Agency in Fertility Decisions in Western Europe during the Demographic Transition –the Role of Childhood Mortality and Sex-Composition

David Sven Reher, *Universidad Complutense de Madrid*

Glenn Sandström, *Umeå University*

Alberto Sanz-Gimeno, *Universidad Complutense de Madrid*

Frans W. A. van Poppel, *Netherlands Interdisciplinary Demographic Institute (NIDI)*

ABSTRACT

A set of linked reproductive histories taken from Sweden, the Netherlands and Spain for the period 1871-1960 is used to address key issues regarding reproductive change and reproductive choice. Using event history analysis the paper investigates how the hazard of additional births was influenced by childhood mortality and the sex-composition among the surviving children when the reproductive decisions were made. The preliminary results show that couples were continuously regulating their fertility to achieve reproductive goals even during the early stages of the fertility transition. Couples experiencing child fatalities as well as gender imbalance in the surviving sibset show significant increases in the hazard of additional births net of any biological impact of terminated breastfeeding. The findings 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.

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). Before the transition these decisions tended to be made at a societal or group level often by means of changes in marriage timing and intensity (Mason, 1997: 447-452), but as it proceeded they became increasingly individual and family-based, responding to concrete conditions of individual families more than to accepted societal norms. Viewed from this perspective, the demographic transition becomes a key episode in the progress of individual rationality, central to all processes of modernization. Proving the existence of rational decision-making during the demographic transition empirically, however, has not been straight forward and until fairly recently was more a basic postulate than a proven cornerstone of transition theory.

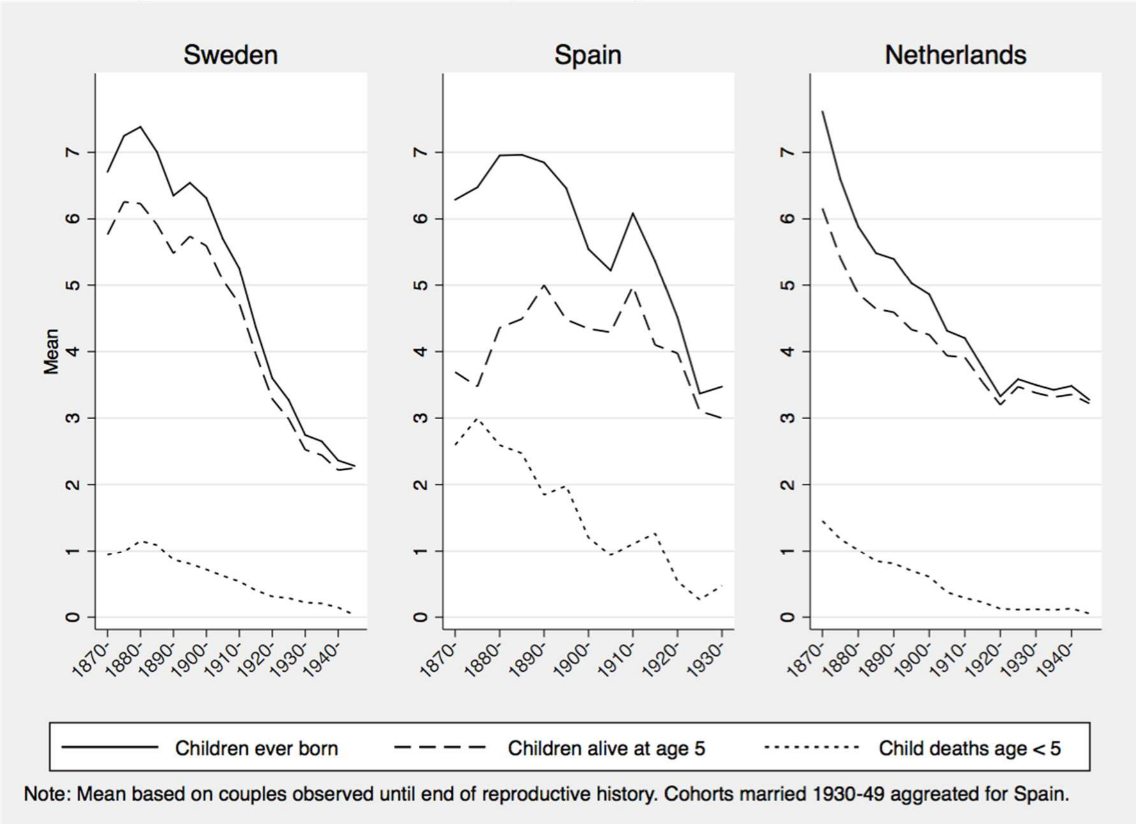
When addressing this issue, the role of mortality is difficult to avoid because of the major changes it underwent as part of the transition itself. Inherent in Notestein's (1945) original formulation of demographic transition theory, especially as subsequently modified by Kingsley Davis (1963), mortality 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: 185; Knodel 1978: 43; Lesthaeghe 1977: 171–176; Livi Bacci 1977: 205–213; Matthiessen & McCann 1978; Van de Walle 1986: 228–230; Rosero-Bixby 1998; Palloni & Rafalimanana 1999). Other scholars, however, have insisted on its validity (Chesnais 1986; Knodel 1988: 393–442; 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 impacted 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 this theme during or even before the demographic transition (Van Bavel 2003, 2004; Van Bavel & Kok 2010; Bengtsson & Dribe 2006; Alter 1988; Knodel 1988).

This paper follows this line of research and builds directly on the results of three recent publications that have addressed this issue specifically by making use of longitudinal micro data (Reher & Sanz-Gimeno 2007; Van Poppel et al. 2012; and Reher & Sandström 2015). In the first two articles, linked reproductive histories over the period of the demographic transition for one Spanish sample (Aranjuez) and another Dutch sample were used 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. 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. In the third paper, again centering on Spanish data, the authors modeled the entire process and were able to validate the original findings by means of multivariate event history analysis that included controls for possible confounding factors not accounted for in previous papers. Further, the paper also shows that not only the number of surviving children at a given time in the reproductive history, but also the sex-composition of the surviving children influenced the decision to either stop or continue childbearing.

In this paper we extend on this approach and compare how both childhood mortality and the sex-composition of the surviving sibset influenced fertility decisions in three different contexts in Northern, Central and Southern Europe during the historical fertility decline. The countries chosen for analysis are Sweden, the Netherlands and Spain. While these countries show marked variation in cultural and economic structures, all of them experience a rapid decline in both childhood mortality and fertility starting in the late nineteenth century that then continued with an increased pace during the first decades of the twentieth century. During the first part of the period under study, the Swedish and the Dutch settings appear to be at a more advanced stage of the demographic transition, though by the end prevailing levels of fertility and mortality are quite similar. Figure 1 that shows the reproductive experience in each setting for couples married 1870-1949 measured as the mean number of fatalities of children under 5 years of age, the mean number of children surviving to age 5 and the total number of children ever born. Despite some differences in the timing and level of the decline in these measures, the similarity in the general trends is evident during the period covered by the figure.

Figure 1: Mean number of children ever born and indicators of child survival in Sweden, Spain and the Netherlands by marriage cohorts 1870-1949



Source: Sweden: POPLINK Database, Demographic Database, Umeå University. Spain: Aranjuez Civil Registers. Netherlands: Historical Sample of the Netherlands (HSN).

When addressing the connection between childhood mortality and 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, p. 393; 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 death 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. Here, there are two different types of strategy. One of them is a short-term strategy designed to replace a child who had just died. This sort of child replacement can be found in many populations past and present, though in the past it is very difficult to distinguish from the mechanical biological response to an early cessation of breastfeeding described above.

Beyond this immediate child replacement effect, if couples had clear fertility goals and the ability to implement them their fertility decisions would tend to 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. Another related mechanism of rational choice is an insurance or hoarding effect (Preston 1978; see also Alter,1988: 163-194). 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 childhood 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.

The biological or lactation effect should be found mainly in a natural fertility setting, both the replacement effect and the hoarding effect should be present wherever fertility control, albeit inefficient, is a realistic possibility as long as childhood mortality is high and unstable enough to make hoarding a sensible strategy. 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. It is important to distinguish wherever possible between these different forms of short term and long-term behavioral responses to childhood mortality.

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 adaptive strategy to increased childhood survival. 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. To the extent that there is a community level effect that is related to differentials in socio-economic structures our models will account for such contextual effects, as a control variable for the socio-economic position of the father is included in all multivariate models. Social norms regarding age at marriage that can both vary in between contexts as well as undergo changes over time might also have an impact on influence childhood survival. However these kind of effects are controlled for by accounting for the mothers age when becoming at risk.

In any natural fertility setting, and even during the early stages of the demographic transition, the association between childhood 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 : 70-71, 398; Van de Kaa 1996: 405). 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 childhood 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) and Reher & Sandström (2015) further by widening the analysis to a comparative perspective across culturally and economically different contexts in Europe. In it, similar methods to those used in Reher & Sandström (2015) in their recent paper on Spain are used in a wider comparative perspective in which individual models for Sweden, Spain and the Netherlands together with a pooled model for all three samples are specified. This will enable us to assess the extent to which the results found for the Spanish case are shared by other very different settings. Further, it will allow an analysis of possible differences and similarities in the effect of childhood mortality and sex-composition across different contexts during the historical fertility decline.

Apart from our focus on the role of childhood mortality the analysis also addresses the impact of the sex composition of the surviving sibset at the time of different reproductive decisions. While this subject has received relatively little attention within the context of the demographic transition, its relevance as an example of rational decision-making should be 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), the US (Bohnert et al. 2012) and Spain (Reher & Sandström, 2015) during the fertility transition. Although comparative studies are available for the contemporary period (Hank & Kohler, 2000; Andersson, Hank, Ronsen, & Vikat, 2006; Mills & Begall, 2010), this paper is to our knowledge the first example of a comparative analysis regarding the role of sex-preferences in Europe for the period covering the demographic transition.

The underlying goal of this paper is to verify whether or not rational decision-making by parents was present during the demographic transition. This general question will be examined in terms of the role played by childhood survival and the sex composition of surviving sibsets for fertility. Is this an unimportant pattern of behavior or, rather, is it a general one, characteristic of a substantial sample of early and transitional societies Europe? How efficient was choice in the pre- and early-transitional period and how did this change with the passing of time? Our enquiry here will return us to square one of demographic transition theory and, in so doing, place the entire concept of 'natural fertility' in a new and somewhat more critical light.

2. Methodological considerations

Data: origins, characteristics and quality

This paper is based on three different data sources. All of them include micro data of individual reproductive histories though their origins are not the same. The specifics of the different sources are discussed briefly in the following paragraphs. All three datasets are based on linked vital registration sources e.g. parish records, civil registers where individuals can be followed over time in terms of births, in- and out-migration, marriages, deaths and their links to other family members. For the Dutch data the individuals are followed in the sources also after out-migration across areas of the Netherlands, which explains the much longer follow up time in the Dutch case as opposed to Sweden and in particular the Spanish data. For these datasets the couples are censored at their first out-migration from the studied area. All data sources contain socio-economic information of at least the occupation held by the individual at the time of vital events and in some cases at more frequent intervals based on censuses or catechetical examination registers.

For matters of comparability we have chosen to follow couples married 1870-1949 in all three countries from their first marriage until they are censored due to either outmigration, death of one of the spouses, or the woman reaching menopause at age 50. Table 1 gives information about the total number of cases and basic information about observation time and number of births while under observation.

Table 1: Size and characteristics of Swedish, Spanish and Dutch samples

	Sweden	Spain	The Netherlands
Total number of couples observed	24,065	3,484	3,394
Number of births while under obs.	86,450	13,443	14,435
Total time at risk in years	383,931	39,817	82,526
Mean time at risk in years	15.9	11.42	24.31

Source: Sweden: POPLINK Database, Demographic Database, Umeå University. Spain: Aranjuez Civil Registers. Netherlands: Historical Sample of the Netherlands (HSN).

Below we describe the specific details pertaining to each of the data sources.

Dutch data

The Dutch sample used here is described in depth in Van Poppel et al (2012) and will only be summarized here. It is based on three different databases that enable us to follow reproductive patterns over a prolonged period. (1) It includes full maternity histories of couples born between 1850 and 1922 who gave birth between 1870 and 1950 based on consecutive series of municipal population registers and its successors. Population registers, enforced in the Netherlands by the Royal Decree of December 22, 1849, combine census listings with vital registration in a linked format for the entire population of a municipality with the household as the registration unit (Alter, 1988, 32-58). For each household member date and place of birth, relation to the head of the household, sex, marital status, occupation, and religion were recorded. New household members, including live births, were added to the list of individuals already recorded, and those moving out by death or migration were deleted with reference to place and date of migration or date of death. These enable us to follow couples from birth to death and, in case of migration, from place to place all over the country; the data make it possible to reconstruct complete life histories of couples from 1850 to the end of the registers in 1939. (2) After 1939 the bound population registers were replaced by personal record cards, containing largely the same information as the population register but with the individual person as the registration unit. Here a record card is the key to following each individual during his/her life from place to place. After the death of an individual, the card is sent to the Central Bureau of Genealogy (CBG) where it is kept in the Archive of Death Registration (Van den Brink, 1966). (3) In 1994 this system was restructured into an electronic database, the so-called Gemeentelijke Basis Administratie (GBA: Municipal Basic Administration) (Prins, 2000) which is a fully decentralised comprehensive population registration system, with individual personal record lists for all inhabitants of the municipality as the basis. These personal record lists also contain information about date and place of birth of parents of ego, his/her spouse and offspring.

The three consecutive data sources make it possible to reconstruct complete life histories of individuals born from 1850 to the present-day, and do not have a restriction for non-mobile couples. Data from the registers, personal record cards and personal record lists were collected in the framework of the Historical Sample of the Netherlands (HSN), a database with information on the complete life histories of a national random sample of the 1850-1922 birth cohorts in the Netherlands (Mandemakers, 2001). The sampled individuals are followed from cradle to grave; information is also collected on the spouses of the sampled individuals, and on children born to these individuals, including the timing of their birth and death, as long as these events took place during the time period that the children were part of the household of the individual. While these data are not without problems related to the coverage of different samples, to the fact that full data are only available for persons who have already died,[1] and to the different types of information from each source especially when changes in the system were introduced, the overall quality is very high.[2]

Spanish data

The Spanish data is already described in Reher & Sanz-Gimeno (2007) and Reher & Sandström (2015) and is only summarized here. The paper takes advantage of data collected from civil registration records for the Spanish town Aranjuez, located some 50km outside Madrid. 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 and a time when the population of the town more than tripled from around 8,000 inhabitants and the weight of agriculture in the urban economy diminished substantially. 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 2006, 2007; Reher, Ortega & Sanz-Gimeno 2008). 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. 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 (1877, 1905, 1912, 1945, 1960 and 1975).

Swedish data

The Swedish data is based on the POPLINK database that today is one of the largest historical population databases in the world covering approximately 350,000 individuals born from the late 18th century up until the 1970s living in the northern coastal region of Sweden in Västerbotten County ("POPLINK – One of the world's largest population databases - Umeå University, Sweden," 2014). Swedish historical population records based on the parish registers are known for their exceptionally high quality and complete coverage of the population as well as having a level of detail rarely found elsewhere in the world (Kälvemark, 1977; Hofsten & Lundström, 1976, p. 150). The POPLINK database has primarily been developed for medical research to link the historical population registers to the modern registers at Statistics Sweden and The National Board of Health and Welfare (Demographic Database -Umeå University, 2015). However, the source also gives unique opportunities for research in historical demography due to its large sample size spanning a time period that

[1] It is possible to link most of the parents and children of all persons ever registered in the GBA from 1 January 1995. Information is thus missing on persons whose parents had already died before 1995. In addition, not all children of parent(s) still living on 1 January 2005 are present in the data-set. Children who died or emigrated before 1995 are not included (Steenhof & Liefbroer, 2008).

[2] Although the quality of these data is high, the population registers have their shortcomings (Janssens, 1993; Knotter & Meijer, 1995; Meijer, 1983; Vulsma, 2002). Janssens (1993) found that some 0.2% of all live births were not entered in the population register, almost all of them being children dying very soon after birth. The omission of less than one percent of births should not alter our conclusions to a large extent.

includes the complete historical fertility decline in Sweden. The POPLINK database contains individual life biographies, family relations (parents-children, spouses) and all vital events of the individuals living in the included parishes. The source also holds extensive longitudinal socio-economic information regarding occupational status updated on a yearly basis from the information found in the catechetical examination registers. The parishes are distributed throughout the coastal region of Västerbotten and include more than 2/3 of the population in the province during the nineteenth and twentieth centuries. The economic development presents the typical distinctive traits of most Swedish regions; being mainly rural up until the early 20th century and thereafter characterized by industrialization and a growing public sector. Västerbotten conform closely to the national trends in fertility and mortality although with somewhat higher levels of completed fertility compared to the national average.

Statistical method

For the analysis we use event history methods in terms of non-parametric survival estimates and Cox proportional hazards regressions to estimate the influence of childhood mortality and the sex-composition of the surviving children in a univariate as well as multivariate context. The main advantage of applying event history methods is that it enables 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.

We have chosen to use an open sample that accounts for right-hand censoring during the period at risk. This choice maximizes the number of observations. It also enables us to follow couples married up until relatively recent periods (1949). It is different from the approach used in Reher & Sandström (2015) for the Spanish data that was based on stable couples married before 1940 and present in the town throughout the entire reproductive period (through 45 years of age). This strategy was used because of the very high levels of out-migration (normally to Madrid) present in the Aranjuez sample, much higher than those present in the Dutch or Swedish samples (see Table 1) and to preserve direct comparability to earlier publications were complete reproductive histories was a requirement of the methods applied. In this comparative paper we choose to model all couples until censoring due to out-migration, death or menopause. Any differences in the estimates for Spain as compared to Reher & Sandström (2015) is thus explained by the bigger sample for the low parities achieved by using this strategy and that cohorts born later during the twentieth century is now also included. Any differences in the results achieved by using the two approaches will be discussed and arguably have interesting methodological implications when dealing with modelling the behaviour of populations showing high levels of censoring.

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 2-6. In the multivariate analysis we model the effect of child survival and the sex composition of the surviving children by using both single failure (parities 2-5) and multiple failure (parities 3-8) 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 surviving children in the household at time ***t***. The analysis starts when the couple becomes at risk of confinement of the second child in the case of the single failure specification and at child 3 in the multiple failure analysis.

All multivariable models include a time invariant control for the socioeconomic position (SES) of the father at the time of marriage (or first child birth in a minority of the cases from Aranjuez) as to adjust our estimates for possible SES differentials in birth intensities. Coding of the occupational titles was done according to the HISCO classification system, which contains approximately 1,600 historical occupational titles and their equivalents in six

European languages (Van Leeuwen et al. 2002; Van Leeuwen et al. 2004; Van Leeuwen and Maas 2011). The HISCO coded occupations were then stratified according to the Social Power coding scheme developed by Van de Putte and Miles (2005).

A control for the marriage cohort of the couple is included in all models as a stratifying variable to adjust for increasing fertility control over time. For analysing period effects marriage cohorts were divided into two groups were the first roughly corresponds to the early stages of the fertility transition in all three settings and another after 1900 when fertility had started to drop substantially in all countries.

To adjust for underlying fecundity differences between the couples all models are stratified by the quartiles of birth interval for child 1-2. The reason is that women having a faster pace of childbearing might also have higher childhood 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 equal to the 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 of their reproductive lives.

In order to adjust for the possible termination of breastfeeding we use a time-varying indicator variable that is set to 1 in the interval 9-12 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 12 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 as used in a number of other fertility studies applying event history analysis (see e.g. Alter 1988, pp. 179–184; Amialchuk & Dimitrova 2012). It should be noted that this strategy does not discriminate between a biological effect of truncated breastfeeding and a replacement response to infant mortality in the very early stages of life. The parameter for infant deaths will aggregate both of these possible influences during the timespan 9-12 mounts after the death of an infant. However, controlling for this timespan will decrease the possibility of biological factors influencing the estimate of our main childhood mortality variable.

In the case of the pooled analysis that includes all cases from the three countries in a joint dataset we include a country variable as an additional stratifying variable to adjust for differences in the baseline hazards across countries. To adjust for differences in sample size in the different datasets each case is also given a weight corresponding to the inverse probability of a case being Swedish, Dutch or Spanish. This gives each country the same impact on estimates despite the differences in sample size between the different countries. In an unweighted analysis the estimates would tend to be dominated by Swedish cases due to the large sample size of this dataset as compared to the other countries.

The outcome measure in hazard regression is sensitive to both timing and incidence and will thus reflect differences in both spacing and stopping behaviour. We do not try to differentiate between the two distinct forms of intentional fertility control in this study because it is not 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 across different settings in Europe during the fertility transition. 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 to more contemporary contexts that differentiate between spacing and stopping in an event history analysis framework, see e.g.

Yamaguchi & Ferguson (1995). 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 models. 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, ….8 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 third child until either parity 8 is reached or the couple is censored due to other reasons. 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.

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 events 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 the full reproductive history. 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 include also these higher parity births arguably giving a more complete picture of the effects in the population under analysis.

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. In episodes where all children are dead this is treated as having a mixed sex-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.

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: 294-296). For a discussion of other approaches to recurrent event models see, for example, Hosmer & Lemeshow (2008: 287-296), Kalbfleisch & Prentice (2002: 279–299) 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

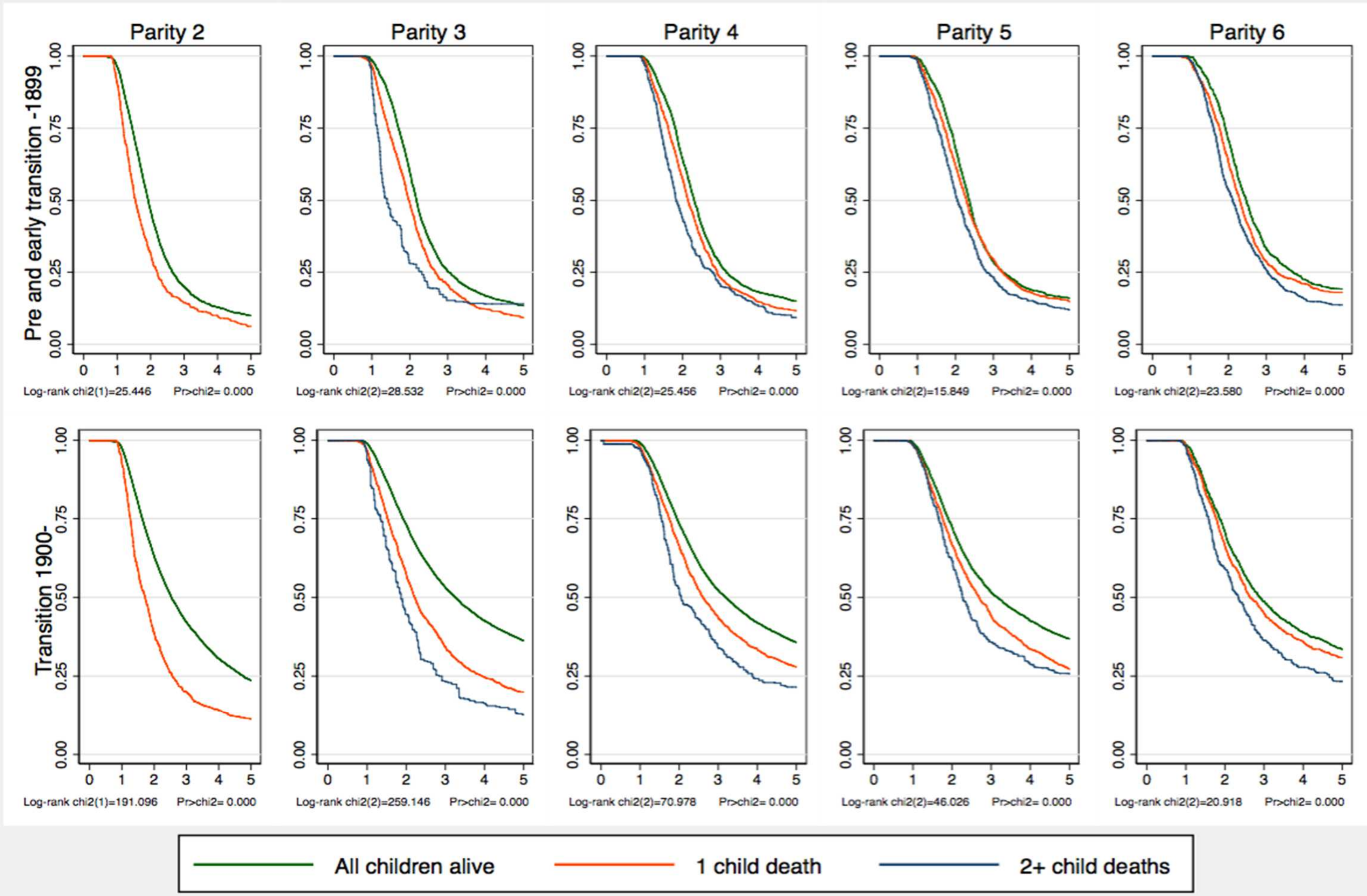
Figure 2 shows the probability of having an additional child for the pooled sample including Sweden, Spain and the Netherlands as a function of time at risk as described by non-parametric Kaplan-Meier survival estimates for parities 2-6 for the entire sample of couples married 1870-1949. Separate survival 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 when we look at the combined sample including all three countries and weighting the cases according to the size of each country in the sample.

It is clear that couples that experience child fatalities have substantially higher risks of progressing to the next parity for all of the parities up until child 6 and that the effect is especially strong for the lower parities as we would expect based on the assumption that fertility control is most prevalent at parities below the mean number of children ever born. The differences in the survival are significant below the 1 percent level for all parities. Estimates for higher parities over 6 (not shown) follow the same trend although effects tend to attenuate in size as expected due to reduced fertility control among families having above mean number of children ever born. Wilcoxon and Tarone-Ware tests that give greater weight to events occurring early when more subject remain at risk as opposed to late during the period at risk yield the same results regarding significance (Hosmer & Lemeshow 2008: 44-59).

Based on a comparison between the two panels showing the association before 1900 when the fertility transition still was in its early stages in all three settings and the second panel showing the association during the more advanced stages after 1900 it is clear that the effect tended to increase as the transition progressed. The differences in survival curves during the early and the late period clearly illustrate how the influence of childhood mortality increases substantially in the latter phase after 1900. When the fertility transition enters its more advanced stage fertility differentials become much larger than during the nineteenth century and child survival started to play a substantial role for the probability to progress to another pregnancy.

Independent of any biological effect related to premature termination of breastfeeding, parents appear to have regulated their fertility in order to achieve a minimum number of surviving children that would reach adulthood and responded to child fatalities by having additional children. In the multivariate analysis below we will test the extent to which this conclusion changes when we control for the biological component of childhood mortality by treating the period when terminated lactation might have significant impact on fecundity separately from the overall childhood mortality effect.

Figure 2: Proportion not progressing to next birth by cumulative number of child fatalities. Kaplan-Meier survival functions and Log-rank tests for parity 2-6, marriage cohorts 1870-1949, in pooled sample for Sweden, Spain and the Netherlands.



Note: Cases are weighted by the inverse probability of being included in the sample to adjust for the different sample sizes in the separate countries.

Source: Same as in Figure 1

In Table 2 we switch to a multivariate setting and estimate single failure Cox-regression for parities 2-5 for the pooled sample including all three countries in order to ascertain the effects of child survival and sex-composition while controlling for the socio-economic position of the father, marriage cohort, the age of the mother when becoming at risk for child 2-5 and the birth interval between first and second birth (underlying fecundity) for parities 3-5. Further we also estimate a control treating the period 9-12 month after the death of an infant separately to adjust our main childhood mortality variable for the possibility of a biological lactation effect on fertility. We split the analysis by two periods before and after 1900 to assess the effect of the independent variables during the early and more advanced stages of the fertility transition. 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.

The substantial effect on further childbearing of the number of surviving children in the sibset are readily visible also in the multivariate models when we control for other important influences on fertility that might confound the effect of childhood mortality including the possibility of infant deaths causing a termination of breastfeeding. To investigate the relative importance of individual biological versus behavioral effects of childhood mortality we include a control variable for the deaths of infants. 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 during the period covered by the control variable. It is impossible to disentangle these two important effects with the available data. Even when including these adjustments 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 1 percent level for both the very early stages of the transition when fertility was still at—or very close to—the pre traditional levels as well as the latter period when fertility entered a stage of consistent secular decline. As we expect the effects of the childhood mortality variable is substantially larger in the later period after 1900 when fertility control had become more widespread, with the relative hazard for the childhood mortality variable approximately double in size as compared to the earlier period. We also see that there is a shift in the effects over the reproductive span in terms of the effect becoming larger at the lower parities especially in the progression to the third child. 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 even when we account for a number of possible confounders such as underlying fecundity differentials, age of the mother and child deaths that possible terminated lactation as opposed to those that did not.

As another indicator of agency in fertility decisions, we estimate the effect of the sex-composition among the surviving children at the time reproductive decisions were made. Here too we find that couples reacted to having children of only one sex by adjusting their fertility in order to have additional offspring of the desired sex. Our results show that there are significant changes over time in how couples responded to lack of male or female children. For the transition to a third child, for example, having no surviving boys before 1900 resulted in a significant increase in the hazard of an additional birth while lack of girls did not. These results suggest that it was more important for the couples married before 1900 to have surviving male offspring, while the lack of surviving girls had no significant impact on fertility decisions at the lower parities. The lower hazard of additional births at parity 5 is also consistent with a boy preference before 1900 as couples were more inclined to stop childbearing if they had surviving boys. The results mirror the preference for male children found also in Germany during the early stages of the fertility transition (Sandström & Vikström (2015) and in the US by Bohnert (2012).

As the countries enter the more advanced stage of the transition after 1900 this preference for boys among couples with family sizes of 2-3 children appears to change and the lack of girls also results in higher birth intensities. What we find is a shift from a boy preference before 1900 to a symmetrical preference during the 20th century, a pattern of behavior that has also been found for Germany (Sandström & Vikström, 2015). Interestingly, the results for the pooled dataset that combines the cases from all three countries indicate that couples that continued to have large families during the fertility decline and reach about the same size as the average of pre-transitional family continued to express a boy preference when deciding to have a 5th child or to stop at 4 children. The country-specific analysis below will reveal interesting country differentials in the effect of sex-composition that shed additional light on the issue of changes over time in the relative value of male and female children.

Table 2: Cox proportional hazard regressions. Relative hazard of reaching parity 2-5 for marriage cohorts 1870-1900 and 1901-1949 in Sweden, Spain and the Netherlands [A]

		Parity 2		**Parity 3**		**Parity 4**		**Parity 5**	
Variables	***Categories***	-1899	1900-	-1899	1900-	-1899	1900-	-1899	1900-
Socio-economic position of the father at the time of marriage (SOCPO)	*Unskilled workers*	1	1	1	1	1	1	1	1
	Semi skilled workers	1.08	0.83***	1.03	0.96	1.06	0.91	1.03	0.93
	Skilled workers	0.96	0.83***	1.06	0.89***	0.97	0.89**	0.99	0.95
	Middle Class: Farmers	1.00	1.11***	1.12***	1.12***	1.02	1.20***	1.04	1.14***
	Middle Class	0.90*	0.75***	1.00	0.84***	0.88*	0.86**	0.92	0.88*
	Elite	0.70***	0.85***	0.87	0.88*	0.88	0.86*	1.00	1.08
	No information	0.93	1.07**	0.99	1.03	0.95	0.97	0.98	1.01
Total number of child deaths at time t	*All children alive*	1	1	1	1	1	1	1	1
	1 dead child	1.28***	1.48***	1.10**	1.24***	1.09**	1.14***	1.05	1.10**
	2 dead children			1.21	1.59***	1.17**	1.29***	1.19***	1.42***
	3 or more					1.28	1.30	1.43***	0.89
Lactation indicator month 9-12 after infant death	*No*	1	1	1	1	1	1	1	1
	Yes	2.27***	2.58***	2.39***	2.63***	2.94***	3.68***	2.70***	3.35***
Sex composition of surviving children at time t	*Mixed*	--	--	1	1	1	1	1	1
	No surviving girls	--	--	1.06	1.06**	0.97	1.03	0.90**	0.99
	No surviving boys	--	--	1.11**	1.06*	1.01	1.03	1.00	1.14**
	Observations	7,173	24,899	6,803	19,252	6,228	12,927	5,586	8,501
	Chi2	147.799	627.296	496.427	2042.387	319.974	745.650	210.627	281.483
	Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Coefficients in exp(β)-form.

Models are stratified for: 10 year marriage cohort, quartiles of birth interval child 1-2 and country.

[A] Models are weighted by the inverse probability of a case being included in the sample to adjust the different sample sizes in the countries.

We now turn to the issue of country specific patterns in the effect of childhood mortality and sex-composition over time. To investigate these issues we pool the events over parities 3-8 and estimate multiple failure Cox regression models to achieve higher statistical power and the ability to estimate more extensive models. The results are found in Table 3, which contains eight different models. Models 1-2 give the average effect on birth intensities for parities 3-8 for all couples in the pooled sample before and after 1900 as a basis for comparison against the parity specific analysis presented in Table 2. Models 3-8 give country specific estimates for the pre/early transitional period before 1900 as well as the period after 1900 when fertility is showing substantial decline in all three settings.

With regard to effect of childhood mortality these results confirm and reinforce the parity-specific results found in the earlier models. In all three settings the effects of childhood survival for reproductive choice tend to increase in the latter period when fertility control becomes more widespread. The increase is most substantial in Spain, the country with the largest relative decrease in childhood mortality (see Figure 1). These results clearly show that differentials in childhood mortality had a substantial impact on the decision to continue having additional children and that this appears to have been a general response to childhood mortality across very different settings in Europe during the fertility decline. The main conclusion from these models is that there is a clear and statistically significant behavioral component of childhood mortality during the course of the fertility transition that remains even when measures are applied to control for the biological component of terminated breastfeeding and other possible confounders. Comparing a model with and without a lactation control (results not shown) the introduction of the control variable reduces the effect of the main mortality variable by less than 50 percent. Given 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 behavioral responses to childhood mortality.

The increased effect of childhood mortality in the latter period after 1900, when survivorship increased 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 increasingly 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 childhood 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 for couples (Reher & Gonzalez-Quiñones 2003: 66, 71). 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 most couples must have expected to lose one or more of their children. 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.

Table 3: Cox proportional hazard regressions for progression to parities 3-8 (Multiple failure per subject model. Marriage cohorts 1870-1949 in Sweden Spain and the Netherlands

		Pooled		Sweden		Spain		Netherlands	
Variables	Categories	-1899	1900-	-1899	1900-	-1899	1900-	-1899	1900-
Socio-economic position of the father at the time of marriage (SOCPO)	Unskilled workers	1	1	1	1	1	1	1	1
	Semi skilled workers	1.02	0.93*	1.03	0.94**	1.14	0.98	0.98	0.94
	Skilled workers	0.98	0.93**	0.99	0.85***	0.99	0.89	0.94	0.96
	Middle Class: Farmers	1.03	1.22***	1.07***	1.23***	1.10	0.90	0.97	1.18**
	Middle Class	0.88***	0.92**	0.87***	0.87***	0.92	1.04	0.84***	0.93
	Elite	0.74***	0.94	0.70***	0.90**	1.15	0.86	0.70**	0.98
	No information	0.98	1.03	1.06	0.98	1.02	1.02	0.70	1.04
Total number of child deaths at time t	All children alive								
	1 dead child	1.05**	1.12***	1.04**	1.11***	0.99	1.14***	1.10**	1.12**
	2 dead children	1.09***	1.21***	1.07**	1.11***	1.06	1.38***	1.11	1.26**
	3 or more	1.17***	1.05	1.09*	0.98	1.13	1.29**	1.12	0.89
Lactation indicator month 9-12 after infant death	No								
	Yes	3.03***	3.51***	3.10***	3.62***	3.13***	3.32***	2.87***	4.06***
Sex composition of surviving children at time t	Mixed								
	No surviving girls	1.01	1.06***	0.98	1.04**	1.03	0.98	1.04	1.14***
	No surviving boys	1.06**	1.08***	1.05**	1.08***	1.12**	1.10**	1.01	1.08
	Observations	31,111	52,959	22,203	39,995	4,678	6,387	4,230	6,577
	Chi2	937.227	1022.072	2021.639	2359.117	293.194	244.588	213.359	204.515
	Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

*** p<0.01, ** p<0.05, * p<0.1

Models are stratified for: 10 year marriage cohort and quartiles of birth interval child 1-2. The pooled model includes the country as an additional stratifying variable.

The pooled models are weighted by the inverse probability of a case being included in the sample to adjust the different sample sizes in the countries.

Looking at our other indicator of agency in fertility decisions, we found in the by parity analysis that prior to 1900 on average couples having no surviving boys was significantly more prone to have an additional child than those having children of both sexes or no surviving girls. Contemporary medical research has conclusively shown 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.

Differently from the effect of childhood mortality there are substantial variations in the effect of sex-composition when the countries are analyzed separately. Sweden shows the same pattern as the one found in Germany (Sandström & Vikström 2015). Here having no surviving boys significantly increase birth intensities among couples married before 1900 while this pattern shifts to a symmetrical preference for couples married after 1900. This indicates an increase in the relative value put on girls by parents that coincide with the shift towards smaller families during the advanced stages of the fertility transition. For parents married after 1900 in Sweden both having no boys and having no girls results in higher birth intensities when we look at the effect across the reproductive history for parities 3-8. The effect increases in strength as the fertility transition progresses as we would anticipate based on the increased ability to express preferences as fertility control becomes more advanced.

Compared to Sweden, both Spain and the Netherlands also exhibit clear effects of the sex-composition but rather differently from the Swedish case. Reher and Sandström (2015) showed that in Spain there is no clear shift towards symmetrical preferences but rather a persistence and even increase of a male preference across the cohorts participating in the transition. In this analysis we have include additional cohorts married up until the 1950s and have extended the sample for the lower parity births by also including couples that are censored before reaching menopause. The results from our earlier analysis is confirmed in that there is no shift to a symmetrical preference, however here we do not find clear indications of an increased strength in male preference that rather remains stable. Additional analysis by parity (not shown) reveal male preference is least visible among couples marrying after 1930 and those with smaller families. Both of these categories have a larger share of the sample in this analysis as opposed to the full reproductive histories chosen for analysis in Reher and Sandström (2015).

The Duch sample shows a different pattern of behavior. Surprisingly there are no indications of boys being preferred over girls even at very early stages of the transition during the nineteenth century. As in Sweden there is a substantial increase in the effect of sex-composition between the period before and after 1900, but in the Netherlands it is primarily the lack of surviving girls that result in increased birth intensities. It should be stressed however that the tendency after 1900 is clearly towards a more symmetrical pattern as the effect for having no surviving boys is also positive. The difference in significance for this parameter in Sweden and the Netherlands is related to the smaller sample size in the Dutch case. In sum, the stronger tendency for preferring girls in the surviving sibset in the Dutch case is a very interesting finding that merits further enquiry in terms of how to explain this early onset of a girl preference in the Dutch case.

The most important finding is however that the results across all three countries for both sex-composition and childhood 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. It is also of interest that the sex-composition of the children had a significant effect on birth intensities in the period before 1900 in both Sweden and Spain when a substantial fertility decline had not yet occurred. It affords additional proof that even during the earlier period couples were reacting to certain outcomes by regulating their fertility decisions this early period when average family size still remained at its pre-transitional levels.

4. Concluding 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. 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 during the pre- an early transitional period likely mirroring the more patriarchal value system before the onset of the societal changes related to the fertility decline . Interestingly there is a clear shift to valuating female children more favorably after 1900 in both Northern and Central Europeans countries included in this study. Parents married after 1900 in both Sweden and the Netherlands that had no surviving female offspring started to show significant increases in birth intensities after 1900. In Spain however this is not the case were we rather observe persistence of a male preference, illustrating that the gender regime in this southern part of Europe did not change as rapidly and early as in Northern and Central Europe. This analysis however indicate that the male preference tended to decline in the cohorts married in the 1940s and among those that had relatively small families, thus suggesting that this may be an interesting byproduct of modernization processes everywhere.

Our results also 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 across all three countries. Even when we include controls for a sudden termination of breastfeeding, the effect of child survival is substantial and statistically significant and increases in strength as the fertility transition progresses. 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. Here we find that experiencing the death of a child did result in an increased probability to have additional children indicating that childhood mortality resulted in replacement behavior and the end result of giving birth to more children than what would otherwise have been the case. 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. 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.

Finally, this paper also illustrates the usefulness of a multivariable modeling techniques that accounts 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. 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. The findings presented here exemplify how behavioral indicators can highlight how the gender regime has changed in different settings characterized by different cultural and religious values across time. A area for further research would be to better assess 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, or if the explanation for country differentials in sex-preferences must be sought after in other contextual changes over time in different settings.

References

Alter, G. (1988). Family and the female life course: the women of Verviers, Belgium, 1849-1880. Madison: The University of Wisconsin Press.

Amialchuk, A. & Dimitrova, E. (2012). Detecting the evolution of deliberate fertility control before the demographic transition in Germany. *Demographic Research*, 27(19), 507–542.

Andersson, G., Hank, K., Ronsen, M., & Vikat, A. (2006). Gendering Family Composition: Sex Preferences for Children and Childbearing Behavior in the Nordic Countries. *Demography*, *43*(2), 255–267. http://doi.org/10.1353/dem.2006.0010

Bengtsson, T. & Dribe M. (2006). Deliberate control in a natural fertility population, Southern Sweden: 1766-1864. *Demography*, 43(4), 727-746.

Bhat, N. (1998). Demographic estimates for post-independence India: a new integration. *Demography India*, 27(1), 23–57.

Bohnert, N., Jåstad, H. L., Vechbanyongratana, J. & Walhout, E. (2012). Offspring sex preference in Frontier America. *Journal of Interdisciplinary History*, 42(4), 519–541. doi:10.1162/JINH_a_00303

Burnham, K. P. & Anderson, D. R. (2004). Multimodel inference understanding AIC and BIC in model selection. *Sociological Methods & Research*, 33(2), 261–304. doi:10.1177/0049124104268644

Chesnais, J. C. (1986). La transition démographique: étapes, formes, implications économiques. Etude de séries temporelles (1720-1984) relatives à 67 pays. *Population (French Edition)*, 41(6), 1059–1070. doi:10.2307/1532931

Cheung, Y. B., Gao, F. & Khoo, K. S. (2003). Age at diagnosis and the choice of survival analysis methods in cancer epidemiology. Journal of Clinical Epidemiology, 56(1), 38–43. doi:10.1016/S0895-4356(02)00536-X

Cain, M. (1988). Patriarchal structure and demographic change. In: N. Federici, S. Sogner, & K. Oppenheim Mason (Eds.). *Women's Position and Demographic Change*, (pp. 43–60). Oxford: Clarendon Press.

Coale, A. (1973). The Demographic Transition Reconsidered. In: International population conference: Liege 1973 = Congres international de la population : Liege 1973. Vol. 1, (pp. 53-72) Liege: IUSSP, 1973.

Davis, K. (1963). The theory of change and response in modern demographic history. *Population Index*, 29(4), 345-366.

Demographic Database -Umeå University. (2015). POPLINK - a unique resource for innovative research on human societies from a longterm perspective [text]. Retrieved March 13, 2015, from http://www.ddb.umu.se/english/database/poplink-/?languageId=1

Eisenberg, M. L., Schembri, M., Croughan, M. S. & Walsh, T. J. (2011). Fecundity and sex ratio of offspring in an infertile cohort. *Fertility and Sterility*, 96(4), 833–836. doi:10.1016/j.fertnstert.2011.07.1141

Galloway, P.R., Lee, R. D. & Hammel, E. A. (1998). Urban versus rural: Fertility decline in the cities and rural districts of Prussia, 1875 to 1910. *European Journal of Population/Revue Européenne de Démographie*, 14(3), 209–264.

Grambsch, P. M. & Therneau T. M. (1994). Proportional hazards tests and diagnostics based on weighted residuals. *Biometrika*, 81(3), 515–526.

Haines, M. R. (1997). The relationship between infant and child mortality and fertility: Some historical and contemporary evidence for the United States. In: B. Cohen (Ed.). *From Death to Birth: Mortality Decline and Reproductive Change*, (pp. 227–253). Washington D. C: National Research Council.

Hank, K. (2007). Parental gender preferences and reproductive behaviour: A review of the recent literature. *Journal of Biosocial Science*, 39(5), 759–767. doi:10.1017/S0021932006001787

Hank, K., & Kohler, H.-P. (2000). Gender preferences for children in Europe: Empirical results from 17 FFS countries. *Demographic Research*, *2*(1), 133–144.

Hofsten, E., & Lundström, H. (1976). *Swedish population history : main trends from 1750 to 1970*. [Stockholm]: [LiberFörlag].

Henry, L. (1961). Some data on natural fertility. *Eugenics Quarterly*, 8(2), 81-91.

Hosmer, D. W., Lemeshow, S. & May, S. (2008). *Applied survival analysis: regression modeling of time to event data* (2nd ed.). New York: Wiley.

Joffe, M., Bennett, J., Best, N. & Jensen, T. K. (2007). Sex ratio and time to pregnancy: analysis of four large European population surveys. *BMJ*, 334(7592), 524. doi:10.1136/bmj.39097.508426.BE

Johnson-Hanks, J. (2008). Demographic transitions and modernity. *Annual Review of Anthropology*, 37, 301–315. doi:10.1146/annurev.anthro.37.081407.085138

Kalbfleisch, J. D. & Prentice, R. L. (2002). The statistical analysis of failure time data. Hoboken, N.J: John Wiley & Sons, Inc. .

Kirk, D. (1996). Demographic transition theory. *Population Studies*, 50(3), 361–387. doi:10.1080/0032472031000149536

Knodel, J. (1988). *Demographic behavior in the past: A study of fourteen German village populations in the eighteenth and nineteenth centuries*. Cambridge: Cambridge University Press.

Knodel, J. (1978). Natural fertility in pre-industrial Germany. *Population Studies*, 32(3), 481–510. doi:10.2307/2173723

Knodel, J. (1974). *The decline of fertility in Germany, 1871-1939*. Princeton, New Jersey: Princeton University Press.

Knodel, J. & Van de Walle, E.. (1967). Breast feeding, fertility and infant mortality: An analysis of some early German data. *Population Studies*, 21(2), 109–131. doi:10.2307/2172715

Korn, E. L., Graubard, B. I. & Midthune, D. (1997). Time-to-event analysis of longitudinal follow-up of a survey: Choice of the time-scale. *American Journal of Epidemiology,* 145(1), 72–80.

Korn, E. L. & Graubard, B. I. (1990). Simultaneous testing of regression coefficients with complex survey data: Use of Bonferroni t statistics. *American Statistician*, 44(4), 270-276.

Kälvemark, A. (1977). The country that kept track of its population: Methodological aspects of Swedish population records. *Scandinavian Journal of History*, *2*(1-4), 211–230. http://doi.org/10.1080/03468757708578919

Lesthaeghe, R. J. (1977). *The decline of Belgian fertility, 1800-1970*. Princeton: Princeton University Press.

Livi Bacci, M. (1977). *A history of Italian fertility during the last two centuries*. Princeton: Princeton University Press.

Lynch, K. A. (2011). Why weren't (many) European women 'missing'? *The History of the Family*, 16(3), 250–266.

Mason KO. 1997. Explaining fertility transitions*. Demography 34: 443–454.*

Matthiessen, C. & McCann, J. C. (1978). The role of mortality in the European fertility transition: aggregate-level relations. In: S. H. Preston (Ed.), *The Effects of Infant and Child Mortality on Fertility,* (pp. 47–68). New York: Academic Press.

Mills, M., & Begall, K. (2010). Preferences for the sex-composition of children in Europe: A multilevel examination of its effect on progression to a third child. *Population Studies*, *64*(1), 77–95. http://doi.org/10.1080/00324720903497081

Notestein, F. W. (1945). Population-The Long view. In: T. W. Schultz (Ed.), *Food for the world*, (pp. 36–57). Chicago: University of Chicago Press.

Oris, M., Renzo R. L. & Breschi M. (2004). Infant and child mortality. In: T. Bengtsson, C. Campbell, J. Lee, et al. (Eds.). *Life under pressure: Mortality and living standards in Europe and Asia, 1700-1900*, (pp. 359–398) . Cambridge, MA: MIT Press.

Palloni, A. & Rafalimanana, H. (1999). The effects of infant mortality on fertility revisited: New evidence from Latin America. *Demography*, 36(1), 41–58. doi:10.2307/2648133

Pebley, A. R., Delgado, H. & Brinemann, E. (1979). Fertility desires and child mortality experience among Guatemalan women. *Studies in Family Planning,* 10(4), 129–136. doi:10.2307/1965691

Prentice, R. L., Williams, B. J. & Peterson, A. V. (1981). On the regression analysis of multivariate failure time data. *Biometrika*, 68(2), 373–379. doi:10.2307/2335582

Preston, S. H. (1978). Introduction. In: S.H. Preston. (Ed.). *The effects of infant and child mortality on fertility,* (pp. 1-18). New York Academic Press, 1-18.

Reher, D. S. (2004). The demographic transition revisited as a global process. *Population, Space and Place*, 10(1), 19–41. doi:10.1002/psp.313

Reher, D. S. (2011) 'Economic and Social Implications of the Demographic Transition' in *Demographic Transition and Its Consequences*, a supplement to Vol 39 (2011) of *Population and Development Review* (RD Lee and DS Reher, guest editors): New York, Population Council, 11-33.

Reher, D. S. & González-Quiñones, F. (2003). Do parents really matter? Child health and development in Spain during the demographic transition. *Population Studies*, 57(1), 63–75. doi:10.1080/0032472032000061730

Reher, D. S., Ortega, J. A. & Sanz-Gimeno, A. (2008). Intergenerational transmission of reproductive traits in Spain during the demographic transition. *Human Nature*, 19(1), 23–43. doi:10.1007/s12110-008-9032-6

Reher, D.-S. y Sanz Gimeno, A. (2006). Marked from the outset: season of birth and health during early life in Spain during the demographic transition. *Continuity and Change* 21(1): 107-129.

Reher, D. S. & Sanz-Gimeno, A. (2007). Rethinking historical reproductive change: Insights from longitudinal data for a Spanish town. *Population and Development Review*, 33(4), 703–727. doi:10.2307/25487619

Reher, D. S., González-Quiñones, F. y Sanz-Gimeno, A. (2004). Procesos de modernización y trayectorias de vida. Propuesta para el análisis sociodemográfico a partir de datos locales en España, *Reconstituição de famílias, fogos e estratégias sociais, Actas del VI Congreso de la Asociación de Demografía Histórica*, 18-20 abril 2001, Vol. II, Castelo Branco, 83-108.

Reher, D. S., & Sandström, G. (2015). Dimensions of Rational Decision-making during the Demographic Transition; Aranjuez (Spain) Revisited. *Historical Life Cource Studies*, *2*(2), 1–21. http://hdl.handle.net/10622/23526343-2015-0002?locatt=view:master

Rosero-Bixby, L. (1998). Child mortality and fertility transition: Aggregate and multilevel evidence from Costa Rica. In: B. Cohen (Ed.). From Death to Birth: Mortality Decline and Reproductive Change, (pp. 227–253). Washington D. C: National Research Council.384–410.

Sandström, G., & Vikström, L. (2015). Sex preference for children in German villages during the fertility transition. *Population Studies*, *69*(1), 57–71. http://doi.org/10.1080/00324728.2014.994667

StataCorp. (2013). Stata Statistical Software: Release 13. Stata Corporation, Texas: College Station.

Thiébaut, A. & J. Bénichou, (2004). Choice of time-scale in Cox's model analysis of epidemiologic cohort data: a simulation study. *Statistics in medicine*, 23(24), 3803–3820.

Van Bavel, J. (2003). Birth spacing as a family strategy: evidence from 19th century Leuven, Belgium. *The History of the Family*, 8, 585-604.

Van Bavel, J. (2004). Deliberate birth spacing before the fertility transition in Europe: Evidence from nineteenth-century Belgium. *Population Studies*, 58(1), 95-107.

Van Bavel, J. & Kok J. (2010). A Mixed effects model of birth spacing for pre-transition populations. Evidence of deliberate fertility control from nineteenth century Netherlands. *The History of the Family,* 15(2), 125-138. doi:10.1016/j.hisfam.2009.12.004

Van de Kaa, D.J. (1996). Anchored narratives: The story and findings of half a century of research into the determinants of fertility. *Population Studies*, 50(3), 389-432.

Van de Putte, B. & Miles, A. (2005). A Social Classification Scheme for Historical Occupational Data. *Historical Methods: A Journal of Quantitative and Interdisciplinary History*, *38*(2), 61–94. http://doi.org/10.3200/HMTS.38.2.61-94

Van de Walle, E. (1992). Fertility transition, conscious choice, and numeracy. *Demography*, 29(4), 487-502.

Van de Walle, F. (1986). Infant mortality and the European demographic transition. In: A. J. Coale and S. C. Watkins (Eds.). *The decline of fertility in Europe : the revised proceedings of a Conference on the Princeton European Fertility Project*, (pp. 201–233). Princeton, New Jersey: Princeton University Press.

Van Poppel, F., Reher, D. S., Sanz-Gimeno, A., Sanchez-Dominguez, M. & Beekink, E. (2012). Mortality decline and reproductive change during the Dutch demographic transition. *Demographic Research*, 27 (11), 299–338. doi:10.4054/DemRes.2012.27.11

Yamaguchi, K. & Ferguson, L.R. (1995). The stopping and spacing of childbirths and their birth-history predictors: rational-choice theory and event-history analysis. *American Sociological Review,* 60(2), 272-298