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The role of cultural and economic determinants in mortality decline in the Netherlands, 1875/1879–1920/1924: a regional analysis

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Abstract

The objective of this study was to determine the relative importance of cultural and economic factors in mortality decline in the Netherlands in the periods 1875/1879–1895/1899 and 1895/1899–1920/1924. Mortality data by region, age, sex and cause of death as well as population data were derived from Statistics Netherlands for the years 1875/1879, 1885/1889, 1895/1899, 1910/1914, 1920/1924. Regional mortality declines were estimated on the basis of Poisson regression models. In a multivariate analysis the estimated declines were associated with economic (wealth tax) and cultural variables (% Roman Catholics and secularisation) corrected for confounders (soiltype, urbanisation). In the period from 1875/1879–1895/1899, %Roman Catholics was significantly associated with all-cause mortality decline and with mortality decline from diseases other than infectious diseases. Mortality declined less rapidly in areas with a high percentage of Roman Catholics. Secularisation was significantly associated with infectious-disease mortality decline. In areas with a high percentage population without a religious affiliation, mortality declined more rapidly. In the period from 1895/1899 to 1920/1924, wealth tax was significantly associated with all-cause and infectious-disease mortality decline. Mortality declined more rapidly in wealthy areas. Intermediary factors in the relationship between cultural factors and mortality decline were fertility decline, but more importantly, the number of medical doctors per 100,000 inhabitants. No intermediary factors were found for the association between the economic variable and mortality decline. Cultural and economic factors both played an important role in mortality decline in The Netherlands, albeit in different periods of time. The analysis of intermediary factors suggests that the acceptance of new ideas on hygiene and disease processes was an important factor in the association between culture and mortality decline in the late 19th century.

Keywords: Mortality transition; Netherlands; History; Statistics

Introduction

Mortality started to decline rapidly in the Netherlands around 1875. Many other western populations have also experienced rapid mortality declines in the 19th century, although the timing was different between countries. The analogous experience in different countries led to the formulation of the demographic transition theory and the epidemiological transition theory. In both the demographic and epidemiological transition theory, mortality decline and shift in cause-of-death pattern have been related to 'modernisation'. (Chesnais, 1992; Omran, 1971). Modernisation encompasses processes of

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economic, political, social and cultural change in society. Socio-economic changes are, for example, industrialisation and specialisation. The percentage of people working in the agricultural sector decreased. Production became more and more mechanised and commercialised. Work became more specialised, which induced a differentiation of occupations and of education. During the modernisation process not only industrial productivity increased, but also consumption by the population. Cultural changes that characterise the modernisation process are, for example, rationalisation and secularisation. Secularisation refers to a diminishing influence of religious institutions in society. Related to this is rationalisation, which can be interpreted as an application of scientific knowledge in diverse areas of society (Goldscheider, 1971).

Overview of existing knowledge on determinants of mortality decline

Many studies addressed the issue of determinants of mortality decline. The focus of these studies was mostly on socio-economic changes of modernisation. The most well-known example is the work of McKeown, who considered improvements in living standards and particularly improvements in nutrition to be the most important factors in 19th and 20th centuries' mortality decline (McKeown & Record, 1962; McKeown, Record, & Turner, 1975). Other determinants through which an increase in living standards might have affected mortality decline are, for example, improvements in housing conditions, access to water supply systems, and access to medical care (Preston, 1975; Flegg, 1982; Kintner, 1998; McFarlane, 1989). Overcrowding was often associated with bad sanitary conditions and lack of ventilation. Water- and food-borne as well as airborne infectious diseases, such as typhus, typhoid fever, cholera, respiratory tuberculosis, and childhood diseases (measles, whooping cough, diphtheria) can be easily transmitted in overcrowded dwellings (Burnett, 1991).

Access to clean drinking water will affect mortality from water-borne infectious diseases, such as cholera, typhoid fever, diarrhoeal diseases, and dysentery. In the late 19th century, the construction of water supply systems was carried out by private enterprises in The Netherlands, and depended on the wealth and size of a town. Government interference began after the turn of the century. The Housing Act of 1901, for example, required access to water mains for every new building (Vogelzang, 1956).

The influence of medical doctors on mortality decline, with respect to curative care, was limited in the late 19th century. During the early decades of the 20th century more efficacious health care services became available, which was best exemplified by the hospital transformation from a nursing home for the indigent sick into an institution for the health of all (Van der Velden, 1996). It has been argued that medical doctors often served as agents of cultural and behavioural change in the late 19th century because they were intermediaries between the upper class and working class. Medical doctors could introduce to lower classes hygienic behaviour and childcare practices that had been accepted earlier by the upper classes (Kunitz, 1991). In the 19th century, medical doctors also played a significant role in the sanitary improvements (Houwaart, 1991).

Cultural processes of modernisation could influence health too. Secularisation and rationalisation can be related to an increased literacy, including an increased knowledge of disease processes and an increased openness to new ideas, for example with respect to (personal) hygiene (Hofstee, 1981; Ewbank & Preston, 1990; Preston & Haines, 1991; Vögele, 1994). Fertility decline, which is strongly related to infant and early childhood mortality decline, is also partly determined by culture. Sustained fertility decline requires 'moral acceptability' (Lesthaeghe & Wilson, 1986). Marital fertility predominantly affects infant and early childhood mortality. High parities and short birth intervals are associated with high infant and mortality levels (Van de Walle, 1986). Recently, cultural factors have received more attention in mortality research. Research which addresses the health transition, for instance, explicitly includes cultural factors such as rising female education, and declining fertility (Frenk, Bobadilla, Stern, Frejka, & Lozano, 1991; Cleland & Van Ginneken, 1988). Those studies are usually carried out for developing countries. In historical studies of developed countries, cultural factors are more and more mentioned as possibly important determinants of mortality (decline) (Preston & Haines, 1991; Vögele, 1994; Corsini & Viazzo, 1997).

Two other factors that can both be related to economic and cultural processes are urbanisation and, a specifically Dutch factor, soil type. Urbanisation is a factor in mortality decline that is both related to economic and cultural variables. In towns, there was more differentiation of occupations as compared to rural areas, and production was market-oriented. Urbanisation is often related to industrialisation, but there is not such a strong urban-industrial complex in The Netherlands compared to other western European countries (Knippenberg & De Pater, 1988). Towns were a melting pot of people with all kinds of socio-cultural backgrounds. Social relationships more easily crossed boundaries of kinship and traditional alliances (Van der Woude, Hayami, & de Vries, 1990). In such an environment new ideas on hygiene, disease processes and childcare, were more easily accepted than in rural areas. Towns had a better infrastructure than rural areas, including better access to education and medical care. Urbanisation can also have an effect on health independent of wealth or culture. In rural areas fresh food was more readily available, the price of milk was lower, the transport of food was less time consuming, and the quality of food was better. There were also negative health effects in towns. The high population density facilitated the transmission of, particularly airborne, infectious diseases (Woods, Watterson, & Woodward, 1988; Huck, 1995).

In The Netherlands, regions can be roughly divided into sandy regions and regions of mainly clay soil. The type of soil affected economic development of the region. The unfavourable sandy soil resulted in mixed farming (to spread risks) and inhabitants were more self-supportive as compared to the clay areas. In the clay regions, the economy was more market-oriented. (Jobse-van Putten, 1990) The market-oriented regions were also the more open-minded regions (regarding new ideas on disease processes and hygiene). Apart from economic or cultural associations, soil type could also affect mortality in other ways. Clay soil was more brackish than sandy soil, which made groundwater in those areas less suitable for drinking water. As a result, the more polluted surface water was used for drinking and cleaning. This in turn resulted in higher levels of mortality from waterborne infectious diseases. (Hofstee, 1981)

Research questions

The overview of determinants of mortality decline has shown that both socio-economic and cultural determinants have been studied in the past. However, historical studies in which both socio-economic and cultural factors are analysed in a multivariate design, and which address mortality *decline* instead of mortality levels are still scarce. The relative importance of the different aspects of modernization for mortality decline and whether this changed over time is not clear. Therefore, the following general research questions will be investigated in this study. First, what is the relative importance of socio-economic and cultural factors in mortality decline in The Netherlands, and second, did the relative importance of economic and cultural factors change over time.

Data and methods

Time periods and regions

Two time periods were used in this study to be able to analyse changes in time of the relative importance of economic and cultural aspects of modernization: 1875/1879–1895/1899 and 1895/1899–1920/1924. The first period encompasses the first decades of progressive mortality decline in The Netherlands. In the second period, mortality decline is well on its way. For example, infant mortality was declining by that time in all regions in The Netherlands (Wolleswinkel-van den Bosch, van Poppel, & Mackenbach, 1998). All-cause and cause-specific mortality data by age and sex were obtained from publications of the Dutch Home Office (which provided data for quinquennial periods) for the years 1875/1879, 1885/1889 and 1895/1899. Data for the years 1910/1914 and 1920/1924 were derived from annual publications of Statistics Netherlands.

Mortality data as well as data on explanatory variables were obtained for (by that time) 11 Dutch provinces and 16 towns (each having more than 20,000 inhabitants). The choice of these regions was determined by the availability of data for explanatory variables, and by the requirements for multivariate statistical models. The number of variables in a model should not exceed the square root of the points of observation (in this case 27) in order to yield valid model estimations. The selected towns have a distinct urban character. They have both a large population size and high population density. During the whole period under study those cities remained the largest cities in The Netherlands. Figures for 11 rural areas were calculated by subtracting the values for the 16 towns from the 11 provinces in which they were situated (Fig. 1).

Cause-specific mortality data

The causes of death were divided into two broad groups: 'infectious diseases' and 'other diseases'. The

Fig. 1. Map of The Netherlands with the regions selected for this study.

period from 1875/1879 to 1920/1924 covers one 19th-century cause-of-death classification and three editions of the International Classification of Diseases and Causes of Death. Therefore cause-of-death groups had to be reclassified into the different classifications in order to create nosologically continuous cause-of-death groups over time. A detailed description of the reclassification procedure has been published elsewhere. (Wolleswinkel-van den Bosch, van Poppel, & Mackenbach, 1996). The following causes of death from the 19th-century classification are included in the group 'infectious diseases': syphilis, abscess/ulcer/pyemia, typhus/typhoid fever, continuous fever, malaria, smallpox, scarlet fever, measles, diseases of the skin (i.e. mainly erysipelas), convulsions, diseases of the nervous system (i.e. mainly tuberculous meningitis, other meningitis and encephalitis), respiratory tuberculosis, diphtheria/croup, whooping cough, acute respiratory diseases, diarrhoea/dysentery, cholera and puerperal fever. The group 'other diseases' includes all other causes of death.

However, it is conceivable that exchanges took place between categories of infectious diseases and other diseases. For example, exchanges might have taken place between respiratory tuberculosis (infectious diseases) and chronic respiratory diseases (other diseases), or acute respiratory diseases (infectious diseases) and chronic respiratory diseases (other diseases). Some researchers mentioned the possibility of such exchanges in the Dutch literature, but others did not consider this to be a major problem. (Evers, 1882; Van Vollenhoven, 1889)

Exchanges like these would have affected the results of the analyses if the inaccuracies in coding were differential between the regions. In other words, in some regions, certain coding inaccuracies occurred only or significantly more than in other regions. If the coding inaccuracies were non-differential between regions, the estimates of the infectious disease and 'other diseases' mortality decline would be inaccurate, but the analysis of regional differences in mortality decline would not be affected.

There is not much literature about regional differences in coding. Onnen (1895) mentioned the occurrence of exchanges between the categories 'debility' (a 19th-century cause-of-death category consisting predominantly of infant and early childhood diseases, and old age) and acute digestive diseases. The 'debility'-category is included in the 'other diseases' group in this analysis, while acute digestive diseases are included in the infectious-diseases group. Onnen's paper shows that mortality from 'debility' and acute digestive diseases fluctuated strongly in several large towns in The Netherlands in the periods 1880/1885 and 1885/1890. Such fluctuations over time within towns will lead to less accurate estimations of mortality decline from that specific cause of death. However, this paper only includes results for the broad groups 'infectious diseases' and 'other diseases', which will have reduced the effect of those inaccuracies on the results of the analyses in this paper.

Operationalisation of the determinants

The two aspects of modernisation studied in this paper, economic and cultural factors, are operationalised as follows. The economic aspect is operationalised with an indicator of wealth, viz. the wealth tax (in guilders per capita). This tax consisted of six components: tax on rental value of houses and other buildings, tax on the number of 'doors and windows connected to open air', tax on the number of fireplaces, tax on furniture, tax on servants and maids, and tax on horses (Blok & De Meere, 1978).

The cultural aspect is much more difficult to study, which probably explains the relatively minor attention for such factors. Culture can be defined as the set of beliefs and attitudes shared by a group of people. Attitudes and beliefs are hard to measure, even more so in a historical setting and at aggregate level. There are, however, variables that can be used as cultural indicators at an aggregate level. A specific religious group, for example, shares sets of beliefs and attitudes. In The Netherlands there is a clear regional distinction between Roman Catholics and Protestants. Roman Catholics were less inclined to accept new ideas on disease processes and hygiene in comparison to Protestants (Philips, 1980). Others described the Roman Catholic population (in particular those that lived in rural areas) as being very obedient to authorities, living within the bonds set by the Roman Catholic clergy (Wichers, 1965). Related to these characteristics are the strong adherence to folk medicine (Philips, 1980; Rutten, 1985), the tendency not to breastfeed infants, and the (persistence of) high fertility rates among Roman Catholics (Van Poppel, 1992). There were also differences in school attendance between Catholics and Protestants. In the 1880s and 1920s Dutch Catholic children were underrepresented in the more modern secondary schooling system. Among children in Catholic gymnasial schools the dropout rate was much higher than in Protestant schools, indicating that within Roman Catholic families finishing the education was less important than among the Protestants (Mandemakers, 1996). Mortality differences between Roman Catholics and Protestants have also been observed (a high percentage of Roman Catholics is related to high mortality levels) (Van Poppel, 1992).

Another way in which the cultural aspect of mortality can be operationalised is through secularisation. A measure for secularisation is the increasing non-adherence to a religious denomination. Both cultural variables, Roman Catholics (the percentage of population with a 'Roman Catholic' affiliation) and secularisation (the percentage of population without religious affiliation).

The effect on mortality decline of the economic (wealth) and cultural variables (secularisation and Roman Catholicism) is indirect. The association with mortality decline is mediated by other determinants of mortality decline, which are more closely related to mortality. Wealth can influence health by improvements at household level, such as better food or housing and access to medical care, but wealth can also have a beneficial effect on health because of increased government expenditure on, for example, water supply systems and sewage systems. The association between secularisation or Roman Catholicism and mortality decline is mediated by behavioural factors such as breastfeeding practices, school attendance, marital fertility, and medical consumption. The intermediate determinants used in this study are the number of persons per dwelling, population percentage with access to water supply system, medical doctor density and marital fertility.

Two other variables that could confound the association between the economic (wealth) and cultural (Roman Catholicism and secularisation) variables and mortality decline were taken into account in the analyses, viz. soil type and urbanisation. These variables are both related to socio-economic and cultural variables, but beside that they can also have an independent effect on mortality (cf. 'overview of determinants').

The indirect determinants are called in this paper 'distal determinants' of mortality; the intermediary determinants are called 'proximate determinants' of mortality because they are more closely related to mortality. Table 1 presents the variables used in the analyses in this study, their parameterisation, the years under study and data source. In Table 2 the range of the values of wealth tax, Roman Catholicism and secularisation are given.

Statistical model

The pace of mortality decline in the regions was estimated on the basis of a log-linear regression analysis. The model used is described below.

$$E(y_{ijrt}) = N_{ijrt}e^{\alpha+\beta_i+\gamma_j+(\varepsilon+\varepsilon_r)\mathrm{T}},$$

where $E(y_{ijrt})$ is the expected number of deaths per age group (i), sex (j), region (r) and quinquennium (t), N_{ijrt}

Table 1
Distal and proximate determinants used in the analyses: parameterisation, data source and years

	Parameterisation	Data source	Years in analysis
Distal determinants			
Soil type	Region consists predominantly of sandy soil: yes/no	Grote Bosatlas (1968)	1875/1879, 1895/1899
Urbanisation	Region is rural area: yes/no	See Fig. 1	1875/1879, 1895/1899
Wealth	Wealth tax in guilders per capita	Historical ecological database (HED)[a]	1875/1879, 1895/1899
Roman Catholicism	Percentage population with 'Roman Catholic' as religious affiliation	HED	1875/1879, 1895/1899
Secularisation	Percentage population without religious affiliation	HED	1875/1879, 1895/1899
Proximate determinants			
Marital fertility	Ig-index[b]	Calculated on the basis of figures derived from the HED and Lesthaeghe (1977)	1875/1879, 1885/1889, 1895/1899, 1910/1914, 1920/1924
Housing conditions	Number of persons per dwelling	Bijdragen tot de Statistiek van Nederland (CBS 1879, 1889, 1899, 1910, 1920)	1875, 1889, 1899, 1910, 1920
Clean drinking water	Percentage of population living in town with piped water	De Grootte, 1995	1879, 1889, 1899, 1914
Medical care	Number of medical doctors per 100,000 inhabitants	Verslagen aan de koningin (1875–1923)	1875/1879, 1885/1889, 1895/1899, 1923

[a] The historical-ecological database is managed by Stichting Beleidsondersteunend Ruimtelijk Onderzoek (BRON) which is related to the University of Amsterdam.

[b] The Ig-index is a standardized ratio of the annual number of legitimate live births to the number of legitimate live births that would occur to married women in each of the child-bearing age groups (ages 15–49), if they were subject to natural fertility (i.e. age-specific marital fertility rates of the Hutterite population (=standard)). (Lesthaeghe, 1977).

Table 2
Range of the values of the cultural and economic variables

	Percentage population Roman Catholics		Percentage population without religious affiliation		Wealth tax guilders per capita	
	1875/1879	1895/1899	1875/1879	1895/1899	1875/1879	1895/1899
Mean	38.1	37.5	0.4	2.2	2.6	2.3
Max	98.5	98.3	1.2	7.9	5.4	4.3
Min	5.2	4.8	0.0	0.0	0.7	0.8

the population numbers per age group, sex, region and quinquennium, α the intercept (i.e. log regional mortality rate 1875/1879, men, age 0, region Amsterdam), β_i the log relative risk sex category i (men reference category), γ_j the log relative risk age category j (age 0 reference category), δ_r the log relative risk regional mortality rate (Amsterdam reference category), ε the log annual mortality decline (region Amsterdam), ε_r the difference in annual mortality decline between region (r) and Amsterdam, T the year since 1875/1879 (0 for 1875/1879, 10 for 1885/1889, 20 for 1895/1899), $(1-\mathrm{e}^{(\varepsilon+\varepsilon r)\times 10})\times 100$ the percentage regional mortality decline per decade.

Mortality declines were estimated for two periods: 1875/1879–1895/1899 and 1895/1899–1920/1924. The same model as described above was used for the second period with 1895/1899 as $T=0$. The estimates for the logarithm of mortality decline in the 27 regions $(\varepsilon+\varepsilon_r)$ were used in a multivariate linear regression analysis in order to relate mortality decline to cultural (percentage of Roman Catholics or percentage of people without religious affiliation) and economic (wealth tax) variables corrected for possibly confounding factors.

The level of wealth, and the percentages for secularisation or Roman Catholicism at the onset of a period of decline were related to mortality decline in that specific period. Wealth and Roman Catholicism or secularisation were considered to be variables of which no immediate effect on mortality was expected, but which would induce change in more proximate variables of mortality. The next step in the analyses was to add the more proximate determinants of mortality decline to the multivariate model. In doing so, we tried to determine which factors mediated between the cultural and economic associations (if present) and mortality decline, and whether the proximate factors showed an independent significant association with mortality decline. The proximate variables were expected to have an immediate effect on mortality. Therefore, absolute change in the proximate variables in the period under study was related to change in mortality (i.e. mortality decline). Results of the multivariate analyses are presented for all-cause mortality, infectious-disease mortality and 'other' causes of death.

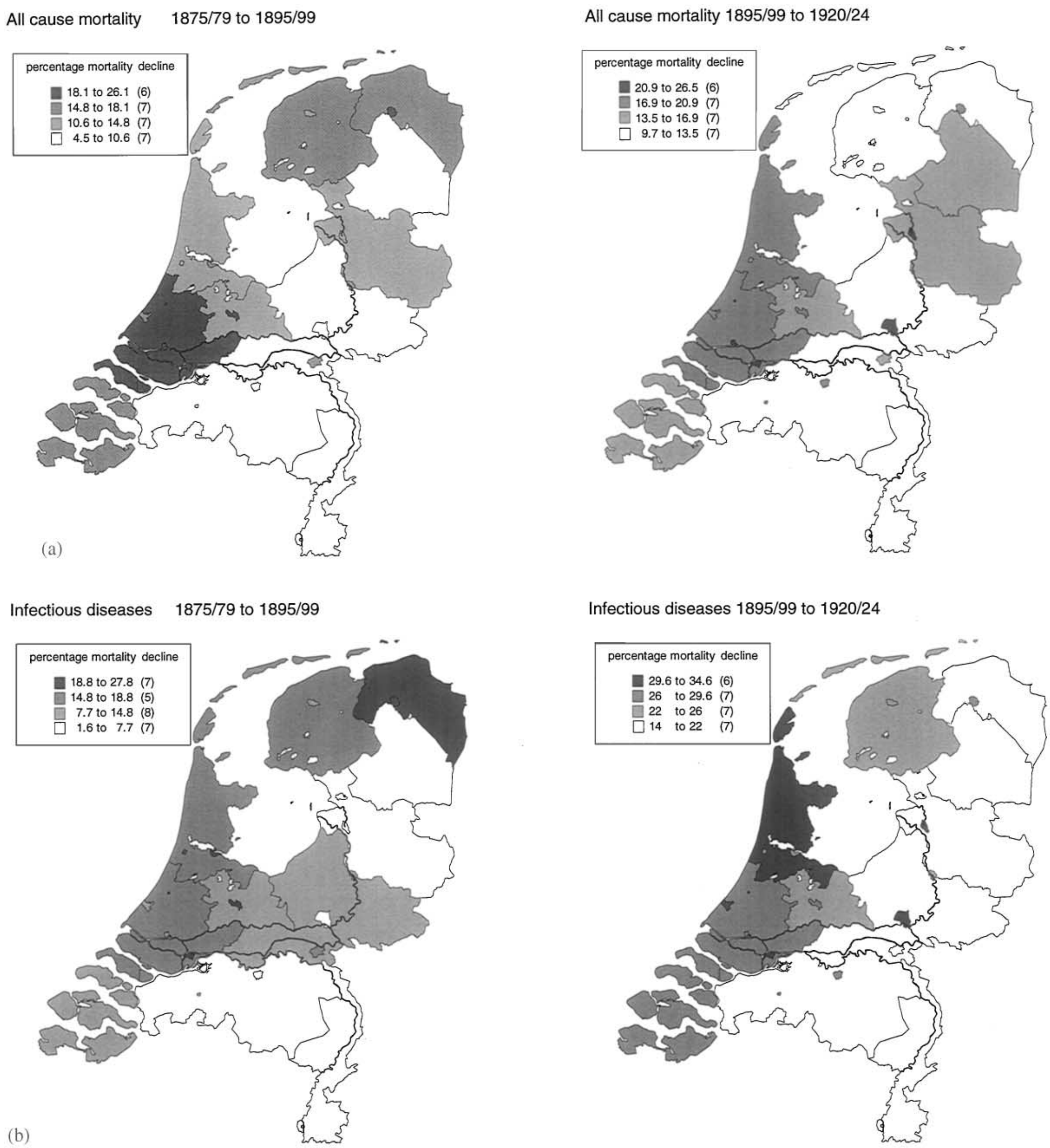
In order to determine whether the regional mortality declines differed significantly, we performed a likelihood ratio test; all tests were significant. To present significant differences in decline from Amsterdam for individual regions (i.e. ε_r differs significantly from zero), results of T-tests will be presented.

Results

Regional variation in mortality decline

Fig. 2 shows the regional differences in all-cause, infectious-disease, and 'other disease' mortality decline in the periods from 1875/1879 to 1895/1899 and from 1895/1899 to 1920/1924. Exact figures are provided in Table 3. The first period is characterised by rapid declines in the rural areas of the south-western provinces (Zuid-Holland, Zeeland) and northern provinces (Friesland, Groningen) of The Netherlands. Mortality declines are slow in the rural areas and most towns in the southern provinces (Noord-Brabant, Limburg) and eastern provinces (Gelderland, Drenthe). In many provinces, mortality declines were equally rapid in towns and rural areas in the period from 1875/1879 to 1895/1899. With respect to infectious-disease mortality decline in this period, a similar pattern to that for total mortality decline could be observed i.e. more rapid declines in the south-western and northern parts of The Netherlands. The declines seem to be more rapid in towns as compared to rural areas. In the case of 'other diseases', declines were most rapid in the rural areas and towns of Zuid-Holland and Overijssel.

In all regions, the pace of all-cause mortality decline was more rapid in the early decades of the 20th century than in the late 19th century (Fig. 2 and Table 3). This was especially due to rapid infectious-disease mortality declines. The pace of decline of 'other diseases' mortality did not accelerate. The regional pattern changed compared to the former period. The northern provinces, for example, no longer show the relatively rapid declines. As for all-cause mortality, declines seem to be more rapid in towns compared to their rural surroundings in the period from 1895/1899 to 1920/1924.



Remarkable are the rapid decline of infectious-disease mortality in the rural areas of the province of Noord-Holland and the rapid decline of 'other-diseases' mortality in the eastern provinces of Gelderland, Overijssel and particularly Drenthe.

Relationship between mortality level and mortality decline

Fig. 2 shows the differences in mortality decline in the periods from 1875/1879 to 1895/1899 and from 1895/1899 to 1920/1924. It could be that regions with the most rapid mortality declines were also the regions with the highest mortality levels at the onset of a period of decline. Mortality levels might have been high in urban areas due to, among other things bad sanitation, but mortality could also decline more rapidly in those areas due to, for example, early fertility declines or early introduction of water supply systems. Correlation coefficients were calculated for the logarithm of regional levels of mortality ($\alpha + \gamma_r$ in the Poisson-regression model) at the onset of a period of decline and the logarithm of regional mortality declines ($\varepsilon + \varepsilon_r$) in that

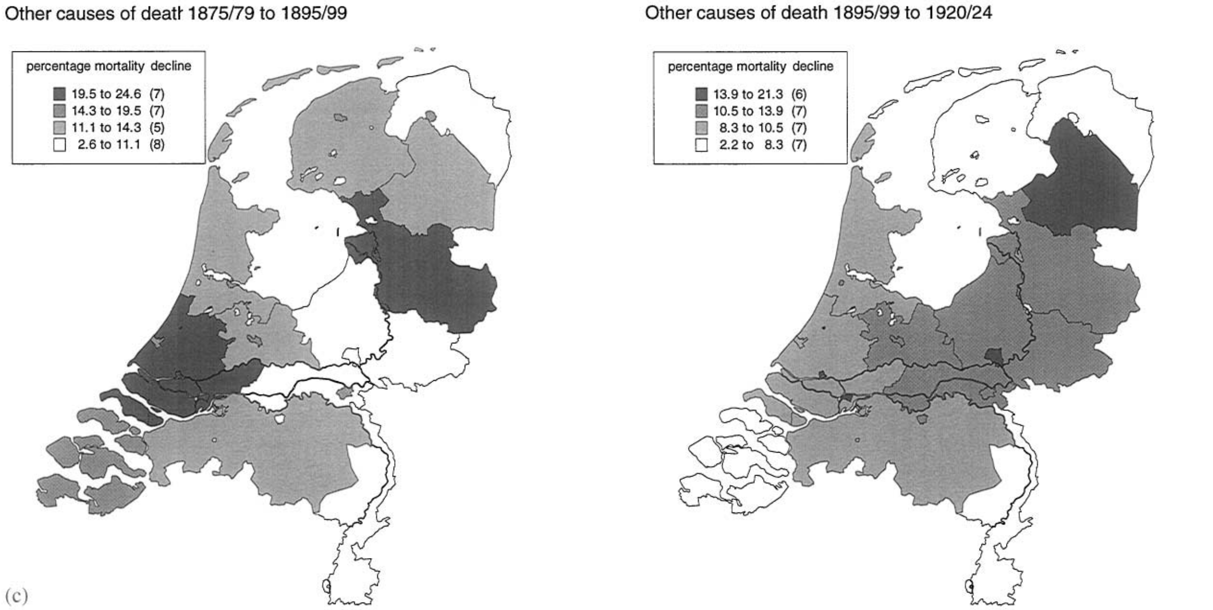


Fig. 2. (a) Percentage all-cause mortality decline per decade, 1875/1879–1895/1899 and 1895/1899–1920/1924. (b) Percentage infectious disease mortality decline per decade, 1875/1879–1895/1899 and 1895/1899–1920/1924. (c) Percentage mortality decline from other diseases than infectious diseases per decade, 1875/1879–1895/1899 and 1895/1899–1920/1924.

period. A significant association (95% level) between levels and decline was found for the period 1875/1879–1895/1899 (−0.49), but not for the period 1895/1899 to 1920/1924 (−0.36). In the period 1875/1879–1895/1899, areas with the highest mortality in 1875/1879 tended to show the most rapid mortality declines.

In order to find out whether regions with relatively high mortality levels still had relatively high mortality levels at the end of a period of decline, correlation coefficients were calculated for mortality levels in 1875/1879 and 1895/1899, and in 1895/1899 and 1920/1924. Both correlation coefficients were significant at the 95% level (0.53 and 0.79, respectively). The correlation between mortality levels in 1875/1879 and 1895/1899 was less strong as compared to 1895/1899 and 1920/1924. Certain towns with the highest mortality in 1875/1879, e.g. Leiden and Dordrecht, showed low mortality levels in 1895/1899.

Multivariate analysis of cultural and economic determinants of mortality decline

Table 4 shows the results of the multivariate analyses to study the relative importance of cultural and economic determinants of mortality decline. The economic and cultural variables were analysed together corrected for confounding variables. Separate analyses were conducted for the variables Roman Catholicism or secularisation. In case of all-cause and 'other-disease' mortality decline, the variable Roman Catholicism showed a significant association. The association for mortality decline from other diseases was somewhat stronger than that for infectious diseases. Secularisation showed a significant association in the case of infectious-disease mortality decline. This association was less significant than the association between Roman Catholicism and mortality decline. In the period from 1895/1899 to 1920/1924 the wealth indicator, wealth tax, is the most important factor in all-cause and infectious-diseases mortality decline. The association was strongest for infectious-disease mortality.

The variables in the model with respect to the percentage of Roman Catholics explained 50% of the variation in total mortality decline, 55% of the variance in mortality decline from infectious diseases, and 28% of mortality decline from 'other diseases' in the period from 1875/1879 to 1895/1899. When the percentage for people without religious affiliation was used as cultural variable, the percentage variance decreased in case of all-cause and 'other-disease' mortality decline. In the models for the period from 1895/1899 to 1920/1924 the percentages variance explained were about similar.

Analysis of intermediary factors in the associations of economic and cultural variables with mortality decline

Besides the distal variables wealth tax and percentages of Roman Catholics or people without religious affiliation, there are more proximate determinants of mortality decline, e.g. housing conditions, medical doctor

Table 3
Poisson regression estimates of percentage mortality decline per decade 1875/1879–1895/1899 and 1895/1899–1920/1924. 16 towns and 11 rural areas (= provinces minus selected towns). All-cause mortality, infectious disease mortality and mortality from other causes of death[a]

	All-cause mortality		Infectious diseases		Other causes of death	
	1875/1879–1895/1899	1895/1899–1920/1924	1875/1879–1895/1899	1895/1899–1920/1924	1875/1879–1895/1899	1895/1899–1920/1924
Towns						
Amsterdam	17.6	16.2	19.6	24.8	15.2	8.9
Arnhem	4.5	23.0	6.3	32.5	2.6	16.1
Breda	8.9	18.1-ns	10.7	28.5-ns	7.3	9.8-ns
Deventer	15.5-ns	12.9	7.7	24.2-ns	24.6	2.2
Dordrecht	24.1	26.5	23.6	33.9	24.3	21.3
Groningen	18.7-ns	16.9-ns	21.2-ns	28.6-ns	15.3-ns	7.6-ns
Haarlem	13.2	16.7-ns	19.1	24.7	6.8	10.9-ns
‘s-Hertogenbosch	4.9	20.8	5.9	28.5	4.2	13.2
Leeuwarden	14.2	13.3	14.4	24.1-ns	14.3-ns	6.5-ns
Leiden	26.1	20.9	27.8	30.8	24.5	13.9
Maastricht	10.6	21.5	17.4-ns	22.5-ns	3.4	20.4
Nijmegen	16.0-ns	13.5	17.6-ns	14.4	14.3-ns	12.7
Rotterdam	18.1	20.9	13.4	28.0	22.5	14.5
‘s-Gravenhage	16.2	17.9	13.3	29.6	19.1	8.7-ns
Utrecht	18.5-ns	18.8	18.8-ns	26.0-ns	18.1	12.6
Zwolle	10.7	20.9	3.5	34.6	19.5	8.3-ns
Rural areas of provinces						
Friesland	14.8	11.8	17.7	22.3	12.3	5.3
Groningen	15.1	11.7	20.4-ns	18.8	9.0	5.9
Drenthe	8.2	15.9-ns	4.9	16.9	11.1	15.1
Overijssel	11.8	16.5-ns	4.1	21.2	19.9	11.6
Gelderland	8.8	12.3	8.2	14.0	9.4	10.9
Utrecht	11.8	15.7-ns	9.6	22.0	13.8-ns	10.5-ns
Noord-Holland	14.4	19.7	15.1	31.1	13.1	10.3
Zuid-Holland	18.7	17.9	14.8	27.5	22.5	10.1-ns
Zeeland	16.9-ns	16.3-ns	14.4	28.2	19.3	6.7
Noord-Brabant	7.1	11.7	1.6	14.7	11.4	9.3-ns
Limburg	6.2	9.7	2.6	14.3	9.4	5.6

[a] ns means that the decline in that region differed not significantly from the decline in Amsterdam.

density, access to clean drinking water and marital fertility. These determinants might mediate the association between the above-mentioned cultural and economic determinants and mortality decline. The proximate determinants might also have an independent significant association with mortality decline.

The addition of absolute change in marital fertility to the model, as presented in Table 4, reduced the association between the percentage of Roman Catholics and mortality decline in the period from 1875/1879 to 1895/1899 by 12% (Table 5a). An increase in marital fertility was related to a less rapid mortality decline. The number of persons per dwelling also turned out to be a mediator between the association of Roman Catholics with total mortality decline. Changing the number of persons per dwelling in the model also reduced the association between percentage of Roman Catholics and mortality decline by 12%. An increase in the number of persons per dwelling was related to less rapid mortality decline. A third proximate determinant that mediated the association between percentage of Roman Catholics and mortality decline was medical doctor density. The addition of this variable to the model reduced the association by 24%. However, an increase in the number of medical doctors per 100,000 inhabitants was associated with less rapid mortality decline whereas an association with more rapid mortality decline was expected.

With respect to infectious-disease mortality, marital fertility and medical doctor density (both 18% reduction) mediated the cultural association. For mortality decline from diseases other than infectious diseases,

Table 4
Association between level of economic variables (wealth tax) and cultural variables (% Roman Catholics or % without religious affiliation) in the periods 1875/1879–1895/1899 and mortality decline in the periods 1875/1879–1895/1899 and 1895/1899–1920/1924. Multivariate analysis with urbanisation and soil type as confounding variables[a]

	Change of percentage of mortality decline per decade per unit difference in the independent variable (in percent points)		
	All-cause mortality	Infectious diseases	Other causes of death
1875/1879–1895/1899			
Wealth tax *(1 guilder per capita higher)*	−0.8	−1.3	−0.4
% Roman Catholics *(10% points higher)*	−0.9[b]	−0.6	−1.3[b]
R^2	0.50	0.55	0.28
Wealth tax *(1 guilder per capita higher)*	−0.3	−1.1	+0.4
% Without religious affiliation (instead of % Roman Catholics) *(1% point higher)*	+3.7	+7.6[c]	−0.5
R^2	0.34	0.57	0.03
1895/1899–1920/1924			
Wealth tax *(1 guilder per capita higher)*	+3.3[c]	+5.9[b]	+1.6
% Roman Catholics *(10% points higher)*	+0.0	−0.0	+0.3
R^2	0.41	0.56	0.14
Wealth tax *(1 guilder per capita higher)*	+3.5[c]	+6.4[b]	+1.5
% Without religious affiliation (instead of % Roman Catholics) *(1% point higher)*	−0.6	+0.0	−0.9[c]
R^2	0.47	0.52	0.24

[a] + Means more rapid decline, −means less rapid decline.
[b] At the 99% level.
[c] Means significance at the 95% level.

changes in the number of persons per dwelling in medical doctor density reduced the cultural associations by 11 and 18%, respectively in the period from 1875/1879 to 1895/1899. The same contra-intuitive association between medical doctor density and mortality decline was found for infectious-disease mortality decline and mortality decline from diseases other than infectious diseases.

With respect to the period from 1895/1899 to 1920/1924 (Table 5b), in which wealth tax turned out to be an important determinant of all-cause and infectious-disease mortality decline, none of the proximate variables seemed to be an intermediate for the association between tax and mortality decline. The addition of medical doctor density made the association even stronger.

Independent significant associations of proximate determinants and mortality decline were found neither in the period from 1875/1879 to 1895/1899 nor in the period from 1895/1899 to 1920/1924.

Discussion and conclusions

Cultural and economic factors played a role in mortality decline in The Netherlands in the late 19th and early 20th centuries. Cultural factors were relatively more important in the late 19th century and economic factors in the early 20th century. Factors that mediated the relationship between the cultural factor and mortality decline seem to be changes in marital fertility, persons per dwelling, and medical doctor density. Intermediary factors could not be identified for the association between tax and total or infectious-disease mortality decline. Before these results will be discussed, some comments on the statistical model will be made first.

Statistical model

The analysis of the relative importance of cultural and economic determinants in mortality decline was

Table 5
Analysis of intermediary factors (proximate determinants) in the significant associations between percentage of Roman Catholics, percentage without religious affiliation, and wealth tax and mortality decline[a]

	Change of percentage mortality decline per decade per unit difference in the independent variables (in percent points)		
	All causes	Infectious diseases	Other causes of death
(a) *Period: 1875/1879–1895/1899*			
Percentage of Roman Catholics *(10% points higher)*			
Confounders only (wealth tax, urbanisation, soil type)	−0.94[b]	No significant association	−1.29[b]
Confounders + marital fertility	−0.83[c]		−1.26[c]
Confounders + persons per dwelling	−0.83[c]		−1.15[c]
Confounders + access to water supply system	−0.94[b]		−1.30[b]
Confounders + medical doctor density	−0.71[c]		−1.06[c]
Percentage without religious affiliation *(1% point higher)*			
Confounders only (wealth tax, urbanisation, soil type)	No significant association	+7.60[c]	No significant association
Confounders + marital fertility		+6.20	
Confounders + persons per dwelling		+8.00[c]	
Confounders + access to water supply system		+7.55	
Confounders + medical doctor density		+6.20	
Wealth tax *(1 guilder higher)*			
Confounders only (Roman Catholics, urbanisation, soil type)	No significant association	No significant association	No significant association
(b) *Period 1895/1899–1920/1924*			
Wealth tax *(1 guilder higher)*			
Confounders only (Roman Catholics, urbanisation, soil type)	+3.3[c]	+5.9[b]	No significant association
Confounders + marital fertility	+3.2[c]	+5.7[b]	
Confounders + persons per dwelling	+3.3[c]	+5.9[b]	
Confounders + access to water supply system	+3.3[c]	+5.9[b]	
Confounders + medical doctor density	+4.1[b]	+6.7[b]	
Percentage of Roman Catholics *(105 points increase)*			
Confounders only (wealth tax, urbanisation, soil type)	No significant association	No significant association	No significant association
Percentage without religious affiliation *(1% point increase)*			
Confounders only (wealth tax, urbanisation, soil type)	No significant association	No significant association	No significant association

[a] + Means more rapid decline, −means less rapid decline.
[b] At the 99% level.
[c] Means significance at the 95% level.

conducted in two steps: First, regional mortality declines were estimated using a Poisson regression model. Secondly, 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 decline is lost during the second step of the analysis. Analysis of the standard errors showed that they were on average about 18% of the differences between the estimates of mortality decline. This means that there was extra variation in the estimates of mortality decline, which is not taken into account in the multivariate analysis. This variation was, however, not sizeable. Besides, strong associations (significance at the 99%-level) between the economic and cultural variables and mortality decline were found in several instances (results not shown).

If variables in a multivariate model are strongly correlated we cannot distinguish their separate associations with the dependent variable i.e. mortality decline. This is known as the multicollinearity problem. The variance–covariance matrix of the parameters of the model was calculated for the periods 1875/1879–1895/1899 and 1895/1899–1920/1924 (Norusis, 1990). Relatively strong correlations were only found for urbanisation and wealth tax. The correlation coefficients were 0.7 and 0.8, respectively, in the two periods. Although the correlation coefficients are not extremely high, it should be taken into account that, especially in the period from 1895/1899–1920/1924, urbanisation and wealth tax are to some extent related.

Absolute change in proximate determinants was related to mortality decline in the analysis presented in this paper. Using relative changes did not change the results so that other proximate determinants turned out to be intermediary factors in the associations between the economic and cultural variables and mortality decline.

Cultural factors in mortality decline

This study shows that cultural factors played a relatively important role in late 19th century mortality decline in The Netherlands. In the literature, the cultural factor in mortality decline has been discussed in terms of increased attention for personal health care, knowledge of disease processes and acceptance of new ideas on hygiene (Ewbank & Preston, 1990; Preston & Haines, 1991; Vögele, 1994). In this paper two different cultural variables have been used, viz. secularisation and Roman Catholicism. Secularisation refers more directly to cultural changes related to the modernisation process, such as the acceptance of new ideas, than Roman Catholicism does. Roman Catholicism refers to a specific set of beliefs and attitudes. These characteristics include high fertility rates and a reluctance to accept new ideas, and also specific practices with respect to infant care such as breastfeeding, which was not common among Roman Catholics (Van Poppel, 1992; Kintner, 1998).

With respect to all-cause mortality decline and mortality decline from 'other diseases' the cultural factor 'percentage of Roman Catholics' was associated with mortality decline, while 'percentage people without religious affiliation' was associated with mortality decline from infectious diseases. The findings that 'percentage without religious affiliation' (secularisation) was only significantly associated with infectious-disease mortality decline might indicate the importance of the acceptance of new ideas on hygiene, personal health care, and knowledge of disease processes for infectious-disease mortality decline.

The two cause-of-death groups 'infectious diseases' and 'other diseases' differ with respect to age distribution. In 1875, about one-third of both groups consisted of mortality at age 0. Infectious-disease mortality consisted for about 20% of cases aged 1–4 years, while this was only about 6% for mortality from diseases other than infectious diseases. With respect to mortality at older ages, only 15% of the cases occurred for people over 50 years of age, while in the case of mortality from other diseases this was about 40%.

Marital fertility decline was a more important intermediary factor in the association between 'percentage without religious affiliation' and infectious-diseases mortality (reduction of the association by 18%), than it was in the association between 'percentage Roman Catholics' and mortality decline from other diseases (reduction of the association by 11%). This may be due to a stronger association between secularisation and marital fertility than between Roman Catholicism and marital fertility, and to the fact that the category 'infectious diseases' consisted for a large part of early childhood mortality as well as infant mortality.

The absolute change in the number of persons per dwelling turned out to be an intermediary factor in the association between 'percentage Roman Catholics' and total mortality decline and mortality decline from other diseases. An age-specific analysis showed that persons per dwelling only played a role at old ages (ages 65–79) (results not shown). The group 'other diseases' consisted of, among other causes of death, chronic digestive diseases, chronic respiratory diseases, and 'consumption of old age' (excluding respiratory tuberculosis). The latter is an important category. The association between poor housing conditions (parameterised as persons per dwelling) such as damp houses and chronic respiratory diseases have been reported (McFarlane, 1989; Condran & Cheney, 1982). It is not clear why Roman Catholicism is related to mortality at older ages. Most of the literature on Roman Catholicism is related to breastfeeding practices and fertility, both of which are determinants of mortality at very young ages.

One possible explanation could be that the association between Roman Catholicism and mortality decline from other diseases indicates another association. Roman Catholicism is strongly confined to the south of The Netherlands. Other variables with the same regional distribution might account for the association between Roman Catholicism and mortality decline, mediated by housing conditions. The most likely variables to be related to housing conditions are urbanisation and wealth. However, both variables were already included in the model.

Another important intermediary factor in the association between cultural factors and mortality decline was the change in the number of medical doctors per 100,000 inhabitants (Table 5a). However, an increase (or a less strong decline) in medical doctor density was associated with less rapid mortality decline. In the analysis presented in this paper, absolute change of the determinant was related to percentage of mortality decline. If relative change was used, the same contra-intuitive association between medical doctor density and mortality decline was observed. Relating change in medical doctor density to mortality decline assumes a direct effect of the supply of medical care on health. This might be the case for curative health care. In the late 19th century, curative effects of health care were, nevertheless, limited. Earlier, we pointed out that medical doctors could play a role in the diffusion of new ideas on health (Kunitz, 1991). When considering this role of medical doctors, no immediate effect of medical doctors on mortality decline is expected. An analysis was conducted, in which not the change in medical doctor density but the level of medical doctor density at the onset of the period of decline was added to the model, so as to investigate medical doctors' role. In the period from 1875/1879 to 1895/1899, a large number of medical doctors per 100,000 inhabitants in 1875/1879 was related to rapid mortality decline. This association was significant with respect to all-cause mortality and mortality from infectious diseases. The association between the percentage of Roman Catholics and mortality decline was reduced by 38% in the case of all-cause mortality and by 24% in the case of mortality from 'other diseases'. The association between percentage without religious affiliation and infectious disease mortality decline was also reduced by 24%. These results suggest that medical doctors in the late 19th century had an important role as 'agents of cultural and behavioural change' (Kunitz, 1991), i.e. health behaviour, rather than a curative role.

Economic factors in mortality decline

We were not able to identify intermediary factors in the association between tax and mortality in the period from 1895/1899 to 1920/1924 (Table 5b). The way in which different intermediary factors have been operationalized might be related to these negative results. Housing conditions, for example, were operationalized as 'persons per dwelling'. This was probably not specific enough to measure overcrowding, bad ventilation and bad sanitary conditions. More specific data such as 'persons per room' or 'rooms connected to open air' were, however, only available at a higher aggregation level. The nature of the tax variable (tax on 'doors and windows connected to open air', tax on fireplaces), and the fact that this variable was especially important with respect to infectious-disease mortality decline, suggest that housing conditions were nevertheless an important factor in mortality decline.

As far as the operationalisation of the availability of water mains is concerned, it was assumed that the whole population had access to clean drinking water since the construction of a water supply system. This may not have been the case, which could have affected the results. However, another Dutch study showed that before 1895 expenditure of municipalities was more strongly related to wealth than after 1895. Expenditure includes public safety (including costs for drinking water) and other public measures (including measures concerned with infrastructure). Wealthier areas started earlier with all sorts of public measures than less wealthy areas. In the early 20th century, the less wealthy areas begin to catch up with the other areas, which weakened the association between wealth and expenditure on public measures. (Knippenberg & De Pater, 1988)

Adding the change in the number of medical doctors per 100,000 inhabitants to the model made the association between tax and mortality decline stronger. It could also be that the wealthiest areas already had sufficient medical doctors, and that less wealthy areas (with less rapid mortality declines) still had room for an increase in medical doctor density in the early 20th century.

Changing importance of economic and cultural factors over time

Cultural factors were more important than economic factors in the late 19th century and economic factors were more important in the early 20th century than cultural factors. Recently, studies for 19th and 20th centuries Spain and Germany have also shown that the association between economic indicators (e.g. income per capita) and mortality (decline) is not constant over time (Reher & Sanz-Gimeno, 2000; Haines & Kintner, 2000). Reher and Sanz-Gimeno (2000) found that mortality from water- and food-borne infectious diseases was not sensitive to economic fluctuations. Infant mortality consisted for a large part of these causes of death, and a large part of mortality in the late 19th century consisted of infant mortality. Haines and Kintner (2000) found that the relationship between mortality and income per capita was small and insignificant in 1871 and 1880, and became more significant in the years 1910 and 1925. They also mentioned the close relationship of infant and early childhood mortality to this pattern.

The insensitivity of infant mortality to economic factors in the late 19th century could explain why the economic factor played a less important role than cultural factors in mortality decline in The Netherlands. A large part of mortality consisted of infant mortality in the late 19th century, and in many regions (especially the Roman Catholic regions) infant mortality *decline* was slow or non-existent. In the early 20th century, there were no such large differences in infant mortality decline anymore. So, in the late 19th century regional differences in mortality decline were more determined by regional differences in infant mortality decline than in the early 20th century, and therefore less related to the economic determinants of mortality decline.

This study has shown, on the basis of multivariate analyses, that both cultural and economic factors played important roles in mortality decline, but in different periods of time. Those findings fit in a series of recent publications from other European countries, which show that historical mortality decline cannot be explained by focussing on one single factor, such as socio-economic improvements, and that the importance of determinants of mortality decline change over time. In this respect, the findings for The Netherlands are not unique, but support the notion that historical mortality decline was a highly complex process and that it is futile to search for one common explanation for a process that encompasses a century.

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