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Differential infant and child mortality in three Dutch regions, 1812–1909[1]

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I

Since the 1980s, socio-economic inequality in mortality has become a continuous topic of academic interest, and a key issue of attention to policymakers in many European countries. The Netherlands is no exception to that rule. A bibliometric analysis showed that in The Netherlands, an explosive growth of the number of publications on the topic took place after 1980; until that year, the number of publications had fluctuated at a rather low level.[2] Interest in the issue arose in the middle of the nineteenth century, when the sanitary reformers started to point to the fact that differences in death rates between poor and rich people were very high. In their opinion, good health was not a privilege of the higher social classes, but rather something that could be claimed by everybody.[3] In particular, socio-economic inequality in the mortality of children attracted attention. This was not only because in this age group, death risks were extremely high; mortality differences between children were also regarded as less acceptable because children had no choice in their living conditions.

Epidemiologists have recently become interested in the history of socio-economic inequalities in infant and child mortality, as trends over time developed into an important contemporary political issue: a possible persistence of mortality differences indicates that efforts to improve the health of the lowest socio-economic groups have not been fully effective.[4] Without a long-run perspective, it is not clear whether the disparities observed over,

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[2] Mackenbach, Stronks, and van Trirum, 'Sociaal-economische gezondheidsverschillen'.

[3] Houwaart, *De hygiënisten*, pp. 248–250; Van Dijk, Dol, Groothoff, and van Rossum, 'Interest in the issue'; Mackenbach, Stronks, and van Trirum, 'Sociaal-economische gezondheidsverschillen'.

[4] Pamuk 'Social-class inequality'; for a recent Dutch example see *Sociaal-economische gezondheidsverschillen*.

for example, the last four decades, are large or small by historical standards. As Ferrie has noted, these disparities might be the continuation of poor outcomes for poor people, but they might also be a product of advancements in medicine and technology in the late twentieth century that have given a new advantage to those with the incomes to purchase them. Knowing how health outcomes differed by economic status in an earlier era, when medical knowledge was rudimentary, can help distinguish between these explanations.[5]

Historians have taken up the issue of socio-economic differences in infant and child mortality to judge more precisely how processes such as urbanization, industrialization, and medicalization have affected the health of social classes in varying degrees. Edvinsson has argued that information on (changes in) social differences in mortality might shed light on the factors behind the mortality decline: if it were the economically more advanced groups that experienced the mortality decline earlier on or faster than impoverished groups in society, economic explanations of the decline in mortality would gain support.[6]

The re-emergence of the importance of geography is central to the ongoing historical debate about socio-economic differences in infant and child mortality. During the last two decades, many authors have pointed to the fact that social class differences might reflect significantly the influence of spatial factors such as the quality of sewerage, water supply, or air.[7] Differences emerge because the higher social classes tended to live in the better environments, and the lower classes in the poorer environments. As a consequence of data limitations, the possibilities for disentangling the influences of locality and social class are very restricted. This is even more the case when the objective is to study socio-economic effects over time, as data are mostly only available from the last quarter of the nineteenth century onwards.

A further complication is the fact that the effect of socio-economic factors and environmental factors might differ considerably over age groups.[8] The impact of socio-economic factors on mortality at different ages varies, however, for modern and historical data. Changes in the cause-of-death panorama, as well as selection effects, might play a role in this. Studies that examine the way in which the relationship between socio-economic factors, locality, and mortality changes with age among children are very limited.

In this article, we try to add to our knowledge of the long-term trends in social inequality in infant and childhood mortality. By studying data for The Netherlands from 1812 to 1912, we are able to study a much longer time

[5] Ferrie, 'The rich and the dead'.

[6] Edvinsson, 'Social differences'.

[7] Woods, *Demography of Victorian England*, pp. 203–4; Reid, 'Locality or class', 132–3; Garret et al., *Changing family size*, 139–72; Spree, *Soziale Ungleichheit*, pp. 89–90; Smith 'Mortality differentials'.

[8] Garrett et al., *Changing family size*, 196; Ferrie, 'The rich and the dead'; Currie and Stabile, *Socioeconomic status and health*.

period than is usually possible, and to focus on an era in which the mortality transition took place. By studying three provinces, each with its particular ecological and economic structure, we are able to distinguish the effects of the environment, and those of the social class to which children belonged. Lastly, by analysing infant and early childhood mortality (for ages one to five) separately, we are able to find out whether the relationship between mortality, locality, social class, and age has changed over time.

II

Most studies of trends in socio-economic differences in infant mortality only focus on a very restricted time period, and most are based on secondary analysis of a few studies from different environments.[9] Comparisons over time are very difficult to make because of changes in successive occupational classifications upon which social groups are based. The change in the disease panorama, from one in which poor environmental conditions were the main factor behind the major infant killers to one in which congenital diseases were the main cause of infant death, adds to the problems.[10]

Antonovsky and Bernstein's 1977 study is one of the first in which long-term trends in socio-economic differences in infant mortality were analysed. The authors argued that between 1910 and 1960, the gap in infant mortality (IMR: deaths under one year of age per 1,000 live births) between the highest and lowest social classes in the Western world had been closing. The closing of this gap was primarily a product of the decline in post-neonatal deaths (second to twelfth months), the category which was and is characterized by the largest mortality differences between social classes. When post-neonatal and neonatal mortality were viewed separately, the long-term pattern of differences by social class was characterized by a persisting inverse relationship between social class and mortality.[11] One of the hypotheses suggested to explain the persistence of the difference was the time-lag argument, which posits that as new medical knowledge, techniques, and services become available, their benefits are likely to be felt first by the upper classes, and only after time to filter downwards. Whether this delay is a result of the lower level of education of the poor, their resistance to new ideas, their inability to finance such services, or the failure of the health establishment to provide them, is unclear. A competing explanation stresses the role of social mobility, and suggests that women with good childhood health, education, and other assets tend to be upwardly mobile, while those lacking these assets will be downwardly mobile. This selective reshuffle creates a permanent tendency for class rates to diverge.

Antonovsky's study was based on a mix of data for whole countries, and separate cities in Sweden, Austria, the USA, and Great Britain, for a variety

[9] Edvinsson, 'Social differences'; Woods, Williams, and Galley, 'Infant mortality in England'.
[10] Williams, 'Death in its season'.
[11] Antonovsky and Bernstein, 'Social class and infant mortality'.

of years, and related to a period in which the mortality decline was well under way. Rainer Spree focused on an earlier stage of the health transition, and shifted the attention away from England.[12] Spree studied trends in social class differences in infant mortality in Prussia from the last quarter of the nineteenth century to the first decade of the twentieth. Social inequality before death was almost non-existent between 1875 and 1886. Between 1886 and 1903, inequality between socio-economic groups increased. A decrease in infant mortality took place within the professional class and the middle class, whereas the working class underwent a slight deterioration of their situation. From 1902 onwards, infant mortality rates decreased in all social groups, but the pace of the decline differed. The rationalization of private life—in the form of birth control, the increase of real incomes, and a more purposeful use of available material resources and time—was the determining factor for the increase in the life chances of children, and it was in the 'new middle class' that this process first took place. This rationalization process took place earlier among groups that were integrated in the urban-industrial world: the industrial and tertiary-sector working class was better off than the agrarian sector.

Spree stressed the fact that the level of socio-economic inequality depended on the specific socio-historical context in which individuals lived. During the industrialization period, the old rural hygiene and sanitary customs were no longer adequate. The failure to remove waste and sewage, and to maintain a pure water supply, provided a breeding ground for bacteria. This combined with the high population density and typical overcrowded housing to create conditions that fostered the spread of contagious diseases. Migration to the city, and city life itself, meant both the breakdown or weakening of extended family ties and the dissolution of the mutual help arrangements that were so essential in caring for infants and nursing the sick. The governmental assumption of responsibility for society-wide implementation of sanitation reforms and hygiene programmes did redress this situation. These reforms equalized the conditions of the social strata, and caused an absolute and relative improvement in the position of low-status segments.

The interplay between social class and the socio-historical environment has also been a key issue in several studies published in the last decade on the socio-economic differences in mortality in England and Wales in the period 1890–1910. These studies were mostly based on outcomes of the 1911 census. Indirect mortality techniques were applied to these data, and the authors make it clear that this made it difficult to examine trends in infant mortality by subgroups.[13] What the results of these studies did show was that both environment—classified on the basis of the industrial structure of the area—and social class had marked effects on the prospects for

[12] Spree, *Soziale Ungleichheit*, pp. 89–90.
[13] Garrett et al., *Changing family size*, 196.

infant survival. When both social class and environment were included in a regression analysis, the effect of environment remained largely unchanged, whereas that of social class was substantially lessened by the inclusion of environment. The favourable position of the higher social classes and agricultural labourers was to a large extent produced by the spatial segregation of social classes: the higher social classes tended to live in the better environments, and the lower classes in the poorer environments.[14] These studies confirmed an earlier study by Woods and colleagues that showed that the aggravation of class differentials in infant mortality during the period 1895–1910 in England and Wales was strongly dependent on the environment.[15] Within urban areas, class differentials were greatly accentuated in neighbourhoods with poor environmental conditions. The professional class showed the largest reduction of infant mortality, because the infants were concentrated in urban areas, and thus benefited disproportionately from the improvement in urban conditions.[16]

The above-mentioned studies relate mostly only to the period of declining infant mortality—from the late nineteenth century onwards—and refer to relatively short periods. Data on socio-economic mortality differentials before the health transition are rarely included. In hypotheses about trends in social inequality, this is nonetheless a crucial element. According to Smith, the first phases of the health transition were associated with a widening of socio-economic differentials in infant mortality precisely as a consequence of the absence or modest size of such differentials *before* the transition.[17] In a mortality regime dominated by variations in the incidence of infectious diseases, it was location in a spatially structured disease environment—presence of effective sewerage and treated water—that mattered most for mortality variation, not the advantages or disadvantages dependent upon the status of individuals. As elites intermingled freely with lower-strata members, especially servants, and could not stay isolated from them, mortality risks did not differ much between the social classes. From the late nineteenth century onwards, more affluent groups distanced themselves from higher mortality groups and areas—the use of servants declined, and residential segregation increased—resulting in an increase in mortality differentials between groups.

Earlier Dutch studies contain data on socio-economic differences in infant mortality for the period before, during, and after the health transition. They were, however, only based on data for Amsterdam and/or made use of a variety of socio-economic criteria and mortality measures, making results hardly comparable over time.[18] For Sweden, Edvinsson recently

[14] See e.g. Reid, 'Locality or class', 137–8; Garrett et al., *Changing family size*, 149–54. For an identical conclusion based on a local study see, Williams, 'Death in its season'.

[15] Woods, Williams and Galley, 'Infant mortality in England'.

[16] Woods and Williams, 'Must the gap widen'.

[17] Smith, 'Mortality differentials'; *idem*, 'Differential mortality'.

[18] van Poppel, 'The relationship'; van de Mheen, Reijneveld, and Mackenbach, 'Socioeconomic inequalities'.

compared infant and childhood mortality in two regions in the north of Sweden. The parishes in the regions were categorized into four groups: urban, industrial, rural, and foundries. Two periods were distinguished, before and after 1860. In the Sundsvall region, differences between social groups were small in the pre-industrial period, but after the start of industrialization, in 1860, a more distinct social pattern could be distinguished, in which the wealthiest group had the lowest infant mortality. For childhood mortality, no clear pattern could be found in the first period, but a social gradient became more apparent again after 1860, with the highest social strata having the highest survival chances for their children. Children aged from one to four were more sensitive to social conditions than infants. In the more agrarian low-mortality Skellefteå region, no clear-cut pattern could be found in the survival of children from different social classes. The conclusion was therefore that the pattern of social inequality differed depending on period and environment, and that childhood mortality was more sensitive to the social conditions than infant mortality.[19] This conclusion is in line with that of Garrett et al. In favourable environments, they also observed very little difference between the child mortality experiences of different classes.[20]

The findings presented above make it clear that it is difficult to generalize from the restricted number of studies on trends in socio-economic mortality differences: considering more than one community or type of community in different environments is a necessity before firm conclusions can be reached. In this article, we try to add to our knowledge of the long-term trends in social inequality in infant and childhood mortality by studying data for The Netherlands from 1812 to 1912. Our study has several distinctive traits, which allow us to partly overcome the drawbacks of earlier studies. First of all, we go back to the original data sources, making it possible to gather comparative information at the micro-level on the socio-economic characteristics of the deceased, and to apply an identical occupational class scheme. Second, we are able to study a long time period, during which The Netherlands underwent radical changes in its economic, social, and family structure—income growth, industrialization, and urbanization. Third, we study a large part of an entire country, not a single community: three of the eleven Dutch provinces, each with its particular ecological, social, and economic structure, covering large cities, smaller cities, and rural areas.

Although our study has mainly an exploratory character, we pay particular attention to the effects of time, environment, and age on social class differences in mortality.

Our first hypothesis is that the relationship between social class and mortality strongly depends on the age of the persons concerned: infants are

[19] Edvinsson, 'Social differences'.
[20] Garrett et al., *Changing family size*, p. 155.

less sensitive to social conditions than children aged one or older, because differences in breast-feeding and weaning practices, which are more or less independent of socio-economic conditions, are more important for survival in the first age group than strict economic factors such as access to better quality food, housing conditions, living in residential areas with better sanitary facilities, better access to medical support, and greater knowledge on means to control personal illnesses. A number of studies have shown that infant feeding practices were sufficiently important to have given even the most economically disadvantaged groups relatively favourable levels of infant mortality.[21] Mixed-fed and weaned infants living in poor sanitary conditions faced more exposure to food-borne pathogens than similarly fed infants in less-contaminated environments. Thus, exclusive breast-feeding could provide greater protection to infants living in highly contaminated environments.[22] We test this hypothesis by comparing infant and early-childhood mortality levels for various social classes.

The second hypothesis is that the level of social inequality in a specific environment depends on the presence of specific risk factors that might affect all social classes at the same time. This hypothesis will be tested by comparing differences in mortality between social classes separately for different regions, as well as for urban–rural regions. In particular we expect that in two of the provinces that we study, Zeeland and much of Utrecht, social class differences will be less pronounced than in large parts of Friesland. The reason is that the sanitary situation in the first two provinces was generally worse than in Friesland, because of the gradual salinization, and the high water table. This rendered the restricted volume of sweet-running and well water undrinkable, and provided an ideal environment for the larvae of the malaria-carrying mosquito, thereby making malaria virtually endemic in this part of The Netherlands until about 1870. The salinization and the high level of environmental contamination of the water enormously increased the risk of diarrhoea, the most important cause of death among infants. High and low social classes had to live with the consequences of this situation. The absence of strict residential segregation between social classes also has to be considered as part of this equalizing effect.

A second characteristic of the environment that might affect the level of social differences in mortality is the urban or rural character of the region. There are reasons to expect that the health situation of the lower social classes differred less from that of higher classes in rural areas than in urban areas. Factors suggesting more equity between social classes in rural areas include the higher level of self-sufficiency in rural areas, with a large part of the population having a section of land at its disposal on which they could grow their own produce, and better access to a familial network, offering material support, information on vital matters, and social contacts of an

[21] Woods, Williams, and Galley, 'Infant mortality in England'.
[22] VanDerslice, Popkin, and Briscoe, 'Drinking-water quality'.

emotional nature. In the cities, the low degree of residential segregation between the social classes hints at more equality. In densely populated areas, where communications with other places were intense, air-borne contagious diseases could spread rapidly, because there were many ways of becoming contaminated, and only a few ways to isolate infected individuals. Escaping the problems of sanitation that followed concentrations of populations was also more difficult for members of higher social classes in urban areas than it was in rural regions. To study whether or not the adverse effects of living in urban areas held only for low-class inhabitants and not for their better-off neighbours, we compared IMR and ECMR by socio-economic status for urban and rural areas.

Our third hypothesis deals with the development of social differences over time. Following Edvinsson, Spree, and Smith we expect to find that differences between social classes increased over time. Although the secular economic development in The Netherlands showed continuous improvement from 1864,[23] and public health policy aimed at improving public health and reducing health differences started after 1875, partly stimulated by these same economic factors,[24] we expect to find that clear decreases in the degree of social inequality in infant mortality did not take place in the last quarter of the nineteenth century. From about the 1870s onwards, water technology was much improved, and there was a gradual improvement of the health situation in Zeeland and Utrecht.[25] The more wealthy groups could take advantage of the new possibilities created by medical knowledge and improved sanitary standards at an earlier stage. Increased social segregation added to the health variation between social classes.

After discussing the data, we first analyse the global development of infant and childhood mortality in the selected regions. In the second stage, we focus on the effects of socio-economic position by analysing some descriptive measures. Lastly, we test the hypotheses by doing a multivariate analysis of the data.

III

The data that are used in this analysis come from the so-called 'Historical Sample of the Population of the Netherlands' (HSN). The aim of this project is to build a national database with information on the complete life history of a 0.5 percent random sample (76,700 birth records) of men and women born in The Netherlands between 1812 (the introduction of the vital registration system) and 1922. In all Dutch provinces, a random sample of births was drawn, which was stratified by period of birth (11 periods) and level of urbanization of the municipality.[26] In this article,

[23] Vermaas, 'Wages, salaries and income'.
[24] Mackenbach, *De veren van Icarus*.
[25] Wolleswinkel-van den Bosch, van Poppel, and Mackenbach, 'Reclassifying causes of death'.
[26] Mandemakers, 'The Netherlands'.

information is used on those three of the eleven Dutch provinces for which the collection of information on life histories has progressed most: Utrecht, Zeeland, and Friesland.

Utrecht, located in the centre of the country, had as its most important towns Amersfoort and the capital city of Utrecht. The latter city was an industrial centre, as well as an important garrison-town, and a centre of trade and services. In the rest of the province, agricultural employment dominated. Much of Zeeland, a province situated at the south-western part of the coastal zone, was below sea level, and protected by a system of river- and sea-dykes. The towns of Middelburg and Vlissingen, with around 15,000 inhabitants each in the 1850s, were the respective administrative and industrial centres of the province.[27] In 1859, 60 per cent of the population was working in agriculture. In the second half of the nineteenth century, agricultural modernization eroded the position of the small farmer and farm labourer, leading to very high out-migration. Friesland, in the north-eastern part of the country, also was a mainly rural province, the only larger town being Leeuwarden. The relatively prosperous agricultural economy was strongly commercialized. Industrial breakthrough began in the early 1880s. Like Zeeland, it was heavily affected by the agrarian depression, leading to very high emigration in the period 1881–1915.[28]

The three provinces act as a perfect illustration of the sharp divide between the high mortality levels of the coastal and low-lying riverine municipalities, and the low levels of the area in the north, characterizing The Netherlands until late in the nineteenth century. In large parts of the western Netherlands, including the provinces of Zeeland and Utrecht, one in four infants were likely to die within their first year. The infant mortality rates were very low in Friesland, where less than 100 children per 1,000 live births died before reaching the age of one. It was only in the last decades of the nineteenth century that the provinces of Zeeland and Utrecht reached lower IMR, whereas Friesland kept its favourable position.[29]

The high mortality in the west during the nineteenth century was largely a result of the specific ecological conditions of this region: the contamination of the surface water because of insufficient environmental sanitation, particularly in urban and densely-populated rural areas; the salinization of the surface and ground water wherever seawater could penetrate inland; the resulting lack of water acceptable for household purposes; and the high frequency of malaria. The high population density in the western part of the country also contributed to the high mortality level. In 1860, the rural areas of the two Western provinces still had higher population densities than most provinces in the north, south, and east.

[27] Wintle, 'Aspects of religion'; Priester, *Geschiedenis van de Zeeuwse landbouw*.
[28] Frieswijk, *Geschiedenis van Friesland*; Galema, *Frisians to America*.
[29] van Poppel and Beekink, 'De biometer'.

IV

In order to estimate infant mortality (before the age of one) and child mortality (between the ages of one and five years) data are needed on the dates of death of children who died in these age intervals, and on the numbers of infants and children who survived the age intervals 0–1 and 1–5 years. For all births in the sample, the death certificates of the municipality of birth were checked for 10–20 years following the year of birth. For the provinces of Utrecht, Zeeland, and Friesland, an electronic database (under construction), with information on death records for all municipalities relating to the respective periods 1812–1940 and 1812–1922, was also available. For the provinces of Utrecht and Zeeland, and to a much lesser extent Friesland, municipal population registers, which combine census listings with vital registration in an already-linked format from 1850 until 1939, were also used. In the 1930s, the population register was replaced by the personal record card, with each individual person registered. At the moment of death, this card is removed from the municipal files and ultimately sent to the Central Genealogical Bureau. Cards of all people who died between 1 January 1940 and 30 September 1994 are available for research. For individuals who died after that date, extracts from the so-called Municipal Basic Administration can be collected, containing the same information. Dates of death could only be found for a part of the sample of births, because of migration. However, for many individuals, a date of marriage could be found in the marriage registers of the community in which the person was born or in another municipality, making it possible to conclude that the person was alive at least up to the date of marriage. Marriage registers were consulted in all three provinces.

Table 1 shows the number of births in the sample, the numbers of deaths in age groups 0–1 and 1–5, and the numbers of births for which information about survival status after the age ranges 0–1 and 1–5 is available (from a population register, a marriage certificate, or a death certificate).

Over all provinces and over the whole period taken together, the survival status for the age interval 0–1 years could be reconstructed for 83 per cent of all births. By subtracting the number of deaths in age group 0–1 from the numbers of births, a maximum estimate of the number of children surviving until the age of one is obtained. The number of children for whom the survival status for the age interval 1–5 years could be reconstructed—through death after age one or through other information on survival status after age five—is 79 per cent of this maximum. These percentages vary considerably by period of birth and province. The low percentages in the oldest cohorts are because population registers are not available as a source of information before 1850. For the most recent cohorts, the percentage with unknown survival status is high (mainly because a considerable proportion of the people born in these cohorts are still alive): it was therefore decided to exclude children born in the period 1910–1922 from the analysis. This increased the percentages of children for whom information on

survival status was available to 86 per cent (age interval 0–1) and 82 per cent (interval 1–5). The differences between provinces reflect the fact that the HSN started in Zeeland and Utrecht, as a result of which the searching procedure has been going on there for a longer period. Some of the differences relate to varying rates of emigration from the provinces, but only a

Table 1. *Number of individuals in sample, and percentages with known survival status in age intervals 0–1 and 1–5 years, by period of birth and province*

Zeeland

Period of birth	*Number of births*	*Number of deaths in age group 0–1*	*% of all births for which survival status is known for interval 0–1 years*	*Number of deaths in age group 1–5*	*% of all children known to have survived age 1 of which survival status is known for interval 1–5*
1811–19	320	75	72.5	20	64.1
1820–29	390	98	80.5	41	74.0
1830–39	478	125	80.1	43	73.1
1840–49	427	110	79.2	52	71.9
1850–59	476	143	80.5	53	70.6
1860–69	518	128	88.4	48	82.3
1870–79	418	92	90.9	29	85.9
1880–89	323	53	93.2	21	89.6
1890–99	359	58	94.7	19	93.4
1900–09	349	54	91.7	13	87.1
1910–22	385	28	74.2	9	68.9
Total	4443	964	83.9	348	78.2

Utrecht

Period of birth	*Number of births*	*Number of deaths in age group 0–1*	*% of all births for which survival status is known for interval 0–1 years*	*Number of deaths in age group 1–5*	*% of all children known to have survived age 1 of which survival status is known for interval 1–5*
1811–19	160	27	78.1	15	73.7
1820–29	228	35	86.4	20	82.4
1830–39	266	45	86.1	29	83.3
1840–49	244	54	94.7	28	92.1
1850–59	286	71	96.9	34	94.4
1860–69	291	73	97.6	39	95.9
1870–79	372	96	97.0	26	95.7
1880–89	383	88	97.7	30	96.3
1890–99	420	76	98.1	35	96.8
1900–09	450	60	90.2	22	88.5
1910–22	569	16	49.2	5	47.0
Total	3669	641	86.6	283	83.0

Table 1. *Continued*

Friesland					
Period of birth	*Number of births*	*Number of deaths in age group 0–1*	*% of all births for which survival status is known for interval 0–1 years*	*Number of deaths in age group 1–5*	*% of all children known to have survived age 1 of which survival status is known for interval 1–5*
1811–19	356	32	78.9	21	76.9
1820–29	497	49	83.1	36	81.3
1830–39	579	58	81.0	45	78.9
1840–49	600	60	82.2	34	80.2
1850–59	625	81	78.7	53	75.6
1860–69	716	103	81.8	54	78.8
1870–79	620	91	81.8	37	78.6
1880–89	504	50	85.9	47	84.4
1890–99	494	55	84.8	24	82.9
1900–09	308	27	79.5	13	77.6
1910–22	306	16	53.3	6	50.7
Total	5,605	622	80.3	369	77.8

proportion of the individuals whose deaths were not recorded had migrated to another region.[30]

Because the availability of information on survival varies according to period of birth, social class, and region, social-class variations in mortality over time and region partly depend on the way in which missing observations—children for whom no date of death, or date of last observation since birth is available—are handled. The estimation of mortality rates in cases where the date of out-migration or the date of marriage of an individual are not recorded is a problem, for which no standard statistical solutions are available. Several methods have been proposed, among others by Blum, Ruggles, and Wrigley et al. Their methods do not really apply to the present situation, because they were restricted to the estimation of adult mortality, using information only on the married population.[31] Jonker estimated a mortality curve from which infant and childhood mortality could easily be deduced, assuming that infants and young children did not out-migrate,[32] but this method is not very useful for the data available here. Statistical methods that yield unbiased estimates for infant and child mortality, when survival status information for some births is incomplete, do not exist.

In the absence of any workable technique to deal with missing data, mortality risks are calculated under the assumption that children for whom no marriage or death certificate has been found, and for whom information

[30] Galema, *Frisians to America*.
[31] Blum, 'An estimate'; Ruggles, 'Migration'; Wrigley et al., *English population history*.
[32] Jonker, 'Maximum likelihood estimation'.

from population registers is not available, survived age intervals 0–1 and 1–5. This implies that estimated infant and childhood mortality rates will be biased downwards. The proportion of infants who died in their first year (in a certain region in a certain time period) is estimated by the ratio

$$\frac{\text{Number of infants who died before age 1}}{\text{Number of live-born infants}} \quad (1)$$

and the proportion of children who died between their first and fifth year by

$$\frac{\text{Number of children who died in age interval 1–5}}{\text{Number of infants who survived their first year}} \quad (2)$$

If there are no missing data (if a date of marriage or death is available for all individuals in the data set), the estimator in (1) is an unbiased estimator for the proportion of infants who die in their first year of life. In case of missing data, the numerator of the estimator in (1) can not be determined exactly. Suppose an infant migrated to another community before the age of one and died after emigration, but before reaching the age of one. If the death certificate for this infant is not found, this death does not contribute to the numerator, although it should. If one assumes that infants who migrated before the age of one survived to the age of one, the numerator is estimated systematically too low, and the estimator for infant mortality will be biased downwards. In order to get an impression of the size of the bias, one might consider the following situation. Suppose that 20 per cent of the births in a cohort were not observed further after their birth. Most of these individuals will have migrated, as registration of subsequent death for live births in the nineteenth century in The Netherlands is considered reliable and complete.[33] As migration at very young ages was relatively rare, it would be a more reasonable estimate that only 1 per cent of migrants migrated before the age of one; the remaining 19 percent of migrants migrated after the age of one.[34] If infant mortality is in the order of 150 per 1,000 (among migrants and non-migrants), and it is assumed that individuals who out-migrated before the age of one are still alive at the end of the first year of life, the infant mortality rate would be in the order of 148.5 per 1,000 instead of 150, and the bias would be very small.[35] Note that migrants who migrated after the age of one *do* contribute to the denominator in (1), but

[33] Deaths reported were fairly complete because no burial was allowed without written permission (See Heederik, *Van kasboekregister*, 171). A report by the Health Inspectorate stated that 'there is no doubt . . . that in the Netherlands all deaths are being brought to the attention of the authorities . . . almost certainly within the appropriate statutory period' (Menno Huizinga and Pijnappel, 'Rapport', p. 35).

[34] Age profiles of migration for the province of Utrecht for the period 1850–1962 make it clear that migration started to rise from age 12 onwards, and that before that age, migration rates were extremely low. See Kok, 'Youth labor migration', p. 513.

[35] A comparison of infant mortality rates based on all live births with rates based only on those births for which information on date of death or on survival after age one is available in general showed relatively small differences. Differences were higher in cohorts 1811–1919 (respectively 160 versus 210 per 1000) and 1910–1922 (48 versus 83 per 1000), higher in the province of Zeeland (231 versus 272 per 1,000) than in Utrecht (202 versus 216 per 1,000) or Friesland (114 versus 140) and higher in the

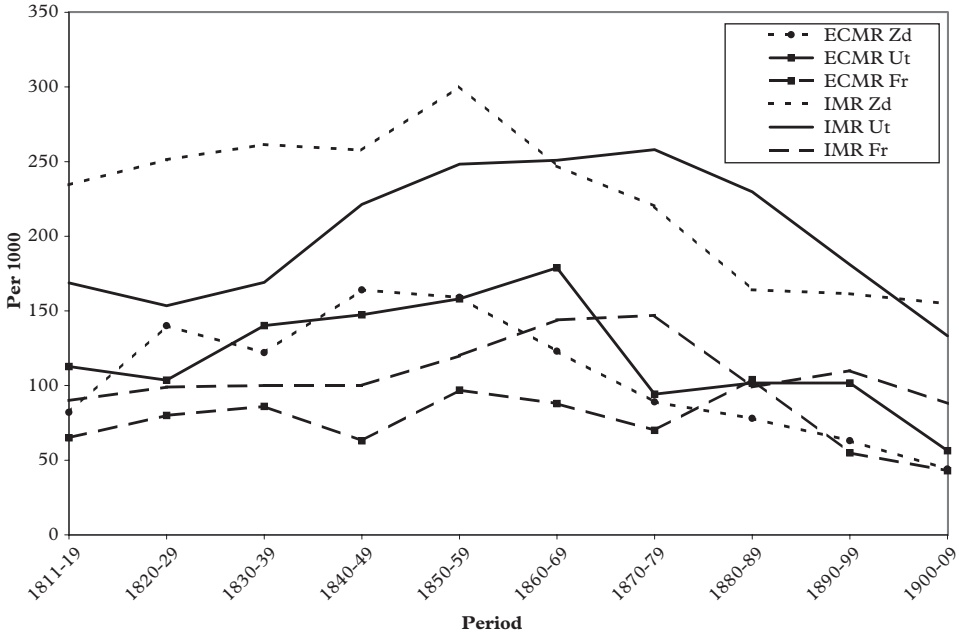

Figure 1. *Infant mortality (IMR) (per 1,000 live births) and early childhood mortality (ECMR) (per 1,000 children aged one) rates, by province and period of birth*

Notes: Zd = Zeeland; Ut = Utrecht; Fr = Friesland

not to the numerator, because they survived to the age of one. Support for the view that the estimation bias might be small is given by the fact that the estimates for infant mortality are in line with the published values of the IMR for the three provinces, based on vital registration data on all live births and children deceased before reaching the age of one.[36]

In a similar way, the bias of the estimates for child mortality can be calculated. The bias of the estimator for child mortality might be slightly higher because migration usually is more frequent between the ages of one and five than between birth and the age of one.

Since the percentage of births for which information on death, marriage, or migration is missing varied by region, cohort, and social class, the size of the bias might sometimes be higher, in other cases lower. Data shown in table 2 (see below) make it clear that the survival status after the age of one for the 1812–1909 cohorts is relatively less known for the upper class (in particular in Friesland and Zeeland) and the white-collar middle class. The

higher social classes (166 versus 233 in the upper class and 204 versus 252 in the white-collar middle class) than in the lower ones (151 versus 170 among farmers, 174 versus 200 among skilled manual workers, 149 versus 179 among the petty bourgeoisie, 190 versus 218 among casual and unskilled labourers).

[36] Vandenbroeke, van Poppel, and van der Woude, 'Le développement séculaire'.

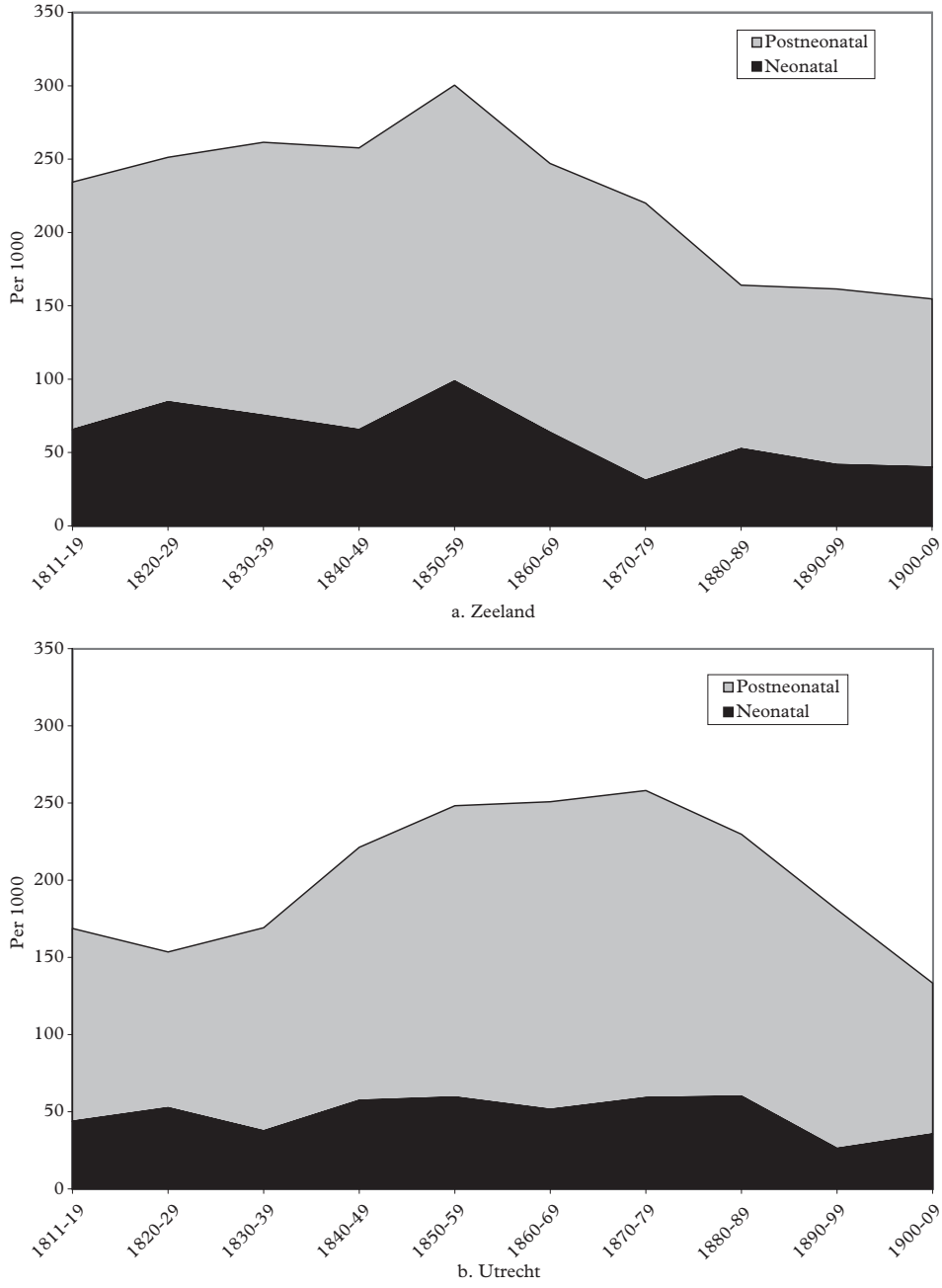

Figure 2. *Neonatal and post-neonatal mortality per 1,000 live births, per period of birth*

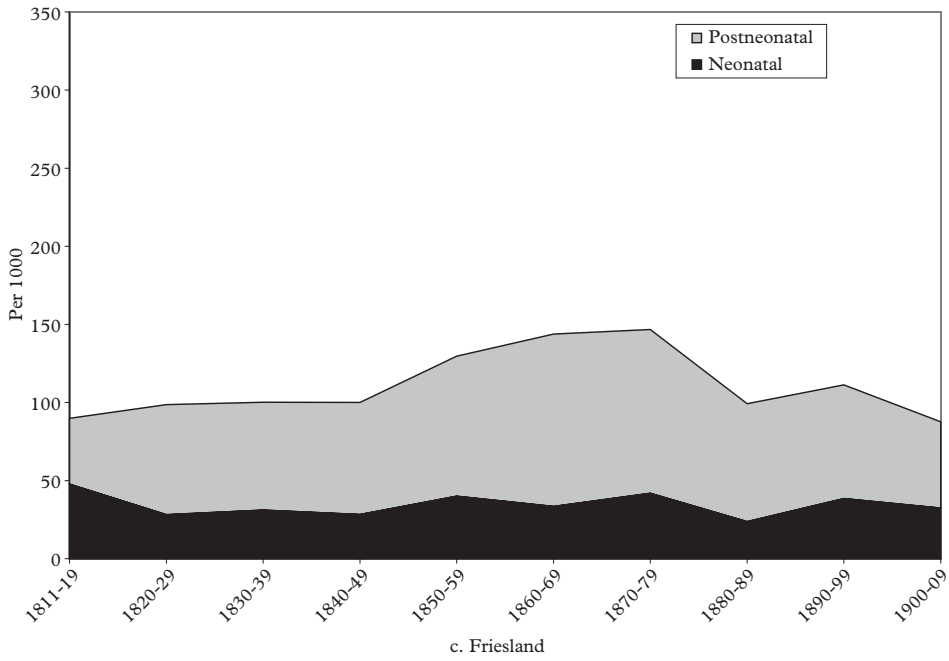

Figure 2. *Continued*

resulting bias would lead to an overstatement of mortality differences when the expected social gradient in mortality is applied to the Dutch situation.

For cohorts born between 1812 and 1909, figure 1 shows what proportion of live births died in the first year of life (IMR) and what proportion of those who survived until the age of one died between the ages of one and five (early childhood mortality, ECMR).

The variation in the level of IMR between the three provinces was enormous. Until 1860, twice as many children died during the first year of life in Zeeland as in Friesland. IMR was on the increase in all three provinces until the 1860s, but after 1860 there was a steep decrease in Zeeland, and a more gradual one after 1880 in Utrecht, and therefore the differences between the provinces were only small in more recent cohorts.[37] The risks of dying between the ages of one and five, per 1,000 children aged one, also changed significantly over time. Mortality rates in Zeeland and Utrecht increased gradually during the period 1812–70, leading to large differences between these two provinces and Friesland. In this age group, Zeeland and Utrecht had again made up their arrears with Friesland by the beginning of the twentieth century.

[37] This increase until the mid-nineteenth century is partly a result of an underestimation of IMR in the oldest cohorts, but mostly is a real phenomenon also observed in other countries of western and northern Europe. See Perrenoud, 'Child mortality in Francophone Europe'.

By analysing the development of neonatal (first month) and post-neonatal (months 1–12) mortality separately, it is possible to focus more specifically on those parts of infant mortality that are more sensitive to endogenous causes, and those that are more related to environmental factors. Viewing both factors separately will allow us to study later in this article whether the findings of Antonovsly and Bernstein regarding the closing of the gap in infant mortality between the highest and lowest social classes applies to the pre-1900 period as well.[38]

Figure 2 reveals that the temporal changes and provincial differences in IMR were mainly caused by the change in post-neonatal mortality. Neonatal mortality in Zeeland was only clearly higher than in the other provinces in the first half of the nineteenth century, and contributed significantly to the excess values of IMR.

V

To study whether differences indeed existed in infant and childhood mortality rates between social classes, information on the father's occupation at the moment of the child's birth was used. Although occupation is by far the best single indicator of the position of individuals in the social stratification system of industrializing societies, constructing meaningful occupational groupings for past populations from this information alone is a difficult task. Some of the occupational titles are local expressions that are difficult to interpret; the significance of any particular designation may have changed over time. Occupational titles may provide only partial information on the status of occupations; it is often not known whether the titles concern self-employed or employed individuals. For all these reasons, any classification based only on occupational designations as given in the birth certificates will necessarily be imprecise. Despite these difficulties, an attempt has been made to group occupations in order to enable an exploration of socio-economic differentials in mortality. The classification used here is a slightly adapted version of the one designed by Giele and van Oenen,[39] in which six main groups were distinguished: upper class (employers in industry, lawyers, medical doctors, high civil servants; army officers); petty bourgeoisie (shopkeepers, small entrepreneurs and merchants and self-employed artisans);[40] white-collar middle class (such as clerks, lower-level civil servants; foremen and supervisors, and non-

[38] Antonovsky and Bernstein, 'Social class and infant mortality'.

[39] Giele and van Oenen, 'Theorie en Praktijk van onderzoek'.

[40] In some cases self-employed and employed could be distinguished because in the birth certificate explicit mention was made of it (subordinate versus head). Where a job title included the word 'assistant' or 'master' a distinction between the two categories could also easily be made. In other cases, the assignment to the categories of self-employed or employed has been based on the usual sizes of the businesses. Thus baker, butcher, etc. are included among the self-employed, cartwright, candlemaker etc. to the employed. The consequences for the mortality differences of a wrong assignment to a social group depend on the social class gradient.

commissioned officers); skilled manual workers (smiths, furniture makers, barrel-makers, diamond workers, tobacco workers, printers, spinners and weavers, service employees such as postmen, shop-assistants, and lower military); casual and unskilled labourers (porters, journeymen, sailors, and agricultural labourers); and people with unknown or no occupation.[41] The three provinces showed considerable differences in the social-class composition of births: between 1.7 and 2.7 per cent of all births in all three provinces were of upper-class origin, while casual and unskilled labourers in Zeeland had a share of 48 per cent, in Friesland of 41 per cent, and in Utrecht of 29 per cent. Utrecht had a much higher share of skilled manual workers and also more children from the white-collar middle class.

Table 2 presents infant and early childhood mortality rates for the six socio-economic groups and the group with unknown social-class background in each of the three provinces. Data for the entire period 1812–1909 are taken together to give an overall picture of social differences. Information is also given on the number of individuals in the sample (numbers of births and the number of children of which the survival status at the age of one is known respectively), and on those parts of these groups for which survival information in the age intervals 0–1 and 1–5 years was complete, for each group. It is particularly in the upper class in Friesland and Zeeland, in the white-collar middle class in Friesland, and in the group with unknown social class, that information on survival status is not yet complete for a considerable proportion of births. The 95 per cent confidence intervals (given in the table) and confidence intervals for the differences between the infant mortality rates of the various social groups (not given in the table) were also calculated.

The table reveals large differences in the pattern of social inequality between the provinces, but these differences only rarely are statistically significant. Only in Utrecht is there a more or less clear social gradient found, with the lowest IMRs in the upper class and among farmers, and higher rates among the petty bourgeoisie and casual and unskilled labourers. Only the differences between farmers and casual and unskilled labourers, and between farmers and the group without occupation, are statistically significant. Almost no social differences were observed in Friesland (statistically significant differences were only observed between the upper class and skilled labourers). In Zeeland the highest mortality was found among the lowest and

[41] Many children in this last group were born to unwed mothers. A sizeable proportion of these infants relied on the mother alone for support, both financial and in the less tangible aspects of care. It is difficult to indicate the socio-economic position of these children; they have therefore mostly been excluded from the analysis. As Pamuk ('Social-class inequality') has shown, this might have an effect on the observed pattern of inequality, as these infants are in a position of greater disadvantage than children born legitimately to employed fathers, regardless of the nature of the employment. This group is characterized by very high infant mortality rates. See Kok, van Poppel, and Kruse, 'Mortality among illegitimate children'. Agricultural labourers are difficult to distinguish from other casual and unskilled labourers in those regions where agriculture is the dominant activity because many of them are simply designated as labourers. The number of agricultural labourers designated as such is only large enough to study as a separate category in Zeeland.

Table 2. *Number of births, percentage of births without survival information in age group 0–1, and infant mortality rate (per 1,000 live births) and early childhood mortality rate by socio-economic group and province*

	Number of births	*Number of survivors at age 1*	*% with known survival information in age group 0–1*	*% with known survival information in age group 1–5*	*IMR*	*95% confidence interval*	*ECMR*	*95% confidence interval*
Zeeland								
Social class unknown	51	42	80.4	73.8	176	(72–281)	167	(54–279)
Casual and unskilled workers	2,010	1,491	87.1	81.4	258	(239–277)	114	(98–130)
Skilled manual workers	528	417	85.0	79.9	210	(175–244)	115	(84–146)
Petty bourgeoisie	590	489	79.3	74.0	171	(141–201)	102	(75–129)
Farmers	542	432	89.7	86.8	203	(169–237)	106	(77–136)
White-collar middle class	230	169	78.7	69.2	265	(208–322)	71	(32–110)
Upper class	107	82	65.4	53.7	234	(153–314)	73	(17–130)
Utrecht								
Social class unknown	51	40	94.1	92.5	216	(103–329)	95	(57–293)
Casual and unskilled workers	910	715	92.9	90.6	214	(188–241)	123	(99–147)
Skilled manual workers	826	656	95.4	93.9	206	(178–233)	104	(80–127)
Petty bourgeoisie	558	443	93.9	91.6	206	(173–240)	111	(81–140)
Farmers	432	358	92.4	90.6	171	(136–207)	95	(65–125)
White-collar middle class	227	182	91.6	85.7	198	(146–250)	132	(83–181)
Upper class	96	81	87.5	82.7	156	(84–229)	99	(34–164)
Friesland								
Social class unknown	84	74	58.3	52.7	161	(50–188)	95	(28–161)
Casual and unskilled workers	2,185	1,931	84.9	82.9	116	(103–130)	80	(68–92)
Skilled manual workers	899	788	80.8	78.0	123	(102–145)	91	(71–111)
Petty bourgeoisie	1,004	900	79.0	76.6	104	(85–122)	73	(56–90)
Farmers	791	709	86.3	84.8	104	(82–125)	61	(43–78)
White-collar middle class	226	193	72.1	67.4	146	(100–192)	73	(36–109)
Upper class	110	98	62.7	58.2	109	(51–167)	61	(14–109)

the highest social classes. The causal and unskilled labourers here had a significantly higher mortality than farmers, skilled labourers, and the petty bourgeoisie. The white-collar middle class had a statistically significant higher mortality than farmers and the petty bourgeoisie. The position of the white-collar middle class was relatively unfavourable in all provinces. In Friesland and in Zeeland, infants born in families of which the father belonged to the upper class, had only slightly lower chances of death during the first year of life than children born in families of casual and unskilled labourers, and even higher risks than children born in families of farmers or the petty bourgeoisie. This conclusion gains more weight when one takes into account that in these provinces in the two higher social layers, a date of death is not yet known for a higher proportion of live births than in other social groups. This implies that the chance of finding a supplementary number of deaths during the first years of life is higher in these groups than in others, which might result in even higher death rates in the highest social classes. Within the group of casual and unskilled labourers, those working in agriculture in the province of Zeeland (where the group was rather numerous) had an infant mortality rate that was lower than that of the other casual labourers, and resembled that of the farmers.

Table 3 shows the neonatal and post-neonatal mortality rates separately by social class and province, per 1,000 live births. Differences between social groups were clearly higher for post-neonatal mortality. Over all provinces, the highest values were observed among children from the white-collar middle class, whereas among farmers the lowest values were found. The upper class, the casual and unskilled labourers, and the skilled manual workers had more or less the same levels of post-neonatal mortality. For neonatal mortality, rates among causal and unskilled labourers were highest; white-collar middle class and farmers were characterized by relatively high values as well.

For infant mortality as a whole, all social groups in Friesland, even those with the worst position on the social ladder, were much better off than the best-ranking social group in Utrecht, and incomparably better off than the best-ranking social group in Zeeland. This shows how important the regional environment was for the level of mortality in the nineteenth century.

Table 3 also shows that differentials in early childhood mortality among socio-economic groups were not wholly comparable to those for infant mortality. In general, one might say that during childhood a stronger social gradient was present. Children whose parents belonged to the highest social classes (the upper class, the middle class, and farmers) were generally better off than the children of the less-well-to-do, and in particular the children belonging to the category of 'unknown social class'. Differences between the last group and other social classes were statistically significant in Zeeland and Friesland. The smallest social differences were again found in Friesland. As far as the agricultural labourers are concerned, this group again had much lower values of ECMR than the rest of the casual and unskilled labourers.

Table 3. *Neonatal and post-neonatal mortality rate (per 1,000 live births) by socio-economic group and province*

	Zeeland		
	Neonatal	*Post-neonatal*	*N*
Social class unknown	39	137	51
Casual and unskilled workers	71	187	2,010
Skilled manual workers	53	157	528
Petty bourgeoisie	44	127	590
Self-employed in agriculture	66	137	542
White-collar middle class	70	196	230
Upper class	56	178	107
	Utrecht		
	Neonatal	*Post-neonatal*	*N*
Social class unknown	59	157	51
Casual and unskilled workers	56	158	910
Skilled manual workers	44	162	826
Petty bourgeoisie	48	158	558
Self-employed in agriculture	39	132	432
White-collar middle class	44	154	227
Upper class	31	125	96
	Friesland		
	Neonatal	*Post-neonatal*	*N*
Social class unknown	36	83	84
Casual and unskilled workers	43	74	2,185
Skilled manual workers	28	96	899
Petty bourgeoisie	25	79	1,004
Self-employed in agriculture	37	67	791
White-collar middle class	31	115	226
Upper class	0	109	110
	Total		
	Neonatal	*Post-neonatal*	*N*
Social class unknown	43	118	186
Casual and unskilled workers	56	133	5,105
Skilled manual workers	40	134	2,253
Petty bourgeoisie	36	112	2,152
Self-employed in agriculture	46	104	1,765
White-collar middle class	48	155	683
Upper class	29	137	313

Table 4 shows the development of infant and early childhood mortality according to socio-economic group over time. Differences refer to three time periods, chosen in such a way that they cover the period of stable mortality from the beginning of the nineteenth century until 1840, the period of increasing mortality lasting until 1880, and the more recent period of steep decreases in infant and early-childhood mortality risks.

Table 4. *Infant and early childhood mortality rate (per 1,000 live births respectively per 1,000 children aged one) by socio-economic group and period*

	Period					
	1812–39		*1840–79*		*1880–1909*	
	IMR	*N*	*IMR*	*N*	*IMR*	*N*
Social class unknown	173	75	165	85	133	30
Casual and unskilled workers	182	1,295	205	2,825	151	1,093
Skilled manual workers	154	544	204	1,223	113	548
Petty bourgeoisie	142	584	162	1,163	118	458
Self-employed in agriculture	144	535	153	939	148	324
White-collar middle class	270	159	209	368	111	171
Upper class	100	80	205	200	86	35
	Period					
	1812–39		*1840–79*		*1880–1909*	
	ECMR	*N*	*ECMR*	*N*	*ECMR*	*N*
Social class unknown	97	62	169	71	130	23
Casual and unskilled workers	96	1,059	113	2,245	70	831
Skilled manual workers	93	460	124	974	56	427
Petty bourgeoisie	104	501	101	975	42	356
Self-employed in agriculture	98	458	83	795	49	246
White-collar middle class	103	116	86	291	95	137
Upper class	139	72	63	159	0	30

Table 4 does not give a simple and unequivocal picture. The small number of observations in the upper class and the 'social class unknown' group plays a role in this. In the first period (1812–39) and last period (1880–1909), a social gradient is visible, be it that the white-collar middle class in the first period strongly deviates from this pattern. In the period 1840–79, characterized by increased levels of mortality, the higher and lower social classes have comparably high levels of infant mortality. Farmers and the petty bourgeoisie were doing relatively well in all periods, and they were hardly affected by the mortality crisis in the middle of the nineteenth century. In both groups, IMR remained almost stable over the whole period 1812–1909; in particular, the farmers were only marginally involved in the strong decrease in IMR that took place after 1880. The largest improvement took place among the white-collar middle class and, to a lesser degree, among the skilled manual workers and the casual and unskilled workers. In the last period, all social groups again reached the pre-1840 values and some—skilled manual workers, casual and unskilled workers, and white-collar middle class—even succeeded in reducing IMR values well below the earlier levels. White-collar middle-class families might be considered as the forerunners in the mortality decline.

Table 5. *Infant and early childhood mortality rate (per 1,000 live births per 1,000 children aged one) by socio-economic group and urban/rural background*

	IMR				*ECMR*			
	Rural		*Urban*		*Rural*		*Urban*	
	IMR	*N*	*IMR*	*N*	*ECMR*	*N*	*ECMR*	*N*
Social class unknown	148	142	205	44	99	121	257	35
Casual and unskilled workers	186	4,533	219	572	95	3,690	136	447
Skilled manual workers	170	1,362	181	891	85	1,131	126	730
Petty bourgeoisie	150	1504	145	648	81	1,278	112	554
Self-employed in agriculture	149	1656	183	109	79	1,410	135	89
White-collar middle class	198	415	213	268	81	333	109	211
Upper class	165	212	168	101	62	177	107	84

For ECMR, the small numbers in the upper-class group distort the picture even more than is the case among infants. Some trends can nonetheless be detected. First, in the period 1812–39, differences in child mortality between social classes hardly existed. Second, from the middle of the nineteenth century onwards, a social gradient in ECMR becomes visible. Third, the rise in mortality in the middle of the nineteenth century was limited to skilled manual workers, and casual and unskilled workers, whereas the petty bourgeoisie and the farmers were spared. Almost all social classes were affected by the decrease in mortality in 1880–1909, although some did so more than others. For skilled manual workers, and for casual and unskilled workers, the risks of dying between the ages of one and five were almost halved after 1880.

Table 5 compares IMR and ECMR by socio-economic status for urban and rural areas. All municipalities in the sample were classified in two categories on the basis of the 'urban' character of the municipality (number of inhabitants). In all social classes except the petty bourgeoisie, IMR was higher in urban than in rural areas, and the same applied to an even stronger degree for ECMR. The level of inequality did not deviate much between the two kinds of municipality. Farmers and unskilled workers were the group that profited most from living in a rural area, whereas for the petty bourgeoisie, the situation in urban areas was relatively more favourable.

VI

A more refined analysis of the socio-economic influences on mortality is possible by supplementing the socio-economic information with data on demographic characteristics of child and parent as given on the birth certificate and applying a multivariate analysis. The primary objective is to test whether social inequality increases or decreases under the influence of the regional and/or urban environment, the time period in which the child is born, and the age of the child. In addition, we control for other risk factors

to which children are exposed—sex of the child, season of birth, labour-market position of mother, marital status of the mother at birth, age of the father at birth and literacy of the father. We used logistic regression analysis, as our dependent variable (dying or surviving a given age interval) might be interpreted as a nominal-level variable.[42] We also made use of hazard analysis (adopting the semi-parametric approach of Cox regression). In this approach, the instantaneous risk of dying at age t is the product of a function of t, and a function of the explanatory variables and unknown parameters. These covariates are supposed to act multiplicatively on the risk of dying. The same set of covariates was included in the hazard models as in the logistic regression analysis. Using hazards does not solve the problem of missing survival data: it was possible, in the case of those children for whom no survival information was available, to make use of information on age at last observation from the population registers, but this related only to very small numbers. These small numbers lead us to expect that for the age intervals concerned, the outcomes of the two methods will not deviate much from each other. We prefer logistic regression, as we are more interested in the percentages of infants and children who died in their first year of life, or between their first and fifth year, depending on their socio-economic status, than in the question of how mortality changed as a function of age.[43]

Regression equations were estimated separately for three age intervals: for neonatal mortality, for post-neonatal mortality, and for the early childhood period (from the end of the first through the end of the fifth year of life).[44] This segmentation is motivated by the differences in the nature of the risk to which children are exposed in these stages of life. The regression models were estimated under the assumption that all children for whom no information on date of death was found had survived until the end of the relevant age intervals.

Information on the age of the mother at the time of the child's birth was only available for a very limited group of children. Given the homogeneity between the ages of husband and wife, we used the age of the father as a proxy for the age of the wife. 'Season of birth' was introduced by distinguishing births in the high-risk summer season (July and August) from those in winter (January, February, and December), spring (March until June) and autumn (September until November). 'Literacy of the father' was derived from the father's ability to sign the birth certificate of the child. When the child's father was not present at the time of birth or when the birth came from an unwed mother, widow, or divorced woman, a separate category was introduced. The 'labour market position of the mother' was

[42] Clayton and Hills, *Statistical models*.

[43] The results of the hazard analysis are available from the authors.

[44] The information on the age at last observation coming from the population registers showed that between birth and the end of the first month only one child migrated; between month one and year one, 11 children migrated; and between age one and age five, 51 migrated (compared to 1915 after age five).

grouped into two categories: mother works or mother does not work, including 'occupational status unknown'. Two categories were distinguished under 'household situation of the mother', married women and other women. This last category included unwed mothers, widows, and divorced women, and the few mothers for whom the marital status was not given on the birth certificate. Three provinces were distinguished, and urban and rural areas were distinguished from each other, following the lines described earlier. Three birth cohorts were used: 1812–39, 1840–79, and 1880–1909. The socio-economic group of the father was divided into eight classes, including the category 'unknown and without occupation'. The results of the analysis are presented in tables 6 and 7 for neonatal, post-neonatal infant, and early childhood periods.

The (log) odds of dying in the first month or year of life are regressed on the seven dummy variables representing social class, with the casual and unskilled labourers acting as a reference category. Table 6 (model 1) gives the odds ratio for those in the selected category versus those in the omitted (reference) category. For example, the odds ratio for children born in the upper class of 0.50 implies that the odds of dying in the first month of life are about 0.50 times as small for those children as they are for children born in the group of unskilled and casual labourers. Tests for each of the dummy coefficients bring to light which social classes are different from the casual labourers, with reference to the odds of dying in the first year of life.

Differences between social classes were indeed statistically significant: compared to the casual and unskilled labourers, the upper class, petty bourgeoisie, and skilled workers all had much lower death risks over the whole period, and for the three provinces together. For post-neonatal mortality (from month one till the end of the first year of life), the pattern was slightly different as, in addition to the petty bourgeoisie, only farmers deviated significantly from the casual labourers. The global test to determine whether the set of predictors was significant, the model chi-square test, revealed that the chosen variables were indeed highly significant ($p < 0.001$). In table 7, infant mortality as a whole is analysed. Here, the results were the same as for post-neonatal mortality: only farmers and the petty bourgeoisie had significantly lower mortality in the first year of life than the casual workers. For early-childhood mortality, farmers and agricultural labourers have statistically significant lower mortality than the casual workers.

Regressions were also run on those births for which information on the date of death was available, or for which a date of last observation was available, which lay above the first month of life (for neonatal mortality), above the first year of life (for post-neonatal and for infant mortality), or above the first five years of life (for child mortality). Only very small differences in the outcomes were observed, again lending support to the view that the estimation bias is small. For neonatal mortality, the relative risk to children from the upper class was still much lower than that of the reference group, but the difference was no longer significant. For

Table 6. *Logistic regression models for the odds ratios for neonatal and post-neonatal neonatal mortality, all live births respectively, all children surviving the first month*

		Neonatal mortality (N = 12,457; Events = 586)			*Post-neonatal mortality (N = 1,1871; Events 1,581)*		
Variable	*Category*	*Model 1*	*Model 2*	*Model 3*	*Model 1*	*Model 2*	*Model 3*
Socio-economic group	Upper class	**0.50**	**0.43**	**0.43**	0.99	0.76	0.78
	White-collar middle class	0.85	**0.32**	**0.32**	1.17	0.92	0.95
	Farmers	0.81	0.79	0.79	**0.74**	**0.78**	**0.77**
	Petty bourgeoisie	**0.63**	**0.65**	**0.65**	**0.80**	0.85	0.87
	Skilled manual workers	**0.69**	**0.67**	**0.67**	0.98	1.00	1.03
	Casual and unskilled workers	1.00	1.00	1.00	1.00	1.00	1.00
	Agricultural labourers	0.93	0.87	0.87	0.86	0.82	0.83
	Without or unknown	0.75	0.82	0.82	0.85	1.13	1.21
Cohort	1812–39		1.00	1.00		1.00	1.00
	1840–79		1.10	1.06		**1.33**	**1.32**
	1880–1909		0.81	0.80		0.86	0.86
Province	Utrecht		**1.45**	**1.45**		**2.24**	**2.28**
	Zeeland		**1.80**	**1.71**		**2.33**	**2.31**
	Friesland		1.00	1.00		1.00	1.00
Sex of child	Female		1.00	1.00		1.00	1.00
	Male		**1.24**	**1.24**		1.11	1.11
Paternal literacy	Unknown		0.00	0.00		1.57	
	Literate		1.00	1.00		1.00	
	Illiterate		1.11	1.10		0.98	
Paternal age at birth	<25 years		1.13			1.17	
	25–49		1.00			1.00	
	50 or older		1.34			1.22	
Level of urbanization	Urban		0.91			1.12	
	Rural		1.00			1.00	
Maternal labour force	Mother had occupation		0.81			**1.22**	**1.21**
	No occupation		1.00			1.00	1.00
Marital status mother	Married		1.00			1.00	
	Not married		0.89			0.59	
Season of birth	Winter		1.00			1.00	
	Summer		1.08			1.02	
	Autumn		0.92			1.01	
	Spring		0.80			1.05	
Intercept (exp.)		0.06	0.42	0.04	0.17	0.07	0.08
Model chi-square		21.01	91.62	80.89	23.23	270.91	262.24
Degrees of freedom		7	22	14	7	22	13

Note: Items in bold are significant at 5% level

Table 7. *Logistic regression models for the odds ratios for infant and early childhood mortality, all live births respectively, all children surviving age one*

		Infant mortality (N = 12,457; Events = 2,167)			*Early childhood mortality (N = 10,290; Events 980)*		
Variable	*Category*	*Model 1*	*Model 2*	*Model 3*	*Model 1*	*Model 2*	*Model 3*
Socio-economic group	Upper class	0.85	**0.65**	**0.65**	0.73	**0.47**	**0.46**
	White-collar middle class	1.08	**0.74**	**0.74**	0.89	0.71	0.69
	Farmers	**0.75**	**0.77**	**0.77**	**0.78**	0.81	**0.79**
	Petty bourgeoisie	**0.74**	**0.78**	**0.78**	0.87	0.82	**0.81**
	Skilled manual workers	0.89	0.90	0.90	0.98	0.87	0.86
	Casual and unskilled workers	1.00	1.00	1.00	1.00	1.00	1.00
	Agricultural labourers	0.74	0.83	0.83	**0.55**	**0.54**	**0.53**
	Without or unknown	0.87	1.04	1.04	1.36	1.17	1.15
Cohort	1812–39		1.00	1.00		1.00	1.00
	1840–79		**1.27**	**1.29**		1.10	1.09
	1880–1909		**0.84**	**0.84**		**0.71**	**0.70**
Province	Utrecht		**2.04**	**2.07**		**1.43**	**1.44**
	Zeeland		**2.23**	**2.29**		**1.47**	**1.48**
	Friesland		1.00	1.00		1.00	1.00
Sex of child	Female		1.00	1.00		1.00	
	Male		**1.15**	**1.15**		0.97	
Paternal literacy	Unknown		1.12			0.66	
	Literate		1.00			1.00	
	Illiterate		1.01			1.08	
Paternal age at birth	<25 years		1.17	1.16		**0.72**	**0.73**
	25–49		1.00	1.00		1.00	1.00
	50 or older		1.27	1.25		0.76	0.76
Level of urbanization	Urban		1.07			**1.54**	**1.54**
	Rural		1.00			1.00	1.00
Maternal labour force	Mother had occupation		1.10			**1.24**	**1.25**
	No occupation		1.00			1.00	1.00
Marital status mother	Married		1.00			1.00	
	Not married		0.65			1.44	
Season of birth	Winter		1.00			1.00	1.00
	Summer		1.03			1.03	1.03
	Autumn		0.99			1.01	1.01
	Spring		0.98			**1.24**	**1.25**
Intercept (exp.)		0.24	0.12	0.12	0.11	0.09	0.09
Model chi-square		30.48	307.58	303.54	14.79	119.37	117.25
Degrees of freedom		7	22	14	7	22	18

Note: Items in bold are significant at 5% level

post-neonatal mortality, the excess risks of the white-collar middle class was now significant, whereas that was not the case in the analysis based on all live births. No such changes were observed for infant mortality.

In some cases a difference was visible in the direction of the relationship between the covariates and the death risk of infants, depending on whether or not live births with missing information are included. Yet this was only the case where relative risks fluctuated around 1.0 and levels of significance were far from reaching statistical significance; this applied, for example, to the upper class for post-neonatal and infant mortality, and for the group without occupation for post-neonatal mortality.

In the next step, we introduced all the above-mentioned risk factors in which we were interested (region, urban/rural background, and time) into the model (model 2). This led to a significant improvement compared to model 1 in all age groups (differences in −2 log likelihood significant at $p < 0.001$). Of the three characteristics in which we were interested—region, time period, and urban/rural background—the first two indeed had a very strong effect on the risks of dying for post-neonatal mortality, for infant mortality as a whole, and for early childhood mortality. Only for neonatal mortality were changes over time not significant. Urban areas had higher mortality than rural areas in all age intervals except neonatal mortality, but differences were only significant for children aged one to five years. It comes as no surprise that Zeeland and Utrecht fared much worse than Friesland. The situation of infants and children during the years 1840–89 was bad compared to the first period, and even worse compared to 1890–1912. The direction and strength of the relationship between social class and mortality during the first five years of life remained more or less the same. For neonatal mortality, the only real alteration was that children from the white-collar middle-class group now also had clearly and significantly lower mortality risks than the reference group. For post-neonatal mortality, the petty bourgeoisie no longer differed significantly from the casual workers. For infant mortality as a whole, groups at the upper range of the hierarchy—upper class, white-collar middle class, farmers, and petty bourgeoisie—all had now significantly lower mortality than the causal workers.

What about childhood mortality? Among children who had survived to the age of one, the socio-economic position of the father also had an effect. In model 1, almost all social groups did better than the casual and unskilled labourers, yet only farmers and agricultural labourers had a statistically significant lower level of mortality. A replication of the analysis on the restricted set of data (survival status known or age at last observation above five) gave almost the same results: the only difference was that the excess mortality of the group with unknown occupations was now statistically significant.

The use of the complete set of variables (model 2) caused some differences in the effects of social class. In addition to agricultural labourers, the upper class had lower mortality, whereas values for the farmers almost

reached significance.[45] Period of birth and province remained important factors in this age group. Urban municipalities had higher mortality in this age group. Remarkably, the season of birth had a statistically significant effect on early childhood mortality but not on infant mortality.[46]

To select a model that is more parsimonious, but captures the basic features of the association in the data of model 2, a backward stepwise procedure was followed in order to decide which variables could be removed from the model. In this procedure, social class was not considered eligible for removal. Model 3 shows the result of this exercise. It is clear from the table that the parameters of this model hardly changed compared with the more extensive model. The social class in which a child is born had a very strong effect on the child's survival prospects, those chances generally being the highest for children from the higher ranks of society. Children from the upper class, the white-collar middle-class group, farmers, and the petty bourgeoisie, did better than the unskilled and casual labourers' children. The more restricted model—model 3—gave almost the same results for young children. In particular, children from the upper class, farmers, and the petty bourgeoisie had higher survival rates. The province of birth and the period of time remained very important for child survival.

Tables 6 and 7 show that the effects of social class were generally much less than that of region (province) and time, but stronger than that of urban/rural background. In particular, social class has a small effect for post-neonatal mortality. This becomes clear when one compares the fit of a model without social class with that of a model in which social class is included.[47] The introduction of the variable social class in the model for neonatal mortality reduces the deviance (the difference in the value of –2 log likelihood) with 12.144 for which seven degrees of freedom are lost. The probability that the reduction in deviance in the model for neonatal mortality is a result of chance instead of a systematic effect of the introduction of social class is more than 10 per cent ($0.10 < p < 0.25$). For neonatal mortality, for infant mortality as a whole, and for early childhood mortality, social class is more important. For the first age interval (0–1), the deviance reduction is 24.114 ($p < 0.001$), for infant mortality 20.262 ($0.005 < p < 0.001$), and for the age interval one to five, 14.676 ($0.05 < p < 0.025$).

[45] Results of the hazard analysis confirm the pattern observed for neonatal mortality; for post-neonatal mortality, the direction of the differences did not change, but there were differences in the statistical significance. Compared to the logistic regression, relative risks were significantly lower for the upper class and white-collar middle class, whereas for farmers, differences were no longer significant. For infant mortality as a whole, farmers now did not differ significantly from the reference group, whereas skilled manual workers did now differ significantly from the casual workers. For early childhood mortality, again the direction of the relative risks was in line with that of the logistic regression outcomes, but more of these differences now reached statistical significance.

[46] A recent study documenting effect of month of birth on lifespan after the age of 50 found that people born in the second quarter of the year had a lower life expectancy. See Doblhammer and Vaupel, 'Lifespan'.

[47] This can be done by calculating the difference between the log-likelihoods and the degrees of freedom of the two models.

Table 8. *Logistic regression models for the odds ratios for infant and early childhood mortality by province, All live births respectively all children surviving age one*

		Infant mortality			*Early childhood mortality*		
Variable	*Category*	*Zeeland*	*Utrecht*	*Friesland*	*Zeeland*	*Utrecht*	*Friesland*
Socio-economic group	Upper class	0.87	0.49	0.65	0.57	0.56	**0.24**
	White-collar middle class	0.81	0.80	0.66	0.65	0.78	0.65
	Farmers	**0.72**	0.77	0.94	0.94	0.79	0.71
	Petty bourgeoisie	**0.64**	1.01	0.82	0.92	0.73	0.77
	Skilled manual workers	0.79	1.01	0.98	0.97	0.70	0.95
	Casual and unskilled workers	1.00	1.00	1.00	1.00	1.00	1.00
	Agricultural labourers	0.68	0.79	1.71	0.62	0.77	0.49
	Without or unknown	0.62	1.34	1.41	1.07	1.41	1.12
Cohort	1812–39	1.00	1.00	1.00	1.00	1.00	1.00
	1840–79	0.97	**1.82**	**1.41**	1.13	1.13	1.02
	1880–1909	**0.61**	1.17	1.01	**0.52**	**0.66**	0.91
Sex of child	Female	1.00	1.00	1.00	1.00	1.00	1.00
	Male	1.02	1.08	**1.44**	0.98	1.02	0.93
Paternal age at birth	<25 years	1.13	1.29	1.13	0.96	0.65	0.60
	25–49	1.00	1.00	1.00	1.00	1.00	1.00
	50 or older	**1.52**	1.04	1.31	1.03	0.50	0.77
Level of urbanization	Urban	0.94	0.84	**1.45**	**1.52**	**1.52**	**1.58**
	Rural	1.00	1.00	1.00	1.00	1.00	1.00
Maternal labour force	Mother had occupation	**1.25**	0.70	0.72	1.27	1.29	**1.12**
	No occupation	1.00	1.00	1.00	1.00	1.00	1.00
Season of birth	Winter	1.00	1.00	1.00	1.00	1.00	1.00
	Summer	**1.39**	0.88	0.82	0.98	0.99	1.11
	Autumn	0.97	1.15	0.89	1.16	0.80	1.04
	Spring	1.03	1.00	0.89	1.18	1.18	**1.34**
N		3,677	2,838	4,949	2,856	2,283	4,397
Intercept (exp.)		0.33	0.19	0.09	0.12	0.14	0.08
Model chi-square		78.33	44.90	54.51	45.80	3263	33.44
Degrees of freedom		17	17	17	17	17	17

Note: items in bold significant at 5% level

To judge the consistency of the relation between social class and survival over time and region, and to study the influence of the region in which one lived and the time of birth on the level of inequality, we stratified our sample, and applied logistic regression with a restricted number of variables to our data. We dropped those variables that did not have a significant effect in any of the models. In table 8 we present results for infant mortality as a whole, and for early childhood mortality.

Table 9. *Logistic regression models for the odds ratios for infant and early childhood mortality by period of birth, all live births respectively, all children surviving age one*

		Infant mortality			*Early childhood mortality*		
Variable	*Category*	*1812–39*	*1840–79*	*1880–1909*	*1812–39*	*1840–79*	*1880–1909*
Socio-economic group	Upper class	**0.35**	0.84	0.60	0.86	**0.20**	0.70
	White-collar middle class	0.93	0.82	**0.60**	0.87	**0.47**	0.96
	Farmers	0.86	**0.69**	0.89	1.13	**0.71**	0.66
	Petty bourgeoisie	0.78	**0.78**	0.84	1.02	**0.73**	0.74
	Skilled manual workers	0.90	1.00	0.80	0.85	0.95	0.74
	Casual and unskilled workers	1.00	1.00	1.00	1.00	1.00	1.00
	Agricultural labourers	0.81	0.99	0.84	0.20	0.53	0.83
	Without or unknown	1.43	1.24	0.48	0.70	1.69	1.22
Province	Zeeland	**3.02**	**2.02**	**1.74**	**1.67**	**1.64**	0.92
	Utrecht	**1.54**	**2.27**	**2.05**	**1.44**	**1.64**	1.17
	Friesland	1.00	1.00	1.00	1.00	1.00	1.00
Sex of child	Female	1.00	1.00	1.00	1.00	1.00	1.00
	Male	1.10	1.09	**1.30**	0.91	0.95	1.08
Paternal age at birth	<25 years	1.11	1.08	1.38	0.94	0.61	0.65
	25–49	1.00	1.00	1.00	1.00	1.00	1.00
	50 or older	1.47	1.10	1.34	0.68	0.78	0.86
Level of urbanization	Urban	**1.47**	0.92	1.05	**1.84**	**1.64**	1.12
	Rural	1.00	1.00	1.00	1.00	1.00	1.00
Maternal labour force	Mother had occupation	1.02	1.22	1.13	1.07	**1.43**	0.79
	No occupation	1.00	1.00	1.00	1.00	1.00	1.00
Season of birth	Winter	1.00	1.00	1.00	1.00	1.00	1.00
	Summer	1.11	1.00	1.07	1.06	1.03	1.01
	Autumn	0.97	1.00	1.02	1.07	1.06	0.87
	Spring	0.96	0.96	1.05	1.31	**1.30**	1.06
N		2,985	5,145	3,334	2,511	4,159	2,866
Intercept (exp.)		0.10	0.16	0.10	0.07	0.09	0.09
Model chi-square		111.44	145.71	53.25	32.22	88.08	11.92
Degrees of freedom		17	17	17	17	17	17

Note: Items in bold significant at 5% level

In all three provinces, children from the higher and middle groups (upper-class, white-collar middle class, petty bourgeoisie, and farmers) had lower infant and childhood mortality than unskilled and casual labourers. The skilled labourers had infant mortality slightly below or at the same level as the casual workers, whereas agricultural labourers did not show a con-

sistent pattern. The differences between farmers and petty bourgeoisie on one hand, and the unskilled labourers on the other, were only significant in Zeeland. For ECMR, the direction of the social-class effects remains almost the same, but statistically significant effects are hardly visible anymore. Only the upper class in Friesland deviates significantly strongly from the casual and unskilled workers.

When the period of birth is the distinguishing factor (see table 9), it appears that in 1812–39, as well as in 1840–79 and 1880–1909, all social classes did better than the casual and unskilled labourers. Nevertheless, the significance of these differences varied over time. In the first decades of the nineteenth century, only children born in upper-class families did significantly better than the reference group. In the middle of the nineteenth century, social inequality was higher, and the farmers and petty bourgeoisie had significantly lower mortality, whereas in the more recent period, the white-collar middle class deviated significantly from the unskilled labourers.

For ECMR, the effect of social class also differed by period. In the middle of the nineteenth century, the expected pattern emerges, with the upper class, white-collar middle class, farmers, and the petty bourgeoisie having statistically meaningful lower mortality than casual labourers. In the last decades of the nineteenth century this pattern is reconfirmed. For infant and early childhood mortality, province was a much more important factor than social class. The effect of region has only disappeared in the last decades of the period.

VII

Notwithstanding the fact that, because of the small sample size and incomplete follow-up, the results of our analysis are provisional and sometimes contradict each other, some general conclusions can be drawn. We found large differences in the pattern of social inequality between the three provinces and over time. In all provinces, the casual and unskilled labourers had higher mortality than the upper and middle layers of society, whereas skilled manual workers were somewhere in between. Farmers and petty bourgeoisie did generally do better than the upper class and white-collar middle class. Social class had a statistically significant effect both on neonatal and on post-neonatal mortality, with mortality higher among the lowest social class than among the upper and middle layers. We also observed that during childhood, a stronger social gradient was present in all three provinces than in infancy. Being born in a rural or urban environment had much less effect on infant and child mortality than region had. Only in Friesland did urban areas have higher infant mortality than rural areas. For children aged one to five, being born in an urban area had the expected increasing effect on mortality. We observed large differences between the provinces in the levels of IMR by social group: in Friesland even the worst-ranking social group was much better off than the best-ranking one in Utrecht and Zeeland. This

showed the importance of the regional environment for the level of infant mortality in the nineteenth century, a finding that was confirmed time and again in our analysis.

Changes in the social gradient over time were also observed. In the first period, differences between social class were relatively small and no clear gradient was visible. In the period of increased mortality, the differences between social classes were accentuated and were more in line with the expected inverse relationship between social class and mortality. When IMR started to decline, the gap between the upper class and the white-collar middle class narrowed again.

Do the results of our study support the hypotheses that we formulated regarding the effects of time, environment, and age on social class differences in mortality?

Our first hypothesis was that infants were less sensitive to social conditions than children aged one or older. Our study did not confirm this hypothesis. For neonatal mortality, as well as for post-neonatal mortality and for infant mortality, differences between social classes were found that were the same as those observed among children aged one to five. This confirms the recent observations by Derosas and Landers that mortality in the first month of life was caused not only by purely endogenous factors, but that the environment, social class included, played a role at this age as well, and contradicts the generally held view.[48]

The second hypothesis was that the level of social inequality depended on the characteristics of the environment. We expected that in provinces with a low sanitary level, social class differences would be less pronounced than in areas with better health conditions, and that in rural areas, equity between social classes would be higher than in urban areas. Our analysis showed that the environment was far more important for survival than the social class to which one belonged. Nonetheless, we might conclude that, in general, in low-mortality Friesland, social class differences in infant mortality were less pronounced than in the provinces characterized by very high mortality. Zeeland in particular had higher degree of inequality than Friesland. For child mortality, differences were larger in Friesland.

Our third hypothesis dealt with the development of social differences over time. We expected that differences between social classes increased over time, as wealthier groups could take advantage at an earlier stage of advances in medical knowledge and improved sanitary standards, and by increased social segregation. If a conclusion is allowed on this aspect, then it is that in the period 1880–1909, the effect of social class was less than it was in the earlier periods, for infant as well as for early childhood mortality.

How do the results of our analysis compare with other studies? As far as time trends are concerned, the problem is, as was indicated earlier, that

[48] Derosas, 'Watch out'; Landers, *Death*, pp. 139–41. For the opposite view see e.g. Haines, 'Inequality'.

most studies of trends in social equality have focused on a very restrictive time period, i.e. on the last quarter of the nineteenth and the first decades of the twentieth century. Only Swedish studies have applied a comparable time frame. The Swedish study that was similar to ours found contradictory results and, in general, no clear changes in socio-economic patterns of mortality. The results of both our own and the Swedish study do show that a limited time perspective can lead to distorted conclusions regarding the trend in social inequality in mortality over time: there is no continuous increase or decrease in differences, and the period that is used as the starting point for the analysis might have a strong effect on the conclusions that are reached.

The Antonovsky study usually taken as the standard reference when studying trends in social-class mortality differences has other important disadvantages as well: it groups together data from a variety of towns and regions over a long time period, and uses these data as the basis for the comparison over time. What our results have in common with the studies done in the UK is that such a procedure is not allowed: the relation between social position and infant mortality differs very strongly depending on the environment, and only by studying a set of varying environments over time is it possible to reach firmer conclusions. Our analysis confirmed the conclusions from the British studies that showed that the environment category is consistently able to explain more variance in infant and child mortality than the social class categories. However, contrary to these studies, the effects of rural-urban differentials were not central to the spatial variations in infant mortality in The Netherlands. This might be explained by the fact that the urban areas in the selected provinces were mostly small towns, not inundated with immigrants and beset with crowding, poor sanitation, and substandard housing, whereas the rural areas were characterized by high population density. Furthermore, the selected provinces were part of the economic and cultural system of the west and north, as a consequence of which, they had a relatively well-developed transportation network (waterways), and agricultural activities that were highly market-oriented.

In line with the British studies cited in the introduction, we observed that poor environments did magnify the socio-economic inequalities in infant mortality. This applies to the provinces with high mortality, but also to periods characterized by heightened levels of mortality (1840–79). Reid, as well as Garrett and colleagues, argued that in poor environments where the threat posed by infant and childhood diseases was high, superior resources and knowledge were able to offer some protection in the early years of life. In situations where the environment did not present such a virulent attack on the health of the young, the meagre resources of the lower classes offered as effective a defence as the greater ones of the middle classes. Reid suggested that this could be accounted for by more effective information networks, by greater pressure from the middle classes for sanitary improvements that enhanced the health of the whole community, or by the fact that the middle-

class's superior resources did not constitute much of an advantage, because the environment represented less of a threat to their children's health.

We suggest that the observed contrast in social inequality in infant mortality between the Dutch provinces, in particular between Zeeland and Friesland, is the combined effect of differences in the sanitation level and differences in the diet of infants. There are many indications that in Friesland breast-feeding was much more widespread over the social classes, and was utilised for a longer period than in Zeeland. A first indirect indication is that our data show that a summer maximum in infant mortality was not observed in Friesland, whereas such a peak was common in Zeeland. For children who were bottle-fed, the summer period was generally much riskier.[49] A second indication is in cause-of-death statistics. Compared to Zeeland and Utrecht, per 1,000 live births in Friesland during the period 1875–99, a much smaller number of children died from convulsions, diarrhoea, and atrophy than in the other provinces.[50] The low fertility in Friesland also fits a context of frequent and long breastfeeding.[51] Lastly, we can refer to several observations of contemporary medical doctors regarding Friesland, as well as Zeeland.[52] It was the interaction between the low incidence of breast-feeding and the atrocious condition of the drinking water and sanitation that led to high mortality in Zeeland and Utrecht. In Friesland, children's diets and the higher quality of the environment offered even children from poor families high chances of surviving the first year of life; in Zeeland and Utrecht low frequencies of breast-feeding, or social differences in their frequency, combined with atrocious ecological conditions, in particular for the lower social classes, caused larger social differences in infant mortality. Such a role for infant-feeding practices is consistent with the conclusion that for early childhood mortality, Friesland did show larger differences.

The results of our analyses did not allow a simple and unequivocal confirmation or rejection of the hypotheses with which we started our article. Many questions regarding the evolution of, and variation in, socio-economic differences in mortality are still unanswered. To reach further progress in this field, it is necessary to improve the quality and volume of the information on mortality at the individual and household levels, as well as the relevant characteristics of the environment in which the child is born and raised. This implies enlarging the existing database, by completing the information on children for whom at this moment no information on survival is available, by adding information on the characteristics of the

[49] Saltet, 'Nederlandsche maatschappij'.

[50] These data are based on *Vijffjarig overzicht van de sterfte naar den leeftijd en de oorzaken van den dood in elke gemeente van Nederland gedurende 1875–1879, 1880–1884,1885–1889, 1890–1894 en 1895–1899*. The classification of causes of death is described in Wolleswinkel-van den Bosch, van Poppel, and Mackenbach, 'Reclassifying causes of death'.

[51] Lesthaeghe, *The breast-feeding hypothesis*.

[52] *Rapport der Commissie*, p. 491; Fokker, 'De volksvoeding'; Broes van Dort, *Bijdrage*; Coronel, *Middelburg*; Helderman, 'De kindersterfte'; Allbutt, 'Sur la mortalité'; Coronel, 'De volksvoeding'.

individual, the parents, and the other household members, and by adding data from other provinces as well. Factors such as birthplace of the mother, age of wife, parity, birth intervals, and the presence of other family members, will become available at the family level, thereby making possible an analysis comparable with the one done for the UK for the last decade of the nineteenth century with census data.[53] The broader geographic coverage of that study will allow us to compare regions that have a greater diversity in factors considered relevant in studying the mortality transition, including heavily industrial environments. This will be done in a research project that started in 2003, and which will be completed in the future.[54] In addition to that, information will be collected that will allow us to reconstruct some characteristics of the environment that might have had an effect on the mortality level of the community as a whole. Included among these are indicators of water quality, income level, indicators of occupational distribution, population density, and migration. By studying children within the context of their families in a greater variety of spatially differentiated health environments it might become possible to find out which individual characteristics in what locational circumstances play a role in the building of the relationship between social class and infant and child mortality.

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[53] Garrett et al., *Changing family size*.
[54] For more information on the project, called *Life courses in context*, see http://www.lifecoursesincontext.nl

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