the role of the first and second category of biological and individual level behavioral effects of child mortality. The possibility of community level effects of a more structural character are not considered here although we do not discard that such effects might also have played a role in the long-term association between fertility and mortality decline.

In any natural fertility setting, and even during the early stages of the demographic transition, the association between child mortality and fertility (especially with respect to stopping behavior) can be bi-directional. While the number of surviving offspring may influence fertility choices, it is also true that the level and the timing of fertility can itself be a cause of childhood mortality (Knodel 1988; Van de Kaa 1996). More generally, the children of women with high fecundity will tend to experience relatively higher levels of mortality that can be attributed both to shorter birth intervals, to a reduction in the time parents (mothers) spend with each child and to greater levels of maternal depletion (Oris et al. 2004). It is important to bear in mind the existence of this sort of reverse causality when analyzing the links between child mortality and fertility in populations before and during the demographic transition and control for it wherever possible.

Our goal in this paper is to build on earlier research in the field and, more specifically, to push the approach of Reher & Sanz-Gimeno (2007) & Van Poppel et al. (2012) further, both by widening the analysis and by deepening it. This is done in three different ways:

1. In line with these earlier publications, the number of surviving siblings at the time individual reproductive decisions were made will continue to occupy a central part of the paper. In addition our analysis will include the sex composition of the surviving sibset at the time of different reproductive decisions. While this subject has seldom been addressed within the context of the demographic transition, its relevance as an example of rational decision-making is evident since boys and girls fulfilled different economic, social and cultural roles within the household (Cain 1988; Hank 2007; Lynch 2011). Parents were well aware of the implications of not having one of them. Some recent studies have found evidence that a lack of male offspring leads to an increased propensity for additional

childbearing as compared to couples with mixed sex sibsets or only girls in both Germany (Sandström & Vikström 2015) and in the US (Bohnert et al. 2012) during the fertility transition. For a discussion of the role of sex-preferences for fertility decisions in past and contemporary societies, see Sandström & Vikström (2015). In this paper, these results will be put to the test within the Spanish context using the Aranjuez data set.

2. Unlike in the original papers, here behavior is modeled formally using multivariable event history analysis that takes into account both the incidence and timing of the event of interest while controlling for other factors that influence the probability of having additional children.

3. In the previous publications parity progression probabilities were dependent on the total number of surviving children. Consequently, both the deaths of older siblings and deaths of the most recently born child contributed to the association with mortality. This means that part of the effect pertains to the biological mechanism by which post-partum infertility is shortened when the death of the previous-born child results in termination of breastfeeding and another part to child replacement (mostly a short-term strategy) or to more far reaching reproductive strategies (goals). Here we control explicitly for the effect of infant deaths that might terminate breastfeeding in addition to the overall effect of the total number of deaths among all children ever born. When infant deaths are controlled for any fertility enhancing effect found of child fatalities among older siblings will not represent a biological or short-term replacement effect but rather long-term reproductive strategies among couples.

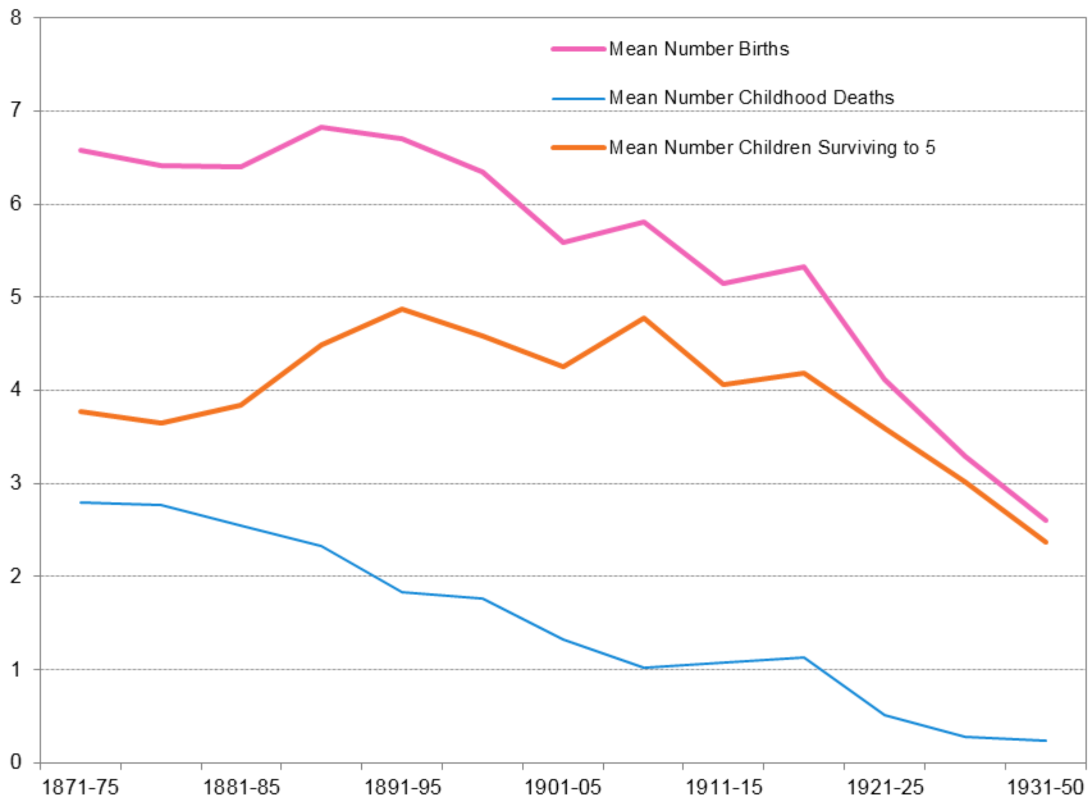
The association between infant and early childhood mortality, on the one hand, and marital fertility, on the other hand, depends on the demographic context. The biological or lactation effect should be found mainly in a natural fertility setting, both the replacement effect and the hoarding or insurance effect should be present wherever fertility control, albeit inefficient, is a realistic possibility as long as child mortality is high and unstable enough to make hoarding a sensible strategy. In this analysis, wherever possible we will attempt to identify the existence of these different effects. We will also attempt to control for the underlying fecundity of women.

2 METHODOLOGICAL CONSIDERATIONS

The paper takes advantage of data collected from civil registration records for the Spanish town Aranjuez, located some 50km outside Madrid, that allow us to follow approximately 900 couples married 1870-1939 over their entire fertile period. Along with traditional agricultural activities centered on the fertile Tagus river valley, the town also had a significant population active in local industry and other occupations related to the town's role as a royal residence for certain periods every year. The paper covers the fertility development of couples living in the town between 1870 into the mid-1960s when the youngest women included in the sample reach menopause. During this period, the population of the town more than tripled from around 8,000 inhabitants, and the weight of agriculture in the urban economy diminished substantially. Demographic transformations were similar to those taking place elsewhere in Spain. The quality of the data has been determined to be high and the particulars of the context of Aranjuez have been discussed in other publications (Reher & González-Quiñones 2003; Reher & Sanz-Gimeno 2007; Reher, Ortega & Sanz-Gimeno 2008) and will therefore only be briefly addressed here. The period of analysis used here includes both very early stages of demographic transition with high mortality and high fertility plus more advanced stages where both variables are low and there are ample indications of widespread fertility control. It provides an ideal context for studying how reproductive decision-making changed over the course of the demographic transition.

Figure 1 summarizes the development of both child mortality and fertility measured as the mean number of fatalities of children aged under 5 years of age, the mean number of children surviving to age 5 and the total number of children ever born. It is clear that the general fertility development can be divided in to three main periods. The first one runs up until the first decade of the twentieth century when substantial decreases in fertility had not yet occurred. This changes abruptly just after the turn of the century when marital fertility drops 18% to then stabilize briefly. Then starting with the women that had their children in the 1920s and onwards fertility drops steeply declining almost 40 percent in little over a decade. For a more extensive discussion of these patterns of mortality and fertility decline, see Reher & Sanz-Gimeno (2007).

Figure 1 *Indicators of reproduction in Aranuez, Spain 1871-1950, organized by first-birth cohorts*



Source: Civil registers, Aranjuez, Spain

The database used for our analysis consists of individual biographies that have been constructed using family reconstitution methods utilizing Civil Registration records as well as six different household listings conducted in the town in the years: 1877, 1905, 1912, 1945, 1960 and 1975. For this paper, only women that could be followed during their entire reproductive history, from marriage until menopause, and whose husband could be determined to be present during the entire period at risk were included in the sample. With this selection criteria we end up with 900 women for whom we have full reproductive histories. Consequently, the sample is not random as only non-migrant couples surviving until the end of their reproductive span are included. Using only couples with full reproductive histories will bias measures of marital fertility upwards and likely also age at marriage downwards. However, for the purpose of studying the link between fertility behavior, differentials in child survival and sibset sex-composition, rather than changes in aggregate levels of fertility, we do not regard this bias of aggregate measures as a serious problem. Although we cannot entirely exclude the possibility, we see no obvious reason why this non-mobile sub-sample of the population would react in a non-representative way to child mortality or the sex-composition of the surviving children.

Both Reher & Sanz-Gimeno (2007) & Van Poppel et al. (2012) find substantive evidence that child survival influenced choices regarding additional children during the fertility transition in Spain and the Netherlands. Here we deepen the descriptive findings of the original papers by applying event history analysis to the Aranjuez dataset. Data analysis is based on non-parametric survival estimates and on Cox proportional hazards regressions to formally test the statistical significance and estimate the size of the effect of child fatalities and the sex-composition of the surviving children in both a univariate and multivariable context. The main advantage of applying event history methods is that it allows us to account simultaneously for differences in both the pace and the propensity of having an additional child, given the survivorship and sex composition of the children at earlier parities at any given time during the reproductive history.

To test the statistical significance of child fatalities in a univariate setting we use Kaplan-Meier estimates of the probability of an additional birth and log rank tests of the equality of the survivor function for parities 2-7. In the multivariable analysis we model the effect of child survival and the sex composition of the surviving children by using both single failure (parities 2-7) and multiple failure (parities 3-12) Cox proportional hazards regression. The propensity to have additional children is modelled dependent on the number of surviving children and the sex composition of the children in the household at time t when the couple becomes at risk of confinement of the second child in the case of the single failure specification and child 3 in the multiple failure analysis. All multivariable models include time invariant controls for the socioeconomic position (SES) of the father at the time of marriage to adjust for possible SES differentials in birth intensities.. Marriage cohorts are divided into three categories roughly corresponding to the different phases of the fertility transition in this setting (see Figure 1) so as to adjust our estimates for increasing fertility control over time.

The outcome measure in hazard regression is sensitive to both timing and incidence and will thus reflect differences in both spacing and stopping behavior. We do not try to differentiate between the two distinct forms of intentional fertility control in this study. The reason for this is that it is not explicitly necessary for our present purpose. We are trying to ascertain if birth intensities were influenced by the number of surviving children and the sex-composition of the surviving sibset. If that is the case we interpret this as an indication that the couple engaged in intentional reproductive strategies to achieve a target family size and/or a particular sex-composition among the surviving children. For studies that apply models that attempt to differentiate between spacing and stopping in an event history analysis framework, see e.g. Yamaguchi & Ferguson (1995).

It is important to control for fecundity variations within the multivariable models since women having a faster pace of childbearing might also have higher child mortality due to maternal depletion and/or resource competition. Here we choose to use the birth interval between the first and second child as a proxy for biological differences in fecundity since any fertility control should have been the least influential on the length of birth intervals at this low parity. All references to parity in the paper refer to the crude parity or the total number of children ever born. Thus, we only compare women that have had the same number of children exposed to the risk of dying at any given point in time.

Statistical significance of added variables is determined by reductions in deviance as measured by likelihood ratio tests in single failure models. In the multiple failure analysis Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) are also used to assess improvements in fit (Burnham & Anderson 2004) as likelihood ratio tests might be biased when we adjust for intra-subject clustering by using robust standard errors (Korn & Graubard 1990).

The effect of declining fecundity as a function of the age of the mother is not estimated with a control variable in the model. Rather we choose to let this effect be part of the baseline hazard by using the attained age of the mother as analysis time. This has been shown to more accurately control for the effect of the age of an individual when becoming at risk than using time-on-study as analysis time and controlling for age at baseline with a covariate (Cheung, Gao & Khoo 2003; Korn, Graubard & Midthune 1997; Thiébaut & Bénichou 2004). Consequently, the women do not enter the analysis at time 0 but enter the risk set for parity 2, 3, ….12 at their attained age with late entry/left truncation in both the single and multiple failure models. In the multiple failure specification we model the effect of the independent variables over the full reproductive history from the birth of the second child until either parity 12 is reached or the mother is censored due to menopause. We also attempted to use a time-on-study definition of analysis time in both the single and multiple failure models and adjusted for the declining fecundity by including a covariate for the mother's age when becoming at risk. Although the alternative definition of analysis time yielded the same results for hypothesis tests and only minor differences in parameter estimates, these models showed signs of non-proportional effects in both single and multiple failure specifications, which were not the case when using the mother's age as analysis time. The models using attained age as a time-scale also proved superior based on the information criteria measures. For these reasons, attained age has been used in all multivariable models.

The reason for starting the analysis when the couple becomes at risk for having a third child in the multiple failure models is that at least two children are needed in order to differentiate between couples that have a mixed sex-composition of offspring and those with only boys or only girls. Also having two previous childbirths makes it possible to distinguish between the separate effects of the death of an older sibling versus the death of the previous child. By implication, this also means that only fertile couples are used in this analysis.

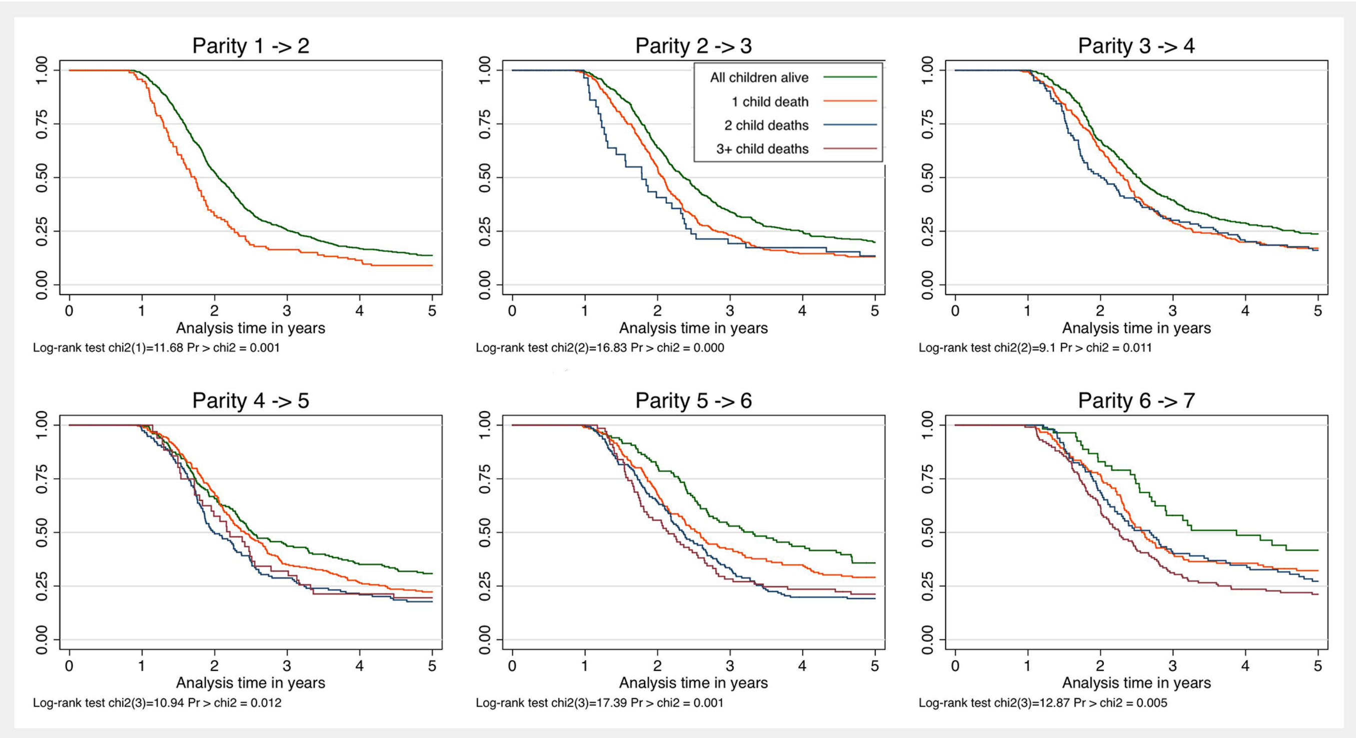
In event history analysis power is determined primarily by the number of failures rather than by the sample size as such. The main reason for pooling the parities in a multiple failure model is to achieve high statistical power and to be able to estimate additional variables in a joint model that describes the effect of child survival and sex composition during full reproductive histories. An additional benefit is that we can include higher parities in the analysis and model the influence of theoretically interesting variables over the full reproductive history. Given usual sample sizes these results tend to become insignificant at parities above the mean family size as the sample is successively diminished due to stopping at lower parities. Using a multiple failure specification gives estimates for the effects of the independent variables that includes also these higher parity births arguably giving a more complete picture of the effects over the full reproductive history. In both single and multiple failure models we treat the number of surviving children and the sex composition as time-varying covariates that are recalculated if the death of a sister or brother occurs during the time at risk. Thus, if a child dies during the time the mother is at risk for conceiving an additional child, a new episode is created starting at the time point of the death of the child. In the new episode the number of child deaths is incremented to reflect the total number of child deaths that the couple has experienced at the beginning of the new episode, given that the time until the next event is more than 9 months. If death occurs during the time the mother was already pregnant, the variable is not incremented until the birth of the next child has occurred. Applying the same rules for time to the next event, a variable reflecting the sex composition of the surviving siblings is calculated in order to reflect any changes caused by the death of either a boy or a girl at the end of the previous episode. In episodes where all children are dead this is treated as having a mixed gender composition. This allows us to estimate the effect of child deaths and sex composition on birth intensities for families with different experiences of child survival and sex composition among the surviving children.

In the multiple failure analysis we also address the issue of the relative importance of child replacement (both biological and as the result of rational decisions) versus a more long-term behavioural response to childhood survival. To adjust for the possible termination of breastfeeding we use a time-varying indicator variable that is set to 1 in the interval 9-15 months after a child younger than 12 months dies. The variable is then reset to 0 if childbirth occurs during the interval or if the 15 months limit is reached before another birth occurs. This limits the effect of the variable to the period when it is most likely that a possible termination of breastfeeding could influence the fecundity of the woman. This is the same method to adjust for the possibility of termination of breastfeeding as used in a number of other fertility studies applying event history analysis (see e.g. Alter 1988; Amialchuk & Dimitrova 2012). When we control for this variable the effect of the variable for the number of dead children shows the effect for deaths of children older than 12 months. It should be noted that this strategy does not discriminate between a biological effect of truncated breastfeeding and a replacement response to infant mortality. The parameter for infant deaths will aggregate both of these possible influences for the children that die at an age under 1 year. However, differentiating between the death of infants and older children will decrease the possibility of biological factors influencing the estimate of the main child mortality variable that now measures only the effect of deaths of children over one year of age. The specification of the multiple failure process is implemented according to the conditional counting process approach suggested by Prentice, Williamson & Peterson (1981). The model is conditional as subjects are treated as not being at risk for event *n* prior to experiencing event *n-1*. The model is stratified on the number of events so that each parity has a separate baseline hazard that can vary freely in relation to the other parities and standard errors are adjusted for intra subject clustering. Subjects enter the first risk set after giving birth to their second child at their attained age by means of late entry rather than at time 0. The clock is not reset after each event and subjects enter subsequent risk sets through late entry at their attained age in order to achieve a model of the hazard of additional births over the full course of the recurrent event process (Hosmer & Lemeshow 2008). For a discussion of other approaches to recurrent event models see, for example, Hosmer & Lemeshow (2008), Kalbfleisch & Prentice (2002) and Prentice et al. (1981). All estimates in the paper have been carried out with the collection of *st*-commands for event history analysis available in Stata 13.1 (StataCorp. 2013).

3 RESULTS

Figure 2 shows the probability of having an additional child as a function of time at risk as described by non-parametric Kaplan-Meier survival estimates for parities 2-7 for the entire sample of couples married 1870-1939. Separate survival curves for couples having different numbers of surviving children at time t since becoming at risk of having a child of parity N is given as well as Log-rank tests of difference in survival between the groups. The results show that there is a clear association between the probability of having an additional child and the number of surviving children. Couples that experience child fatalities have substantially higher risks of progressing to the next parity for all of the parities up until child 7. The differences in the survival are significant at either the 5 or 1 percent level depending on the parity in question. Estimates for higher parities over 7 (not shown) followed the same trend although effects are no longer significant due to diminishing sample size as most couples stopped childbearing at parities below 8. Wilcoxon and Tarone-Ware tests that give different weight to events occurring early as opposed to late during the period at risk when fever subjects are left in the risk set yield the same results regarding significance (Hosmer & Lemeshow 2008). The analysis thus indicates that child fatalities tended to stimulate further childbearing. Independent of any biological effect related to premature termination of breastfeeding when the previous child dies, parents appear to have regulated their fertility in order to achieve a minimum number of surviving children that would reach adulthood. As we aggregate the number of child deaths including both deaths of older siblings and deaths of the last-born child in our mortality measure we expect the biological component to be fairly muted, especially at the higher parities. For example at parity 6 the last child was not alive in about ¼ of the episodes in which the couples had experienced 2 child deaths when at risk of a 7th birth. In Figure 1 it is evident that progression probabilities for these couples are more than 40 percent higher in relative terms than for those that experienced no child deaths. In the multiple failure analysis shown below we will return to the issue of the relative size of the behavioral component versus the biological component of child mortality in more detail.

Figure 2 *Proportion progression to next birth by cumulative number of child fatalities. Kaplan-Meier survival functions and Log-rank tests for parity 2-7, marriage cohorts 1870-1939, Aranjuez Spain*



Source: Civil registers, Aranjuez, Spain

In Table 1 we switch to a multivariable setting and estimate single failure Cox-regression for parities 2-7 in order to ascertain the effects of child survival and sex-composition while controlling for the socio-economic position of the father, marriage cohort and the age of the mother when becoming at risk for child 2-7 and the birth interval between first and second birth (underlying fecundity) for parities 3-7. Diagnostics of the models showed no signs of misspecification or unduly influential cases. Further, analysis of Schoenfeld residuals (Grambsch & Therneau 1994) revealed no signs of non-proportional effects indicating that model estimates are robust.

Table 1 *Cox proportional hazard regressions for progression to parities 2-7 (Single failure per subject models.) Marriage cohorts 1870-1939, Aranjuez Spain.*

VARIABLES	*Category*	Parity 2	Parity 3	Parity 4	Parity 5	Parity 6	Parity 7
Birth interval child 1-2 in years	--	--	0.78***	0.78***	0.83***	0.79***	0.90
Period	*1870-1904*	1	1	1	1	1	1
	1905-1919	0.92	0.95	0.92	0.86	0.84	0.75*
	1920-1939	0.73***	0.65***	0.49***	0.69**	0.58***	0.56**
Socio-economic position of the father at the time of marriage	*Day Laborers*	1	1	1	1	1	1
	Urban workers	0.76**	0.82	0.77*	0.98	0.90	0.90
	White-collar low	0.94	0.99	0.82	0.87	0.57***	0.92
	White-collar high	0.91	0.95	0.94	0.90	0.88	0.89
	Others/no data	0.78**	0.78***	0.88	1.01	0.92	1.14
Sex composition of surviving children at time t	*Mixed*	--	1	1	1	1	1
	Only boys	--	1.10	1.04	1.09	1.04	1.29
	Only girls	--	1.20*	1.12	1.39***	1.15	1.40*
Total number of child deaths t	*No child death*	1	1	1	1	1	1
	1 dead child	1.55***	1.25**	1.19*	1.06	1.16	1.32
	2 dead children	--	1.49**	1.27*	1.29*	1.46**	1.10
	3 or more	--	--	--	1.48*	1.58**	1.40
	Number of episodes	1,051	1,041	939	816	690	566
	Chi2	41.3	57.7	57.6	30.8	32.9	22.1
	Prob> Chi2	0.000	0.000	0.000	0.001	0.000	0.023

* $p < 0.1$ ** $p < 0.05$, *** $p < 0.01$ Coefficients in exp(β)-form.

Source: Civil registers, Aranjuez, Spain

The substantial effect on further childbearing of the number of surviving children in the sibset is also verified in the multivariable model when we control for other important influences on fertility that might confound the effect of child mortality. For all parities up until 6 there are strong effects on birth intensities with approximately 40-60 percent increase in the hazard of additional births among the couples that experience the most unfavorable child survival outcomes. Effects are significant below the 5 percent level for parities 2-3 and 6 and slightly higher for parities 4-5 where they only fall below the 10 percent cut off value. This effect increases more or less linearly as a function of the number of child fatalities. In sum, these results show that couples experiencing childhood deaths ended up having a significantly higher number of children ever born compared to those having a more favorable mortality experience.

As another indicator of agency in fertility decisions, we estimate the effect of the sex-composition among the surviving children at the time the reproductive decision was made. The results show positive estimates both for couples that had no surviving boys or no surviving girls, indicating that a mixed sibset was preferable. However, the estimates for lacking boys are substantially larger at all parities and significant below either the 10 percent or the 5 percent level at parity 3, 5, and 7, while the coefficients for lacking girls do not reach statistical significance in any of the models for parities 3-7. The overall pattern emerging here is thus that the goal of having at least one surviving male offspring was relatively more important than having at least one girl. Consequently, the results mirror the preference for male children found also in Germany during the fertility transition (Sandström & Vikström 2015) and in the US by Bohnert (2012). The male bias appears stronger in the Spanish setting than in Germany as the hazard ratios are bigger and statistically significant at a greater number of parities than what was found in the study by Sandström and Vikström on Germany.

The effect of child mortality and the perceived value of male and female offspring can perceivably be different for couples in different social strata. It is often suggested that children from working class and agricultural families had different economic functions in terms of functioning as surplus labor compared to children in higher strata families. To test this we also investigated the possibility of interactions between child mortality, sex-composition and social class. No significant differences in the effect of these variables dependent on the social class of the couple were found. Consequently it appears that the effects of both child mortality and sex-composition generally resulted in similar behavioral responses independent of the socio-economic position of the couple.

We now turn to the issue of the relative importance of behavioral effects versus biological effects of child mortality as well as the possibility of a change over time in the effect of both child mortality and sex-composition. To effectively investigate these issues we pool the events over parities 3-12 and estimate multiple failure Cox regression models to achieve higher statistical power and the ability to estimate more extensive models. This gives us the opportunity to split the analysis by periods. In addition it allows sufficient power to determine the statistical significance of a possible difference in the effect of deaths among older siblings, as opposed to the death of the previous infant. The results are found in Table 2 which contains four different models. Models 1-2 give the effects for all couples married between 1870-1939 with and without a lactation control for the death of infants as opposed to deaths of older siblings. In Models 3 and 4 we give separate estimates for the cohorts married up until 1904 that show only modest signs of fertility reduction as opposed to couples married 1905-1939 who exhibit markedly declining birth intensities.

3.1 BIOLOGICAL VERSUS BEHAVIORAL COMPONENTS OF THE EFFECT OF CHILD MORTALITY

To investigate the relative importance of individual biological versus behavioral effects of child mortality we introduce a control variable for the deaths of infants in Model 2. The main effects for different levels of aggregate child mortality thus shows the effect of deaths of children older than 1 year of age that should not be substantially influenced by any biological component related to termination of breastfeeding. On the other hand it is important to note that the estimate for infant deaths of the preceding child will include both the effect of terminated breastfeeding if it occurred as well as any deliberate replacement behavior that the death of the previous child might give rise to. It is impossible to fully disentangle these two important effects with the available data.

In Model 1, which does not differentiate between the two different types of child fatalities, we find that the number of dead children has a substantial positive effect on birth intensities when we model the effect over the full reproductive history. The effect increases approximately linearly as a function of the number of dead children in the sibset. Couples having 3 or more children that have died have a 37 percent higher hazard of additional births compared to families where all children have survived. The effects are all highly significant. The estimates are slightly lower than the average effect in the single parity models indicating that the effect of child mortality tends to attenuate at higher parities that are now included in the model. The fact that the effects tend to be lower at parities above 6 is confirmed by estimating event-specific effects by interacting child mortality with the parity (results not shown). However the parity interactions are jointly not significant and result in relative increases in both AIC and BIC leading us to prefer the more parsimonious model that estimates one effect for mortality over the complete span from parities 3-12. Tests of proportionality as given by analysis of Schoenfeld residuals are also insignificant showing that the more parsimonious model that assumes a constant effect over time is preferable.

Table 2 *Cox proportional hazard regressions for progression to parities 3-12 (Multiple failure per subject model.) Marriage cohorts 1870-1939, Aranjuez Spain.*

VARIABLES	*Category*	1870-1939	1870-1939	1870-1904	1905-1939
		(1)	(2)	(3)	(4)
Birth interval child 1-2 in years		0.84***	0.84***	0.87***	0.81***
Period	*1870-1904*	1	1	--	--
	1905-1919	0.89***	0.89***	--	1
	1920-1939	0.64***	0.63***	--	0.71***
Socio-economic position of the father at the time of marriage	*Day Laborers*	1	1	1	1
	Urban workers	0.84**	0.85**	0.89	078**
	White-collar low	0.85***	0.86***	0.91	0.72***
	White-collar high	0.94	0.93	0.97	0.84
	Others/no data	0.91	0.92	0.91	0.90
Sex composition of surviving children at time t	*Mixed*	1	1	1	1
	Only boys	1.14**	1.14**	1.13**	1.18*
	Only girls	1.23***	1.22***	1.17**	1.40***
Total number of child deaths at time t	*All chldren alive*	1	1	1	1
	1 dead child	1.13***	1.08	1.01	1.16**
	2 dead children	1.22***	1.11	1.04	1.30**
	3 or more	1.37***	1.21***	1.17*	1.16
Lactation indicator for period 9-15 months after infant death	*No*	--	1	1	1
	Yes	--	3.19***	3.08***	3.37***
	Episodes	5,326	5,326	3,432	1,894
	AIC	28577	28348	15614	9009
	BIC	28656	28524	15682	9076
	Chi2	176.4	1650.1	885.6	493.4
	Prob> Chi2	0.000	0.000	0.000	0.000

* $p < 0.1$ ** $p < 0.05$, *** $p < 0.01$ Standard Error adjusted for clusters in id Coefficients in exp(β)-form.

Source: Civil registers, Aranjuez, Spain

In Model 2 we deepen the analysis and differentiate between the deaths of older siblings and the infant death of the previous child. Here a slightly different pattern emerges. As expected based on the theoretical argument stated earlier the main effect of child deaths decreases by slightly less than 50 percent as this now measures only the effect of deaths of older siblings. The inclusion of the lactation control is also strongly significant. Model 2 is also favored over Model 1 based on the lower AIC as well as a lower BIC that penalizes model complexity more extensively than the AIC.

The main conclusion that can be drawn from the model that includes the lactation control is that there is a clear and statistically significant behavioral component of child mortality during the course of the fertility transition in this setting that remains even when the biological effect is controlled for. Given that the more complex model reduces the effect of the main variable by less than 50 percent and that the infant death indicator also in part reflects behavioral adjustments of fertility caused by the death of the previous child, we conclude that the biological mechanism is substantially less important for reproductive outcomes than the short- and long-term behavioral responses to childhood mortality.

3.2 CHANGES OVER TIME IN THE EFFECTS OF CHILD MORTALITY AND SEX-COMPOSITION

We now turn to the issue of possible changes in the association between the independent variables and birth intensities over the course of the fertility transition. The univariate analyses conducted by both Reher & Sanz-Gimeno (2007) and by Van Poppel et. al. (2012) suggested that the relative importance of child fatalities increased as the demographic transition progressed and the question here is whether this finding can be verified in a formal model where we control for other influences on fertility.

The estimates in Model 3 and Model 4, that show results for couples married before and after 1905, support the finding that the effect of child fatalities tended to increase as the fertility transition progressed. The effect in the later period after 1905 (Model 4) is substantially larger than in the earlier period (Model 3), mainly due to stronger effects at a lower number of childhood deaths. In the earlier period before 1905, significant effects are found only for the categories of 3 or more child fatalities and only at the 10 percent level. Comparing the size of the effects in the two models, the estimate for both one and two childhood deaths increase from approximately unity to 16 and 30 percent and both reach significance below the 5 percent level.

The increased effect of child mortality in the latter period, when both child mortality and fertility declined rapidly, can be explained by two different factors at work during the demographic transition. Firstly, the ability of couples to express preferences in response to differentials in child survival improved during the transition because they were ready, willing and able to control their fertility, thus fulfilling the classical norms mentioned years ago by Ansley Coale as preconditions for the onset of conscious fertility control (Coale 1973). Secondly, as child mortality decreased rapidly during the same period that fertility decline accelerated, losing one or even two children increasingly became an exceptional –and therefore inadmissible– experience (Reher & Gonzalez-Quiñones 2003). Consequently, the death of a child became a much more important event for the parents that experienced it than it was during the nineteenth century when child mortality was higher. It is not surprising that the behavioral response to the loss of a child increased in magnitude during the latter period when the death of a child had become a much more uncommon event and the ability to regulate fertility had improved.

3.3 THE EFFECT OF THE SEX-COMPOSITION OF THE SURVIVING CHILDREN

Looking at our other indicator of agency in fertility decisions, we find that couples having only girls were more prone to have an additional child than those having children of both sexes or only boys. Different from the effect of mortality there is a consensus in contemporary medical research that there is no association between fecundity and the probability of having a child of either sex (Eisenberg et al. 2011; Joffe et al. 2007). Consequently we can assume that any differentials in birth intensities between couples lacking either girls or boys are caused by behavioral factors reflecting different preferences for girls and boys. Looking at the effect over a larger range of parities than what we did in the single parity analysis, it appears that the desire to have surviving boys was more important in Aranjuez than having girls and so couples actively regulated their fertility to achieve this goal. It is also true, however, that couples without girls also tended to have a higher risk of continued childbearing. The fertility stimulating effect of lacking male offspring during the fertility transition mirrors the results found for Germany by Sandström & Vikström (2015) and for the US by Bohnert (2012). One important difference compared to the results for Germany, however, is that the male preference more than doubled in size for the transition cohorts as opposed to the couples married before 1905. In the German setting Sandström and Vikström (2015) find that a shift to a more symmetrical preferences occurred for the cohorts that married already during the last decades of the nineteenth century. This early shift to a symmetrical preference pattern, similar to the one found in most contemporary Western societies, where the lack of either sex in the sibset tends to stimulate fertility, is not as clear in the Spanish data at this point in time. Even though the estimate for lacking girls is positive it is substantially lower than the estimate for lacking boys and is only borderline statistically significant on the 10 percent level in the latter period after 1905. In fact, the relative difference between the couples lacking boys and those that are lacking girls actually increases.

The fact that the effect of lacking boys increases in strength during the transition cohorts might indicate the persistence of a male preference pattern in combination with an increased ability to regulate fertility that made it more feasible for the couples to achieve the desired sex composition in the surviving sibset. The most important finding is however that the results for both sex-composition and child mortality show how agency influenced fertility outcomes even at the early stages of the fertility transition. The results also illustrate how these influences increased in importance as couples acquired the means to regulate their fertility more successfully over time as parity dependent control became widespread. An important detail is that the sex-composition of the children also had a significant effect on birth intensities in the period before 1905 when substantial fertility decline had not yet occurred. This shows that couples did react to certain outcomes by regulating their fertility decisions and that fertility was regulated at least to some degree during this early period when average family size still remained at its pre-transitional levels.

Regarding the control variables in all models 1-4, the associations do not offer any substantial surprises. The control for fecundity has the expected sign and shows a strong negative effect on the birth intensities in terms of longer intervals between the first and second child resulting in lower birth intensities at higher parities. Regarding the socio-economic differentials it is interesting to note that SES has a very weak influence on fertility before the onset of the fertility decline but becomes much more accentuated later in the period when fertility control started to become widespread. In this setting, urban workers and the middle class were the pioneers of family limitation, while participation in the transition process was more gradual among agricultural workers as well as among the upper strata of the population.

4 CONCLUSION AND DISCUSSION

In this paper we set out to investigate the impact of child survival and sex-composition as an expression of rational decision-making in fertility decisions during the demographic transition in Aranjuez Spain. The evidence shows that couples responded to both the number and the sex make-up of surviving children in terms of being more prone to go on to additional births if one or more previous children had died, or if they lacked gender balance in the surviving sibset. This was especially the case when the couple lacked surviving male offspring. Further, the results show that this tendency to regulate fertility based on child survival and sex-composition increased in strength as fertility control became more widespread during the later stages of the fertility transition. Consequently, the findings support the notion that rational decision-making and agency became more important for individual level fertility outcomes as the fertility transition progressed in this region of Spain. Even when we include controls for the biological effect of a sudden termination of breastfeeding, the effect of child survival remains substantial and statistically significant. Consequently, the importance of childhood survival for fertility outcomes during the demographic transition receives firm validation in this study.

This paper offers little support for two traditional and related views of pre- and early-transitional societies. The ongoing pattern, visible even in the earlier period, of what appear to be efforts by couples to control their net fertility outcomes in view of their entire history of childhood survival and sex-composition of the surviving children suggest that people had at least an approximate idea of desired family size. This pattern becomes sharper as time goes by, but it is present from the outset. These results appear to offer scant support for the long-held idea that fertility prior to the demographic transition was completely 'natural' (Henry 1961) and that people were unable to conceptualize rationally the number of children they desired (lack of numeracy) as hypothesized originally by Etienne Van de Walle (1992). While in this study the ability to do so increased with the passing of time, it was always present. It is time that researchers return to the seminal notion of 'natural fertility' with a more critical eye. While it is true that behavior during the late nineteenth century is not necessarily like reproductive behavior during earlier periods, the issue is worth reopening for even earlier periods especially in the light of the improved micro data available to many researchers.

The other notion is that some families were biologically and behaviorally linked to high mortality and high fertility and others to low mortality and low fertility. In studies of historical populations this indeed appears to have been the case. Judging from the results presented here, however, this general pattern tends to mask a very important cause and effect relationship linking childhood survival to reproduction that explains why generalizations like this appear to be rooted in truth. In this paper, the nexus between mortality and fertility has been shown to be a very close one that was also laced with cultural and economic preferences for gender composition within the sibset. The end result (net fertility) was invariably the byproduct of the way these factors played out in individual families. In scenarios such as this, and possibly of many others, the entire stability of the micro-system became unhinged once childhood mortality began its breathtaking decline. Replicating the type of approach proposed here both for transitional and pre-transitional populations would help bring these issues into sharper focus.

Finally, this paper also illustrates the usefulness of multivariable modeling techniques that account for the influence of independent variables over the full reproductive history. Multiple failure models of the kind employed here enable researchers to estimate richer models by pooling all childbirths in a joint model. When sample size is not excessively large it is often necessary to forgo the analysis of higher parities as single failure modeling tends to suffer from decreased power due to a diminishing number of events at higher parities. Pooling all childbirths also allows us to consider the influence on parameters exerted by these higher parity childbirths. The results also illustrate how behavioral indicators that show how people act can be used to indicate the intrinsic value ascribed to gender and how this has changed over time in different societies. Further studies of the extent, continuity and change in sex preferences in historical Europe promise to provide new and interesting insights. Such results can provide behavioral indicators of how the gender regime has changed in different settings characterized by different cultural and religious values. Further it would be interesting to investigate if there is any association over time between the level of economic modernization in a given society and the relative value that parents put on girls relative to boys.

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