

**Birth circumstances and adult health and mortality in northeast China
1749-1909**

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Abstract

We investigate whether length of preceding birth interval, maternal age at birth, and season of birth influence health and mortality in adulthood and old age. These features of birth circumstances have been shown to influence infant and child mortality developing countries and historical populations, and we assess whether they have longer term consequences as well. Our data comprise a large (approximately 250,000 individuals) database of life histories of largely rural residents of northeast China in the 18th and 19th centuries recorded in triennial household registers. We estimate logistic regressions to examine how birth circumstances affect the risks of dying or being recorded as disabled, accounting for unobserved community and household characteristics with fixed- and random-effects models. Preliminary results suggest that maternal age and previous birth interval influence health and mortality in adulthood. Contrary to several previous studies, preliminary results do not suggest associations between adult mortality and season of birth.

Extended Abstract

Background

Although interest in the long-term effects of childhood circumstances on adult health is longstanding, more complete longitudinal data and newer research methods are driving this research agenda forward (Kuh and Ben-Shlomo 2004, Kuh and Davey Smith 2004). The interest in 'childhood effects' is driven, at least in part, by the inability of models including only adult variables to account for the persistent health differentials among individuals and groups (Kuh and Davey Smith 2004, Palloni 2006). Within this recently reinvigorated research agenda, a number of studies have found associations between conditions in childhood, infancy, or in utero and adult health (Haas 2008, Zeng et al. 2007, Palloni 2006, Hayward and Gorman 2004, Kuh et al. 2002, Preston et al. 1998, Elo and Preston 1992). This 'childhood effects' literature hypothesizes links between social and biological factors in early life and adult health and mortality. These early life factors are hypothesized to influence health and mortality both indirectly through adult SES and behavior and directly through latent health impairments that only manifest themselves symptomatically many years after onset (Kuh and Ben-Shlomo 2004). 'Fetal programming' is one hypothesized mechanism between early life environment and later health outcomes (Barker 2007, 1992). An adverse fetal environment brought on by nutritional deprivation or disease exposure of the mother may lead to developmental changes that help the fetus survive but manifest themselves in increased mortality risks later in adulthood.

In this paper we examine the associations between adult health and mortality and three aspects of birth circumstance that may be proxies for an impaired fetal environment: maternal age at birth, previous birth interval, and season of birth. These three aspects of birth have all been linked to increased infant and child mortality risks (Knodel and Hermalin 1984, Curtis et al. 1993, Moore et al. 2004). Previous birth interval, especially, has been linked to neonatal health and mortality in a number of studies (Conde-Agudelo et al. 2006, Conde-Agudelo et al. 2005, Rutstein 2005, Zhu et al. 1999, Kallan 1997, Fedrick and Adelstein 1973). Nutritional deficits, particularly involving the nutrient folate, have been hypothesized as a mechanism linking short birth intervals with subsequent adverse birth outcomes (Smits and Essed 2001). For maternal

age, an association between older mothers and perinatal death has also been consistently found in previous studies (Kiely et al. 1986, Pebley and Strupp 1987). Declining reproductive fitness with age, perhaps working through reduced uterine blood flow to the placenta and lower fetal oxygenation, has been hypothesized as the general biological mechanism linking maternal age to perinatal mortality (Kiely et al. 1986).

For our particular interest in the long-term effects of early life conditions, studies linking birth interval to pre-term births (Zhu et al. 1999), intrauterine growth retardation (Kallan 1997), and/or low birth weight (Conde-Agudelo et al. 2005), as well as studies linking maternal age to chromosomal abnormalities (Cleary-Goldman et al. 2005) are suggestive. These adverse developmental circumstances are consistent with fetal programming hypotheses and raise the possibility that the mortality effects of short birth intervals may be long lasting.

For season of birth, there are several studies linking it to adult mortality risks as well (Munoz-Tuduri and Garcia-Moro 2008, Lerchl 2004, Vaiserman et al. 2002, Doblhammer and Vaupel 2001), although not all studies find such a link (Moore et al. 2004, Kannisto et al. 1997). If season of birth effects are real, they may be a proxy for varying environmental conditions affecting the fetus through nutritional deprivation and increased disease exposure of the mother during key developmental stages of her pregnancy (Vaiserman et al. 2002). Alternatively they may proxy environmental conditions in infancy that could also affect long-term health prospects (Munoz-Tuduri and Garcia-Moro 2008).

Data

We will employ triennial household register data covering the period 1749 to 1909. In total, the dataset includes 1.4 million triennial records on approximately 250,000 rural Chinese living in 600 villages in Liaoning province, northeast China. For pre-20th century China these data provide more accurate and complete demographic and sociological data than any other household register or lineage genealogy data currently available. These data are well suited to examining the long-term health and mortality consequences of early life experience in a preindustrial, high-mortality population. The registers provide complete life histories from birth to death. Migration into or out of the population was rare and when it occurred it was specifically annotated. The result was an essentially closed population from a demographic point of view, making censoring of observations much less problematic than in most other historical

data, and accurate recording of mortality, and record individual, household and community circumstances in detail. For adult males, the registers record any official positions or statuses they held, thereby providing a measure of socioeconomic status. The registers also identify men who were exempted from corvee labor or military service by a disability, and in early decades specify the disability in detail. The data are described in detail in Lee and Campbell (1997, 223-237) and features of the data that make it especially useful in event history models are discussed in Campbell and Lee (2008).

Methods

For mortality, we will estimate discrete-time event-history models by application of logistic regression and/or complementary log-log regression in which the outcome of interest is death between the current register and the next. For disability, we will estimate logistic regressions for men at specific ages in which the outcome variable indicates whether or not they are listed as disabled. Additional analysis will consider specific types of disability. We will use fixed and/or random effects models to better account for household or community characteristics that may influence adult mortality as well as birth circumstances. We may also take advantage of the size of the dataset to make use of data intensive approaches such as matching and propensity-score matching.

We expect patterns of interactions to yield insight into the mechanisms accounting for observed relationship. Accordingly, we will examine patterns interactions of characteristics of the mother, family, household and community with birth circumstances. Of particular interest will be whether effects of preceding birth interval or maternal age varied by socioeconomic status, economic conditions around the time of birth, and community characteristics such as size and geographic location.

We will also estimate models with disability as an outcome and look for patterns of association between birth circumstances and disability in adulthood.

Preliminary results

We have already established the usefulness of these data for analyzing the long-term

impacts of early life circumstances (Campbell and Lee, forthcoming; Davis, Campbell, and Lee 2008). Campbell and Lee (forthcoming) examined the long-term health and mortality consequences of loss of a parent in childhood, and reported evidence that the loss of a mother in childhood was associated with higher mortality later in life, but that the loss of a father in childhood had no discernible effect. That paper included length of previous birth interval and maternal age as control variables and reported that short preceding birth interval and high maternal age were associated with elevated mortality risks later in life, but did not follow up on these results. Those findings deserve more attention both because of the established links between maternal age and preceding birth interval and infant and child health, at least in developing country populations. Because this was to our knowledge these results were among the first ever reported for associations between preceding birth interval and maternal age and health and mortality in adulthood and old age, this paper takes them as a starting point, and seeks additional insight into underlying mechanisms via the approaches described earlier.

For season of birth, we have already run some preliminary models. These models indicate no association between season of birth and adult mortality. These results are preliminary because we have not yet converted the recorded birth month from lunar to solar month—which will give a more accurate and consistent timing of the seasonal weather patterns. In addition, controls for socioeconomic and household circumstances, as well as interactions between variables, have not yet been added to model.

We anticipate finding associations between birth circumstances, specifically previous birth interval and maternal age, and adult disability and mortality based on the work we have done so far (Campbell and Lee, forthcoming) and our reading of the literature that suggests links between birth circumstances and child health and mortality. We anticipate no overall association between season of birth and adult disability and mortality based on our preliminary results, but inclusion of season of birth in the full model with interactions may still identify population subgroups where season of birth has lasting effects. Given the attention to and debate over reported associations between season of birth and mortality risks in adulthood and old age, we expect even a negative result to be a contribution to the literature.

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