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Determinants of infant and early childhood mortality levels and their decline in The Netherlands in the late nineteenth century

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Objective To study the relative importance of various determinants of total and cause-specific infant and early childhood mortality rates and their decline in The Netherlands in the period 1875–1879 to 1895–1899.

Data and Methods Mortality and population data were derived from Statistics Netherlands for 16 towns and 11 rural areas. Mortality levels and their decline were estimated with a Poisson regression model. The associations of the estimated levels and declines, and determinants of infant and early childhood mortality were analysed using multivariate linear regression analysis. The causes of death studied were major contributors to infant mortality (convulsions, acute digestive disease, acute respiratory disease) and early childhood mortality (encephalitis/meningitis, acute respiratory disease, measles).

Results Infant mortality rates were high in the south-western part of The Netherlands in 1875–1879. Due to a rapid decline in the western regions, this pattern changed to a north-south gradient in 1895–1899. Early childhood mortality showed an urban-rural gradient in 1875–1879 with mortality high in towns. This gradient had largely disappeared by1895–1899, due to a rapid decline in mortality in towns. Roman Catholicism was significantly associated with infant mortality (particularly from diarrhoeal disease) in 1875–1879 and 1895–1899. The association with Roman Catholicism was stronger in 1895–1899 because mortality declines were less rapid in Roman Catholic areas in 1875–1879 to 1895–1899. Urbanization was significantly associated with early childhood mortality (particularly from respiratory disease) in 1875–1879 and 1895–1899. This association weakened over time, due to the rapid decline in mortality in towns.

Conclusions Different determinants of mortality (decline) were important in infant and early childhood mortality and they acted on different causes of death. Therefore, infant and childhood mortality should be studied separately. International comparison of the results showed that findings with respect to determinants of mortality (decline) for one country do not necessarily apply to other countries. The results for The Netherlands with respect to infant mortality differed from England and Wales.

Keywords History, infant mortality, early childhood mortality

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Over the years much has been published on determinants of historical infant and child mortality. A decline in infant and child mortality contributed significantly to the progressive decline in mortality which started in Western countries in the 18th or 19th centuries. Mosley and Chen[1] defined five sets of factors that can directly influence child mortality: maternal factors (e.g. age,

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parity), environmental contamination (e.g. food, water), nutrient deficiency (e.g. calories), injuries (accidental or intentional) and personal illness control (e.g. personal preventive measures). Historical data are, however, lacking for most of these factors.

The rise in living standards and particularly improvements in nutrition have long been considered as the most important determinants of the decline in mortality (including infant and child mortality).[2] Others have questioned the importance of the role of nutrition in mortality decline and concluded that the public health movement working through local governments should be seen as the leading force behind the decline of mortality in the late 19th and 20th centuries.[3] There are also some important studies that specifically address historical infant and childhood mortality decline, and they have shaped the existing ideas on determinants of 19th and early 20th century infant and child mortality.

Woods *et al.*[4,5] have published two papers on the causes of the rapid infant mortality decline in England and Wales in the period 1861–1921. Infant mortality rates were high in urban areas in England and Wales. This was called the 'urban-sanitary-diarrhoeal-effect'. It implies higher infant mortality in towns in hot summers, in which due to bad sanitary conditions, high mortality from diarrhoeal disease occurred. The effect of bad sanitary conditions on infant mortality in towns has also been highlighted by others.[6–9] Woods *et al.*[4–5] also concluded that social class and income had a significant effect on the *level* of infant mortality but it was not so influential on the timing and pace of infant mortality decline. This conclusion has been confirmed in a multivariate explanatory analysis (including urbanization and fertility) for the period 1895–1911.[10]

In the US, child mortality was amongst the highest of the world around 1900, while income levels were among the highest. The inequality in child mortality by social class was much lower in the US compared to England and Wales. The most advantaged social classes enjoyed no advantage with regard to mortality. These findings led Preston and Haines to argue that 'lack of knowledge rather than lack of resources was principally responsible for foreshortening life'.[11] They also found that ethnicity was a more important factor in mortality than social class, urbanization and income. The idea that cultural factors, such as the effect of new ideas on disease processes and health behaviours, have been important determinants of infant and childhood mortality (decline) has been put forward by many authors, and has been suggested as a new direction for research on infant and childhood mortality decline.[11–14]

The aim of this study is to determine the relative importance of several determinants of all-cause and cause-specific infant and early childhood mortality rates and their decline in The Netherlands in the period 1875–1879 to 1895–1899. Mortality started to decline rapidly in The Netherlands around 1875–1879. The decline in early childhood mortality was greater compared to infant mortality decline.[15] So far, few studies have analysed *cause-specific* infant and early childhood mortality or included mortality *decline* beside mortality levels. In this paper results will be presented for three important causes of infant and early childhood mortality. The relative importance of determinants of infant and early childhood mortality (decline) are analysed with a multivariate regression model, in which the regional variation in the prevalence of determinants, mortality levels and their decline in The Netherlands is used.

Data and Methods

Data

Mortality and population

Total sex- and cause-specific infant (age 0–1) and early childhood mortality (age 1–4) data were obtained from publications of the Ministry of the Interior (which gave data for quinquennial periods) for the years 1875–1879, 1885–1889 and 1895–1899. Data on live births and population figures for the years 1875–1879, 1885–1889 and 1895–1899 were also obtained from publications of the Ministry of the Interior. Data on live births were not available by sex. Mortality and population data as well as data on explanatory variables were obtained for the 11 Dutch provinces and 16 towns (with more than 20 000 inhabitants) (Figure 1). Figures for then 11 rural areas were calculated by subtracting the values for the 16 towns from the 11 provinces in which they were located.

The three infectious diseases which contributed significantly to infant or early childhood mortality in the late 19th century were included in the study. In the case of infant mortality these were convulsions (15%), acute respiratory disease (10%) and acute digestive disease (17%). For early childhood mortality these causes of death were acute respiratory disease (about 25%), measles (5%), and diseases of the nervous system (10%). The category 'acute digestive disease' did not include cholera, typhoid fever or abdominal tuberculosis, but did include other diarrhoeal disease; the category 'acute respiratory disease' did not include whooping cough, scarlet fever, measles or diphtheria, but was primarily influenza and pneumonia. One classification of causes of death consisting of 34 categories was used during the period 1875–1879 to 1895–1899, so no reclassification of cause-of-death categories was needed for this study.[16]

Figure 1 Map of The Netherlands showing regions selected for this study

Table 1 Determinants used in the analyses: parameters, data source and years

Determinant	Parameters	Data source	Years in analysis
Soil type	Region consists predominantly of sand soil: yes/no	De Grote Bosatlas, 1968	1875–1879, 1895–1899
Urbanization	Town yes/no	See Figure 1	1875–1879, 1895–1899
Roman Catholicism	Percentage population with 'Roman Catholic' as religious affiliation	Historical Ecological Database (HED)[a]	1875–1879, 1895–1899
Wealth	Wealth tax in guilders per capita	HED	1875–1879, 1895–1899
Female labour participation	Percentage working women	HED	1875–1879, 1895–1899

[a] The Historical-Ecological Database is managed by Stichting Beleidsondersteunend Ruimtelijk Onderzoek (BRON) which is related to the University of Amsterdam.

Determinants of mortality

The determinants of infant and early childhood mortality used in this study are wealth tax, female labour participation, percentage Roman Catholic, urbanization and soil type. These are indirect determinants of infant and early childhood mortality that affect mortality through other, more direct, determinants, for example breastfeeding and housing conditions. Data for these determinants were most readily available in The Netherlands.

Wealth tax is used as an indicator of wealth. Wealth can influence health through improvement at the household level, such as better food or housing, access to medical care, but wealth can also have a beneficial indirect effect on health through increased governmental expenditure on e.g. water supply and sewage systems. The wealth tax variable used in this study consisted of six components: rental value of houses and other buildings, tax on the number of 'doors and windows connected to the open air', tax on the number of fireplaces, tax on furniture, tax on servants and maids, and tax on horses. The tax on rental value (part of the wealth tax variable used in the analyses) differed according to the size of the town. Other components such as tax on horses or servants were independent of town size.[17] Adding urbanization to the regression model partly corrects for the effect of differential tax values by town size.

The effect of female labour participation on mortality can either be positive or negative. Labour participation by the mother can increase the level of wealth of the household through a second wage. However, a working mother could also mean reduced care levels for the children, e.g. no breastfeeding (or for a shorter period) for the infants.[8,18]

Cultural factors can influence mortality (decline) through determinants related to health behaviours. In this study percentage Roman Catholics is used as a cultural factor. It has been reported that breastfeeding was less common among Roman Catholics compared to other religious denominations.[19] High marital fertility levels were also related to Roman Catholicism, there was a strong adherence to folk medicine among Roman Catholics, and they were less inclined to accept new ideas (e.g. on hygiene).[20,21]

Urbanization can be related in various ways (positive and negative) to infant and early childhood mortality (decline). High urban infant mortality rates have been related to the negative health affects of industrialization.[4,5,22,23] However, there were no major urban-industrial conurbations in The Netherlands like those found in England and Wales.[24] On the other hand, urban society was more open to new ideas (including those on hygiene and child care) compared to rural areas. People with different socio-cultural backgrounds lived together in the cities which facilitated the acceptance of other opinions on a number of things.[25] City life could also affect health through good infrastructure in the form of schooling and medical care.

The type of soil was also related to mortality. In The Netherlands, regions can be roughly divided into sandy areas and those with predominantly clay soil. The type of soil affected economic development of the region. The farming in the unfavourable sandy soil areas was largely mixed subsistence farming when compared to the clay areas. In the latter regions, the economy was more market-oriented.[26] The market-oriented regions were also the regions that were culturally the most diverse. Besides this economic and cultural relationship with mortality (decline), the type of soil could also have a direct association with mortality. Clay soil was more brackish as compared to sandy soil, which made the groundwater less suitable as drinking water. As a result more polluted surface water was used in those areas for drinking and washing.[27] Table 1 gives the variables used in the analyses in this study using the parameters of years in the study and data source.

Method

The mortality level and decline estimates were derived from a log-linear regression model (Poisson regression) designed to estimate mortality levels for the years 1875–1879 and 1895–1899, and mortality decline in the period 1875–1879 to 1895–1899. Separate models were used for infant mortality and early childhood mortality. The model used is described below.

$$E(Y_{irt}) = N_{in}e^{\alpha+\beta_i+\gamma_r+(\delta+\delta_r)T}$$

$E(Y_{irt})$ = expected number of deaths per sex category (i), region (r) and 5-year interval (t)
N_{irt} = population numbers per sex category, region and 5-year interval
α = intercept (i.e. log regional mortality rate 1875–1879 men, region Amsterdam)
β_i = log relative risk sex-category i (men reference category)
γ_r = log relative risk regional mortality rate (Amsterdam reference category)
δ = log annual mortality decline (region Amsterdam)
δ_r = difference in annual mortality decline between region(r) and Amsterdam
T = year since 1875–1879 (0 for 1875–1879, 10 for 1885–1889, 20 for 1895–1899)

Regional mortality rate in 1875–1879 for men = $e^{\alpha+\gamma_r}$

Percentage regional mortality decline per decade = $(1 - e^{(\delta+\delta r).10})$ *100

In the case of infant mortality the population numbers were live births, and no distinction between the sexes could be made. In the case of early childhood mortality the population was the number of children aged 1–4 years by sex. The estimates for the logarithm of infant and early childhood mortality levels in the 27 regions for the 5-year intervals 1875–1879 ($\alpha+\gamma_r$) and 1895–1899 ($(\alpha+\gamma_r)+(\delta+\delta_r).20$) and the estimates for the logarithm of mortality decline in the period 1875–1879 to 1895–1899 ($\delta+\delta_r$) were used in a multivariate linear regression analysis in order to relate those estimates to the determinants of mortality (decline) used in this study. In order to determine whether the regional mortality rates and declines differed significantly, we performed a likelihood ratio test; all tests were significant. To present significant differences in rates and decline from Amsterdam for individual regions (i.e. γ_r and δ_r differs significantly from zero), results of T-tests will be presented.

Results

Regional variation in infant and early childhood mortality levels

Figure 2 shows maps for The Netherlands for the years 1875–1879 and 1895–1899 with regional differences in infant mortality levels. In Table 2 figures for the different towns and rural areas are given. In 1875–1879, *infant mortality* rates were higher in the south-west of The Netherlands compared to the north-east. However, in 1895–1899 there was a south-north difference. This change in geographical pattern can be explained by the slow decline (or even increase) in infant mortality in southern regions (Noord-Brabant, Limburg) (Table 2).

With respect to *early childhood* mortality levels (Figure 3), the geographical pattern for early childhood mortality shows an urban-rural division. Early childhood mortality levels are higher in towns compared to surrounding rural areas. In 1895–1899, this urban-rural gradient had for the largest part disappeared as a result of strong declines in the south-western towns compared to their surroundings (Table 2). In general, early childhood mortality declined more rapidly compared to infant mortality in the period 1875–1879 to 1895–1899 (Table 2).

Infant mortality rates in 1875–1879 and 1895–1899, and early childhood mortality rates in those years were strongly related (Table 3). High infant mortality rates in 1875–1879 were associated with rapid infant mortality declines. The same holds for early childhood mortality. Regions with rapid infant mortality declines were mostly the regions which also had a rapid decline in early childhood mortality.

Multivariate analyses of the association between determinants and (cause-specific) mortality (decline)

In Tables 4 and 5 results of the multivariate analyses are presented. The variables soil type urbanization, percentage Roman Catholic, wealth tax, and female labour participation have been analysed together in the regression model. With respect to *infant mortality* (Table 4), percentage Roman Catholics turned out to be significantly associated with higher infant mortality rates in 1875–1879, and this association became stronger in 1895–1899. Infant mortality, predominantly from convulsions and acute digestive disease, was associated with percentage Roman Catholic in both years. The stronger association of percentage Roman Catholic and high infant mortality from all causes in 1895–1899

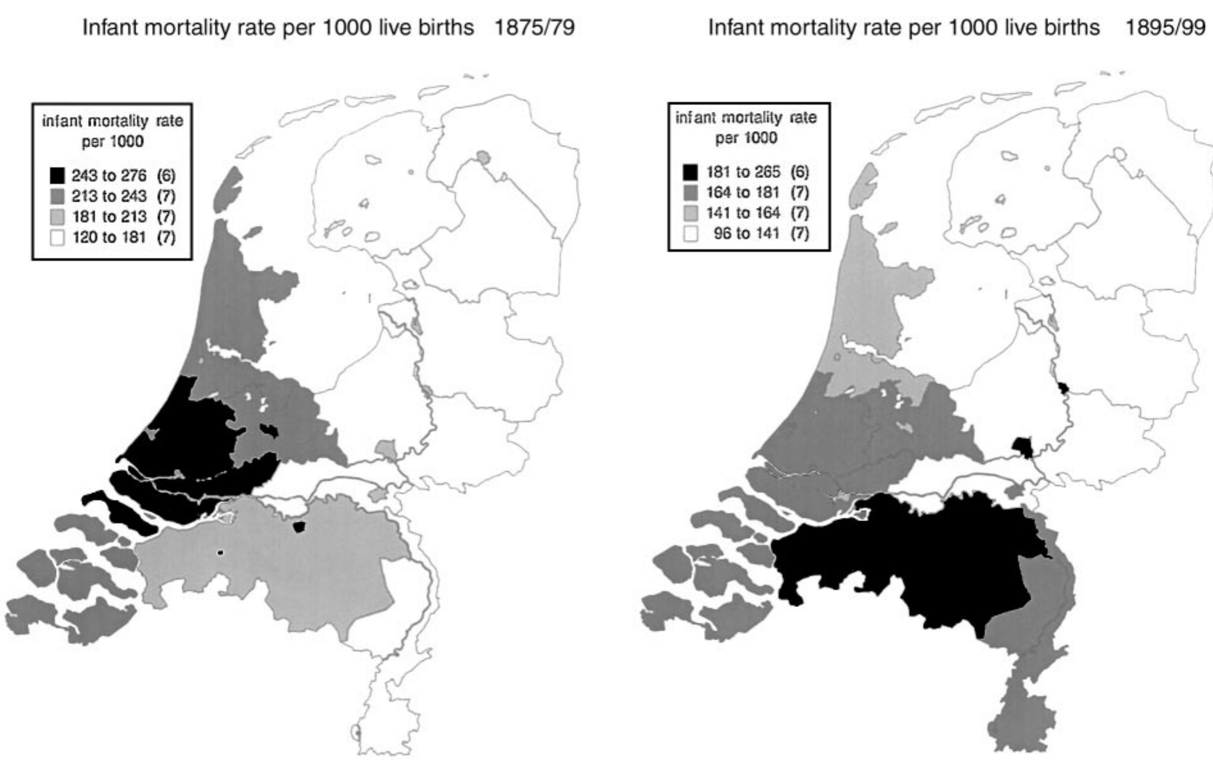

Figure 2 Regional differences in infant mortality levels, 1875–1879 and 1895–1899

Table 2 Poisson regression estimates of infant mortality (per 1000 live births) and early childhood mortality (per 1000 person-years) for males[a] in 1875–1879 and 1895–1899, and percentage infant and early childhood mortality decline per decade in the period 1875–1879 to 1895–1899

	Infant mortality			Early childhood mortality		
	Rate 1875–1879	Rate 1895–1899	% decline per decade	Rate 1875–1879	Rate 1895–1899	% decline per decade
Towns						
Amsterdam	216	152	16	44	23	27
Arnhem	186	183	1	30	23 ns	12
Breda	250	225	4	39	22 ns	25 ns
Deventer	187	170	5	40	23 ns	23 ns
Dordrecht	256	155ns	22	56	19	42
Groningen	197	119	22	36	19	27 ns
Haarlem	212 ns	150 ns	16 ns	31	20	19
's-Hertogenbosch	243	244	0	41 ns	30	14
Leeuwarden	167	115	17 ns	34	19	25 ns
Leiden	253	147 ns	23	56	19	41
Maastricht	215 ns	245	+7	51	24 ns	32
Nijmegen	204 ns	171	8	42 ns	23 ns	26 ns
Rotterdam	232	177	12	44 ns	21	30
's-Gravenhage	237	166	16 ns	31	20	19
Utrecht	248	163	19	40	22	26 ns
Zwolle	181	147 ns	10	45 ns	26	24 ns
Unweighted average towns	218	171	12	41	23	26
Rural areas of provinces						
Friesland	137	95	16 ns	27	14	26 ns
Groningen	135	110	9	25	16	21
Drenthe	120	111	4	29	17	16
Overijssel	137	124	5	33	21	20
Gelderland	146	137	3	26	19	14
Utrecht	224	173	12	27	20	13
Noord-Holland	213 ns	142	18	27	19	16
Zuid-Holland	276	170	21	34	20	22
Zeeland	219	165	13	25	14	25
Noord-Brabant	204	196	2	25	20	10
Limburg	146	159	+5	24	17	17
Unweighted average rural areas	178	144	9	27	18	18
Observed for The Netherlands	197	153	12	30	19	23

[a] Only the figures for males are given in this Table. Due to the nature of the model the relative differences between regions are the same for males and females.
+ = increase in mortality.
ns = the rate or % decline did not differ significantly from the value for Amsterdam ($P < 0.05$).

could be explained by the less rapid declines (or increases) in infant mortality in Roman Catholic regions (Noord-Brabant and Limburg) in the preceding decades. The variance explained by the variables in the model was larger for infant mortality levels in 1895–1899 compared to 1875–1879 (except for acute respiratory disease), and was the largest for infant mortality from convulsions in both years. The variance explained was larger in case of levels of infant mortality as compared to declines.

With respect to *early childhood mortality* (Table 5), urbanization was significantly associated with mortality from all causes, measles, encephalitis/meningitis and acute respiratory disease. Rural life was healthier compared to urban life in 1875–1879, and in 1895–1899. In 1895–1899 the association was, however, only significant for all-cause mortality and mortality from encephalitis/meningitis. In general, early childhood mortality declined significantly faster in cities compared to rural areas in the late 19th century, except for encephalitis/meningitis. Early childhood mortality declined less rapidly in Roman Catholic areas, just like the decline in infant mortality. This resulted in positive associations between infant mortality from all causes and from acute respiratory disease and Roman Catholicism.

The variance explained by the variables in the model for early childhood mortality was higher in 1875–1879 as compared to 1895–1899. The variables in the model explained most of the variance in early childhood mortality from encephalitis/meningitis. As far as early childhood mortality declines are concerned, the variables explained best the variance in acute respiratory disease mortality.

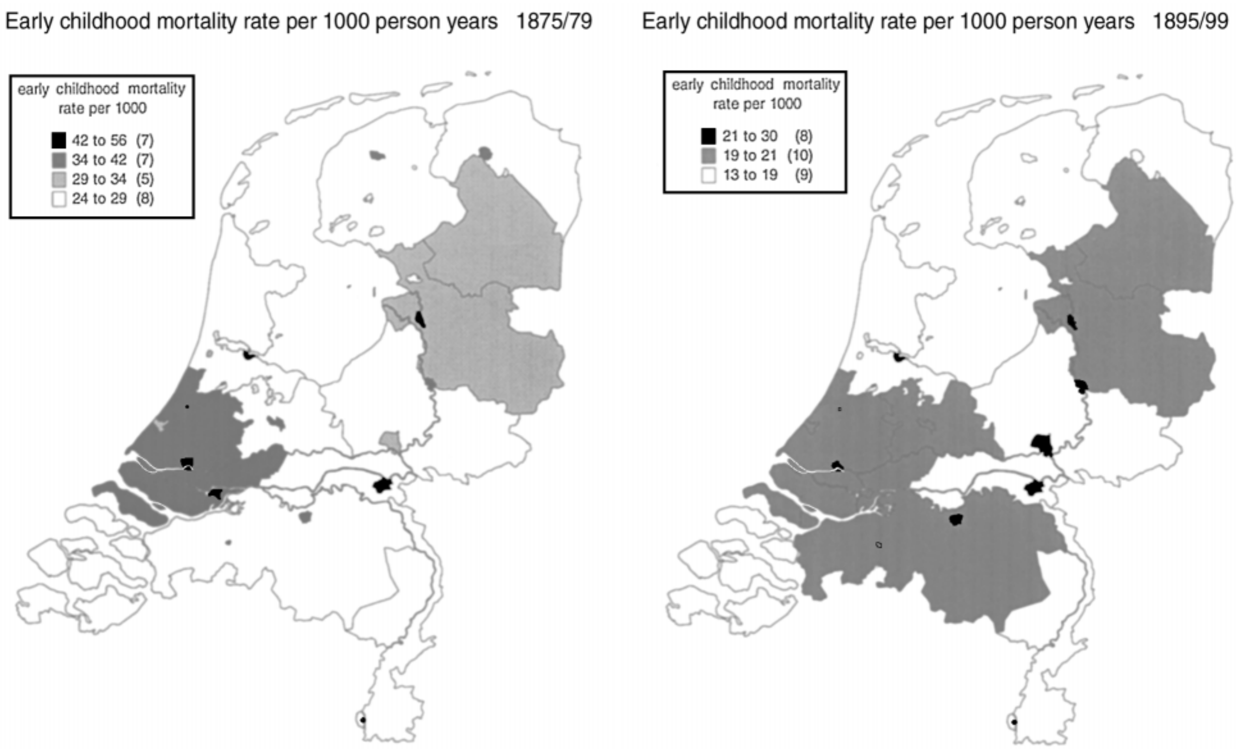

Figure 3 Regional differences in early childhood mortality levels, 1875–1879 and 1895–1899

Table 3 Pearson's correlation coefficients between infant and early childhood mortality levels and declines in 1875–1879, 1895–1899 and the period 1875–1879 to 1895–1899

	Infant mortality 1875–1879	Infant mortality 1895–1899	Infant mortality decline	Child mortality 1875–1879	Child mortality 1895–1899	Child mortality decline
Infant mortality 1875–1879	1.00	0.60**	–0.40*	0.52**	0.36	–0.37
Infant mortality 1895–1899		1.00	0.40*	0.32	0.69**	0.06
Infant mortality decline			1.00	–0.30	+0.33	0.50**
Child mortality 1875–1879				1.00	0.60**	–0.76**
Child mortality 1895–1899					1.00	0.07
Child mortality decline						1.00

* Significant at the 95% level.

**Significant at the 99% level.

– A high mortality level is associated with a low mortality level, or a high mortality level is correlated with (rapid) mortality decline.

Discussion

In the late 19th century, percentage Roman Catholics was significantly associated with all-cause infant mortality levels and their decline (particularly diarrhoeal disease); urbanization was most significantly associated with early childhood mortality levels and their decline (particularly respiratory disease).

Data and Methods

Cause-specific mortality data

In this study, specific causes of death were studied beside all-cause infant and early childhood mortality. The reliability of historical cause-specific mortality data has been the subject of much debate. As far as the causes of death studied in this paper are concerned, 'convulsions' is not a clearly defined cause of death. Convulsions might be a symptom of a variety of diseases with fever.[28] Others have argued that the category 'convulsions' mainly covered diarrhoeal disease with cramps.[29]

In the case of acute respiratory disease, confusion with tuberculosis and chronic respiratory disease has been suggested by several authors.[30] We do not consider this a big problem here because we only studied the age groups 0 and 1–4 years. This makes confusion with chronic respiratory disease and tuberculosis, causes of death occurring mostly at adult ages, less likely.

With respect to acute digestive disease, confusion with the vague cause-of-death category 'debility' has been reported in a 19th century Dutch article on health in several cities.[31] This suggests that in the case of acute digestive disease regional differences in coding or diagnosis existed in the late 19th century. Therefore, it should be kept in mind that part of the regional variation in the estimates of mortality from acute digestive disease in this study could be caused by differences in

Table 4 Multivariate analyses of level of distal determinants and (cause-specific) infant mortality levels and decline

	All causes	Convulsions	Acute respiratory disease	Acute digestive disease
Percentage change of infant mortality 1875–1879 per unit difference in the independent variables				
Sand soil (sand versus clay)	–18%	+4%	–11%	–57%
Urbanization (town versus rural area)	2%	23%	15%	–52%
% Roman Catholics (10 per cent points higher)	+3%*	+17%**	–0%	+13%*
Wealth tax (1 guilder per capita higher)	+8%	–2%	–4%	+44%*
% Female labour participation (1 per cent point higher)	–1%	–4%*	+1%	–2%
R^2	0.50	0.68	0.31	0.41
Percentage change of infant mortality 1895–1899 per unit difference in the independent variables				
Sand soil (sand versus clay)	–8%	+23%	–2%	–18%
Urbanization (town versus rural area)	–0%	42%*	4%	–29%
% Roman Catholics (10 per cent points higher)	+7%**	+18%**	+2%	+14%**
Wealth tax (1 guilder per capita higher)	+6%	–8%	+1%	+29%
% female labour participation (1 per cent point higher)	+0%	–4%	–0%	–1%
R^2	0.68	0.74	0.17	0.49
Change of percentage infant mortality decline per decade in 1875–1879 to 1895–1899 per unit difference in the independent variables (%)				
Sand soil (sand versus clay)	–6	–8	–6	–33*
Urbanization (town versus rural area)	+1	–17	+8	–6
% Roman Catholics (10 per cent points higher)	–2**	–1	–1	–0
Wealth tax (1 guilder per capita higher)	+1	+3	–4	+4
% female labour participation (1 per cent point higher)	–0	–0	+1	–0
R^2	0.58	0.25	0.30	0.34

* Significant at the 95% level.

**Significant at the 99% level.

+ An increase in mortality level, or a more rapid mortality decline.

– A decrease in mortality level, or a less rapid mortality decline.

registration. The association between infant mortality from acute digestive disease and percentage Roman Catholics is so strong that it is unlikely that incorrect coding can completely explain the association.

Regression models

The analysis of determinants of infant and early childhood mortality levels and their decline was conducted in two steps. First, regional mortality levels and declines were estimated using Poisson regression models. Second, those estimates were related to a set of independent variables in a multivariate linear regression analysis. By using the estimates of mortality decline in the multivariate regression analysis, the estimated declines are used as point-estimates. Information on the accuracy of the estimates of regional mortality levels and declines is lost in the second step of the analysis. In order to determine whether residual variation in the estimates was large, the average variation around the point estimates was expressed as a percentage of the variation between the point estimates. Residual variation was not very large in most cases. Considerable residual variation was present in case of infant mortality from acute respiratory disease in 1875–1879 and 1895–1899, for early childhood mortality from diphtheria in 1875–1879 and 1895–1899, and in case of early childhood mortality from acute respiratory disease and measles in 1895–1899.

If variables in a multivariate model are strongly correlated we cannot distinguish their associations with the dependent variable, i.e. mortality rate or decline. This is known as the multicollinearity problem. The variance-covariance matrices of the parameters of the models used in this study were calculated.[32] A relatively high correlation was found for urbanization and wealth tax (0.70) in 1875–1879 and 18959–1899.

Determinants of infant and early childhood mortality levels and decline

Percentage Roman Catholics

The percentage Roman Catholics was an important determinant of infant mortality (decline) in The Netherlands in 1875–1879 and 1895–1899 (Table 4). The association of percentage Roman Catholics and infant mortality became stronger over time, because infant mortality declined less rapidly in Roman Catholic regions in the period 1875–1879 to 1895–1899. Characteristics of Dutch Roman Catholic regions were the high level of marital fertility, the fact that Roman Catholics were less inclined to accept new ideas on disease processes and hygiene compared to Protestants (the Roman Catholic population has been described as strongly obedient to authorities, i.e. the Roman Catholic clergy), and, related to these characteristics, there was a strong adherence to folk medicine,[20,21] and a tendency not to breastfeed infants.[19] Two important changes occurred in the late 19th century among Dutch Catholics which are important in this respect. There was a change in attitude and habits regarding sexuality, also called a ‘shame complex’. There was a lot of emphasis on repressing physical and sexual urges, and as a

Table 5 Multivariate analyses of level of distal determinants and (cause-specific) early childhood mortality levels and decline

	All causes	Measles	Encephalitis/ meningitis	Acute respiratory disease
Percentage change of early childhood mortality 1875–1879 per unit difference in the independent variables				
Sand soil (sand versus clay)	–1%	+10%	–11%	–14%
Urbanization (town versus rural area)	42%**	74%**	61%**	39%**
% Roman Catholics (10 per cent points higher)	–1%	–6%	–4%	+1%
Wealth tax (1 guilder per capita higher)	–8%	–4%	–8%	–7%
% Female labour participation (1 per cent point higher)	+0%	–5%*	–0%	+0%
R^2	0.66	0.71	0.75	0.68
Percentage change of early childhood mortality 1895–1899 per unit difference in the independent variables				
Sand soil (sand versus clay)	+4%	–15%	–23%*	+10%
Urbanization (town versus rural area)	21%*	47%	45%**	15%
% Roman Catholics (10 per cent points higher)	+4%*	–15%**	+0%	+6%**
Wealth tax (1 guilder per capita higher)	–0%	–42%*	–1%	+14%
% female labour participation (1 per cent point higher)	–1%	+4%	–0%	–2%
R^2	0.53	0.41	0.81	0.52
Change of percentage early childhood mortality decline per decade in 1875–1879 to 1895–1899 per unit difference in the independent variables (%)				
Sand soil (sand versus clay)	–4	–7	+3	–12*
Urbanization (town versus rural area)	+15*	+38*	–16	+17*
% Roman Catholics (10 per cent points higher)	–2*	+5	–2*	–2*
Wealth tax (1 guilder per capita higher)	–4	–2	–2	–8*
% Female labour participation (1 per cent point higher)	+1	–2	–0	+1
R^2	0.47	0.45	0.33	0.57

* Significant at the 95% level.

**Significant at the 99% level.

+ An increase in mortality level, or a more rapid mortality decline.

– A decrease in mortality level, or a less rapid mortality decline.

result of that women had to cover their bodies completely, and breastfeeding (particularly intensive and long-term breastfeeding) was discouraged. This development started after 1850. A second change was the development of a 'social contamination complex', which made contact between Dutch Catholics and other groups increasingly problematic. This development occurred after 1865. The intellectual growth of Dutch Catholics was limited by the teachings of the church. In 1864 the Pope, in his encyclical 'Syllabus Errorum', renounced liberal and socialist ideology. This resulted in a very suspicious attitude towards new ideas including those in the area of medical care and public health.[19]

Convulsions and acute digestive disease were the causes of death most strongly related to the percentage Roman Catholics in a region. Acute digestive disease mortality was strongly related to marital fertility as well (results not shown). The association of infant mortality from acute digestive disease and Roman Catholic regions with high levels of marital fertility might be related to a common determinant viz. breastfeeding. Breastfeeding is related to longer birth intervals, and is beneficial for the infant: it is sterile and contains maternal antibodies.[33,34] There are, however, no data on breastfeeding available for the regions in this study.

Urbanization

There have been many publications on the deleterious effects of the urban environment on infant mortality. Infant mortality levels increase as a result of insanitory conditions in towns, in particular in summer where high mortality from diarrhoeal disease has been described (the urban-sanitary-diarrhoeal-effect) not only for England and Wales, but also for other European countries such as France and Sweden.[35,36]

In The Netherlands, however, urbanization was not a significant factor in infant mortality in the late 19th century, and acute digestive disease mortality was even lower in towns compared to rural areas (Table 4). Percentage Roman Catholics was an important determinant of infant mortality instead. Comparable findings have been reported for nearby Germany.[37,38] Others have reported that, in case of Germany, there was no clear urban-rural difference in infant mortality levels, but rather a regional difference.[13]

Early childhood mortality, on the other hand, was significantly higher in towns. In 1875–1879, mortality from encephalitis/meningitis, and measles and acute respiratory disease mortality were all significantly higher in towns compared to rural areas. Early childhood mortality from acute digestive disease (results not shown) was also higher in towns, but this association was not significant. The deleterious effect of urban life on early childhood health in The Netherlands seemed to act predominantly through airborne infectious disease instead of acute digestive disease. The urban-rural difference for early childhood mortality had diminished by 1895–1899. Mortality declined more rapidly in towns in the period 1875–1879 to 1895–1899, so rural and urban mortality levels converged, except for early childhood mortality from encephalitis/meningitis (Table 5). This convergence of urban and rural mortality is in concordance with findings for England and Wales, and the US during comparable periods of time.[9,11] In the US, mortality decline was most rapid in the, by then, ten largest cities, and has been related to the earlier introduction of all kinds of public health measures in those cities.[11] Simple correlations in another Dutch study have shown that towns which spent relatively more money on water supply and sewerage systems had relatively strong mortality declines (Swartsenburg, unpublished manuscript 1981).

Other determinants of infant and early childhood mortality

Research for England and Wales has shown that income was an important determinant of levels of infant mortality, but that it was less important in cases of infant mortality decline.[4,10] In our analyses, wealth tax was significantly associated with infant mortality from acute digestive disease in 1875–1879, but the association was not as expected (high tax levels were associated with high mortality rates). In the case of early childhood mortality, however, high tax levels (i.e. wealthy areas) were associated with significant lower mortality rates from measles in 1895–1899. Measles is a cause of death strongly related to living standards, especially nutrition, and probably also overcrowding.[39,40] As in England and Wales, we did not find a significant association of infant or early childhood mortality decline and wealth. Another study for The Netherlands has shown that wealth tax did not play a role in all-cause mortality decline in the late 19th century, but it did play a role in the early 20th century (Wolleswinkel-van den Bosch, submitted).

Female employment has been implicated as a possible determinant of infant mortality.[8,18] Simple correlations showed associations of high female employment levels with high infant mortality levels (results not shown). However, if other variables related to infant and childhood mortality were added to the model, female employment was, in most cases, associated with low infant (convulsions) and early childhood (measles) mortality (Table 4a,b). This suggests that the positive effect of female employment (increased household income) was more important than the negative effects (less breastfeeding or reduced child care) in The Netherlands in that period. The finding that, in particular, measles mortality was reduced in regions with high percentages of female labour participation fits in with the explanation of increased household income.

Conclusion

Cultural factors (percentage Roman Catholics) were predominantly associated with infant mortality and diarrhoeal disease. In cases of early childhood mortality on the other hand, urbanization played the most important role and was predominantly associated with acute respiratory disease. Different determinants of mortality (decline) played a role in both age groups, and they acted on different causes of death. Therefore, studies on the explanation of child mortality levels and decline should consider both age groups separately, as has also been argued in a recent publication on the decline of infant and child mortality in Europe.[41] With respect to determinants of infant mortality, the results for The Netherlands differed from the findings for England and Wales. Urbanization did not seem to play an important role in infant mortality (no 'urban-sanitary-diarrhoeal-effect'), but was important in case of early childhood mortality. A cultural factor, percentage Roman Catholics, was the key determinant for infant mortality. A lot of historical literature on infant mortality stems from England and Wales because of the abundance of data. These findings tend to shape our understanding of the determinants of infant mortality. However, those findings do not necessarily apply to other countries, as our results and others[11] have shown.

References

1 Mosley WH, Chen LC. An analytical framework for the study of child survival in developing countries. In: Mosley WH, Chen LC (eds). Child survival. Strategies for research. *Pop Dev Rev* 1984;**10(Suppl.):** 25–45.

2 McKeown TF. *The Modern Rise of Population*. London: Edward Arnold, 1976.

3 Szreter S. The importance of social intervention in Britain's mortality decline c. 1850–1914: a re-interpretation of the role of public health. *Social History of Medicine* 1988;**1:**5–37.

4 Woods RI, Watterson PA, Woodward JH. The causes of rapid infant mortality decline in England and Wales, 1861–1921. Part I. *Pop Studies* 1988;**42:**343–66.

5 Woods RI, Watterson PA, Woodward JH. The causes of rapid infant mortality decline in England and Wales, 1861–1921. Part II. *Pop Studies* 1989;**43:**113–32.

6 Williams N, Galley C. Urban-rural differentials in infant mortality in Victorian England. *Pop Studies* 1995;**49:**401–20.

7 Williams N. Death in its season: class, environment and the mortality of infants in nineteenth-century Sheffield. *Social History of Medicine* 1992;**5:**71–94.

8 Brändström A. The impact of female labour conditions on infant mortality: a case study of the parishes of Nedertorneå and Jokkmokk, 1800–96. *Social History of Medicine* 1988;**1:**329–58.

9 Watterson PA. Infant mortality by father's occupation from the 1911 census of England and Wales. *Demography* 1988;**25:**289–306.

10 Haines MR. Socio-economic differentials in infant and child mortality during mortality decline: England and Wales, 1890–1911. *Pop Studies* 1995;**49:**297–315.

11 Preston SH, Haines MR. *Fatal Years. Child Mortality in Late Nineteenth-century America*. Princeton: Princeton University Press, 1991.

12 Ewbank DC, Preston SH. Personal health behaviour and the decline in infant and child mortality: the United States, 1900–1930. In: Caldwell JC *et al*. (eds). *What We Know About Health Transition*. Series 1990, no.2, vol. I.

13 Vögele J. Urban infant mortality in imperial Germany. *Social History of Medicine* 1994;**7:**401–25.

14 Corsini CA, Viazzo PP (eds). *The Decline of Infant and Childhood Mortality. The European Experience: 1750–1990*. Dordrecht: Martinus Nijhoff Publishers, 1997.

15 Wolleswinkel-van den Bosch JH, Van Poppel FWA, Tabeau E, Mackenbach JP. Mortality decline in The Netherlands in the period 1850–1992: a turning point analysis. *Soc Sci Med* 1998; **47:**429–43.

16 Wolleswinkel-van den Bosch JH, Van Poppel FWA, Mackenbach JP. Reclassifying causes of death to study the epidemiologic transition in The Netherlands, 1875–1992. *Eur J Pop* 1996;**12:**327–61.

17 Blok L, De Meere JMM. Wealth, inequality in wealth and census-suffrage in mid-nineteenth century Netherlands. *Economic and Socio-historic Yearbook* 1978;**41:**175–290 [in Dutch].

18 Graham D. Female employment and infant mortality: some evidence from British towns, 1911, 1931 and 1951. *Continuity and Change* 1994; **2:**313–46.

19 Van Poppel FWA. Religion and health: Catholicism and regional mortality differences in nineteenth century Netherlands. *Social History of Medicine* 1992;**5:**229–53.

20 Philips JFR. *Health Services in Limburg. Growth and Acceptation 1850–1940*. Assen: Van Gorcum, 1980 [in Dutch].

21 Rutten WJMJ. Mortality and medicalisation. A regional analysis of mortality without medical treatment in The Netherlands (1870–1900). In: *Holland and Historical Demography.* Dordrecht: Historical Studies no. 16, 1985 [in Dutch].

22 Huck P. Infant mortality and living standards of English workers during the industrial revolution. *J Economic History* 1995;**55:**528–50.

23 Huck P. Infant mortality in nine industrial parishes in Northern England, 1813–1836. *Pop Studies* 1994;**48:**513–26.

24 Knippenberg H, De Pater B. *The Unification of The Netherlands. Increase in Scale and Integration since 1800*. Nijmegen: SUN, 1988 [in Dutch].

25 Van der Woude A, Hayami A, De Vries J (eds). *Urbanization in History. A Process of Dynamic Interactions*. Oxford: Clarendon Press, 1990, p.44.

26 Jobse-van Putten J. Self-supportion in spatial perspective. A cultural-historical comparison of regional divisions in The Netherlands. *Volkskundig Bulletin* 1990;**16:**21–47 [in Dutch].

27 Hofstee EW. *Short Demographic History of The Netherlands, 1800 Up to Now*. Haarlem: Fibula-Van Dishoeck, 1981 [in Dutch].

28 Hardy A. Diagnosis, death and diet: the case of London, 1750–1909. *Journal of Interdisciplinary History* 1988;**19:**387–401.

29 Kintner HJ. Classifying causes of death during the late nineteenth and early twentieth centuries: the case of German infant mortality. *Historical Methods* 1986;**19:**45–54.

30 Evers JCG. *Contribution to Population Studies of The Netherlands*. The Hague: Belinfante, 1882.

31 Onnen PW. The health status of twelve large cities in the Netherlands. *Geneeskundige Bladen* 1895;second series:237–64 [in Dutch].

32 Norusis MJ. *SPSS Base System Users Guide*. SPSS Inc., 1990.

33 Huffman S, Lamphere B. Breastfeeding performance and child survival. In: Mosley WH, Chen LC (eds). Child survival. Strategies for research. *Pop Dev Rev* 1984;**10(Suppl.):**93–116.

34 Palloni A, Millman S. The effects of breastfeeding and pace of child-bearing on mortality at early ages. *Demography* 1986;**23:**31–52.

35 Preston SH, Van der Walle E. Urban French mortality in the nineteenth century. *Pop Studies* 1978;**32:**275–97.

36 Nelson MC, Rogers J. Cleaning up the cities: application of the first comprehensive public health law in Sweden. *Scand J History* 1994; **19:**17–39.

37 Kintner HJ. Determinants of temporal and areal variation in infant mortality in Germany, 1871–1933. *Demography* 1988;**25:**597–609.

38 Kintner HJ. The impact of breastfeeding patterns on regional differences in infant mortality in Germany, 1910. *Eur J Pop* 1988;**2:**223–61.

39 Hardy A. *The Epidemic Streets. Infectious Disease and the Rise of Preventive Medicine, 1856–1900*. Oxford: Clarendon Press, 1993.

40 Aaby P, Bukh J, Lisse IM *et al*. Overcrowding and intensive exposure as determinants of measles mortality. *Am J Epidemiol* 1984;**120:**49–63.

41 Woods R, Williams N, Galley C. Differential mortality patterns among infants and other young children: The experience of England and Wales in the nineteenth century. In: Corsini CA, Viazzo PP (eds). *The Decline of Infant and Child Mortality. The European Experience: 1750–1990*. Dordrecht: Martinus Nijhoff Publishers, 1997, pp.57–73.