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Infant and early childhood mortality in a historical context

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Introduction and hypotheses

In contemporary populations the health of infants and very young children is largely determined by the socioeconomic status (SES) of the family in which the children are born. Newborns in lower socioeconomic groups tend to have a lower birth weight, are born prematurely and have a higher risk of birth defects (Agyemang et al. 2009, Yang et al. 2007, Parker, Schoendorf & Kiely 1994). Moreover, infants have a higher risk of dying during birth and in the first year of life (Thomas, Dorling & Smith 2010). The socioeconomic health differences in current western countries appear to be persistent and are found to be a general characteristic of modern society. Several studies have connected socioeconomic status to breastfeeding practices: whereas breastfeeding is the healthiest way of feeding newborns, children in lower socioeconomic families are less likely to be breastfed.

The objective of this paper is to test, in a historical setting, whether and how social class influences the level of infant mortality and how this may be related to or explained by breastfeeding practices. What social groups are affected most with high infant mortality in a high mortality regime and how does it evolve along with overall mortality decline. Socioeconomic variation in infant mortality can be explained by the uneven distribution of risk and protective factors between social groups. Infants are exposed to different health risks because socioeconomic status is highly correlated with housing, sanitary conditions, proper nourishment, and medical treatment. We expect therefore that infant mortality was higher among the poorer classes. In addition to analyzing infant mortality according to social group, we test – using individual level data including causes of death regarding the population of the Dutch town of Roosendaal – several hypotheses in order to explain social differentials and its mechanisms regarding infant mortality. The explanations for the findings are considered in the context of different social and environmental conditions, disease environment, and infant feeding practices. Besides socioeconomic determinants, previous research on infant mortality in past and present has discussed the role of breastfeeding and its direct effect on infant survival. In order to connect social differences with distinct feeding practices and related health risks we will particularly focus on: 1. timing (or occurrence) of death within the first two years of life (related to the incidence of weaning); 2. the distribution of infant death throughout the year (the practice of artificial feeding accompanied by poor sanitary standards will result in excess summer mortality); 3. the main causes of infant death (the practice of bottle feeding will result in high numbers of deaths because of gastro-enteritis or diarrhea); and 4. differences or changes in historical time.

As far as we know, historical individual cause of death data is rare and only available for a few Dutch towns for short periods of time or covering only specific parts of the population, for example hospital patients. These longitudinal data can shed light on the cause of death of infants in relation to family background and other life course information.

Birth and death certificates offer a consistent data source as they follow more or less uniform registration rules for an extensive period of time. Our dataset covers the period 1863-1938 thus covering a period in which enormous demographic transformations took place – changes in fertility and mortality (i.e. the demographic transition) accompanied with other macro processes such as industrialization and urbanization – affecting the lives of individuals and families. The significance of Roosendaal as case study lies within the fact that this community embodies many of the economic, social, and cultural changes typical of the nineteenth and twentieth centuries:

the emergence of a large working class, transformations within agriculture, population growth and urbanization, and gradually improved public health regulation.

Analytical framework

We will employ the analytical framework developed by Mosley and Chen in 1984. This conceptual framework for the study of child survival in developing countries is based on the presumption that all social and economic determinants of infant and child mortality necessarily operate through a common set of biological mechanisms (called the proximate determinants or intermediate variables) to exert an impact on morbidity and mortality (Mosley and Chen 1984). In the model, five categories of intervening variables are identified that can directly influence the risk of morbidity and mortality of children: *maternal characteristics* like age, parity, and birth interval which exert an independent influence on infant survival through its effects on maternal health; *environmental contamination*, referring to the transmission of infectious agents; *nutrient deficiency*, referring to the intake of the three major classes of nutrients available to the child as well as the mother (calories, protein, vitamins and minerals); *injuries* (accidental or intentional); and *personal illness control* (personal preventive measures, quality of care during pregnancy and childbirth, and medical treatment). It is through these factors that all social and economic determinants that affect child survival must operate. These socioeconomic determinants can act at the level of the family, its individual members, and the community (ecological setting, political economy, and health system).

Although the model of Mosley and Chen was intended to study child survival in modern Third World countries, is has also been employed in several historical studies. In 1997, Jan Kok, Frans van Poppel, and Ellen Kruse introduced the Mosley-Chen analytical framework in order to study the risks of mortality of illegitimately born children in the Dutch city of The Hague in the mid-nineteenth century (Corsini and Viazzo 1997, 193-211). Making use of the same data sources as the present study, the Dutch vital registration system, they studied to what extent illegitimately born children were exposed to higher death risks than children born in wedlock, and to ascertain to which factors this excess mortality might be attributed (Corsini and Viazzo 1997, 195). According to Kok *et al.* "the problem is that even the sources that we used provide very little information on these intervening variables, apart from the age of the mother. What we can do is to indicate that the (unobserved) intermediate variables are clustered in certain groups, defined for example by the socioeconomic group to which the child belonged, the urban back-ground of the mother, the household situation and, last but not least, the legal status of the child. This social clustering of the intervening biomedical variables may provide important clues as to their nature" (1997, 195).

Although breastfeeding is the healthiest kind of infant diet (because of transferable immunity, composition of the food, hygiene, no contact with poor quality drinking water et cetera), not all infants were breastfed – in the present as well as the past. Regarding the relationship between breastfeeding practices and SES, the overall view is that women of lower socioeconomic status are less likely to breastfeed although this may not always be that straightforward, particularly among historical populations.

The main reasons for the association between breastfeeding and SES are embedded in factors like education and household income. It is expected that the higher educated differ from the lower educated in terms of (health) knowledge, attitudes, experiences, and beliefs. This may lead to specific choices of infant feeding and care. Women from higher household income groups may be more likely to breastfeed because of peer group contact or frequent contact with professionals (and their knowledge/ideas). Also, they may have more time to breastfeed whereas women from lower classes often are employed, particularly so in hazardous and more strenuous occupations. Employment also means that women spend more time away from their infants. On the other hand, upper class women have the means to buy artificial food or hire a wet-nurse whereas poorer women are 'forced' to breastfeed. In some communities, the fact that one can

afford supplementary food is related to status. Finally, also breastfeeding policies and campaigns might only affect specific groups of women.

Data and method

Data
We analyze a dataset of infants born in the Dutch municipality of Roosendaal, born between 1863 and 1938. The town of Roosendaal lies in the south of the Netherlands between the cities of Rotterdam and Antwerp. The dataset is based on a linkage of several datasets including vital registration records of births, deaths, causes of death, and marriages. For those persons who died in Roosendaal between 1863 and 1938, a death certificate was made out. Additionally, for every deceased person the cause of death was recorded including some personal information. The local authorities kept these records in order to keep an eye on infectious and epidemic diseases within municipal borders. In this study the cause of death data at the individual level are linked to the birth records. The dataset includes the Christian names of the deceased person and his or her parents, date and place of birth and death (and age), the occupational titles of both parents, the age of the father and the cause of death.

Operationalization of variables
In our study the following variables were examined:
Mortality: a dichotomous alive/dead outcome, survival up to age 2.
Cause of death: Cause of death information has been regrouped in the following way. We took the approach in which we distinguished infectious diseases from other, more vaguely described causes of death, and in which infectious diseases were further differentiated according to the means of transmission. Diseases transmitted mainly by air and direct human contact, summarized as airborne diseases, include whooping cough, measles, smallpox, scarlet fever, respiratory tuberculosis, disseminated tuberculosis, acute respiratory tuberculosis, acute respiratory diseases (influenza/acute bronchitis, pneumonia, diseases of pleural cavity), diphtheria/croup, scarlet fever, rheumatic fever and acute nephritis. A second group of infectious diseases includes causes of death indicating water- and foodborne infectious diseases or signs of poor hygienic conditions: this includes Asiatic cholera and cholera nostras, typhus/typhoid fever, acute digestive diseases (diarrhea/dysentery, appendicitis, and peritonitis), and abdominal tuberculosis. The common denominator is the assumption that deficient hygiene and/or (the lack of) breastfeeding were a contributing factor. Other infectious diseases with mixed etiology included brain diseases (syphilis, convulsions, puerperal fever, and malaria: intermittent fever, pernicious fever). All external causes of death are taken together in one category. Finally, congenital anomalies and debility were distinguished from all other causes with no obvious symptoms of infectious diseases and from unspecified, ill-defined or unknown causes of death. Besides these 8 categories we also regrouped all causes into a variable indicating death because of lack of breastfeeding:

1 Diseases in any way related to breastfeeding practices (i.e. acute digestive disorders/diarrhea)
2 Diseases that may be related to breastfeeding practices (i.e. convulsions)
3 Diseases not related to breastfeeding practices (remaining causes)

Socioeconomic status: in order to study socioeconomic status (SES) of the family in which the child was born we used evidence from the birth certificates on the occupational title of the father. These occupations were classified according to the Historical International Social Class Scheme (HISCLASS) (Van Leeuwen, Maas and Miles 2002) and were regrouped into 6 social classes and a residual group of cases in which the father was unknown (illegitimate births). Social class 1 includes those occupations of higher managers and professionals and social class 2 those of lower managers and professionals, clerical and sales personnel. Skilled workers were classified in social class 3 and the lower-skilled in social class 5. Social class 4 was mainly for farmers and fishermen. In social class 6 all unskilled occupations were included. This considerable group included

day-labourers employed in both agriculture (field workers) and industry (factory workers). Of the 7 classes we used the one with unskilled occupations as reference group.
Paternal, maternal and related factors: the age of the father at birth, the sex of the child, the birth order of the child (parity).
Legal status child: whether a child is born either within or out of wedlock.
Season of birth

Analytical strategy
The analysis uses Cox proportional hazard regressions to examine socioeconomic differences in infant mortality. We control for a number of child- and parent-specific factors that are known to affect mortality, including sex of the child, parity and father's age. Parity controls for the number of older siblings in the household who can either function as alternative caregivers or as potential competitors in the allocation of food and (health) care.

In order to study breastfeeding practices, which cannot be directly observed in historical datasets, as a mechanism in causing socioeconomic differences in infant mortality, we employ the following strategy. We start with a baseline model of infant mortality by socioeconomic status and controls. Then, we first examine changes in historical time. We include historical time as a co-variate and include interactions with socioeconomic position. Government campaigns to promote breastfeeding are more likely to have been picked up by the higher social classes first. Furthermore, over time there have been large changes in female labor participation but differently so for different social classes and female labor participation is correlated with breastfeeding. Second, we will examine variations in mortality over the year. In the summer there is a higher risk of infectious diseases for children who are not breastfed. Third, we reexamine these analyses using a survival analysis model with competing risks. We are mainly interested in a subset of causes of death (related to breastfeeding) while the other causes are in a way 'disturbing' events, which we would actually like to ignore in interpreting the results. For example, when an infant dies due to external causes (like drowning) he or she can no longer die of breastfeeding related diseases (such as diarrhea).

Preliminary results
For now, we only present very basic models that show a high degree of difference in mortality by socioeconomic group. Whereas both multiple births and illegitimately born children show a considerable higher hazard of infant mortality, all socioeconomic groups present a *lower* hazard of mortality than the group of unskilled laborers. Farmers have a 22 per cent lower hazard and the lower professionals and clerical staff a 16 per cent lower hazard of infant mortality than lower class families.

Table 1. Hazard Ratio's.

Variable	base	hisclass
birth year	1.02***	1.02***
male	1.23***	1.23***
twin	3.33***	3.38***
parity mother	1.01	1.01
age father	1.01***	1.01***
hprof_hpa		0.78*
lprof_hpa		0.84***
skill_hpa		0.98
farm_hpa		0.78***
nlaw_hpa		2.73***
N	25636	25636
number of deaths	6176	6176
days at risk	15,307,999	15,307,999

LL	-61014.317	-60912.775

* p<.05; ** p<.01; *** p<.001

Future work

Future analyses will further elaborate the current analyses and examine competing risks models. Moreover, we will fit shared frailty models as the infants are clustered 'in' mothers and are not independent observations. Such work may further shed light on the issues studied as infant mortality is also quite likely to be clustered within a specific subset of mothers.

In addition, we will examine parametric survival models next to the current non-parametric approach, as the shape of the hazard may also relate to breastfeeding practices.