Max-Planck-Institut für demografische Forschung
Max Planck Institute for Demographic Research
Konrad-Zuse-Strasse 1 · D-18057 Rostock · GERMANY
Tel +49 (0) 3 81 20 81 - 0; Fax +49 (0) 3 81 20 81 - 202;
http://www.demogr.mpg.de

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# The *helping* and the *helpful* grandmother - The role of maternal and paternal grandmothers in child mortality in the 17th and 18th century population of French Settlers in Quebec, Canada

Jan Beise (beise@demogr.mpg.de)

This working paper has been approved for release by: James W. Vaupel (jwv@demogr.mpg.de)
Head of the Laboratory of Survival and Longevity.

# The *helping* and the *helpful* grandmother - The role of maternal and paternal grandmothers in child mortality in the 17$^{th}$ and 18$^{th}$ century population of French Settlers in Quebec, Canada

*Jan Beise*

Max Planck Institute for Demographic Research, Rostock, Germany

## Introduction

The helping grandmother plays an important role in explaining human life history, in particular the evolution of human longevity (see e.g. Hawkes 2003). The interest of evolutionary biologists in grandmothers originates in William's seminal paper of 1957 on the evolution of senescence. He aimed at finding an evolutionary explanation for the existence of the sudden decline in reproductive function, followed by a post-reproductive life span in human females - a trait that according to evolutionary theory should not exist since "sterility is the selective equivalent of death" (Williams 1957:407). In an explanation for this apparent contradiction, he pointed out that in a species that has a considerable dependency of offspring on the care of parents, any post-reproductive period does not begin with senile sterility but at the earliest when the last child is self-sufficient. This is because "any individual, of whatever age, who is caring for dependent offspring is acting in a way that promotes the survival of his own genes" (Williams 1957: 407). Although Williams was thinking in particular of mothers caring for their children, his statement is valid for any genetic relationships and generational overlap.

In William's scenario, the prolonged need for the care of children started an evolutionary development in which the termination of female fertility shifted to younger ages. Since late pregnancies increasingly comprise risks for the mother (Loudon 1992) and with her death would leave the existing children without maternal care, it could pay for the inclusive fitness of the mother to give up reproduction at an earlier stage than physiologically possible and instead invest the resources saved thereby in her living children. Looking at it this way, female menopause would be an adaptation in its own right.

This "stopping-early-hypothesis" became increasingly disputed in recent years on empirical and analytical grounds (see, for instance, Packer et al. 1998; Peccei 2001). The main argument is that it is difficult for women to compensate for forgone direct reproduction by the indirect benefits of help and support (see Grainger & Beise 2004 for a dynamic model approach to this problem). Instead, it is argued that it is not menopause but an extended post-menopausal longevity identifying parental care and intergenerational transfer as the driving evolutionary force that is the adaptive trait (Kaplan 1997; Carey & Judge 2001). Irrespective of which hypothesis one prefers critical to both is the existence of substantial contributions of post-menopausal women to their kin and thereby to their inclusive fitness.

Looking at the hunting and foraging Hadzabe in northern Tanzania, Hawkes and colleagues were the first to show that grandmothers were helpful supporters by providing food for their adult daughters' families (Hawkes et al. 1989, 1997). Hill and Hurtado (1991, 1996), studied the Ache of eastern Paraguay and found a positive relationship between the survival of grandmothers and that of their grandchildren but this effect was statistically insignificant. Only in very recent years was it shown that grandmothers had a measurable effect on important fitness components. Sear and colleagues (2000, 2002) analyzed the effect of grandparents on nutritional status (height and weight) in a farming population of Gambia and the survival of their grandchildren. They found that while maternal grandmothers improved both nutritional status and survival significantly, the paternal grandmothers and both grandfathers had almost no effect.

Beise and Voland (2002; Voland & Beise 2002) studied a historical agrarian population of northern Germany (Krummhörn, 18$^{th}$ and 19$^{th}$ centuries) and found here, too, that the presence of maternal grandmothers decreased the grandchildren's mortality significantly. Jamison and colleagues (2002) found the same effect for a historic village population in central Japan (17$^{th}$ to 19$^{th}$ centuries). Again, in both populations this positive effect was solely limited to the maternal grandmother, not to any of the other grandparents.

And, finally, Lahdenperä and collegues (2004) presented a study of a historic Finish populations, in which a number of fitness correlates are positively associated with the presence of a grandmother. Furthermore, the longer the women's post-reproductive life span was, the more grandchildren she had. This last relationship was found both for the Finish population as for a $19^{th}$ and $20^{th}$ century Canadian population.

In this study, we will further explore the ecological and cultural validity of these findings by analyzing the French Canadian population of the $17^{th}$ and $18^{th}$ centuries in Quebec, Canada. The population differs substantially from all previous tested ones. It consists of the first French emigrants to Quebec, who established a permanent European settlement in the beginning of the 17th century, and their descendents. The population experienced a high growth rate of 2.5 to 3%, which only in the beginning was due to immigration (Charbonneau et al. 2000). As early as 1673, population growth was fueled mainly by the reproduction of the local population and immigration became increasingly marginal in relation to the population already existing (Desjardins 1997). The population experienced a high-fertility regime, the average family had between seven and eight children. Mortality was lower in the first years of settlement but then increased over time but still remained below the level found in France during the same period. This pattern reflects a favorable environment, selectiveness of healthy immigrants and low population density (Charbonneau et al. 2000).

We will analyze child mortality in the first five years in relation to the survival of their grandmothers and other kins. We will apply event history models, that allow us to find out at which age of the child grandmothers had the biggest impact on its survival. Furthermore, in order to obtain deeper insight into the potential mechanisms of this support, we analyze the grandmaternal effect in relation to the mother’s age.

# Population and Data

The data came from the population register created by the Programme de Recherche en Démographique Historique (PRDH) at the University of Montreal. The PRDH data are based on some 690,000 baptisms, marriages and burials registered in Quebec parishes (St. Lawrence valley) from the first settlers in 1621 to 1799. The final data set was compiled using the family reconstitution technique (Fleury & Henry 1976; see Voland 2000 for a summary on its use in evolutionary anthropology). The Quebec data set is unique since it covers a complete population over the whole territory, thus freeing the observation largely of the usual problem of out-migration.

Although the first Europeans settled permanently in Quebec in 1608 already, the actual populating process started only two decades later. Between 1632 and 1650, the population grew from around 60 inhabitants to over 1,000 and finally reached a size of around 55,000 about 100 years later. By the year 1750, approximately 10,000 immigrants had settled in the colony. After the end of the great immigration 1663-1673, the population growth was mainly "home made". Whereas in 1663, around 60% of the inhabitants were immigrants, in 1700 this was true for only less than 20% (Charbonneau et al. 2000).

Our analysis will be limited to children born between 1680 and 1750. This has the advantage of excluding pre-1680 high migration rates and of limiting the analysis to the more stable period of the expanding colony. The year 1750, then, marks the beginning of increasing political turmoils owing to conflicts between the French and English colonies which have had an impact on the quality of the data (Desjardins 1997; Charbonneau et al. 2000).

Only children were included in the data sample that were born to a married couple whose exact wedding date was known. The exact date of birth had to be known: cases with a calculated date of birth (using age declaration) were excluded. If no date of birth was given, the date of baptism was used instead (according to Charbonneau (1985) the majority of children were baptized within few days after birth).

Another kind of data selection results from the necessity to construct family histories over three generations. For many children, no grandmothers could be identified or information about their deaths was missing. Only those children were included in the data sample for whom information about both grandmothers was available. These selections resulted in the primary data sample that was then used to calculate child mortality rates and survival. A final selection concerns missing covariate values used in the parametric model. In the secondary sample, only those children were included that had valid values for all covariates.

The existence of missing death entries needs some careful considerations since they can cause some bias in the analysis. Missing values are a commong problem in nearly all family reconstitution data. In our secondary sample around 34% of all children have no recorded date of death. Death entries may be missing due to under-registration, the loss of registers, out-migration (not relevant here) or due to survival beyond the end of the observation period (which means that the death of the individual is not recorded in the evaluated registers). However, for the majority of these cases, a marriage entry was registered, confirming a survival beyond childhood (75% of all cases with missing death entry). We considered the remaining cases without death entry as having survived, in particular for two reasons. First, there is a strong bias towards younger cohorts and this suggests that death after the end of the observation (1765, fifteen years after the end of the period of analysis) is the major reason for the missing entries. Second, where under-registration led to missing death entries, it is more likely that the children survived age five (over three quarters survived age one and around two third lived until age fifteen; Nault et al. 1990). Although this method underestimates the true level of mortality, the error is smaller than ignoring those cases which would overestimate mortality. Furthermore, although the absolute level of mortality is biased, this is not necessarily true for the relative effects of our main covariates, the survivorship of the grandmothers. In fact, our estimated infant mortality rates (in total and differentiated for different periods) are very close to what Nault et al. (1990) found. Nault and colleagues analyzed the same population using more sophisticated control methods in order to account for under-registration and loss of registers. Finally, we estimated the same models presented later in this study, using a very rigid data selection criteria (considering only children with known dates of death which grossly overestimate infant mortality) and found almost identical patterns of the estimated parameters (not shown here).

# Methods

### *The model*

We used event history models to analyze the probability of children's death over time. These models have the advantage of accounting for the time dependency of the process itself and of the covariates, and they can cope easily with censored data. Transition rate models can be represented mathematically by:

$$\ln \mu_i(t) = y(t) + \sum_k \beta_k x_{ik} + \sum_l \lambda_l z_{il}(t) \qquad (1)$$

where $\ln \mu_i(t)$ is the log-hazard of the event occurrence at time $t$ for the $i$th child, $y(t)$ captures the baseline hazard, $x_k$ is the $k$th time constant covariate and $z_l$ is the $l$th time varying covariate with $\beta$ and $\lambda$ as the respective regression parameters.

In order to control for confounding effects, some of the following analyses are based on parametric event history models. A piecewise constant exponential model was chosen because it has some features that are useful for our case. First, no strong assumptions about the time-dependency of the process need to be made since the model allows to split the time axis into several time intervals for which the transition rates are estimated separately (the only assumption is that the rates are constant within each interval). Second, since it is known from previous studies that grandmaternal help is not evenly distributed over large age intervals (Beise & Voland 2002a; Sear et al. 2002), it is important to be able to pin point potential effects on specific age intervals. This can be done by choosing meaningful age intervals (following to theoretical and/or empirical considerations) and to allow the parameters of the covariates to change freely between these intervals ("period-specific effects" - see for example Blossfeld & Rohwer 1995 (pp. 110-119) for a detailed description of such models). This means that we do not need to assume proportionality of the hazards concerning the covariates.

We used the following age classes for the parametric modeling: 0 months (from birth to 30.4 days), 1-5, 6-11, 12-23, 24-35 and 36-59 months. We separated the first month because neonatal mortality is caused by different factors than mortality at higher ages. The former is mainly caused by endogenous factors such as congenital malformations and prenatal life circumstances in contrast to post-neonatal mortality which is dominated by exogenous reasons such as infections etc. (McNamara 1982). Note that in this study we included stillbirths since stillbirths and neonatal deaths are outcomes of the same causal processes (Hart 1998; note further that the stillbirth rate in this sample - based only on the number of children for whom we had the birth record - is rather low, 1.9% , which may be an indication of stillbirth under-registration). All surviving children were censored at the end of their fifth year (60.0 months).

All event-history models were estimated using the free (under the terms of the GNU General Public License) software TDA version 6.3b (Rohwer & Pötter 2000).

### *The covariates*

The effect of grandmothers is the main focus of this study. Since we have no information on the quality and quantity of support that a grandmother gave to the mother or the child, we used her survival as a proxy instead. Besides the grandmother, we included in the model the survival status of the mother, the father and both grandfathers in order to control for any other kin effect. All variables are entered as time varying covariates.

Furthermore, following time constant covariates were included, all of which are known to have an impact on infant and child mortality: sex of the child, age of mother at the birth of the child, birth cohort, number of living siblings at time of childbirth. The covariates are categorized to allow for non-linear dependencies.

In order to decrease the number of parameters that need to be estimated, constraints were added to the time constant variables so that the parameters of each variable are equal across the model's time periods (which means that for these variables the assumption of proportional hazards is reintroduced).

Table 1 gives a short statistical description of the sample used in the parametric model.

TABLE 1

## Results

Figure 1 shows the death rate and the associated survival function resulting from the life table for the 49,206 children which formed the primary data sample (this sample is substantially larger than the sample used in the parametric model below since it is based on all children in the data set irrespective of information on grandparents). Mortality was high in the very first month, with a rate of over 0.11 in the neonatal period. Between the age of three and approximately nine months, mortality declined exponentially but still remained at a high level. From age nine months to the end of censoring age (five years) the mortality rate continued to decline exponentially but now at a lower rate. The mortality trajectory resulted in a proportion of children dying in the first month of over 10%. After one year, over one fifth of all children born were dead and only 73% survived age five.

FIGURE 1

Figure 2 displays the survivor functions (Kaplan-Meier estimators) for children over the first five years of age according to the survival constellation of maternal and paternal grandmothers at the time of the child's birth. When both grandmothers were alive, around 76% of all children survived age 5; when none of the grandmothers were alive, only 71% reached this age. Almost right in between these two extremes are the survival outcomes for those children who had either only a living maternal or paternal grandmother at the time of their birth (75% survival after five years). Although their outcome after five years is almost identical, it can be noted that in the very early ages the paternal grandmother seems to have had a greater impact on the child's survival and that only from approximately age 12 months onwards the gap between the two grandmothers narrows and finally closes at around 29 months.

FIGURE 2

Although these survivor plots are very illustrative, it is dangerous to translate observable differences directly into causal relationships. The reason is that the non-parametric techniques do not allow controlling for potential influential background variables. In this case, the most important variable is maternal age at birth. As seen in Figure 3, maternal age at birth had an important effect on child survival. Younger mothers offered their children higher survival chances than old mothers did: While over three quarters of the children of mothers aged between 25 and 30 years survived until age five, only two third of those whose mother was above 35 years of age did so (note that the children of the youngest maternal age group showed even slightly higher mortality, a result of the in general J-shaped relationship between infant death rates and maternal age (e.g. McNamara 1982)). Naturally, maternal age is also highly correlated with the survival status of the grandparents: the older the mother, the older the grandparents and therefore the more likely it is that they are not alive when the child is born. Furthermore, due to the age gap between wife and husband every child is more likely to have a paternal grandmother that is not alive rather than a maternal one. Translated into the child's situation this means: A child with a paternal grandmother that is alive is born in average to a younger mother than one with a maternal grandmother alive - and the children of younger mothers experienced a higher survival.

FIGURE 3

In order to control for these hidden confounding effects, the following analyses are based on parametric event history models. Table 2 shows the results of the applied piecewise constant model with period specific effects.

The death of the mother had a very strong influence on the child's mortality as could be expected. Its risk to die increased by a factor between 2 and 3 plus in almost all age intervals. Also, the death of the father increased the mortality risk for the child, but this effect was much less pronounced. Only at ages six months to two years these effects exceeded the five percent significance level.

Children without a living maternal grandmother had a significantly increased mortality risk in the second and third year of life; it rose by around one third and one fourth to one fifth, respectively. This effect is very pronounced and contrasts sharply with the complete lack of maternal grandmothers' influence in the surrounding age classes. Interestingly, this temporal pattern fits nicely with breastfeeding behavior in Quebec. Henripin (1954) estimated for its early 19$^{th}$ century population an approximately 14 months of breastfeeding in the average and Landry (cited in Charbonneau et al. 2000, footnote 5) estimated a duration of 14 to 15 months. Thus, it seems that maternal grandmothers were most valuable during weaning and the transition to a milk substitute. Grandmaternal experience and knowledge may have played an important role here - but also directly taking care of the child while the mother increased gradually her work participation for the household economy.

The paternal grandmother shows a very moderate effect only - and it is limited furthermore to the very first month after birth only. At this age, children without a paternal grandmother suffered from a 12% higher mortality compared to children with one that is alive. All other ages are insignificant. Although this effect seems to be quite moderate - in particular compared to the effects of the maternal grandmother, which is three times greater - it has to be taken into account that mortality in the first month was much higher. This means that although a paternal grandmother that is alive saved only every ninth child which would have died otherwise these lives amount to a considerable number because the underlying mortality was very high (see Figure 1). A living maternal grandmother, by contrast, could save even every third child during the second year and every fourth to fifth child during the third year. However, since mortality was comparatively low at these ages, these effects were not translated into very large numbers of saved lives. In fact, based on the observations, it can be shown that a paternal grandmother that was alive saved almost as many lives in the first month of the child's life than a maternal grandmother one and two years later. Nevertheless the great difference between the two grandmothers is that the maternal grandmothers seems to have saved children's lives by directly helping with childcare while the effect of the paternal grandmother was mediated via the mother's condition during pregnancy (referring to the endogenous nature of mortality during the first month).

Both grandfathers have almost no effect on the child's survival chances. The only exception is the maternal grandfather who has a significant effect on the child's mortality just in the very last age interval, i.e. from three to five years. Here, the risk to die increased by 33% when the maternal grandfather was not alive.

All other control variables show the expected effects on children's mortality (note that constraints are added to the parameters of these covariates, resulting in the same estimate for all ages): Girls had a lower mortality than boys, it increased at higher maternal ages and children that occupied a low position in the birth order showed increased mortality, too, compared to children at the higher positions. Later cohorts suffered from higher mortality compared to the earlier ones. Prima facie, this seems to be a surprising finding but it is a distinctive feature of the Quebec population. It is related to a healthy migrant effect and to the generally favorable environmental conditions as mentioned above.

TABLE 2

Since it is known that at least parental investment in children may depend on the children's sex (e.g. Sieff 1990; Beise & Voland 2002b) we ran the same model also separately for both sexes. The second and third columns in Table 2 show the corresponding results.

For both sexes, the death of the mother is a dramatic event in terms of mortality. But it seems that the early death of the mother was affecting sons more than daughters. Up to age three, sons suffered a higher risk of dying than girls when the mother died. Only in the last age group is this relation reversed. The higher responsiveness at early ages of boys to the loss of their mother may be a consequence of the general higher biological frailty of boys compared to girls at young ages, which is also reflected in the generally higher general infant mortality of boys.

The loss of the father had a mixed effect on the mortality of sons and daughters although it seems that the sons were influenced more strongly. When the father was dead, daughters suffered from a twofold risk of dying between age one to five months and sons suffered from up to almost two and a half times higher a risk in the second half of the first year and the following second year of life. These effects are difficult to interprete, not least because it is unclear how the mechanism could look like. A direct beneficial effect of a living father on the children at these ages (when most children were still breastfed) is unlikely, rather there may be a harmful effect by the death of the father on the household economy or the mother's mental health due to the loss of her husband. But still then, these sex differences are not expected.

The effect of the maternal grandmother is quite stable for children of both sexes, although there seems to be as slight preference for daughters. In the second and third year of life, girls without a living maternal grandmother suffered from a mortality risk that is around 30% higher, while this was true for boys only in the second year. In the third year, boys' risk is still increased by 12% but this effect does not differ statistically from a zero effect.

We observed only very slight sex differentiating effects concerning the paternal grandmother. Although the effect for boys and girls differ in the level of significance, the absolute values are very similar (a risk to die when the paternal grandmother was not alive that increased by 13% and 11% for boys and girls respectively). This is not surprising since: if we assume that the effects can be traced back to the maternal condition during her pregnancy, then there is no place for an intentional preference of one sex (since the sex of the developing child is unknown). The still remaining difference between boys and girls, if it is real, could then again be related to boys' higher frailty at the time around birth or a potentially higher receptivity for an improvement of their foetal environment.

Grandfathers had only small effects on boys and girls. A missing maternal grandfather increased the mortality of boys by almost 30% and that of girls by 37% in the last age group (four to five years). The paternal grandfather had a similar effect on the same age group, but only concerning girls. Their risk to die was rising by 51% when the grandfather was not alive. The effects on the last age group are difficult to interprete, but note again that although the effect values seem to be high, they are much less influential compared to the grandmaternal effects because mortality is very low at these ages.

As already mentioned grandmothers seem to be especially important in the context of weaning (see Beise & Voland 2002a; Sear et al. 2002). But the question remains about the quality of this help. Was help especially important to young and inexperienced mothers? Or was grandmaternal help something given additionally to improve the child's condition - not necessarily intended for compensating insufficiency by the mother. In answer to this question we introduced an interaction between the survival status of the grandmother and the age of the mother in the model presented in Table 2. This was done by creating four dummy variables, which coded for four maternal age categories, and a maternal grandmother that passed away (in order to get a contrasting age group of very young mothers the first age group was reduced to mothers from age 15 to 22). The mortality risks of the children were compared to the average mortality risk for children when their maternal grandmother was alive (irrespective of the mother’s age). The dummy variables entered the full model, substituting the grandmother variable but additional to the variables coding for the mother's age. This was done in order to catch the true interaction effect and not to confound this relationship by the strong maternal age effect. Furthermore, it was done only for the maternal grandmother since she was the only one who showed a substantial influence on the child's wellbeing.

Figure 4 depicts that part of the model’s results that concerns the maternal grandmother. It shows the risks for children to die when the maternal grandmother was dead - depending on the age of the mother at the time of birth and relative to the risk of children whose grandmother was alive. As can be seen, the effect of grandmothers on the survival of their grandchildren did indeed show an age-graded effect: The older the mother, the less important the grandmaternal effect, it seems. But still, even for older and therefore presumably experienced mothers in their early thirties, the presence of the maternal grandmother increased the survival chances substantially, especially during the second year of the children's life. Grandmothers seemed to be most important to the youngest mothers, though: Aged three, their children faced even a double risk of dying when the grandmother was not present (although the observed pattern speaks in favor of a delayed grandmaternal effect compared to older mothers: perhaps young mothers weaned slightly later than the older mothers). And in the very first month of life, the children's risk was 35% higher when the maternal grandmother was dead. Since infant mortality in the first four weeks is mainly due to endogenous causes reflecting among others maternal health (McNamara 1982), this effect can be interpreted as support which the mother's mother gave to her daughter during pregnancy.

FIGURE 4

## Discussion

Grandmaternal or grandparental support was postulated based on theoretical considerations. Up until very recently almost no hard empirically tests on grandmaternal help were available. Psychological or sociological studies found special relationships between grandparents and grandchildren, which are in accordance with expectations based on evolutionary theory (e.g. Euler & Weitzel 1996). Anthropological studies provided evidence for support that grandmothers give to their adult children and grandchildren (Hawkes et al. 1997; Hewner 2001).

Only as recently as in the last few years did studies emerge that focused on the immediate genetic fitness benefits of grandparents on their grandchildren. Most of these studies took the survival of the grandchildren as (the ultimate) outcome (Jamison et al. 2002, Sear et al. 2002, Beise & Voland 2002, Voland & Beise 2002, Lahdenperä et al. 2004) but also their nutritional status (Sear et al. 2000) or the fertility of the parent generation (Sear et al. 2002, Voland & Beise 2002, Lahdenperä et al. 2004). Very interestingly, these studies show a remarkable resemblance to the basic pattern: Grandmothers have a significant survival benefit on children. This applies, however, mainly to the maternal grandmother. The paternal grandmother had no impact on the child's life after the very first month (only Lahdenperä et al. 2004 found no differences for the Finish grandmothers). Furthermore, both grandfathers also did not reach by far the level of support that the maternal grandmother gave.

Irrespective of why only maternal grandmothers are supportive, the contrasting pattern among the grandparents is a lucky result from an analytic point of view: It gives support to the argument that the observed relationships are driven by causality and are not just phenotypic associations based on shared genetic, behavioral or environmental background (Lee, 1997, warns of such flawed conclusions). Phenotypic associations would have led to similar patterns for all four grandparents.

A further parallel finding concerns the timing of this beneficial effect in the populations of Gambia, the Krummhörn and Quebec. Although the age at which the survival effect is most pronounced differs between the three populations who offer such information, it is possible to establish a connection between these ages and the weaning event. In Gambia, weaning occurs mostly in the second year, the only age at which a significant grandmaternal effect was found (Sear et al. 2002); in the Krummhörn population the average age at weaning is estimated to be around 10 months[1] and the grandmaternal effect is most pronounced at ages six to eleven months (Voland & Beise 2002); in the Quebéc population the children were breastfed in average for 14 to 15 months with the age categories that are most sensitive towards grandmaternal presence being the second and third year.

Thus, the observed pattern of differential grandparental support (with influence on the survival) seems to be a robust finding. We find very similar patterns across time, space and socio-ecological conditions. Furthermore, the discriminative grandpaternal effect was also found in psychological studies. Most of these studies noted a pattern of caregiving or emotional closeness among the grandparents, with the maternal grandmother being the most caring grandparent (some studies find even a ranked pattern for all four grandparent types; see van Ranst et al. 1995; Euler & Weitzel 1996).

But the question remains why it is only the maternal grandmother who helps most? A good candidate reason is the notorious paternity uncertainty. As with most mammals, men can never be entirely sure about their genetic relatedness while mothers are. This imbalance has also an impact on the relatives of both parents. The mother of the mother can be sure about her relatedness with her daughter’s children while the father's mother is sure about the relatedness with her son but not about the one with his children. Both grandmothers have therefore different motivations to invest in their grandchildren. It may be argued that in a society that is characterized by a moderate uncertainty concerning paternity it still may be beneficial for a paternal grandmother to invest in a grandchild rather than not to invest at all because the chances that she is genetically related to the child (and thus that the investment is not wasted) are not

[1] This value is based on own calculations following Gehrmann 2000 (p. 717f) who regards the difference of the interbirth intervals following a surviving child and following a child which died in the first month as a good estimation for the age at weaning in historical populations (only the first two intervals and no last one should be considered).

negligible. Let's remember, though, that many of these women have adult sons *and* daughters, so they are both a maternal and a paternal grandmother. Their support resources - may they be in terms of time or energy - are limited and may be only partially dividable, if at all (especially if the daughter's family and the son's family live apart at considerable distance). Thus, if a grandmother has to decide whether to invest in her daughter's children or her son's she "should" decide for her daughter's children even if the difference in terms of probability of relatedness is only small.

Nevertheless it seems that there is an additional level of grandmaternal behavior than solely the support a paternal grandmother is willing - or in this case - not willing to give to their grandchildren: that is her behavior towards her daughter-in-law. Voland and Beise (2002 and in this volume) argue that in the Krummhörn population a tense relationship between mother- and daughter-in-law is responsible for the observed increased risk of a stillborn fetus or - if born alive - to die in the very first month if the mother-in-law was alive. The argumentation is based in principle on the three following factors: the causal relationship between the early death of the child (stillbirth or death in the first month) and maternal health during pregnancy (see Hart 1998), the conflicting life-course interests of the (genetically unrelated) mother- and daughter-in-law and the specific socio-ecological context of the Krummhörn.

Our results for the Quebec population show that the mother-in-law has an effect on the child's risk to die in the first month (in fact, it is the only effect found concerning her) - but - contrary to the situation in the Krummhörn - the effect here is positive, i.e. an alive mother-in-law *decreased* the risk of dying. Does this mean that there were no in-law-conflicts in Quebec? Not necessarily, but at least potential conflicts could not have been so stressful for the mother that it harmed her condition during pregnancy. Rather it seems that a mother-in-law influenced the mother's environment during her pregnancy in a beneficial way. The reason for the opposing effects lies very likely in the differing socio-ecological conditions of the two populations.

The Krummhörn population was in a demographic sense an almost stationary population characterized by high population density, very low growth rates and low fertility. The agrarian economy was very competitive and common land was virtually not existing (see Voland 1995 for a more detailed description of the socio-ecological situation of the Krummhörn population). There were plenty of opportunities - and needs - for women to contribute to the family economy. In total, the situation favored the exploitation of the daughter-in-law's labor for the sake of the patrilineal household economy (see Voland and Beise, this volume, for a more detailed description of the exploitation scenario).

The Quebec case is very different. The colonization of the region took place just a few generations before the start of the period under analysis, the population still grew at high rates, fertility was high and enough new land was available. But above all else, women have been for a long time a rare and therefore valuable "resource" in the Quebec population due to the male bias in immigration (leading among other factors to very low marriage ages for women and high rates of remarriage after widowhood: Charbonneau et al. 2000). Therefore, women in Quebec were less replaceable than their counterparts in the Krummhörn population and should have been less exploited (Voland and Beise, this volume). This may have led mother-in-laws to help their son's family with domestic and subsistence work during times when the daughter-in-law was pregnant and thereby relieve her of her work load. The Quebec population was comparatively mobile due to the easy and cheap availability of land. Nevertheless, it may have existed sufficient opportunities for such help because parents tried to establish their offspring in the close neighborhood - which was in particular true for sons (Bouchard & Pourbaix 1987; Bouchard 1991).

In conclusion we state that although in Quebec both grandmothers saved in the end almost the same amount of lifes, their motivations and the pathway of their help was very different. The maternal grandmother a true *helping* grandmother, who supports her daughter and her grandchildren in times of increased needs – in terms of the mother’s age (when the mother was young and still comparatively unexperienced) and in terms of the child’s developmental stage (when it got weaned). The paternal grandmother, on the other hand, is less willing to support her grandchildren and is interested in her daughter-in-law only as much as it fits her reproductive strategies. Since reproductive women were precious in Quebec, the parental grandmother was supporting her daughter-in-law during the hazardous time of pregnancy and only in this sense she was *helpful* in the survival of her grandchildren.

## Summary

This study analyzed the effect of grandparents and in particular grandmothers on child's mortality in the population of historic Quebec (1680-1750). The population consisted of French immigrants who started to settle in Quebec in 1621, and their descendents. The results show that the only helping grandparent is the maternal grandmother. With her being alive, the risk to die decreased for grandchildren by around 20 to 30% at the ages one and two years. This time pattern of the effect makes it very likely that this influence is connected with the process of weaning. Furthermore, it seems that children of young women benefited most from the grandmother's help even so the maternal grandmother continued to be important also for children of older mothers. Neither paternal grandmother nor both grandfathers reached by far the survival increasing effect in post-neonatal ages to the extent that the maternal grandmother showed. The differential pattern of grandparental support and the temporal aspect of it is astonishingly similar to what was found in comparable studies despite the fact that all these populations differ largely with regard to geographical, historical and socio-cultural conditions. But contrary to these studies, which could not find any effects by the paternal grandmother, this study found a beneficial effect of these grandmothers on the survival in neonatal age (first month). We argue that this effect is not due to a direct grandmaternal support for the child but rather reflects her efforts in improving the mother's environment during pregnancy which influences the fetus viability by mediation through the mother's body. The reason for this variability in the paternal grandmother's behavior may lie in the specific socio-ecological conditions of Quebec in which women and therefore mothers were a rare "resource". Under these special conditions, the usually tense relationship between mother- and daughter-in-law probably eased and the mother-in-law turned out to be even helpful for the child's survival by improving the mother's health condition during pregnancy.

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Table 1: Description of the sample and explanatory variables considered in the parametric event-history model (both sexes).

| Baseline | Number of Children at Risk[1] | Number of Deaths |
|---|---|---|
| Total | 26,449 | 7,992 |
| | | |
| Age Classes [months] | | |
| 0 | 26,449 | 2,670 |
| 1-5 | 23,779 | 2,116 |
| 6-11 | 21,663 | 856 |
| 12-23 | 20,807 | 888 |
| 24-35 | 19,919 | 400 |
| 36-59 | 19,519 | 441 |

| Time Varying Covariates | Number of Episodes with Children at Risk[2] | Number of Deaths |
|---|---|---|
| Total | 41,296 | 7,992 |
| | | |
| Mother | | |
| Dead | 1,788 | 247 |
| Alive | 39,508 | 8,521 |
| | | |
| Father | | |
| Dead | 1,472 | 145 |
| Alive | 39,824 | 8,623 |
| | | |
| Maternal grandmother | | |
| Dead | 16,152 | 3,389 |
| Alive | 25,144 | 5,379 |
| | | |
| Paternal grandmother | | |
| Dead | 20,534 | 4,254 |
| Alive | 20,762 | 4,514 |
| | | |
| Maternal grandfather | | |
| Dead | 23,238 | 4,786 |
| Alive | 18,058 | 3,982 |
| | | |
| Paternal grandfather | | |
| Dead | 27,870 | 5,882 |
| Alive | 13,426 | 2,886 |

*(continued)*

*Table X1, continued*

| Time Constant Covariates | | Number of Children at Risk | Number of Deaths |
|---|---|---|---|
| Total | | 29,431 | 7,992 |
| | | | |
| Sex | | | |
| | Male | 15,087 | 4,207 |
| | Female | 14,344 | 3,785 |
| | | | |
| Age of Mother | | | |
| | 15-25 | 7,561 | 1,822 |
| | 25-30 | 7,775 | 1,938 |
| | 30-35 | 6,959 | 1,926 |
| | 35-50 | 7,136 | 2,306 |
| | | | |
| Birth Cohort | | | |
| | 1680-1710 | 3,479 | 698 |
| | 1710-30 | 9,617 | 2,360 |
| | 1730-50 | 16,335 | 4,934 |
| | | | |
| Number of Living Siblings | | | |
| | none | 4,610 | 1,261 |
| | 1-2 | 8,683 | 2,181 |
| | 3-5 | 9,948 | 2,716 |
| | 6+ | 6,190 | 1,834 |

[1] At the beginning of each age class.
[2] For the time varying covariates not the number of *cases* are given but the number of *episodes*, since the death of a kin divides (if the death occurred after the child was born) the child's time at risk in one episode in which the kin concerned is still alive and one episode in which the kin is dead.

Table 2: Parameter estimates (for the baseline) and relative risks (= antilog of parameters estimations, for the covariates) from the piecewise constant model with period specific effects.

| | All Children | Male Children | Female Children |
|---|---|---|---|
| Baseline | Estimate | Estimate | Estimate |
| Age of Child [months] | | | |
| 0 | -2.59 | -2.51 | -2.74 |
| 1-5 | -4.27 | -4.26 | -4.38 |
| 6-11 | -5.29 | -5.21 | -5.46 |
| 12-23 | -6.07 | -6.03 | -6.20 |
| 24-35 | -6.80 | -6.77 | -6.90 |
| 36-59 | -7.43 | -7.31 | -7.68 |
| Covariate | Relative Risk | Relative Risk | Relative Risk |
| Mother | | | |
| 0 | 2.88 ** | 3.00 ** | 2.80 ** |
| 1-5 | 3.83 ** | 4.55 ** | 3.19 ** |
| 6-11 | 2.94 ** | 3.07 ** | 2.91 ** |
| 12-23 | 2.16 ** | 2.18 ** | 2.16 ** |
| 24-35 | 1.83 ** | 1.90 * | 1.75 + |
| 36-59 | 1.95 ** | 1.81 * | 2.09 ** |
| Father | | | |
| 0 | 1.28 | 1.22 | 1.35 |
| 1-5 | 1.40 | 0.84 | 2.00 ** |
| 6-11 | 1.66 * | 2.28 ** | 0.91 |
| 12-23 | 1.93 ** | 2.45 ** | 1.50 |
| 24-35 | 1.12 | 0.98 | 1.20 |
| 36-59 | 1.35 | 1.22 | 1.46 |
| Maternal grandmother | | | |
| 0 | 1.07 | 1.06 | 1.07 |
| 1-5 | 1.04 | 1.02 | 1.06 |
| 6-11 | 1.06 | 1.14 | 0.98 |
| 12-23 | 1.30 ** | 1.33 ** | 1.28 ** |
| 24-35 | 1.22 * | 1.12 | 1.31 * |
| 36-59 | 0.92 | 1.09 | 0.79 + |
| Paternal grandmother | | | |
| 0 | 1.12 ** | 1.13 * | 1.11 + |
| 1-5 | 1.03 | 0.99 | 1.08 |
| 6-11 | 0.96 | 0.95 | 0.97 |
| 12-23 | 1.03 | 0.94 | 1.12 |
| 24-35 | 1.04 | 0.94 | 1.15 |
| 36-59 | 0.95 | 0.98 | 0.91 |

*(continued)*

*(Table X2, continued)*

| Covariate | Relative Risk | Relative Risk | Relative Risk |
|---|---|---|---|
| Maternal grandfather | | | |
| 0 | 1.01 | 1.06 | 0.95 |
| 1-5 | 1.00 | 1.03 | 0.97 |
| 6-11 | 0.94 | 0.88 | 1.01 |
| 12-23 | 1.01 | 1.03 | 0.99 |
| 24-35 | 1.02 | 1.01 | 1.02 |
| 36-59 | 1.33 ** | 1.29 + | 1.37 * |
| | | | |
| Paternal grandfather | | | |
| 0 | 1.05 | 1.04 | 1.07 |
| 1-5 | 1.03 | 1.08 | 0.99 |
| 6-11 | 1.09 | 1.14 | 1.03 |
| 12-23 | 1.10 | 1.05 | 1.17 |
| 24-35 | 1.11 | 1.14 | 1.07 |
| 36-59 | 1.12 | 0.85 | 1.51 * |
| | | | |
| Sex | | | |
| Male | 1 | - | - |
| Female | 0.92 ** | - | - |
| | | | |
| Age of Mother | | | |
| 15-25 | 1 | 1 | 1.00 |
| 25-30 | 1.04 | 1.05 | 1.03 |
| 30-35 | 1.16 ** | 1.17 ** | 1.15 * |
| 35-50 | 1.37 ** | 1.31 ** | 1.45 ** |
| | | | |
| Birth Cohort | | | |
| 1680-1710 | 1 | 1 | 1.00 |
| 1710-30 | 1.18 ** | 1.14 * | 1.22 ** |
| 1730-50 | 1.49 ** | 1.44 ** | 1.54 ** |
| | | | |
| Number of Living Siblings | | | |
| none | 1 | 1.00 | 1.00 |
| 1-2 | 0.84 ** | 0.83 ** | 0.85 ** |
| 3-5 | 0.81 ** | 0.79 ** | 0.84 ** |
| 6+ | 0.78 ** | 0.75 ** | 0.80 ** |

Note: ** p<0.01, * p<0.05, + p<0.1

Figure 1: Death rate and associated survival function by age over the first five years of life.

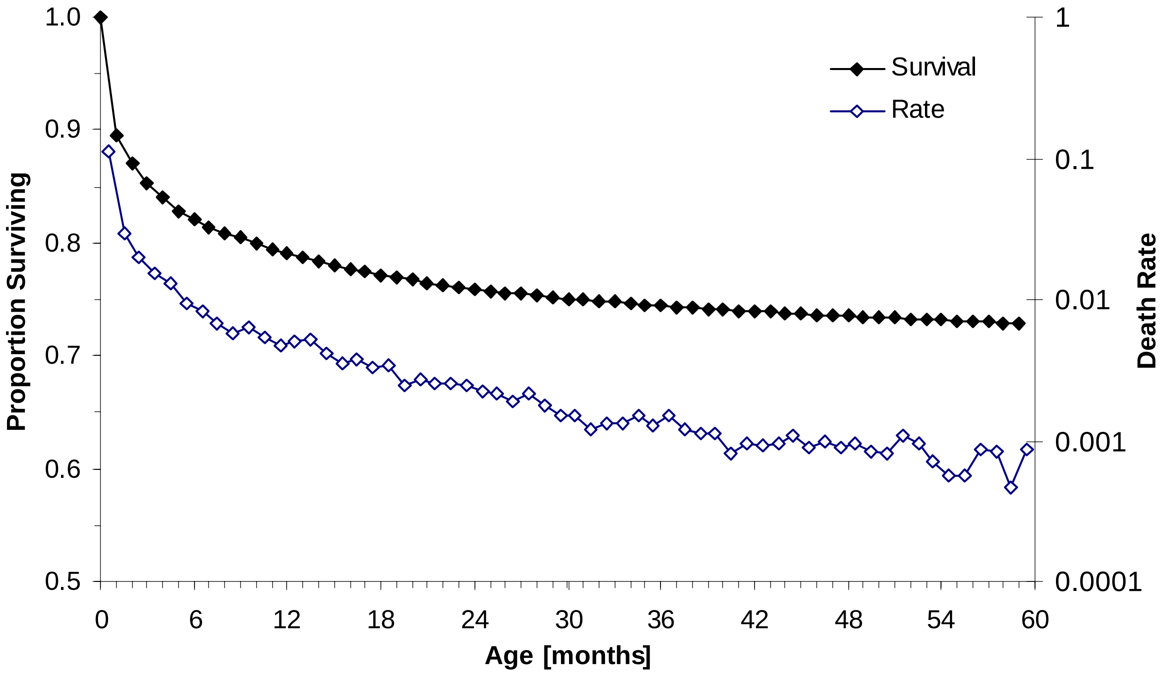

Figure 2: Kaplan-Meier plots showing survival for children over the first five years according to the different combinations of survival of maternal and paternal grandmother.

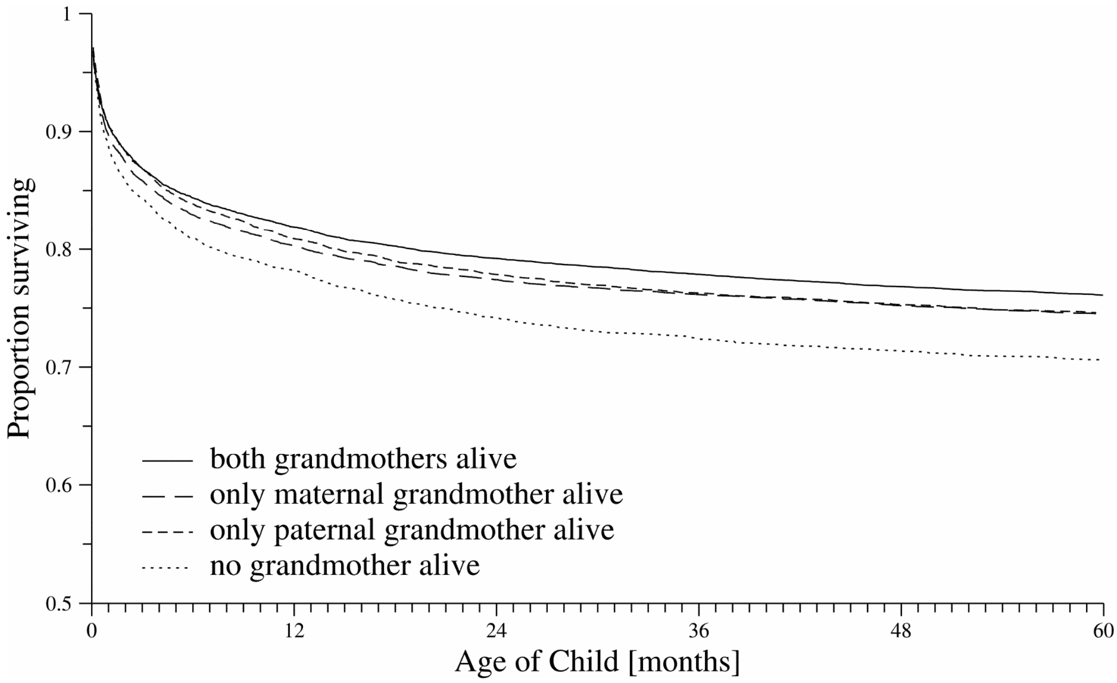

Figure 3: Kaplan-Meier plots showing survival for children over the first five years according to the age of mother when giving birth.

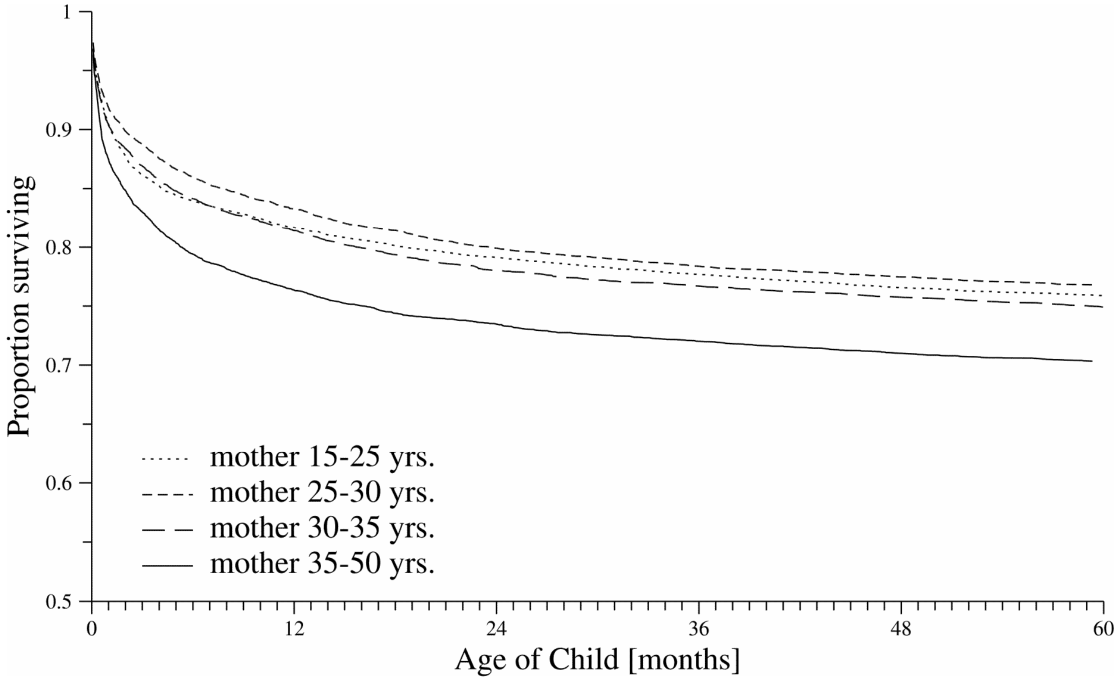

Figure 4: Grandmaternal effect and its relationship to mother's age when giving birth. Shown is the outcome of a piecewise constant model with period specific effects as relative risks: These are the risks for a child of a mother of a specific age to die if a maternal grandmother was dead at childbirth compared to the average risk for a child when she was alive (Note: ** p<0.01, * p<0.05, + p<0.1).