

DEMOGRAPHIC RESEARCH

A peer-reviewed, open-access journal of population sciences

DEMOGRAPHIC RESEARCH

VOLUME 42, ARTICLE 21, PAGES 615–656

PUBLISHED 24 MARCH 2020

<https://www.demographic-research.org/Volumes/Vol42/21/>

DOI: 10.4054/DemRes.2020.42.21

Research Article

Between rivalry and support: The impact of sibling composition on infant and child mortality in Taiwan, 1906–1945

Tim Riswick

Ying-Hui Hsieh

© 2020 *Tim Riswick & Ying-Hui Hsieh.*

This open-access work is published under the terms of the Creative Commons Attribution 3.0 Germany (CC BY 3.0 DE), which permits use, reproduction, and distribution in any medium, provided the original author(s) and source are given credit.

See <https://creativecommons.org/licenses/by/3.0/de/legalcode>.

Contents

1	Introduction	616
2	Background: Competition and support between siblings in Asia	617
3	Historical context	621
3.1	Families in Taiwan during the Japanese colonial period	621
3.2	Regional variation: Diversity in historical contexts	624
3.3	Hypotheses	627
4	Data, measurements, and methods	627
5	Results	634
5.1	Univariate analyses	634
5.2	Cox proportional hazard models	637
6	Concluding discussion	641
7	Acknowledgements	643
	References	644
	Appendix	655

Between rivalry and support: The impact of sibling composition on infant and child mortality in Taiwan, 1906–1945

Tim Riswick¹

Ying-Hui Hsieh²

Abstract

BACKGROUND

Many studies have neglected family processes that take place in more complex households in non-Western societies, while the position in the sibling set of a given person in these societies may be an important factor for determining infant and child mortality risks.

OBJECTIVE

This article addresses the association of sibling composition with infant and child mortality between the ages of 0 and 5 in Taiwan in the period 1906–1945. Furthermore, the article takes into account regional differences that may affect the impact of the sibling composition on mortality risks.

METHODS

The Taiwan Historical Household Register Database (THHRD) is analysed by using univariate and Cox proportional hazard analyses. By doing so, the changing household composition over time is taken into account.

RESULTS

The presence of siblings close in age (younger or up to 5 years older) of either sex, and the presence of same-sex siblings in general, increased mortality risks for male and female infants and children. In addition, the presence of non-adopted and adopted sisters over the age of 5 decreased male infant mortality risks, while the presence of non-adopted brothers over the age of 5 decreased child mortality risks for girls. Limited regional differences in sibling effects are observed.

CONTRIBUTION

The presence and gender of siblings is not the only important factor in resource dilution in terms of how it influences mortality risks. The age and adoption status of siblings

¹ Radboud Group for Historical Demography and Family History, Department of History, Art History, and Classics, Radboud University, The Netherlands. Email: t.riswick@let.ru.nl.

² Department of Human Development and Psychology, Tzu Chi University, Taiwan.

seems to be just as important in determining whether siblings compete for similar resources or are actually able to provide support.

1. Introduction

Most research investigating the influence of sibling size and composition on social and demographic outcomes is focused on Western societies. Moreover, these studies explain the association between the number and composition of the sibling set and social and demographic outcomes using the resource dilution model, which neglects many of the family processes in larger extended households.³ Improvements have been made by proposing adjustments to the resource dilution model which include contextual factors that may moderate the association between sibling size and composition, such as social and cultural norms originating from long-standing gender regimes, family systems, and (state) institutions that contribute directly to the economic conditions of households (Gibbs, Workman, and Downey 2016; Kalmijn and van de Werfhorst 2016; Riswick 2018). Nevertheless, this conditional resource dilution model continues to emphasise competition, whereas cooperation may also be found in more collectively orientated societies (Kramer 2005, 2010). This is especially important to realise, as the historical context, especially when looking at kinship, has been acknowledged to be different when comparing patriarchy and sex preferences in historical Western European and Asian families (Das Gupta 1999; Lynch 2011; Santos and Harrell 2017; Wolf 2005). Patriarchy resulted in highly stratified households, with multiple overlapping hierarchies causing inequality (Folbre 1986; Klep 2004; Wolf 1990), in which the position of a given person in the household, particularly with respect to his or her siblings, was an important determining factor of life-course transitions (Campbell and Lee 2004; Hsieh and Chuang 2005; Lee and Campbell 1997) and may also have resulted in different specific arrangements of tangible and intangible resources. Therefore, sibling competition very likely also varied with sibling age and gender composition, and not just with sibship size (Kramer, Veile, and Otárola-Castillo 2016).

In order to better understand the impact of sibling position, this study will address the association of sibling composition by investigating infant (between 0 and 1 year old) and child mortality (between 1 and 5 years old) in Taiwan in the years 1906–1945. Given how little is known about the connection between sibship configuration in terms

³ More economic- and evolution-orientated studies also use the quality–quantity trade-off model, which is often connected to the principle of allocation and its implication for reproduction. In short, it departs from the assumption that, because time and resources are limited, mothers cannot both have more children and produce higher-quality offspring, measured by survivorship (Kramer 2010; Lawson and Borgerhoff Mulder 2016).

of age composition and survival chances, studying this connection advances the literature in both fields. On the one hand, examining how siblings of different ages influence survival chances helps shed light on the most extreme inequalities within the household: those which eventually result in death (Riswick 2018; Sen 1998). In that sense, this study contributes to an under-investigated subject in child mortality research, especially for historical Asian societies.⁴ This is extremely important as overview studies looking into kin effects on mortality outcomes emphasise the positive and negative effects of kin by concluding that there is much variation in the ways in which relatives are helpful to the survival of children (Sear and Coall 2011; Sear and Mace 2008). In addition, the classical family decision model, which treats the family as if it is a unit with its own strategy, is too simplified to provide empirical predictions. In reality, family members have common objectives as well as conflicting ones (Baud and Engelen 1997; Chu and Yu 2010; Engelen et al. 2004; Folbre 2008). Interactions between members of an enlarged family can broaden the scope of current empirical analysis to how non-Western families shaped life courses. This is important as children of both sexes often provide benefits to their parents in context-specific ways (Mattison et al. 2016). Siblings are, however, rarely studied in most research, which examines infant and child survival while also including the specific historical context. This study contributes to the overall literature on sibling effects by testing the resource dilution model as a conceptual framework on infant and child mortality in Taiwan, which it does by using longitudinal data and time-varying variables that take changing sibship composition into account by exploiting fixed effects multivariate event history models.

In the following section, theories and previous research findings on the resource dilution hypothesis are briefly presented, mostly focusing on Asia and health outcomes. Next, hypotheses about mechanisms by which possible sibling effects influenced infant and child mortality are formulated specifically for the Taiwanese historical context. After the data, measurements and methods are introduced, and the results of the descriptive statistics and the Cox proportional hazard models are discussed. The article concludes with a discussion on the interpretation of the influences of sibling composition on infant and child survival in Taiwan and offers suggestions for future research.

2. Background: Competition and support between siblings in Asia

Most research uses the resource dilution model to investigate the possible influences of siblings on all kinds of outcomes – but mostly educational attainment – by looking at

⁴ Because of the lack of data or under-registration, it is often not possible to study infant and young child mortality between 0 and 5 years. See, for example, Dong et al. (2017) and Park, Han, and Kye (2018).

the effects of family size, birth order, sibship size, sex, and the age composition of the sibling set (Heer 1985; Steelman et al. 2002). The resource dilution model suggests that there is a negative relationship between any additional child and the amount of resources that any one child can obtain, since material and immaterial resources are finite. It provides a generalisable explanation for why children in larger families would fare worse in outcomes such as education, marriage, health, and so on (Blake 1981; Downey 2001).⁵ While a lot of research finds negative associations between high birth order, large sibship size or composition, and different demographic outcomes using this model, it has become increasingly clear that negative associations are not present in all populations, for all outcomes, or in all time periods (Bras 2014:14–15; Öberg 2017; Riswick and Engelen 2018).

The ‘conditional’ resource dilution model was created to explain the variety of findings in empirical studies on sibship size and demographic outcomes by taking the specific context into account while still following the general argument about additional siblings affecting the amount of resources that are diluted (Gibbs, Workman, and Downey 2016). Next to parents, one’s kin, non-kin, and community- or state-level social institutions can affect resource dilution by influencing the decision-making process and the total amount of resources available. This indicates that deviations in child-rearing practices and the specific roles of siblings across time and place may cause different effects for sibship size and composition for different populations. Moreover, gender affects the distribution of resources and roles of siblings within households because of specific sex preferences and the inequalities resulting from them. Across societies, the gender composition of the sibling set may therefore lead to different effects on social and demographic outcomes of boys and girls, in which the most extreme forms may be found in strongly patriarchal societies in which gender and generation play a crucial role (Kalmijn and Van de Werfhorst 2016; Santos and Harrell 2017).

In general, a gendered resource dilution model implies that gender preferences are taken into account when allocating parental resources. In most societies this model implies that daughters are allocated fewer resources compared to boys because of customs of son preference. Thus, the presence of brothers will have the largest effect on the dilution of resources for both boys and girls because the number of sons in a family determines the actual division of resources if inheritance is able to be equally divided (Kalmijn and van de Werfhorst 2016; Parish and Willis 1993). Most studies that investigate contemporary populations and look at the impact of sibling composition on

⁵ There has been much research on the topic of sibling effects, but in different fields there are different dominating theories, such as the quality–quantity trade-off in economics and the parental investment theory in evolutionary biology/ecology. In this study, we tried to incorporate the main findings of these fields, although our discussion of the literature departs from the (conditional and gendered) resource dilution hypothesis.

young girls' health have observed that sibship size was positively associated with infant mortality (Knodel and Hermalin 1984) and that a child's gender was key for child survival, depending on the gender of other siblings present in the household (Bhargava 2003; Choe et al. 1995; Garg and Morduch 1998; Das Gupta 1987; Muhuri and Menken 1997; Sear et al. 2002). In Southeast Asia in particular, the existence of a brother mattered much less, but a greater number of sisters increased mortality rates for girls (Arnold, Choe, and Roy 1998; Das Gupta 1997). The same was observed for contemporary rural China (Chen, Xie, and Liu 2007; Li, Zhu, and Feldman 2004). Muhuri and Preston (1991) estimate that in Matlab, Bangladesh, girls with older sisters faced a considerable disadvantage, explaining a large part of the excess mortality among girls. Boys who were born after the first sibling were, however, also discriminated against when older brothers were present in the sibling group. Similar results are found for survival and other health outcomes, such as height, in India (Chamarbagwala 2011; Jayachandran et al. 2017; Pande 2003). In contrast, sibling size influenced infant mortality for boys and not for girls in Indonesia, although this seems to be dependent on the location, as this result was significant only in the Highlands (Wahab et al. 2001). This indicates that, there being a strong son preference in most of Asia, this does not automatically lead to discrimination against girls. Instead, parents selectively discriminated against some children, usually those born later, more than others.

The importance of gender and age for survival is also shown by studies investigating survival chances in historical Taiwan and China (Campbell and Lee 1996, 2009; Choe et al. 1995). A recent study by Dong et al. (2017) investigates the effect of household composition and birth rank on male child mortality (aged between 1 and 10 years) in northeast China (1789–1909), northeast Japan (1716–1870), and northern Taiwan (1906–1945). Results demonstrate that birth order itself had no effect, but interactions between birth order and specific kin show that there was differential parental investment: Being a first- or near-firstborn boy was more beneficial for survival than being born later. Another study by Park, Han, and Kye (2018) investigating child mortality (aged between 1 and 5 years) in a rural mid-twentieth-century Korean village finds a stronger association between sibling size and child mortality among girls compared to boys. However, the implications for sibling composition were different for boys and girls. Younger siblings increased mortality among boys, while older siblings reduced it among girls. The latter demonstrates that siblings could also have positive effects. In contrast, Lin (2013) finds that effects of same-sex sibling order are the same for male and female infant mortality risks in Taipei, Taiwan (1906–1935). A later study by Dong, Kurosu, and Lee (2019) finds consistent evidence that sibling effects are specific to gender and seniority in shaping child mortality (aged between 1 and 15 years) in China and Japan.

In most of these studies, the birth order or total number of siblings is examined without taking the age of coresident siblings into account. More evolutionary anthropological studies have demonstrated that the specific age of siblings, and cultural norms associated with them in a specific context, may be important in determining how siblings are rivals or helpers. Siblings of different ages can have different effects, and sibship size may not capture this (Lawson and Mace 2008, 2011). In other words, variable ecological and demographic conditions may give rise to a number of pathways in which siblings compete for similar resources or are actually lowering the burden of childcare, domestic tasks, and economic activities for mothers, which is often dependent upon their age (Kramer 2005, 2010). Since infants and older children require different time and energy investments, mothers are challenged to divide their time and attention between tasks. When resources were limited, as was often the case, more children did indeed lead to dilution of resources, especially when they were close in age (Lawson and Borgerhoff Mulder 2016). However, when siblings were not so close in age that they were competing for similar resources, they may actually have been a source of help, which is often overlooked in the literature (Kramer 2002). Children who were still young enough to receive childcare, food, and resources from mothers and others often cared for their younger siblings and may have made food and labour transfers to older generations as well. Juveniles in many traditional societies therefore contributed to their own and their siblings' needs from a young age. Moreover, children may be coerced or strongly urged to help or punished for not cooperating. However, the time that children allocate to these activities varies widely across context and depends on the age and gender of potential helpers. In societies where parents did not limit their fertility, they more often opted for strategies of biased investment based on gender and age (Borgerhoff Mulder 1998; Kramer, Veile, and Otárola-Castillo 2016).

In short, following the logic of resource dilution and family decision models, children with different household size and composition may have access to fewer or more resources. Common variants of economic theories of the household also imply that, in particular, the gender and age of a child's siblings may determine differences in human capital allocations between siblings in the same household that are just as large as the differences between siblings from different households (Dunn and Plomin 1990). However, the implication that gender and age always have a specific effect on infant and child mortality risks seems unlikely, as the literature has shown that considerable variation in the effects of sibling size and composition exists even in Asia, where most families are patrilocal and patrilineal in nature. Knowing the historical context – temporal and regional – seems therefore to be essential because household composition and organisation are connected to economic conditions and cultural practices, which determine competition over resources on the basis of gender preferences and sibling size and composition. Norms and practices surrounding family and kinship within a

certain region, which are often labelled as household systems, are important because of the ways in which they shape sibling relationships. Such household systems shape norms to which people relate and position themselves, as well as the type and kind of social control (Das Gupta 1997; Reher 1998; Skinner 1997; Therborn 2004; Todd 1985). By knowing the norms of a certain household system, it becomes possible to hypothesise whether siblings are willing or forced to step in and help their siblings and whether they are mainly competitors for resources. Therefore, in the next section, we will first discuss the historical context before formulating any hypotheses.

3. Historical context

3.1 Families in Taiwan during the Japanese colonial period

During the period under study (1906–1945) Taiwan was occupied by the Japanese as a result of the First Sino-Japanese War. Economic development was the main goal of the Japanese government, with infrastructure and healthcare as its main drivers. Still, the intention of the Japanese colonial government was to achieve this in a way which was consonant with the culture, customs, and economy of Taiwanese society. By 1905 Taiwan as a whole was making a profit which resulted in more investments in roads, rail, education, and healthcare (Manthorpe 2009). While most economic changes remained modest compared to the period after World War II, the emphasis on public health was beginning to affect the mortality rates from the 1920s onwards. Many tropical diseases were tackled and living standards improved, while a decrease in the number of early deaths led to the steady growth of the Taiwanese population (Barclay 1954; Liu 2004; Olds 2003). While some cultural practices, like foot-binding and the selling of girls as servants, became forbidden, the Japanese colonial administration operated a strict system of ethnic segregation.⁶ Chen (1966:1) pointed out that “various constructions carried out by colonizers do have influences upon their subject, but ways of daily life, family life, religion or folk belief, and the attitude of the people, etc. are not easy to change.” In other words, the importance of family continuity, the ideal of large households, and the agrarian society still remained (Wolf 1972).

The literature on Taiwanese families, like that on Chinese families, is very clear about the stratified structure and patriarchal hierarchy within the household, in which many Taiwanese lived in families based on the coresidence of adult brothers. Brothers not only lived together, they also shared meals and other social activities; in other

⁶ For example, a marriage between a Japanese person and a Taiwanese person was allowed only after 1932. Only from 1942 onwards could a Taiwanese person take a Japanese name (Wolf 1972). At that time, Japanese residents in Taiwan had specific living areas and did not live among the Taiwanese.

words, they pooled resources and offered mutual support (Nuckolls 1993; Thornton and Lin 1994; Wang 1985; Wolf 1981). Parental authority was absolute during a person's life as a result of virilocal marriage, in which the married couple lived with the husband's father's family.⁷ In these families, scholars argue, parental background, family composition, the gender of the child, and his or her position among same-sex and different-sex siblings had a decisive influence on what parents, especially the father, decided regarding the life course of a particular child (Chu and Yu 2010; Wolf 2005). In addition, the authorities confirmed and strengthened the position of parents by establishing the authority of parents in legislation (Gates 1997). Only after marriage were children seen as adults, but even then they were still firmly under the control of parental authority. For example, most, if not all, of children's earnings had to be surrendered to the family budget (Diamond 1969). Lastly, outside the family itself, patriarchal authority was supported by patrilineal extended kinship networks and male monopolies on public positions of power. Next to kinship networks and male monopolies, patrilineal inheritance and virilocal residence thus gave males both control of property and the opportunity for kin solidarity (Santos and Harrell 2017).

Next to seniority, gender is an important basis of differential parental investment within the Taiwanese family because descent and lineage were central to the definition of the family. The duty of a son towards his father not only extended past death itself by means of ancestor worship but also included having sons himself to continue the lineage. Sons were therefore important for the household since they were the ones whose membership of the family and lineage extended throughout all stages of the life course. Conversely, daughters were not important for family continuity because they joined their husband's household at marriage (Wolf 1972, 2005; Wolf and Huang 1980). In other words, sons could perform the function of 'social reproduction' of the family, causing women to be needed only for 'biological reproduction' (Thornton and Lin 1994; Wolf 1976). This was also reflected in the status of men and women, as men were seen as superior to women. An old saying in Chinese society is "Women should obey the father before marriage, the husband after marriage, and the son after the husband's death." This resulted in differential parental investment in sons and daughters, which is reflected in ethnographic studies looking at Taiwanese villages and households (Harrell 2014; Pasternak 1972, 1983; Wolf 1968). References to female infanticide are sometimes made (King 2014; Olds 2006), but the differences in investments between little boys and little girls also demonstrate discrimination within the household in many other facets of daily life. For instance, when a boy was born, the new mother's parents were informed by gifts such as rice, wine, and a chicken. When a

⁷ It should be noted that uxoriocal marriages were also frequent in some areas, which meant that the husband in the relationship did not have a strong position. This was, however, not the norm and was mostly frowned upon (Li et al. 2019). Nevertheless, the father-in-law would be the one who held the most power.

girl was born, only rice was given. Another example is the length of the breastfeeding period: generally, girls were weaned two months earlier than boys (Wolf 1968, 1972). Lastly, girls had to watch over their little brothers and could eat only after their brothers had eaten. These differences in social roles were part of the way in which Taiwanese parents raised their children (Olsen 1971, 1973, 1974; Wolf 1978). The consequence, according to M. Wolf (1972: 66), was that “[b]y age five most little girls have learned to step aside automatically for boys, at least when their parents are watching.” Although, the preference was not to have too many girls, there was also the belief that having some young girls in the household was necessary for specific chores (Gallin 1966; Gates 2005). One can therefore conclude that sons were preferred but most families also wanted at least one daughter if they could afford her (Wolf 1978).

Looking closer at how the childhood of Taiwanese children is described gives further insight into the world in which these children lived, which reaffirms the importance of sibling seniority and gender and the collective nature of the family. Infants were nursed for on average two years, or until a mother became pregnant again. From three years onwards they were already partly self-reliant: They fed themselves, ate apart from the adults, were toilet trained, and were already weaned (Diamond 1969; Wolf 1978). Yet, the best foods at the table went to the adults, not to the children. In addition, children were allowed out of the house, where they could play alone or with other toddlers, usually under the watchful eye of an older sibling. When children fought with each other, this was seen as a very serious offence. Similarly, hitting or teasing younger siblings was strongly frowned upon. Care of younger siblings began around the age of 5 for both sexes, freeing the mother for other household tasks. Girls in particular would be assigned these roles, but boys without any sisters would also be expected to take them on. Since in general adults rarely played, joked, or talked with children – unless it was to give instructions, make requests, or lecture them – they mostly relied on each other, or on a grandparent, to talk about the things that happened to them during the day. Older siblings or grandparents also taught them songs and told tales to the younger children. While older brothers take care of younger ones, younger brothers had to show respect to their older brothers. The early years of childhood were still pleasant ones for most children as they were free to roam the village, but work responsibilities began around age 6. A variety of chores were considered appropriate, as Diamond (1969: 36) explains: “gathering firewood for the fire, tending the fire and cooking pot, sweeping the courtyard, carrying the baby outside, running errands to the store or stalls for the adults in the household.” Little girls, however, were given responsibility earlier than boys, and their activities were restricted to a greater extent (Gallin 1966; Gates

2005).⁸ When children were around 11 years old, they were also able to take on jobs that brought in a small income. The belief was that the sooner a child could begin earning money, the better. This resulted in the constant reminder that being a wage earner is important (Diamond 1969).

Although, in Taiwan, households were ideally based on the coresidence of adult brothers and were collectively orientated, this does not mean that there were no conflicting interests of specific individuals that affected whether resources within the household were equally divided (Newell 1985; Sung 1981; Tang 1985). Fraternal solidarity manifested itself as a sentiment in childhood, but the fact that inheritance was equally divided also meant that (married) male siblings exercised control over each other's behaviour. The latter can be considered as their main motivation for solidarity (Cohen 1976: 195; Freedman 1966: 45–47). Yet, jural equality mainly describes the status of brothers and does not necessarily describe the social relationships between them during childhood. Inequality may arise when looking at the life cycle of a household in which the needs of the household and specific individuals depend on the phases in the life courses of these individuals. For example, inequality in consumption results from things like the sequence of marriage of brothers and the birth of other siblings, causing households to face different consumer requirements and resource production over time. Since each child enters the household at a particular moment, his or her individual life course is affected by the circumstances at that moment and by the decisions made by those who managed the family affairs. Furthermore, while married brothers had a motivation to keep the household together, the relationships between their wives are often described as hostile. For them, their own nuclear family was most important, which meant that a preferential treatment or unequal distribution of resources to others was always viewed as being at the expense of their own children (Harrell 2014; Wolf 1972). At this time, the mother-in-law (grandmother) was mostly responsible for upholding equality between the sisters-in-law within the household to prevent possible conflict (Cohen 1976). In short, it can be concluded that both conflict and cooperation were present in households, which determined household decision-making processes on how resources were allocated.

3.2 Regional variation: Diversity in historical contexts

The cultural norms that defined Chinese household structures and family relations varied widely from region to region and even from town to town. Taiwan is no

⁸ Gates (2014) even goes further in her work, arguing that small girls could spin long before they were useful for other tasks and that this may be the reason for why foot-binding was common as it limited the physical freedom of girls.

exception. Yet, the most extreme differences within the country can be found between northern and southern, and rural and urban Taiwan (Chuang and Wolf 1995; Hsieh and Chuang 2005; Wolf and Gates 2005). In all areas, households tried to continue and strengthen the family line, an extended household was the ideal, the nature of the family was collective, parental authority was absolute, gender and seniority determined the position within the household, and infanticide and adoption were options within the calculus of choice. Nonetheless, much regional variation existed, as economic conditions and cultural norms varied with regard to how common certain marriage practices were and to what extent urbanisation and modernisation changed daily life. In other words, these differences may also change the norms, beliefs, rights, and obligations that determine how social relationships and kinship organisation were shaped.

A concrete example is the main difference in marriage patterns between northern and southern Taiwan.⁹ Because of the frequency of minor marriages in northern Taiwan, in which a daughter-in-law was adopted at a young age to marry the son in the household at a future date, the likelihood of being adopted out of the family was much higher (Riswick and Lin 2019). For daughters in particular the differences were greatest: for northern Taiwan the average ranged from 45% to 66%, while in southern Taiwan it ranged from 12% to 17% of the girls being adopted out of the household before the age of 15. It is hypothesised that in northern Taiwan the demand for adopted daughters was much higher due to the minor marriage system, indicating that giving away (unwanted) daughters was much easier and normalised there. In other words, if resources were limited, households could choose to give away a daughter instead of allocating fewer resources to her. In that sense, the competition between siblings may

⁹ Most marriages in Taiwan can be classified as belonging to one of three types: major, minor, and uxori-local. Marriages performed in the major fashion were probably most common in Chinese societies, as this was the 'proper' way to marry. Another type of marriage was the minor form. In a minor marriage, a *sim-pua*, or little daughter-in-law, would be adopted into the family at a very young age to be a future bride to a son of the couple adopting her. The main difference between a major and minor marriage was therefore the timing and the ceremonial complexity of the marriage, which also resulted in lower costs. The third and final form found was the uxori-local marriage. While in most cases the daughter left her family to join her husband's family, in this form of marriage the husband married into the bride's (Wolf and Huang 1980). It is also hypothesised that the occurrence of minor marriage originated partly from the economic situation (Chuang and Wolf 1995). In northern Taiwan, marriage did not follow the major marriage pattern found in most Mandarin-speaking areas. The pattern that was found can be best characterised as one in which minor marriages tended to replace major marriages as the preferred form of marriage. This meant that between 30% and 50% of all marriages involved the adoption of young girls as a way to secure a future minor marriage. In central and southern Taiwan marriage was a radically different institution from that in northern Taiwan: between 65% and 95% of the marriages were major marriages. The difference in the frequency of minor marriages is even sharper, as the highest level that can be found in a village is only 15%. The frequency of uxori-local marriages is on average almost the same in the south as in the north, around 12%. Yet, the distribution of this type of marriage was highly irregular, which may indicate that it was a local rather than a regional phenomenon (Chuang and Wolf 1995; Li et al. 2019; Lin, Yang, and Chuang 2014).

have been less. However, at the same time, adopted daughters were also much more common in households in northern Taiwan. There is little knowledge concerning how adopted girls differ from non-adopted girls with regard to the allocation of resources, but it can be argued that adopted children in general may also compete for similar resources when they are close in age to non-adopted children. This is all in contrast to southern Taiwan, where female adoption was much more limited. Girls were seen as part of the labour force, and in turn the competition of older sisters may have been more severe. Moreover, as adoption was much less common and occurred at later ages, adopted children might be given similar, or even more, resources compared to natural children, since they were needed within the adopting household for their labour. Therefore we hypothesised that female child mortality risks might be influenced more by sisters in southern Taiwan, while adopted sisters may affect survival more in northern Taiwan. For adopted boys we do not expect differences as in both regions they normally required much effort and resources to acquire because of their importance for the lineage and in turn may be valued much more. Their presence may therefore cause a reallocation of resources that negatively affected other children.

A second example is provided by the regions of Taodaoheng and Mengjia, which were small port towns that grew into Taipei City in the 19th century. These are representative of the oldest and most commercialised parts of the city. Residences of the people living here varied in size from mansions to warrens of tiny rented rooms, and the economies of these places mainly focused on small-scale production and commerce, mainly relating to tea. As the tea trade flourished, it affected Taipei's social structure, as women and children were no longer restricted to labour within their households but instead had the opportunity to earn wages picking tea for the tea companies. Many women were also employed in prostitution and handicraft industries. In short, Taipei offered subsistence careers for women other than marriage, which were most often not available in other more rural areas (Gates 1987; Lin 2011, 2013). This even resulted in very low urban marriage rates (Barclay 1954). These low marriage rates were, however, most likely not the result of women themselves taking advantage of employment opportunities. Parents used their authority to delay or avoid daughters' marriage so they could make money off their wage labour. In other words, urban parents used their authority over their children differently from rural parents because other employment opportunities were available in Taipei, causing them to put their children to other uses (Engelen and Wolf 2006; Gates 1997; Wolf and Gates 2005). It may therefore also suggest that in Taipei, older siblings, including sisters, may have competed more for resources within the household as parents perceived them as valuable because of the income they brought into the family.

3.3 Hypotheses

Based on the assumption that household resource availability affects mortality, the resource dilution hypothesis predicts that, for both boys and girls, sibship size will be negatively associated with survival chances. Yet, we depart from the assumption – which is in line with the discussed recent studies and the historical context – that, on account of existing cultural norms with regard to gender, sibship characteristics will be associated with boys' and girls' survival chances differently. Three hypotheses are therefore formulated:

Hypothesis 1 (H1): Due to the patriarchal kinship system, it is more likely that household resources would be used to raise healthy sons, while daughters would suffer as a consequence. This should result in the situation that having older brothers will have negative effects for boys and girls on infant and child mortality risks. However, if children mostly compete with same-sex siblings, the effect of having brothers present should be stronger for boys while having sisters present should be stronger for girls.

Hypothesis 2 (H2): Siblings who are close in age and are coresident are competing for the similar resources. They may therefore have a stronger negative effect on survival chances as older siblings may claim different resources and in turn have no effect on survival. Moreover, if siblings are much older and can help alleviate the childcare burden or help with economic activities, having sisters or brothers may be beneficial for boys because they can (be forced to) provide care and support.

Hypothesis 3 (H3): There might be regional differences because of different roles of adopted and non-adopted siblings. First, having sisters may have stronger negative effects for girls in rural southern Taiwan because in northern Taiwan parents could easily adopt out an unwanted daughter. At the same time, since having an adopted daughter was common in northern Taiwan, their effect may be different compared to southern Taiwan. Second, in Taipei older siblings, including sisters, may compete more for resources within the household.

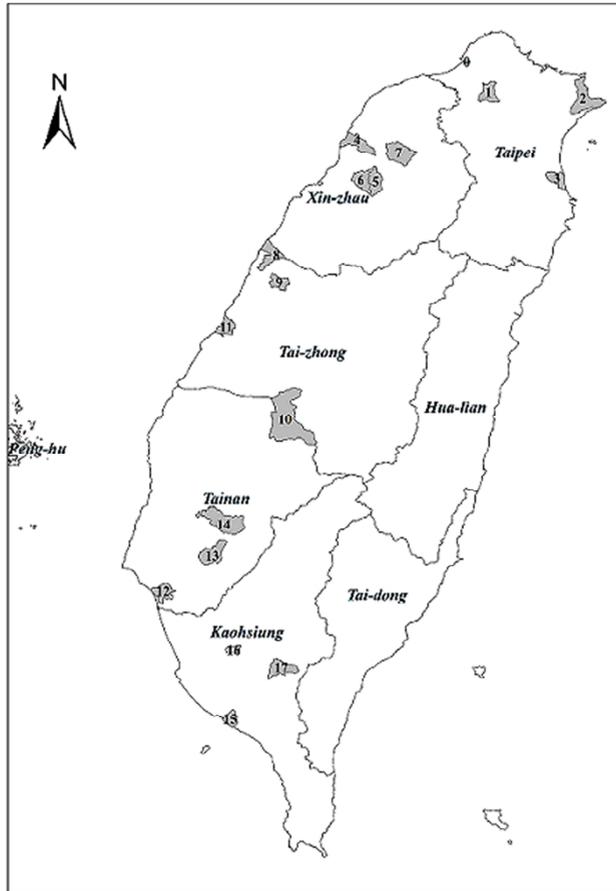
4. Data, measurements, and methods

For this study the Taiwanese Historical Household Register Database (THHRD) is used. The information in this database comes from the household registry system which

was in place during the Japanese occupation (1895–1945). This system originated in the old Chinese practice of mutual family responsibility but differed from it in several ways. Not only did the Japanese combine it with a police system that did not tolerate any corruption of low-level officials, but they also put more effort into maintaining the registration system, over which they were able to exercise greater supervision by means of their police force (Lin and Tseng 2014). From the head of the family to the village chief, everyone was responsible for providing accurate information. If information was incorrect or incomplete, family elders could be placed under arrest and eventually be publicly punished. Even when a family moved, their register would be closed only when a confirmation from another district was received (Chen 1975; Manthorpe 2009; Wolf and Huang 1980).

The registration system covered almost the whole of Taiwan, but only a small sample of communities has been digitised so far. The sample of the THHRD for this study consists of all children who were born between 1906 and 1940 from the research areas of Mengjia and Taodaocheng (1), Zhubei (4), Beipu (5), Emei (6), Guanxi (7), Danei (13), Jibei (14), Donggang (15), and Jiuru (16) (see Figure 1). These research areas were made available by the Program for Historical Demography at Academia Sinica for this study. They are located in northern and southern Taiwan and make it possible to study urban and rural differences. It is important to note that all children from each household born between 1906 and 1940 are included in this study, which means that these observations are clustered within households. A further selection was made by including only non-adopted children who can be observed from birth onwards. This is important because adoption may influence survival chances as well, and therefore children who were given away for adoption were censored after adoption. Research focusing specifically on the mortality of adopted children are part of another study (Riswick 2019) because siblings may play a very different role for adopted siblings and adoption also affects mortality risks (Mattison et al. 2015, 2018).

Figure 1: Map of Taiwan and the research sites available in the THHRD



Notes: The research sites selected for this study are Mengjia and Taodaocheng (1), Zhubei (4), Beipu (5), Emei (6), Guanxi (7), Danei (13), Jibei (14), Donggang (15), and Jiuru (16).

Source: Program for Historical Demography, Research Center for Humanities and Social Sciences, Academia Sinica.

The THHRD provides basic information for children on their address, the circumstances under which the head of the family acquired this position, relation to the household head, date of birth, date of death, date and reason of departure from the household, ethnicity, whether parents were opium addicts, whether a mother had bound

feet, and so on. By using this method of registration, the name, sex, date of birth, father's name, mother's name, and same-sex sibling order all provide unique identities for every individual in the registers. Moreover, for all events the exact date was recorded. One can therefore investigate the influence of changing household composition throughout an individual's life course on demographic outcomes. It is important for this study that the dynamic composition of the sibling set on child mortality outcomes can also be studied (Dong et al. 2015; Wolf and Huang 1980). The ability to follow individuals on a day-to-day basis is key, since what matters for competition and support is not the biological birth placement but the presence of siblings in the household during the period of parental investment. In a pre-transitional society, the biological birth order and actual birth order within a household differed greatly due to high mortality, adoption, marriage, and migration. Neglecting this changing composition of the household has led to shortcomings in previous studies, but by using reliable longitudinal datasets from the THHRD, this problem is solved. This is a major strength of the current study. Nevertheless, it must be noted that non-resident siblings could also contribute to the household, but these cannot be taken into account because of data limitations.

To analyse all data, methods appropriate for the statistical analysis of quantitative life course data are used. The univariate analysis is carried out by employing Kaplan–Meier survival curves, while event history Cox proportional hazard models can analyse mortality risks by taking time and control variables into account (Broström 2012). Observation time begins with the birth of a child and ends when the child dies (failure event) before his or her 5th birthday. All remaining children (which are research persons) are censored on their 5th birthday. Fixed effects Cox proportional hazard models are estimated, which are stratified at the family level (following Fox et al. 2017).¹⁰ By doing so, a within-family approach is employed to account for unobserved family characteristics. It allows each family to have their own individual baseline function and therefore differs in the sense that it uses the variation within, but not between, families. Between-family heterogeneity – such as genetic traits, shared environment, different parental preferences, and investment strategies between siblings – from different families can be accounted for in these models. Probability values of less than 0.05 are assumed to represent statistical significance.¹¹

The main variable of interest is the presence of adopted and non-adopted brothers and sisters in different age categories as coresidents in the household on child mortality

¹⁰ Cox proportional hazard models without fixed effects are also calculated; these can be found in the Appendix to be able to demonstrate the differences and similarities between the two models.

¹¹ Diagnostics were run to check whether all assumptions were met and adjusted accordingly when needed. In most cases the variables were not violating the proportional hazard assumption, and when the assumptions were not fully met, other models were run with time interactions. These models confirmed the same qualitative conclusions and were in line with the results presented.

risks. Siblings are defined as having the same father or mother as the research person, while adopted siblings are defined as having been adopted by the biological father or mother of the research person. It is important to note that the presence of coresident siblings is treated as a time-varying covariate. This accommodates the fact that siblings could move in and out of the household while the index child was growing up. Based on the assumption that the age of the present siblings may be of importance for the allocation of certain resources (following Kippen and Walters 2012), coresident siblings close in age (younger or up to 5 years older) may compete for similar resources, while coresident siblings more than 5 years older may compete for other resources and may even offer support.¹² The presence of siblings is therefore divided into two age categories compared to the age of the research person. Gender and adoption are also included by explicitly looking at the presence of adopted and non-adopted brothers and sisters in each age category. Lastly, the kin that have the most important influence on child mortality according to the literature – namely the presence of coresident parents and grandparents – are also included as time-varying variables (Sear and Mace 2008).

Control variables are included in the models because they may be correlated with both the dependent outcome and sibling formation, and also to exclude mediating or confounding factors. Birth intervals and mother's age are included to control for general biologically determined infant and child health. Short birth intervals or high mother's age may cause maternal depletion that increases mortality risks. In addition, they may also reflect availability and experience in caregiving (Conde-Agudelo, Rosas-Bermúdez, and Kafury-Goeta 2007; Engelen and Wolf 2011; Winkvist, Rasmussen, and Habicht 1992). The time period is added to control for the time in which the research persons lived. Separate analyses are carried out for infant (0 to 12 months) and young child (12 to 60 months) mortality because the interaction of endogenous and exogenous mortality determinants changes throughout childhood, and covariates are thus likely to have different effects during each of these age categories.

The summary statistics of all variables – measured at the moment when the research persons were born – are presented in Table 1. It demonstrates that at birth, most parents were alive, in half of the cases a grandmother or grandfather was present, and birth intervals were long. Hakka is the largest ethnic majority in our sample, and the head of most families was a farmer or an unskilled worker. The research persons are evenly distributed across the time periods, although this is not the case for the regions under study.

¹² This division is made based on the idea that although older children may also compete for resources, these are not the same resources young children need. In other words, the nature of the competition changes.

Table 1: Description of the variables at the time of birth of the research persons (1906–1940)

	N	%	Dies	%
Sex				
<i>Man</i>	27,182	51.58	4,665	17.16
<i>Female</i>	25,490	48.37	5,767	22.62
Brothers 5 years older present				
<i>No</i>	31,096	59.01	6,289	20.22
<i>Yes</i>	21,599	40.99	4,149	19.21
Brothers up to 5 years older present				
<i>No</i>	34,810	66.06	6,879	19.76
<i>Yes</i>	17,885	33.94	3,559	19.90
Adopted brothers 5 years older present				
<i>No</i>	51,737	98.18	1,0261	19.83
<i>Yes</i>	958	1.82	177	18.48
Adopted brothers up to 5 years older present				
<i>No</i>	52,227	99.11	10,323	19.77
<i>Yes</i>	467	0.89	115	24.63
Sisters 5 years older present				
<i>No</i>	37,427	71.03	7,365	19.68
<i>Yes</i>	15,268	28.97	3,073	20.13
Sisters up to 5 years older present				
<i>No</i>	37,860	71.85	7,543	19.92
<i>Yes</i>	14,835	28.15	2,895	19.51
Adopted sisters 5 years older present				
<i>No</i>	31,548	59.87	6,244	19.79
<i>Yes</i>	21,147	40.13	4,194	19.83
Adopted sisters up to 5 years older present				
<i>No</i>	48,437	91.92	9,573	19.76
<i>Yes</i>	4,258	8.08	865	20.31
Mother present				
<i>No</i>	346	0.66	84	24.28
<i>Yes</i>	52,349	99.34	10,354	19.78

Table 1: (Continued)

	N	%	Dies	%
Father present				
<i>No</i>	2,635	5.00	592	22.47
<i>Yes</i>	50,060	95.00	9,846	19.67
Grandfather present				
<i>No</i>	31,534	59.84	6,508	20.64
<i>Yes</i>	21,161	40.16	3,930	18.57
Grandmother present				
<i>No</i>	27,775	52.71	5,773	20.78
<i>Yes</i>	24,920	47.29	4,665	18.72
Birth interval				
<i>< 16 months</i>	28,87	5.48	1,385	47.97
<i>16 to 24 months</i>	6,769	12.85	746	11.02
<i>> 24 months</i>	31,657	60.08	6,022	19.02
<i>First born</i>	11,140	21.14	2,243	20.13
Mother's age at birth				
<i>< 20</i>	10,891	20.67	2,086	19.15
<i>20 to 35</i>	22,622	42.93	4,446	19.65
<i>> 35</i>	12,568	23.85	2,540	20.21
<i>Unknown</i>	6,591	12.51	1,360	20.63
Occupation head of the household				
<i>Farmers</i>	34,616	65.69	6,534	18.88
<i>Low</i>	8,148	15.46	1,860	22.83
<i>High</i>	6,809	12.92	1,471	21.60
<i>Unknown</i>	3,099	5.88	567	18.30
Ethnicity				
<i>Hokkien</i>	12,768	24.24	3,189	24.97
<i>Hakka</i>	30,545	57.99	5,304	17.36
<i>Other</i>	9,359	17.76	1,939	20.71

Table 1: (Continued)

	N	%	Dies	%
Region				
<i>Zhubei</i>	7,660	14.54	1,381	18.03
<i>Beipu</i>	8,461	16.06	1,236	14.61
<i>Emei</i>	4,547	8.63	581	12.78
<i>Guanxi</i>	14,877	28.23	2,239	15.05
<i>Danei</i>	7,013	13.31	1,489	21.23
<i>Jibei</i>	1,297	2.46	418	32.23
<i>Donggang</i>	2,515	4.77	533	21.19
<i>Jiuru</i>	2,216	4.21	441	19.90
<i>Mengjia</i>	2,320	4.40	387	16.68
<i>Taodaocheng</i>	1,789	3.40	325	18.17
Period				
1906–1925	28,343	53.79	5,768	20.35
1926–1945	24,329	46.17	4,664	19.17
Total	52,695	100.00	10,438	19.08

Notes: The percentage of deaths is calculated from the total number of research persons. This means that mortality is underestimated, as research persons can also move out, which causes the persons-years at risk to be lower. This is taken into account in the calculation in the next section.

5. Results

5.1 Univariate analyses

Previous studies have shown that mortality risks differ between place and time in the studied regions in Taiwan (Shepherd 2011). Therefore, to gain an understanding of the differences of the mortality levels in the regions under study, child mortality risks are calculated first (Table 2). For the whole of Taiwan about 15% of boys and 13% of girls died before age 1. Thereafter, 7% of boys and 9% of girls would die before reaching their 5th birthday. In all regions, boys experienced higher mortality risks than girls, which confirms earlier studies that demonstrate that boys are more vulnerable at younger ages because of a biological disadvantage. Neonatal infant mortality risks for boys are almost the same. This offers a second indication of their natural disadvantage, although in the urban areas in northern Taiwan, male and female infant mortality risks

are roughly the same. In general the mortality risks of children are lower in northern compared to southern Taiwan. This is in line with earlier observations of mortality differences in Taiwan, as the northern region was more developed and was slightly wealthier compared to the southern region (Barclay 1954; Engelen, Shepherd, and Yang 2011).

Table 2: Mortality risks of infants and children until age 5 in Taiwan by region, gender, and age category for newborn children (1906–1945)

Months	Taiwan		Northern rural Taiwan		Southern rural Taiwan		Northern urban Taiwan	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
0 to 1	0.062	0.043	0.062	0.039	0.068	0.049	0.048	0.056
1 to 12	0.086	0.082	0.079	0.076	0.103	0.095	0.091	0.084
12 to 60	0.073	0.088	0.059	0.074	0.107	0.120	0.075	0.070
0 to 60	0.221	0.213	0.200	0.189	0.278	0.264	0.214	0.210

To obtain insight into the mortality risks of children with diverse sets of adopted and non-adopted children in different ages categories, child mortality risks until age 5 are analysed for newborn children. We present mortality risks after five years for the number of brothers and number of sisters at birth who were aged between 0 and 5 years old and older than 5 years in the selected research sites in Taiwan. This makes it possible to obtain, even at this stage, a first indication of whether having similarly aged brothers or sisters is associated with higher mortality risks and whether having siblings who are older is associated with similar or lower mortality risks. In addition, a difference is shown between non-adopted (Table 3) and adopted (Table 4) siblings in these age categories.¹³ For boys, there seems to be no clear differences in mortality risks of the number of young or old non-adopted brothers or sisters in all age categories, but for having adopted siblings, some statistically significant effects are observed for boys. Having adopted sisters aged 5 years or older, compared to having none, decreased mortality risks at age 5 (about 1.5%). In contrast, boys who have one young adopted brother or sister had increased mortality risks at age 5 (about 8% and 2%) compared to those who had none. For girls there does seem to be differences in mortality risks at age

¹³ To be able to construct Tables 3 and 4, Kaplan–Meijer analyses were carried out for each gender (boys and girls) for the number of non-adopted and adopted siblings coresident in the household, which resulted in 16 different Kaplan–Meijer survival analyses. For example, the first column in Table 3 is based on the Kaplan–Meijer survival analysis of the number of non-adopted brothers up to 5 years older for boys. Three different categories are compared with each other (0, 1, 2+ brothers), and the statistical significance of these differences is tested using a log-rank test. To be able to present the most important conclusions in a comprehensive way, the probability at the end of the observation (at age 5) is included instead of all information, as the goal of these univariate analyses is to get a first impression of possible influences. The disadvantage is that no information is presented on the time-dependence of the process.

5 for the number of non-adopted sisters and brothers aged between 0 and 5 years old. In particular, having two or more siblings compared to none increased mortality risks at age 5 (between 3% and 5%). In addition, having sisters more than 5 years older also increased mortality risks at age 5 (about 2%), while having older (non-adopted and adopted) brothers decreased mortality risks (between 2% and 4%).

Table 3: Mortality risks of children in Taiwan by the number of siblings in different age groups and by gender at age 5 for newborn children (1906–1940)

	Boys				Girls			
	Brothers < 5 years old	Brothers > 5 years old	Sisters < 5 years old	Sisters > 5 years old	Brothers < 5 years old	Brothers > 5 years old	Sisters < 5 years old	Sisters > 5 years old
0	0.219	0.223	0.222	0.222	0.208	0.214	0.214	0.207
1	0.222	0.221	0.218	0.215	0.219	0.221	0.209	0.225
2+	0.243	0.213	0.224	0.221	0.245	0.199	0.229	0.234
Ch2	3.3	2.3	0.6	1.7	4.1	4.9	3.4	10
p-value	0.20	0.30	0.80	0.40	0.10	0.07	0.10	0.01

Table 4: Mortality risks of children in Taiwan by the number of adopted siblings in different age groups and by gender at age 5 for newborn children (1906–1940)

	Boys				Girls			
	Brothers < 5 years old	Brothers > 5 years old	Sisters < 5 years old	Sisters > 5 years old	Brothers < 5 years old	Brothers > 5 years old	Sisters < 5 years old	Sisters > 5 years old
0	0.220	0.221	0.219	0.223	0.212	0.213	0.213	0.213
1+	0.301	0.221	0.237	0.208	0.259	0.175	0.212	0.211
Ch2	8.9	0	4.5	3.6	1.4	2.3	0.2	0
p-value	0.00	0.90	0.03	0.06	0.20	0.10	0.70	0.90

These univariate results demonstrate that the position of one’s siblings was important for determining child mortality risks up to age 5. However, the exact influence of differences in resource allocation seems to be complex, as they are dependent on the age, gender, and adoption status of the present siblings. While for boys differences in mortality risks are observed for the number of adopted brothers, for girls there are also differences for non-adopted siblings. The presence of older siblings can also lead to lower mortality risks. Still, there might be confounding variables that explain these results. Moreover, the number and composition of the sibling set is modelled at the moment children are born and is therefore not followed over time. To

be able to look in more detail, and to take changing sibling composition into account, the next section investigates sibling effects in fixed effect event history Cox proportional hazard models, with time-varying variables for the presence of specific household members.

5.2 Cox proportional hazard models

The family fixed effects Cox proportional hazard models show that for both infant boys and girls mortality risks were higher when there were more same-sex siblings present in the household. For boys the presence of brothers in general, and adopted brothers up to 5 years older, increased infant mortality risks. For girls the presence of sisters in general increased infant mortality risks. A difference between the sexes is that in the fixed effects models for infant boys, the presence of non-adopted and adopted sisters who were 5 years or more older decreased the probability of dying, while the presence of adopted brothers who were up to 5 years older increased it.

For child mortality risks the effect of the number of non-adopted and adopted brothers and sisters in specific age categories also seems to matter. Many of the effects confirm the general picture of infant mortality risks, although the impact of the presence of same-sex siblings is more pronounced and stronger. However, a difference is that siblings of the opposite sex who were up to 5 years older also increased mortality risks, although this effect was less strong than that of same-sex siblings who were up to 5 years older. For male children, the presence of brothers in general increased child mortality risks, with the effect being the strongest for those up to 5 years older. In addition, the presence of sisters and adopted sisters who were up to 5 years older also increased child mortality risks.¹⁴ Girls faced higher probabilities of death when sisters were present or when brothers up to 5 years older were present. Yet, the presence of brothers or adopted brothers more than 5 years older decreased mortality risks.

These results suggest that which types of siblings are present in the household is already important for infant mortality risks, and even more important for child mortality

¹⁴ To account for the fact that adopted girls up to 5 years older have an effect on male child mortality risks, but not on female child mortality risks, two explanations are possible. The first is the adopted girls were also used as a way to secure old-age support, and maybe even safeguard the continuation of the family line. In that sense, an adopted daughter might be considered as important as a son because they serve the same function and remain part of the household, which may have resulted in being allocated an equal share in the resources of a household. Yet, this goes against observations by anthropologists who argue that adopted girls are not valued the same as boys (Wolf 1972). Therefore, it is more likely that adopted girls up to 5 years older just compete in the same way as other children up to 5 years old. This effect is not observed for female child mortality risks because there are relatively few cases where a similarly aged non-adopted girl was not adopted out of the household (and therefore still present) when a little daughter-in-law was adopted into the household.

risks. When infants have siblings who are close in age, they may be competing for the same kind of resources from the mother (and other family members). This effect seems to be gendered and depended on the age of the child, as only same-sex siblings increased mortality risks of infants, while siblings of the opposite sex up to 5 years older also increased child mortality risks. It indicates that resources were used in gender-specific ways as the gendered resource dilution model suggests but also that the kind of competition over resources is dependent on the age of the child and the age of his or her siblings.

A protective effect of the presence of (non-adopted and adopted) sisters who are 5 years or more older exists for infant boys. These girls may directly contribute to the health of their infant brothers by providing care or bringing in additional income. It is more likely, however, that older girls alleviated the burden of the mother by taking over some household chores or economic activities so she had more time to spend on her infant son. That this effect exists for only boys may result from their perceived value, as well as the fact they were in general more vulnerable in infancy, and the additional time and care of the mother may have mattered more as well. That the presence of non-adopted brothers and adopted brothers more than 5 years older decreased female child mortality risks suggests that their activities may have actually increased the amount of resources within the household, which in turn benefited girls. An explanation may be that when resources are limited, it is most likely that only sons received sufficient resources, while girls got less. However, when there was more to go around, girls were the first to experience this improvement as, in relative terms, more resources were given to them than before.

Next to the effects of siblings, the presence of the mother decreased child mortality risks for boys and girls. This is an indication of the importance of the resources, time, and attention a mother provides for her children. For boys, having a short birth interval increased infant mortality risks, while for girls it increased infant and child mortality risks. This endogenous indicator of infant health is associated with higher infant mortality risks and is as expected from the literature. It suggests that maternal depletion played an important role and that it affected girls for a longer period of time. Lastly, for girls, child mortality risks decreased most over time, and this is also reflected in the lower female child mortality risks during the period 1926–1945.

Table 5: Cox proportional hazard (fixed effects) models for male and female child infant and mortality, Taiwan 1906–1945

Age	Infants (0 to 1 year)		Children (1 to 5 years)	
	Boys	Girls	Boys	Girls
<i>Variables</i>				
Brothers 5 years older present	1.220***	0.986	1.279***	0.879*
Brothers up to 5 years older present	1.384***	1.156	1.878***	1.280**
Adopted brothers 5 years older present	1.251	0.732	0.570	0.492*
Adopted brothers up to 5 years older present	1.847**	1.186	1.198	1.250
Sisters 5 years older present	0.798***	1.300***	1.019	1.642***
Sisters up to 5 years older present	1.007	1.486***	1.222**	1.532***
Adopted sisters 5 years older present	1.090**	0.883	0.852	0.933
Adopted sisters up to 5 years older present	0.790	0.973	1.317*	1.101
Mother present	1.090	0.816	0.554**	0.581*
Father present	0.790	0.984	0.882	1.083
Grandfather present	1.026	1.173	1.015	0.919
Grandmother present	1.030	0.896	1.194	0.924
<hr/>				
Birth interval				
< 16 months	1.159*	1.167*	0.883	1.424*
16 to 24 months	Ref.	Ref.	Ref.	Ref.
> 24 months	1.118	1.035	0.819*	1.055
First born	1.335***	1.452***	1.057	1.098
<hr/>				
Mother age at birth				
<20	1.060	1.073	1.039	1.135
20 to 35	Ref.	Ref.	Ref.	Ref.
>35	0.935	1.029	0.942	0.899
Unknown	0.992	1.044	0.825	1.088
<hr/>				
Period				
1906–1925	Ref.	Ref.	Ref.	Ref.
1926–1945	1.010	0.968	0.898	0.775**

Notes: Significance codes: *** 0.001, ** 0.01, * 0.05.

Table 6, which presents the estimates of family fixed effects Cox proportional hazard models for boys and girls for child mortality risks, shows the ways sibling effects may differ between regions. It should be noted that most effects in all regions are similar in direction and size and that the importance of same-sex siblings and siblings who are close in age is confirmed for child mortality risks of both sexes.¹⁵ In that sense, regional differences between northern and southern Taiwan in household organisation, and between rural and urban areas, seem to have only limited effects on

¹⁵ Although not always significant, the direction and magnitude of the effect is similar. When this is the case (the only difference is that the variable is statistically significant in one region but not in the other), we do not suggest that there is a difference as it is more likely that if more observations were available, it would be statistically significant.

the way siblings compete and provide support. Nonetheless, some indications of regional differences in sibling effects that are observed deserve further investigation. First, whereas sisters more than 5 years older increased female child mortality risks in rural northern and southern Taiwan, this is not the case for Taipei. This might be because they could provide additional income due to the work opportunities provided by the city. It demonstrates that the nature of the expectations that parents in Taipei have for a daughter is a dynamic process that depends on whether the girl is old enough to demonstrate her contribution to the household. Second, this may also be the reason why they competed more with boys, as they could be used in other ways to contribute to the total resources available in the household. The reason that older girls might indeed be seen as valuable is supported by the fact that they were not adopted out and that in Taipei adoption occurred much sooner after birth than in rural northern Taiwan, or not at all. In other words, when they were not adopted out, these daughters were apparently needed within the household for future contributions (Riswick and Lin 2019). Third, for girls, the presence of adopted boys also had different effects in northern and southern Taiwan. This indicates that they possibly played different roles within these households, but this is difficult to confirm because of the low number of adopted boys in southern Taiwan.

Table 6: Cox proportional hazard (fixed effects) models for male and female child mortality (1 to 5 years) in northern and southern Taiwan, 1906–1945

Sex Region	Boys North	Boys South	Boys Taipei	Girls North	Girls South	Girls Taipei
Variables						
<i>Brothers 5 years older present</i>	1.246**	1.463***	1.116	0.877	0.883	0.889
<i>Brothers up to 5 years older present</i>	1.781***	2.154***	1.256	1.234*	1.335*	1.516
<i>Adopted brothers 5 years older present</i>	0.564	0.336	1.053	1.085	0.330*	
<i>Adopted brothers up to 5 years older present</i>	1.204	0.967	1.393	2.309*	0.539	
<i>Sisters 5 years older present</i>	1.027	0.984	2.868*	1.597***	1.762***	0.958
<i>Sisters up to 5 years older present</i>	1.265*	1.205	0.938	1.443**	1.557***	1.557
<i>Adopted sisters 5 years older present</i>	0.840	0.920	1.065	0.981	0.993	0.541
<i>Adopted sisters up to 5 years older present</i>	1.346*	1.185	1.469	1.241	0.750	0.505
<i>Mother present</i>	0.666	0.469	0.723	0.517	0.725	0.735*
<i>Father present</i>	0.778	0.835	1.159	1.026	1.081	1.222
<i>Grandfather present</i>	0.976	1.027	0.682	0.909	1.033	0.336*
<i>Grandmother present</i>	1.170	1.145	1.341	0.967	0.871	1.113

Notes: Significance codes: *** 0.001, ** 0.01, * 0.05.

6. Concluding discussion

Research on the relation between child mortality and household structure and organisation is moving from the general assumption of the resource dilution model to more nuanced views such as the conditional or gendered resource dilution model. The aim of this study was to look at a patriarchal non-Western historical society in which large households were the ideal in order to be able to study these concepts and use them to examine the impact of the composition of the sibling set on infant and child mortality risks. By doing so, the position, gender, and age of individuals within household hierarchies were examined in Taiwan during the period 1906–1945. Taiwan was chosen because it allowed us to use reliable data to look at how highly stratified households in terms of gender and generation influenced sibling effects, as economic conditions and cultural norms caused son preference. The most important observation is the impact of the presence of non-adopted and adopted brothers and sisters on infant and child mortality risks. It confirms hypotheses that children mostly compete with same-sex siblings. This was true for both boys and girls (H1). Moreover, siblings who are similar in age are competing more for the same resources, while siblings who are much older may instead offer support (H2). Limited regional differences in sibling effects are observed (H3).

The results demonstrate that resource dilution plays a role but that its effect is complicated as the division of resources largely depends on which kinds of sibling are present in terms of gender, age, and adoption status. In general the number of same-sex non-adopted siblings increased infant and child mortality risks and that the number of similarly aged non-adopted and adopted siblings increased child mortality risks. However, the number of non-adopted and adopted sisters more than 5 years older decreased male infant mortality, and the number of older brothers decreased female child mortality, pointing to the possible supportive effect of siblings. Daughters, adopted or not, could easily act as a replacement for the mother in taking care of a male infant or in taking over domestic tasks, while – as mentioned earlier – older brothers may also add to the resources available in a household. The results from comparing regional differences in household organisation and urbanisation give some suggestions for looking closely at how the specific context, in the sense of cultural norms and economic conditions, affects household composition. However, to obtain a better idea about how and why these differences are found, more research into how regions differ and in what way they could condition resource dilution is needed. Nevertheless, the findings of this study underscore the conclusions of previous studies that gender is not the only important factor in resource dilution in terms of how it influences mortality risks. The age of siblings seems to be just as important.

The main conclusions above are in line with the general observations made in recent literature, as discussed earlier in this article. It seems that households opted for strategies of biased investment based on gender and age. Yet, this preference was not solely based on what would be expected in a patriarchal society where sons were preferred over daughters. Therefore, our findings demonstrate that although there was jural inequality between brothers, this was not reflected in survival chances during life itself. It may suggest that households calculated the relative (future) economic value of household members to preserve a balance between their available means of production and the number of males needed to perpetuate its ownership (Gates 1997). If this was indeed the reason that Taiwanese allocated more resources to some children and less to others, the results of our study provides further evidence of strategic decision-making of households (Bengtsson et al. 2004; Mattison et al. 2015). It can, however, be questioned whether these results are evidence for active agency of households, and household members, as they may simply be due to unintended consequences of traditional household roles and/or the product of a reality in which households have to take care of too many children of specific ages. The invariance found across the research areas also suggests a strong and persistence household organisation tied together in cultural norms. This was little affected by exogenous conditions as it might be buffered by household organisation and structure. It therefore seems that the persistence of family norms and unconscious decision-making processes shaped how resource allocation based on sibling composition influenced infant and child mortality risks.

In summary, this study helps us to understand how inequality is created within the household and how it shapes individual life courses. First, it has demonstrated the importance of including the presence, age, and gender of non-adopted and adopted siblings in child mortality research. It can enrich our perspective on the determinants of well-being in general and the processes of sibling competition and support in particular. Most studies include only birth order or sibling composition at birth, but this study has demonstrated that it is important to incorporate changing household composition over time in future studies. Furthermore, it is crucial to use the number and age of siblings as a time-varying variable and to differentiate between non-fixed and fixed effects in order to be able to take the actual presence of the siblings in the household into account and to differentiate between, within, and across family dynamics. Second, this study showed that sibling composition through resource dilution may have an important impact on children's survival chances and that it is important to take the historical context into account in order to be able to incorporate specific economic conditions and cultural norms. Gender and age differences are confirmed, and while indications for regional differences are limited, differences that were found demonstrate that reality is more complex than the resource dilution model suggests. Future research on siblings should

therefore be undertaken with the understanding that they may function as rivals, helpers, or a role somewhere between the two.

7. Acknowledgements

The sources of Japanese household registers in Taiwan used in this paper are partly collected by Hsiang-Shui Chen (Jiuru), Paul Katz (Donggang), and Ying-Chang Chuang (Zhubei and Emei). Those registers were digitised as the Taiwan Historical Household Registers Database, 1906–1945 (THHRD) by the Program of Historical Demography, Research Center for Humanities and Social Sciences, Academia Sinica, and contributed to this paper. Furthermore, this article has benefited from meticulous and insightful critiques provided by three anonymous reviewers. Initial drafts were presented at the European Historical Demography Conference in 2016, the N.W. Posthumus Masterclass with Stefan Öberg in 2018, and the Conference for Young Demographers in 2019, where useful input was provided by the audience and the commentator George Alter. Members of the Radboud Group for Historical Demography and Family History at Radboud University and members of the Program of Historical Demography at Academia Sinica provided valuable comments. We are especially grateful to Yulin Huang for his help with the database and to Xingchen ChiaChi Lin, Ying-Chang Chuang, and Wen-Shan Yang for their support. Theo Engelen and Hilde Bras in particular helped to improve this paper by providing key suggestions. This work was supported by The Netherlands Organisation for Scientific Research (NWO) Graduate Programme under Grant [022.002.003] and the Neys-Van Hoogstraten Foundation under Grant [TW266].

References

- Arnold, F., Choe, M.K., and Roy, T.K. (1998). Son preference, the family-building process and child mortality in India. *Population Studies* 52(3): 301–315. doi:10.1080/0032472031000150486.
- Barclay, G.W. (1954). *Colonial development and population in Taiwan*. Princeton, NJ: Princeton University Press.
- Baud, M. and Engelen, T. (1997). Introduction: Structure or strategy? Essays on family, demography, and labor from the Dutch N.W. Posthumus Institute. *The History of the Family* 2(4): 347–354. doi:10.1016/S1081-602X(97)90020-8.
- Bengtsson, T., Campbell, C., and Lee, J.Z. (eds.). *Life under pressure: Mortality and living standards in Europe and Asia, 1700–1900*. Cambridge, MA: The MIT Press.
- Bhargava, A. (2003). Family planning, gender differences and infant mortality: Evidence from Uttar Pradesh, India. *Journal of Econometrics* 112(1): 225–240. doi:10.1016/S0304-4076(02)00162-8.
- Blake, J. (1981). Family size and the quality of children. *Demography* 18(4): 421–442. doi:10.2307/2060941.
- Borgerhoff Mulder, M. (1998). Brothers and sisters: How sibling interactions affect optimal parental allocations. *Human Nature* 9(2): 119–162. doi:10.1007/s12110-998-1001-6.
- Bras, H. (2014). *Inequalities in food security and nutrition: A life course perspective* (Inaugural lecture upon taking up the post of Professor of Sociology of Consumption and Households at Wageningen University on December 4, 2014). Wageningen: Wageningen University.
- Broström, G. (2012). *Event history analysis with R*. London: CRC Press.
- Campbell, C. and Lee, J.Z. (1996). A death in the family: Household structure and mortality in rural liasoning: Life-event and time-series analysis, 1792–1867. *History of the Family* 1(3): 297–328. doi:10.1016/S1081-602X(96)90026-3.
- Campbell, C.D. and Lee, J.Z. (2004). Mortality and household in seven Liaodong populations, 1749–1909. In: Bengtsson, T., Campbell, C., and Lee, J.Z. (eds.). *Life under pressure: Mortality and living standards in Europe and Asia, 1700–1900*. London: The MIT Press: 293–324.

- Campbell, C.D. and Lee, J.Z. (2009). Long-term mortality consequences of childhood family context in Liaoning, China, 1749–1909. *Social Science and Medicine* 68(9): 1641–1648. doi:10.1016/j.socscimed.2009.02.017.
- Chamarbagwala, R. (2011). Sibling composition and selective gender-based survival bias. *Journal of Population Economics* 24(3): 935–955. doi:10.1007/s00148-010-0314-z.
- Chen, C. (1975). The Japanese adaptation of the Pao-Chia System in Taiwan, 1895–1945. *The Journal of Asian Studies* 34(2): 391–416.
- Chen, J., Xie, Z., and Liu, H. (2007). Son preference, use of maternal health care, and infant mortality in rural China, 1989–2000. *Population Studies* 61(2): 161–183. doi:10.1080/00324720701340194.
- Chen, S. (1966). Taiwan as a laboratory for the study of Chinese society and culture. *Bulletin of the Institute of Ethnology Academia Sinica* 22: 1–14.
- Choe, M.K., Hao, H., Wang, F., Hongsheng, H., and Feng, W. (1995). Effects of gender, birth order, and other correlates on childhood mortality in China. *Social biology* 42(1–2): 50–64. doi:10.1080/19485565.1995.9988887.
- Chu, C.Y.C. and Yu, R.-R. (2010). *Understanding Chinese families: A comparative study of Taiwan and Southeast China*. Oxford: Oxford University Press.
- Chuang, Y.-C. and Wolf, A.P. (1995). Marriage in Taiwan, 1881–1905: An example of regional diversity. *The Journal of Asian Studies* 54(3): 781–795. doi:10.2307/2059451.
- Cohen, M.L. (1976). *House united, house divided: The Chinese family in Taiwan*. New York: Columbia University Press.
- Conde-Agudelo, A., Rosas-Bermúdez, A., and Kafury-Goeta, A.C. (2007). Effects of birth spacing on maternal health: A systematic review. *American Journal of Obstetrics and Gynecology* 196(4): 297–308. doi:10.1016/j.ajog.2006.05.055.
- Das Gupta, M. (1987). Selective discrimination against female children in rural Punjab, India. *Populations and Development Review* 13: 77–101. doi:10.2307/1972121.
- Das Gupta, M. (1997). Kinship systems and demographic regimes. In: Kertzer, D.I. and Fricke, T. (eds.). *Anthropological demography: Toward a new synthesis*. Chicago: The University of Chicago Press: 36–52.

- Das Gupta, M. (1999). Lifeboat versus corporate ethic: Social and demographic implications of stem and joint families. *Social Science and Medicine* 49(2): 173–184. doi:10.1016/S0277-9536(99)00096-9.
- Diamond, N. (1969). *K'un Shen: A Taiwan village*. New York: Holt, Rinehart and Winston Inc.
- Dong, H., Campbell, C., Kurosu, S., Yang, W., and Lee, J.J.Z. (2015). New sources for comparative social science: Historical population panel data from East Asia. *Demography* 52(3): 1061–1088. doi:10.1007/s13524-015-0397-y.
- Dong, H., Kurosu, S., and Lee, J.Z. (2019). *Hierarchical sibling effects on child survival in East Asia: A comparative within-family study of two populations from Northeastern China and Japan, 1716–1909*. Paper presented at NWO-Research Project Genes, Germs and Resources Closing Conference “The Impact of the Family”, Nijmegen, The Netherlands, June 14, 2019.
- Dong, H., Manfredini, M., Kurosu, S., Yang, W., and Lee, J.Z. (2017). Kin and birth order effects on male child mortality: Three East Asian populations, 1716–1945. *Evolution and Human Behavior* 38(2): 208–216. doi:10.1016/j.evolhumbehav.2016.10.001.
- Downey, D.B. (2001). Number of siblings and intellectual development: The resource dilution explanation. *American Psychologist* 56(6–7): 497–504. doi:10.1037/0003-066X.56.6-7.497.
- Dunn, J. and Plomin, R. (1990). *Separate lives: Why siblings are so different*. New York: Basic Books.
- Engelen, T.L.M., Knotter, A., Kok, J., and Paping, R. (2004). Labor strategies of families: An introduction. *The History of the Family* 9(2): 123–135. doi:10.1016/j.hisfam.2004.01.001.
- Engelen, T.L.M., Shepherd, J.R., and Yang, W. (2011). *Death at the opposite ends of the Eurasian continent: Mortality trends in Taiwan and the Netherlands, 1850–1945*. Amsterdam: Amsterdam University Press. doi:10.1515/9789048514687.
- Engelen, T.L.M. and Wolf, A.P. (2006). Fertility four ways: Dutch urban and rural and Taiwanese urban and rural. In: Chuang, Y.-C., Engelen, T.L.M. and Wolf, A.P. (eds.). *Positive or preventive? Reproduction in Taiwan and the Netherlands 1850–1940*. Amsterdam: Aksant: 107–120.

- Engelen, T.L.M. and Wolf, A.P. (2011). Maternal depletion and infant mortality. In: Engelen, T., Shepherd, J.R., and Yang, W. (eds.). *Death at the opposite ends of the Eurasian Continent: Mortality trends in Taiwan and the Netherlands, 1850–1945*. Amsterdam: Aksant Academic Publishers: 275–288. doi:10.1515/9789048514687-011.
- Folbre, N. (1986). Hearts and spades: Paradigms of household economics. *World Development* 14(2): 245–255. doi:10.1016/0305-750X(86)90056-2.
- Folbre, N. (2008). *Valuing children: Rethinking the economics of the family*. London: Harvard University Press. doi:10.2307/j.ctvjnrt57.
- Fox, J., Willführ, K.P., Gagnon, A., Dillon, L., and Volland, E. (2017). The consequences of sibling rivalry on survival and reproductive success across different ecological contexts: A comparison of the historical Krummhörn and Quebec populations. *The History of the Family* 22(2–3): 364–423. doi:10.1080/1081602X.2016.1193551.
- Freedman, M. (1966). *Chinese lineage and society: Fukien and Kwangtung*. New York: The Athlone Press.
- Gallin, B. (1966). *Hsin Hsing, Taiwan: A Chinese village in change*. Berkeley: University of California Press.
- Garg, A. and Morduch, J. (1998). Sibling rivalry and the gender gap: Evidence from child health outcomes in Ghana. *Journal of Population Economics* 11(4): 471–493. doi:10.1007/s001480050080.
- Gates, H. (1987). *Chinese working-class lives: Getting by in Taiwan*. Ithaca: Cornell University Press.
- Gates, H. (1997). *China's motor: A thousand years of petty capitalism*. Ithaca: Cornell University Press.
- Gates, H. (2005). Girls' work in China and North-Western Europe: Of Guniang and Meisjes. In: Engelen, T.L.M. and Wolf, A.P. (eds.). *Marriage and the family in Eurasia. Perspectives on the Hajnal hypothesis*. Amsterdam: Aksant Academic Publishers: 319–341.
- Gates, H. (2014). *Footbinding and women's labor in Sichuan*. London: Routledge. doi:10.4324/9780203491836.
- Gibbs, B.G., Workman, J., and Downey, D.B. (2016). The (conditional) resource dilution model: State- and community-level modifications. *Demography* 53(3): 723–748. doi:10.1007/s13524-016-0471-0.

- Harrell, S. (2014). *Ploughshare village: Culture and context in Taiwan*. Seattle: University of Washington Press.
- Heer, D.M. (1985). Effects of sibling number on child outcomes. *Annual Review of Sociology* 11: 27–47. doi:[10.1146/annurev.so.11.080185.000331](https://doi.org/10.1146/annurev.so.11.080185.000331).
- Hsieh, Y.H. and Chuang, Y.C. (2005). Sibling order SES marriage and fertility: Four Hokkien and Hakka communities at Chu-shan Er-mei and Chu-pei in colonial Taiwan. *Journal of Population Studies* 31: 41–68.
- Jayachandran, B.S., Pande, R., Coffey, D., Deaton, A., Dizon-ross, R., Drèze, J., Field, E., Leggett, D., Ray, D., Spears, D., Strzalecki, T., and Tarozzi, A. (2017). Why are Indian children so short? The role of birth order and son preference. *American Economic Review* 107(9): 2600–2629. doi:[10.1257/aer.20151282](https://doi.org/10.1257/aer.20151282).
- Kalmijn, M. and van de Werfhorst, H.G. (2016). Sibship size and gendered resource dilution in different societal contexts. *Plos One* 11(8). doi:[10.1371/journal.pone.0160953](https://doi.org/10.1371/journal.pone.0160953).
- King, M.T. (2014). *Between birth and death: Female infanticide in nineteenth-century China*. Stanford: Stanford University Press. doi:[10.111126/stanford/9780804785983.001.0001](https://doi.org/10.111126/stanford/9780804785983.001.0001).
- Kippen, R. and Walters, S. (2012). Is sibling rivalry fatal? Siblings and mortality clustering. *Journal of Interdisciplinary History* 42(4): 571–591.
- Klep, P.M.M. (2004). Introduction to special issue: Contradictory interests of offspring and parents, 1500–2000. *The History of the Family* 9(4): 349–354. doi:[10.1016/j.hisfam.2003.01.001](https://doi.org/10.1016/j.hisfam.2003.01.001).
- Knodel, J. and Hermalin, A.I. (1984). Effects of birth rank, maternal age, birth interval, and sibship size on infant and child mortality: evidence from 18th and 19th century reproductive histories. *American Journal of Public Health* 74(10): 1098–1106. doi:[10.2105/AJPH.74.10.1098](https://doi.org/10.2105/AJPH.74.10.1098).
- Kramer, K.L. (2002). Helping behavior among Maya children. *Human Nature* 13(2): 299–325. doi:[10.1007/s12110-002-1011-8](https://doi.org/10.1007/s12110-002-1011-8).
- Kramer, K.L. (2005). Children’s help and the pace of reproduction: Cooperative breeding in humans. *Evolutionary Anthropology: Issues, News, and Reviews* 14(6): 224–237. doi:[10.1002/evan.20082](https://doi.org/10.1002/evan.20082).
- Kramer, K.L. (2010). Cooperative breeding and its significance to the demographic success of humans. *Annual Review of Anthropology* 39(1): 417–436. doi:[10.1146/annurev.anthro.012809.105054](https://doi.org/10.1146/annurev.anthro.012809.105054).

- Kramer, K.L., Veile, A., and Otárola-Castillo, E. (2016). Sibling competition and growth tradeoffs: Biological vs. statistical significance. *PLoS One* 11(3): 1–17. doi:10.1371/journal.pone.0150126.
- Lawson, D.W. and Borgerhoff Mulder, M. (2016). The offspring quantity-quality trade-off and human fertility variation. *Philosophical Transactions of the Royal Society B: Biological Sciences* 371(1692). doi:10.1098/rstb.2015.0145.
- Lawson, D.W. and Mace, R. (2008). Sibling configuration and childhood growth in contemporary British families. *International Journal of Epidemiology* 37(6): 1408–1421. doi:10.1093/ije/dyn116.
- Lawson, D.W. and Mace, R. (2011). Parental investment and the optimization of human family size. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences* 366(1563): 333–343. doi:10.1098/rstb.2010.0297.
- Lee, J.Z. and Campbell, C. (1997). *Fate and fortune in rural China. Social organization and population behavior in Liaoning 1774–1873*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511563058.
- Li, C.-H., Kolk, M., Yang, W., and Chuang, Y. (2019). Uxorilocal marriage as a strategy for heirship in a patrilineal society: Evidence from household registers in early 20th-century Taiwan. *The History of the Family* 25(1): 22–45. doi:10.1080/1081602X.2019.1641131.
- Li, S., Zhu, C., and Feldman, M.W. (2004). Gender differences in child survival in contemporary rural China: A county study. *Journal of Biosocial Science* 36(1): 83–109. doi:10.1017/S0021932004006121.
- Lin, T.H. and Tseng, H.J. (2014). The politics of Hukou: A comparative study of the household registration system in China and Taiwan [in Chinese]. *Mainland China Studies* 57(1): 63–96.
- Lin, X.C. (2011). *Female heads of households in Eurasian societies: Taipei and Rotterdam in times of industrialisation*. Nijmegen: Radboud University.
- Lin, X.C. (2013). Headship, household burden, and infant mortality in Taipei (1906–1944). *Journal of Family History* 38(3): 344–364. doi:10.1177/0363199013484722.
- Lin, X.C., Yang, W., and Chuang, Y. (2014). Another marriage choice: A study of uxori-local marriage in Taiwan, comparative research of Taipei (urban) and Xinchu (rural), 1906–1944. *Journal of Family History* 39(4): 388–403.

- Liu, S. (2004). Differential Mortality in colonial Taiwan (1895-1945). *Annales de démographie historique* 107: 229–247.
- Lynch, K.A. (2011). Why weren't (many) European women 'missing'? *The History of the Family* 16(3): 250–266. doi:10.1016/j.hisfam.2011.02.001.
- Manthorpe, J. (2009). *Forbidden nation: A history of Taiwan*. Basingstoke: Palgrave Macmillan.
- Mattison, S.M., Beheim, B., Chak, B., and Buston, P. (2016). Offspring sex preferences among patrilineal and matrilineal mosuo in southwest China revealed by differences in parity progression. *Royal Society Open Science* 3(9). doi:10.1098/rsos.160526.
- Mattison, S.M., Brown, M.J., Floyd, B., and Feldman, M.W. (2015). Adoption does not increase the risk of mortality among Taiwanese girls in a longitudinal analysis. *PloS One* 10(4): 1–18. doi:10.1371/journal.pone.0122867.
- Mattison, S.M., Seabright, E., Adam, Z., Cao, J.B., Brown, M.J., and Feldman, M.W. (2018). Adopted daughters and adopted daughters-in-law in Taiwan: A mortality analysis. *Royal Society Open Science* 5(171745): 1–15. doi:10.1098/rsos.171745.
- Muhuri, P.K. and Menken, J. (1997). Adverse effects of next birth, gender, and family composition on child survival in rural Bangladesh. *Population Studies* 51(3): 279–294. doi:10.1080/0032472031000150056.
- Muhuri, P.K. and Preston, S.H. (1991). Effects of family composition on mortality differentials by sex among children in Matlab, Bangladesh. *The Population and Development Review* 17(3): 415–434. doi:10.2307/1971948.
- Newell, W.H. (1985). Structural conflicts within the Chinese family. In: Hsieh, J. and Chuang, Y. (eds.). *The Chinese family and its ritual behavior*. Taipei: Academia Sinica: 84–97.
- Nuckolls, C.W. (ed.) (1993). *Siblings in South Asia: Brothers and sisters in cultural context*. London: The Guilford Press.
- Öberg, S. (2017). Too many is not enough: Studying how children are affected by their number of siblings and resource dilution in families. *The History of the Family* 22(2–3): 157–174. doi:10.1080/1081602X.2017.1302890.
- Olds, K. (2003). The biological standard of living in Taiwan under Japanese occupation. *Economics and Human Biology* 1: 187–206.

- Olds, K.B. (2006). Female productivity and mortality in early-20th-century Taiwan. *Economics and Human Biology* 4(2): 206–221. doi:10.1016/j.ehb.2005.12.002.
- Olsen, N.J. (1971). Sex differences in child training antecedents of achievement motivation among Chinese children. *The Journal of Social Psychology* 83(2): 303–304. doi:10.1080/00224545.1971.9922476.
- Olsen, N.J. (1973). Family structure and independence training in a Taiwanese village. *Journal of Marriage and Family* 35(3): 521–519. doi:10.2307/350587.
- Olsen, N.J. (1974). Family structure and socialization patterns in Taiwan. *American Journal of Sociology* 79: 1395–1417. doi:10.1086/225707.
- Pande, R. (2003). Nutrition and immunization in rural India: The role of siblings. *Demography* 40(3): 395–418. doi:10.1353/dem.2003.0029.
- Parish, W.L. and Willis, R.J. (1993). Daughters, education, and family budgets: Taiwan experiences. *The Journal of Human Resources* 28(4): 863–898. doi:10.2307/146296.
- Park, H., Han, S., and Kye, B. (2018). Changes in child mortality in Korea during the mid-twentieth century: Gender, birth order and sibling composition. *The History of the Family* 23(4): 594–622. doi:10.1080/1081602X.2018.1485114.
- Pasternak, B. (1972). *Kinship and community in two Chinese villages*. Stanford: Stanford University Press.
- Pasternak, B. (1983). *Guests in the dragon: Social demography of a Chinese district 1895–1946*. New York: Columbia University Press.
- Reher, D.S. (1998). Family ties in Western Europe: Persistent contrasts. *Population and Development Review* 24(2): 203–234. doi:10.2307/2807972.
- Riswick, T. (2019). Consequences of infant adoption in Taiwan, 1906–1945: The impact of regional context and household composition on child mortality. SocArXiv: 1–23. doi:10.31235/osf.io/w8g9e.
- Riswick, T. (2018). Testing the conditional resource-dilution hypothesis: The impact of sibship size and composition on infant and child mortality in the Netherlands, 1863–1910. *History of the Family* 23(4): 623–655. doi:10.1080/1081602X.2018.1532310.
- Riswick, T. and Engelen, T. (2018). Siblings and life transitions: Investigating the resource dilution hypothesis across historical contexts and outcomes. *The History of the Family* 23(4): 521–532. doi:10.1080/1081602X.2018.1532309.

- Riswick, T. and Lin, X.C. (2019). Causes of child adoption in Taiwan, 1906–1940: The importance of gender, household composition and variation over time and place. *SocArXiv*. doi:10.31235/osf.io/4jb3u.
- Santos, G. and Harrell, S. (eds.) (2017). *Transforming patriarchy: Chinese families in the twenty-first century*. Seattle: University of Washington Press.
- Sear, R. and Coall, D. (2011). How much does family matter? Cooperative breeding and the demographic transition. *Population and Development Review* 37: 81–112. doi:10.1111/j.1728-4457.2011.00379.x.
- Sear, R. and Mace, R. (2008). Who keeps children alive? A review of the effects of kin on child survival. *Evolution and Human Behavior* 29(1): 1–18. doi:10.1016/j.evolhumbehav.2007.10.001.
- Sear, R., Steele, F., McGregor, I.A., and Mace, R. (2002). The effects of kin on child mortality in rural Gambia. *Demography* 39(1): 43–63. doi:10.1353/dem.2002.0010.
- Sen, A. (1998). Mortality as an indicator of economic success and failure. *The Economic Journal* 108(446): 1–25. doi:10.1111/1468-0297.00270.
- Shepherd, J.R. (2011). Regional and ethnic variation in mortality in Japanese colonial period Taiwan. In: Engelen, T., Shepherd, J.R., and Yang, W. (eds.). *Death at the opposite ends of the Eurasian continent: Mortality trends in Taiwan and the Netherlands, 1850–1945*. Amsterdam: Aksant: 99–152. doi:10.1515/9789048514687-005.
- Skinner, G.W. (1997). Family systems and demographic processes. In: Kertzer, D.I. and Fricke, T.E. (eds.). *Anthropological demography: Toward a new synthesis*. Chicago: University of Chicago Press: 53–95.
- Steelman, L.C., Powell, B., Werum, R., and Carter, S. (2002). Reconsidering the effects of sibling configuration: Recent advances and challenges. *Annual Review of Sociology* 28: 243–269. doi:10.1146/annurev.soc.28.111301.093304.
- Sung, L. (1981). Property and family division. In: Ahern, E.M. and Gates, H. (eds.). *The anthropology of Taiwanese society*. Taipei: SMC Publishing Inc.: 361–378.
- Tang, M.-C. (1985). Equal right and domestic structure. In: Hsieh, J.-C. and Chuang, Y.-C. (eds.). *The Chinese family and its ritual behavior*. Taipei: Academia Sinica: 61–69.
- Therborn, G. (2004). *Between sex and power: Family in the world 1900–2000*. London: Routledge. doi:10.4324/9780203643297.

- Thornton, A. and Lin, H.-S. (1994). *Social change and the family in Taiwan*. Chicago: University of Chicago Press.
- Todd, E. (1985). *The explanation of ideology: Family structures and social systems*. Oxford: Blackwell.
- Wahab, A., Winkvist, A., Stenlund, H., and Wilopo, S.A. (2001). Infant mortality among Indonesian boys and girls: Effect of sibling status. *Annals Of Tropical Paediatrics* 21(1): 66–71. doi:10.1080/02724930020028948.
- Wang, S. (1985). On the household and family in Chinese society. In: Hsieh, J.-C. and Chuang, Y.-C. (eds.). *The Chinese family and its ritual behavior*. Taipei: Academia Sinica: 50–58.
- Winkvist, A, Rasmussen, K.M., and Habicht, J.P. (1992). A new definition of maternal depletion syndrome. *American Journal of Public Health* 82(5): 691–694. doi:10.2105/AJPH.82.5.691.
- Wolf, A.P. (1976). Aspects of ancestor worship in northern Taiwan. *Ancestors*: 339–364.
- Wolf, A.P. (1981). Domestic organization. In: Ahern, E.M. and Gates, H. (eds.). *The anthropology of Taiwanese society*. Taipei: SMC Publishing Inc.: 341–360.
- Wolf, A.P. (2005). Europe and China: Two kinds of patriarchy. In: Engelen, T.L.M. and Wolf, A.P. (eds.). *Marriage and the family in Eurasia: Perspectives on the Hajnal hypothesis*. Amsterdam: Aksant: 215–240.
- Wolf, A.P. and Gates, H. (2005). Marriage in Taipei city: Reasons for rethinking Chinese demography. *International Journal of Asian Studies* 2(1): 111–133. doi:10.1017/S1479591405000057.
- Wolf, A.P. and Huang, C. (1980). *Marriage and adoption in China: 1845–1945*. Stanford: Stanford University Press.
- Wolf, D.L. (1990). Daughters, decisions and domination: An empirical and conceptual critique of household strategies. *Development and Change* 21(1): 43–74. doi:10.1111/j.1467-7660.1990.tb00367.x.
- Wolf, M. (1968). *The house of Lim: A study of a Chinese farm family*. New York: Appleton-Century-Crofts.
- Wolf, M. (1972). *Women and the family in rural Taiwan*. Stanford: Stanford University Press.

Wolf, M. (1978). Child training in Chinese families. In: Wolf, A.P. (ed.). *Studies in Chinese society*. Stanford: Stanford University Press: 221–246.

Appendix: Cox proportional hazard models for male and female child infant and mortality, Taiwan 1906–1945

Age Sex	Infants (0 to 1 year)		Children (1 to 5 years)	
	Boys	Girls	Boys	Girls
<i>Variables</i>				
Brothers 5 years older present	0.965	0.930*	0.974	0.895**
Brothers up to 5 years older present	0.952	0.980	1.160**	1.121*
Adopted brothers 5 years older present	1.094	0.799	0.884	0.837
Adopted brothers up to 5 years older present	1.501**	1.080	1.278	1.361
Sisters 5 years older present	0.902*	1.061	0.973	0.998
Sisters up to 5 years older present	0.966	0.941	1.022	0.994
Adopted sisters 5 years older present	1.040	1.080	0.942	0.992
Adopted sisters up to 5 years older present	1.235***	1.109	1.124	1.127
Mother present	0.899	0.567*	0.509***	0.456***
Father present	0.914	1.071	0.918	1.120
Grandfather present	1.029	1.028	0.954	0.935
Grandmother present	0.979	0.931	0.934	0.894*
Birth interval				
< 16 months	1.376***	1.498***	0.875	1.187
16 to 24 months	Ref.	Ref.	Ref.	Ref.
> 24 months	0.892*	0.864*	0.855*	0.930
First born	0.935	1.029	0.855	0.825*
Mother age at birth				
<20	0.967	1.000	1.001	0.974
20 to 35	Ref.	Ref.	Ref.	Ref.
>35	1.026	1.108	1.055	1.095
Unknown	1.121	1.206*	1.090	1.047
Occupation household head				
Farmers	Ref.	Ref.	Ref.	Ref.
Low social economic status	1.202***	1.362***	1.229**	1.299***
High social economic status	1.269***	1.182*	0.967	1.081
Unknown social economic status	0.907	0.984	0.933	1.053
Ethnicity				
Hokkien	Ref.	Ref.	Ref.	Ref.
Hakka	0.914	0.831**	0.743**	0.753**
Other	1.005	1.012	0.898	0.830*
Region				
Northern Taiwan	Ref.	Ref.	Ref.	Ref.
Southern Taiwan	1.168**	1.170*	1.433***	1.445***
Period				
1906–1925	Ref.	Ref.	Ref.	Ref.
1926–1945	0.982	0.937	0.852**	0.827***

Notes: Some of the same observations can be carried out when not using a family fixed effects approach and by controlling for more covariates. In general it confirms that more (non-adopted and adopted) brothers who are up to 5 years older increased infant and child mortality risks. In addition, it confirms the observation by Fox et al. (2017) that, through side-by-side comparison of across-family and within-family analyses, sibling competition seems to be manifested as an internal familial dynamic but is obscured in non-fixed effects models by a broader trend of family cooperation.

Significance codes: *** 0.001, ** 0.01, * 0.05.

