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Historical Demography of Iceland

Johan Fellman[1*]

[1]*Hanken School of Economics, P.O.Box 479, FI-00101 Helsinki, Finland.*

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Knowledge of the seasonal variation in births and deaths during normal years is important for analyses of the effects of wars, famines, epidemics or similar privations on these variables. In studies of seasonality, multiple trigonometric regression models are more flexible than the simple sine curve. The seasonal variation in mortality in Iceland, 1856-1990, shows a strong secular decrease, and a connection between this and the epidemiological transition is considered. Comparisons with findings in other European countries are made. The temporal trends in Iceland of the birth components; the twinning rate, the still birth rate and the secondary sex ratio, are presented and compared with the corresponding values in neighbouring countries. No marked differences were emerged.

Keywords: Seasonality; trigonometric regression model; epidemiological transition; epidemic; years of famine; war; privation; death rate; twinning rate; still birth rate; sex ratio; Denmark; France; Germany; Italy; Norway; Scotland; Sweden.

1. INTRODUCTION

A good knowledge of the seasonal variation in births and deaths during normal years is of fundamental importance for studies of the effects of wars, famines, epidemics or similar privations [1]. In annual demographic data, the sine curve has been a common feature of studies on the

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**Corresponding author: E-mail: fellman@hanken.fi;*

seasonal variation. However, Eriksson and Fellman [2,3] and Walter and Elwood [4] have shown that such investigative attempts are often unsatisfactory. Multiple trigonometric regression models have proved useful for studying all kinds of periodic data, for they are flexible when the data differ from a simple sine curve. Diggle [5] discusses these models and states that they are good summary descriptions of time series showing a periodic pattern. In its simplest form, the trigonometric regression model is a sine curve and is comparable to the original and the generalised St. Leger models [2].

Fellman and Eriksson [3] studied regional, temporal and seasonal variations in demographic data, especially in data on mortality. They used trigonometric regression models and considered the different lengths of the months, including the effect of leap year; therefore, the estimation formulae are more complicated than in the case of equidistant observations. For equidistant data, the regressor vectors are orthogonal, resulting in parameter estimates that are uncorrelated and independent of the number of trigonometric terms in the models. However, Fellman and Eriksson [3] observed that despite the non-equidistant variables the regressor vectors are almost orthogonal, resulting in approximately uncorrelated parameter estimates that are relatively independent of the number of trigonometric terms in the models.

They observed that the optimal trigonometric regression models fit well with the different seasonal patterns observed in the mortality data from different countries in the 19th century. In countries in southern or central Europe (Italy, France and Germany), the seasonal pattern showed two marked peaks, one in winter and the other in the late summer. In countries in north-western Europe (Scotland, Denmark, Norway and Sweden), there is only one peak, in the spring. Furthermore, the annual mortality level showed a marked decreasing trend from south to north.

Omran [6] proposed the epidemiological transition, consisting of three stages, and later Olshansky and Ault [7] introduced a fourth stage. Rogers and Hackenberg [8] named the fourth stage the hybristic stage and suggested that the respective turning points of the stages were 1875, 1930 and 1970.

Fellman and Eriksson [3] presented the stages in the following way:

1.1 The Age of Pestilence and Famine

During this first stage of the epidemiological transition the death rates fluctuated very strongly between peaks and troughs in response to the epidemics that periodically ravaged the population. Infants and children were the most hard hit by the major killers of this era, although women of reproductive age also faced an unusually high risk because of complications associated with pregnancy and delivery.

1.2 The Age of Receding Pandemics

This second stage is noted as a transitional phase and is chiefly characterized by rapid changes in the components of our epidemiological history. During this stage the peaks and troughs of mortality were smoothed out initially by rapid improvements in sanitation and in living standards. Those who would previously have succumbed to infections and parasites survived through their early years into middle and older age, where they faced a high risk of dying from chronic degenerative diseases.

1.3 The Age of Degenerative Man-made Diseases

This third stage has been described basically as a plateau phase in our epidemiological history, in which we again reached an equilibrium in mortality, but at a level considerable lower than that of the first stage. At this stage, the pace of the declines in mortality rates throughout the age structure slowed as we approached the theoretical limits of mortality declines.

1.4 The Hybristic Stage

This fourth stage is characterised by unexpectedly rapid declines in mortality rates for the major degenerative diseases. While the greatest benefits of these declining death rates were first experienced by the population passing through middle age, today some of the largest declines are occurring among those in whom one might least expect them — cohorts recently passing through advanced ages [7].

1.5 The Secondary Sex Ratio

Hawley [9] stated that where prenatal losses are low, as in the high standard of living in Western countries, the secondary sex ratios (SRs) are usually around 105 to 106. On the other hand, in areas with a lower standard of living, where the frequencies of prenatal losses including still birth rates (SBRs) are relatively high, SRs are around 102. Visaria [10] stated that racial differences appear to exist in the SR. Furthermore, he noted that the observed SRs are strongly influenced by random errors, and he constructed confidence intervals (CIs) for the SR. Fellman and Eriksson [11] presented the alternative CI

$$\left(SR-\frac{k}{1-p}\sqrt{\frac{p}{(1-p)N}},SR+\frac{k}{1-p}\sqrt{\frac{p}{(1-p)N}}\right),$$

where N is the sample size, p is the proportion of males, $SR=\frac{p}{(1-p)}$ and k defines the confidence level (e.g. $k=1.96$ yields 95% CIs). In empirical studies, the SR is given as a percentage, that is $SR=\frac{100p}{(1-p)}$. For moderate data sets, the CI is broad, and consequently, it is difficult to identify statistically significant differences [10,11]. The CIs given by Visaria [10] and Fellman and Eriksson [11] are asymptotically equivalent and both are applicable for large N. Fellman and Eriksson [11] analysed in detail the SR among singletons, twins and higher multiple births in Sweden (1869-1967). Later, Fellman and Eriksson [12] analysed the temporal variations in the SR in Sweden, Denmark, Finland, Norway and Iceland.

Variations in the SR that have been reliably identified in family data have in general been slight and without notable influence on national birth registers [13,11].

1.6 The Geography and History of Iceland

Fig. 1 shows that Iceland is an isolated island in the Northern part of the Atlantic Ocean. In old times, the living conditions of the inhabitants were extremely severe. The mortality is mostly dependent on the living conditions and less on the demographic structure and therefore, it is difficult to compare in detail their living conditions with those of individuals in the neighbouring Northern countries. Furthermore, it is impossible to compare the mortality statistics in Iceland with the statistics in other European countries.

Fig. 1. Map of the Nordic countries including Iceland. Iceland is isolated and its closest contacts have been to Denmark and Norway. For details, see the text

Other demographic comparisons will be executed. Birth statistics are compared with the closest neighbour countries of Norway and Denmark. Iceland has been connected for several centuries to both Norway and Denmark. Iceland was under Norwegian rule for the period 1262-1550. After this, Iceland was connected to Denmark from 1550 to 1848. These two long annexation periods seem to have mixed to some degree the populations. Therefore, one can assume that the populations in these countries may be related, yielding some demographic similarities. Such resemblances may be found when for instance birth statistics are compared, but as stressed above, not when mortality is considered.

2. MATERIALS AND METHODS

2.1 Statistical Methods

Eriksson and Fellman [2,3] noted that in many situations, although there are marked seasonal variations, the simple sine curve model does not fit the data. For example, this is the case when the data show more than one peak, but data showing one peak and one trough may also differ markedly from the sine curve, e.g. when the peak or the trough are markedly prolonged or when the distance between the peak and the trough differs from that at six months. Therefore, multiple trigonometric regression models are noteworthy alternatives.

Eriksson and Fellman [2,3] considered the *multiple trigonometric regression model*

$$\begin{aligned} R_i(t_i) &= K + \sum_{m=1}^{M} R_m \sin(mt_i + \alpha_m) + \varepsilon_i \\ &= K + \sum_{m=1}^{M} \left(A_m \cos(mt_i) + B_m \sin(mt_i)\right) + \varepsilon_i , \end{aligned} \qquad (1)$$

where *M* is the number of pairs of trigonometric terms, $A_m = R_m \sin\alpha_m$ and $B_m = R_m \cos\alpha_m$. The error terms ε_i are assumed to be independent and homoscedastic. With monthly data, one has to introduce the restriction $M \le 5$.

The intercept and the parameters $A_m \text{ and } B_m \ (m = 1,\ldots,M)$ are estimated by ordinary least squares (OLS) for the monthly data, and the basic parameters α_m and the amplitudes $R_m = \sqrt{A_m^2 + B_m^2}$ by the equations:

$$\tan(\hat{\alpha}_m) = \frac{\hat{A}_m}{\hat{B}_m} \qquad (2)$$

and

$$\hat{R}_m = \sqrt{\hat{A}_m^2 + \hat{B}_m^2} \qquad (3)$$

On account of the fact that the angle α_m and the amplitudes R_m have to be estimated from formulae (2) and (3), statistically non-significant estimates $\hat{A}_m$ and $\hat{B}_m$ $(m = 1,\ldots,M)$ cannot be ignored. Therefore, Fellman and Eriksson [3] recommended full pairs of trigonometric terms. Another argument for this is that $\hat{R}_m$ may differ significantly from zero, but the angle α_m may be such that $\hat{A}_m$ or $\hat{B}_m$ is close to zero and consequently non-significant. From this, it follows that the tests for significance should be applied to $\hat{R}_m$ and $\hat{\alpha}_m$, but not to $\hat{A}_m$ or $\hat{B}_m$. The geometric interpretation is that when one fits the model to the data one focuses on the initial model in (1), and consequently, the amplitude R_m and the angle α_m are of interest. These assumptions indicate that the intercept *K* is an estimate of the mean annual level of the mortality rate.

Fellman and Eriksson [3] assumed that the model is *optimal* when the adjusted coefficient of determination, $\overline{R}^2$, attains its maximum. If $\overline{R}^2$ increases monotonically, for all *M* they chose *M = 4*. In doing so, they left three degrees of freedom for the testing. The multiple trigonometric regression models and the corresponding tests of the estimates are discussed in detail in [2] and in some of the references given in that paper.

With the simple regression model, $M = 1$, the optimum is obtained for the angle $\hat{t}_1 = 90^\circ - \hat{\alpha}_1$ or $\hat{t}_1 = 450^\circ - \hat{\alpha}_1$ if $\hat{\alpha}_1 > 180^\circ$; this angle can be compared with the estimated angle θ^* in the Walter-Elwood model [4]. Good agreement between data and model is obtained when the data pattern is at least approximately sinusoidal.

According to [3], the regressor vectors are almost orthogonal and therefore the parameter estimates are fairly constant, irrespective of the number of terms in the regression model. Consequently, the model chosen has very little influence on the parameter estimates. Exact orthogonality is obtained if the data are equidistant, that is, if the months are assumed to be of equal length, 30 days, and hence, corresponding exactly to 30°. On the other hand, the error variance is based on the unexplained sum of squares, and, accordingly, the parameter tests are strongly affected by the model chosen. Following [3], we assume in this study that the error terms are independent and homoscedastic. If this is not the case, the estimates obtained, although unbiased and consistent, will not be efficient. When the data are based on a large number of observations, the monthly rates can be assumed to be asymptotically normal. The whole model can then be tested by the *F* test and the individual parameters by *t* tests. The goodness of fit of the regression model can also be analysed with the coefficients of determination (R^2 and $\overline{R}^2$).

2.2 Rates and Indices

If one studies the specific seasonal pattern of twinning rates (TWRs), for instance, “the population at risk” is the monthly number of maternities. If this population at risk is ignored, then the specific seasonal variation in twin maternities is masked by the seasonal variation in general maternities. For births, deaths, etc., the seasonal variation is disturbed by the different lengths of the months, and one must consider the rates per day. In data sets showing markedly different levels (e.g. births from different periods or different populations), comparisons of the seasonality must be based on standardised indices [3]. Let the number of births (or deaths) in month number *i* during a given period be n_i and the total number of births be $n = \sum n_i$. Let k_i be the length of month number *i* and $k = \sum k_i$ be the length of the year. The monthly rates per day $r_i = \frac{n_i}{k_i}$ and the monthly indices

$$I_i = 100\frac{\frac{n_i}{k_i}}{\frac{\sum n_i}{\sum k_i}} = 100\frac{k}{k_i}\frac{n_i}{n} \quad (i = 1,...,12) \qquad (4)$$

If the proportion of births in this month exceeds the relative length of the month formula (4) yields an index greater than 100; otherwise it is less than 100. The sum of the indices may differ slightly from 1200. For the monthly indices,

$$SE(I_i) \approx 100\left(\frac{k}{k_i}\right)\sqrt{\frac{n_i(n-n_i)}{n^3}} \qquad (5)$$

For a more detailed discussion of the statistical methods concerning rates and indices, see [3].

3. RESULTS

3.1 Temporal Variation and the Seasonal Pattern of Mortality

Statistics Iceland has published a long-term series concerning demographic data [14]. Fellman and Eriksson [15] analysed the birth data and obtained interesting results. Fellman and Eriksson [3] considered the mortality data from Iceland for the period 1856-1990. The seasonal data published consist of monthly indices (deaths per month). These indices were transformed to indices measuring deaths per day. In addition, total yearly numbers of deaths are available. Fig. 2 shows the time series of the seasonal indices and the annual rates of deaths per 1000. After 1856 the death rate shows a steadily decreasing trend from over 30 per 1000 and in the 1850s and 1860s to about 7 per 1000 during the second half of the 20th century. However, according to [16], the crude death rate reached a maximum in the middle of the 19th century, showing lower values both before and after. The index data show marked temporal changes in the seasonal pattern, and some marked peaks are discernible. The extreme peak for the period 1861-1870 is largely caused by an increased number of drownings and accidents of other types (Figs. 4 and 5). In 1861-1865, the death rate in males caused by drowning was about 3 per mille. For Icelandic males, the drownings was an important indicator of the harsh living conditions. The fishermen had a hard life when they practised their profession and braved the Atlantic storms in the small vessels of that time.

After that, a continuous decreasing trend is discernible. At the beginning of the 20th century, the corresponding death rate was between 1 and 2 per mille. After the Second World War, the decreasing trend is even more marked ([14], p. 195). In the 1980s, the death rate in males from drowning was only about 0.12 per mille (see also

Fig. 5). The average annual number of deaths (calculated per decade) in Iceland is between 1140 and 2159. Thus, random fluctuations are marked (cf. Fig. 2). In order to make the seasonal pattern more distinct, additional pooling of the data is necessary.

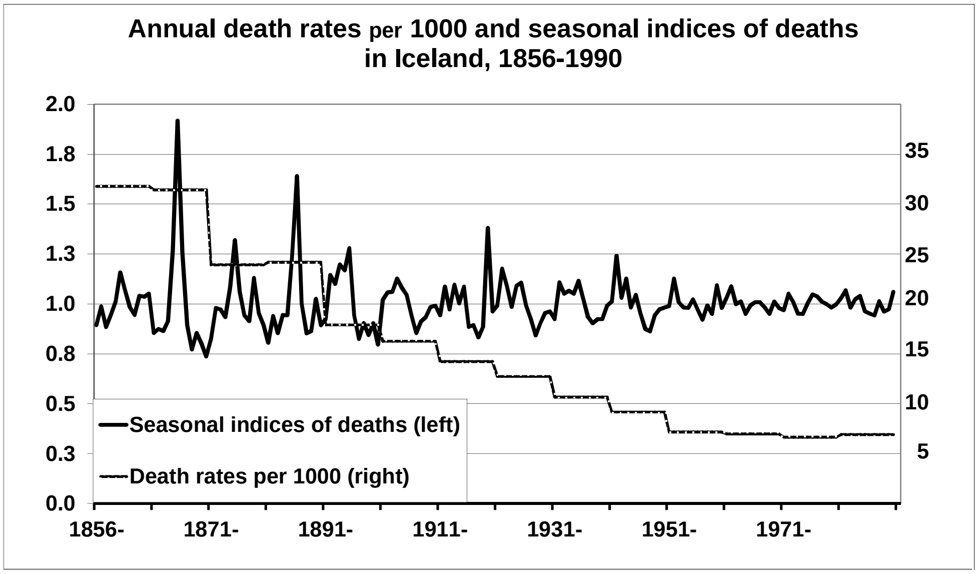

Fig. 2. Temporal variation in the mortality per 1000 and in the monthly death indices (deaths/day) in Iceland, 1856-1990. The data show marked temporal changes in the mortality level and in the seasonal pattern and, furthermore, strong irregular random fluctuations. In addition, some marked peaks are discernible ([3], Fig. 4)

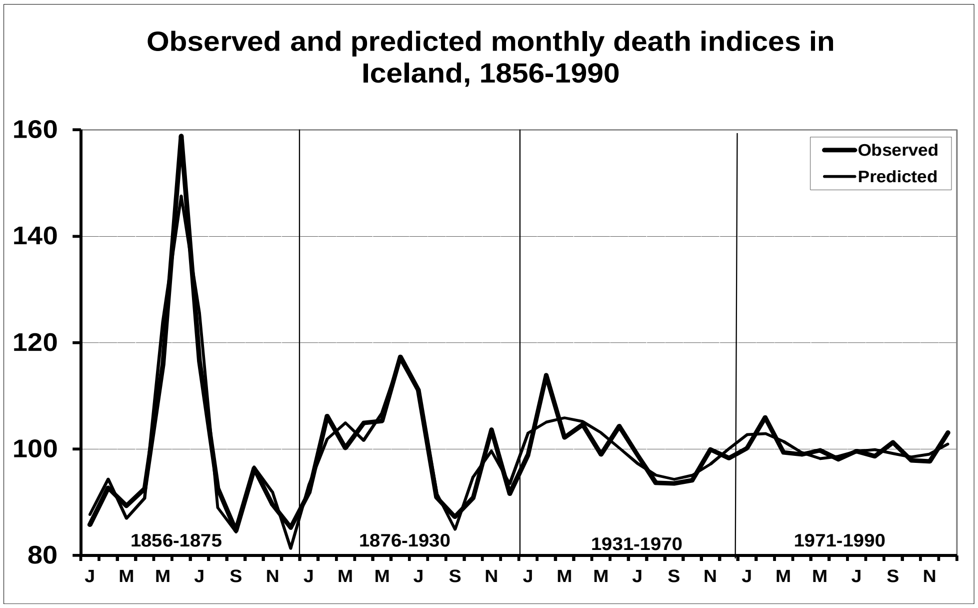

Fig. 3. Temporal variation in the monthly death indices (deaths/day) in Iceland, 1856-1990. The data are pooled in four subperiods, 1856-1875, 1876-1930, 1931-1970 and 1971-1990 (see text). The observed indices are compared with those predicted (obtained with multiple trigonometrical regression models). For no subperiod does a simple sine curve fit the data satisfactorily ([3], Fig. 5)

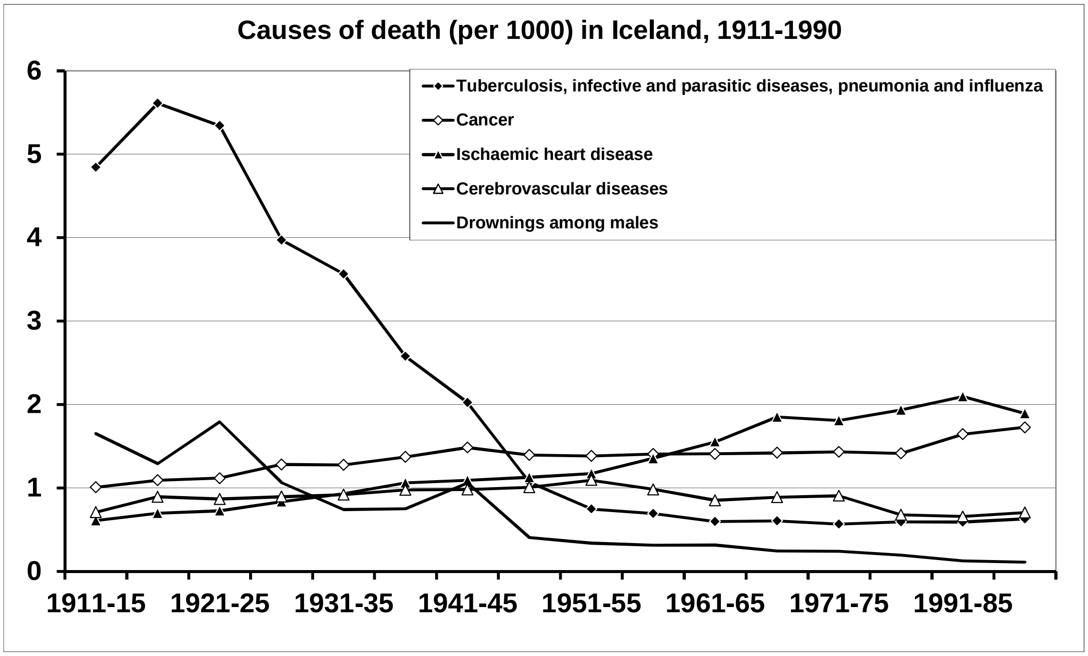

Fig. 4. Mortality per 1000 caused by different diseases in Iceland, 1911-1990. For comparison, the mortality among males caused by drownings is included. Fellman and Eriksson [3] observed a marked decline around 1930, in the mortality caused by pneumonia and tuberculosis. This finding is in good agreement with the general theory of the epidemiological transition. They could not discern any marked changes around 1970. Consequently, their findings did not support the existence of a turning point around 1970 (see [3], Fig. 6)

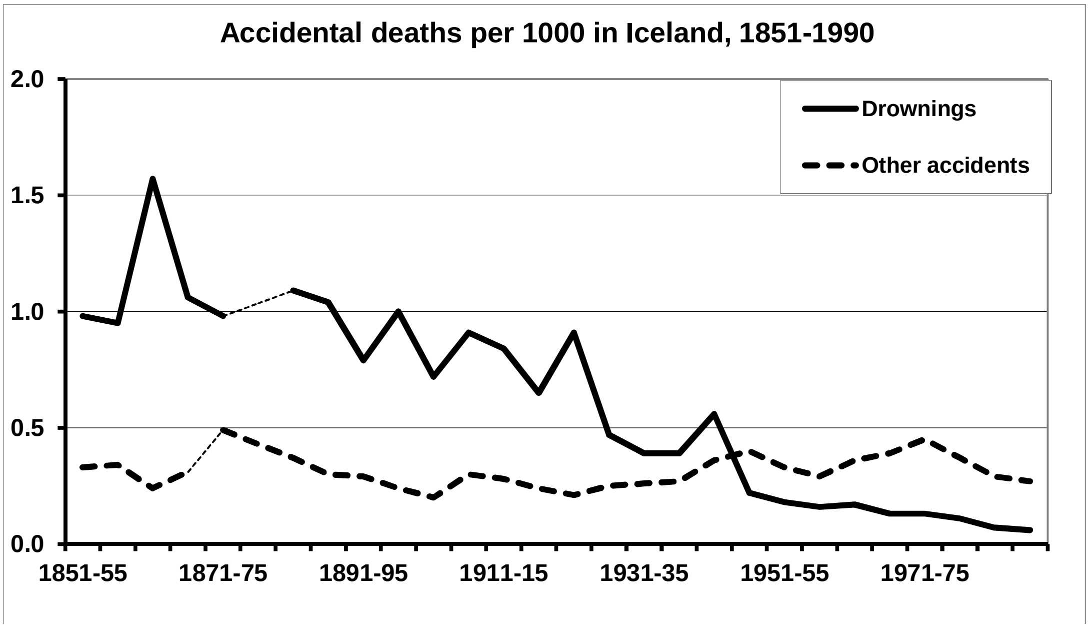

Fig. 5. Mortality per 1000 caused by drownings and other accidents in Iceland, 1856-1990. For drownings, we observe a marked decrease from over *1.50* in 1861-1865 to around *0.30* at the end of the period. For other accidents, no marked trend is noted ([3], Fig. 7)

Although Fellman and Eriksson [3] did not have clear indications that the epidemiological transition in Iceland advanced at the same pace as in the US, they pooled the data into four subperiods: 1856-1875, 1875-1930, 1931-1970 and 1971-1990 and compared the seasonal patterns for these subperiods. The pooling of the death indices was based on the total number of deaths (given for 5-year periods) and the published monthly indices per decade. More detailed data are not available. The first step consisted of estimation of the monthly number of deaths per subperiod. The formula for this is

$$\hat{n}_{iP_j} = \sum_{d \in P_j} N_d \frac{I_{id}}{\sum_{i=1}^{12} I_{id}} \quad (i = 1,...,12; \quad j = 1,...,4), \qquad (6)$$

where $\hat{n}_{iP_j}$ is the estimated number of deaths in month number *i* in subperiod P_j, N_d is the total number of deaths in decade *d* and I_{id} is the monthly death index for month number *i* in decade *d* (belonging to the subperiod P_j). The monthly indices (deaths per day) for the subperiod P_j can be obtained with formula (6) using the estimated monthly numbers of deaths. The combined formula for the estimated monthly indices is according to [3] as follows:

$$I'_{iP_j} = 100 \frac{k}{k_i} \frac{\sum_{d \in P_j} N_d \frac{I_{id}}{\sum_{i=1}^{12} I_{id}}}{\sum_m \sum_{d \in P_j} N_d \frac{I_{md}}{\sum_{s=1}^{12} I_{sd}}} \quad (i = 1,...,12; \quad j = 1,...,4) \qquad (7)$$

In addition, it is worth mentioning that when they pooled the data for the periods 1856-1875 and 1876-1930 they had to assume that the monthly indices for the whole decade 1871-1880 held for both subperiods 1871-1875 and 1876-1880.

The pooled data for the epidemiologic transition periods are presented graphically in Fig. 3, together with the predicted monthly indices estimated with the optimal trigonometric regression model for the corresponding subperiod. The estimated regression models were given in [3], Table 3, here presented as Table 1. A diminishing trend in the seasonality is clearly discernible. The Icelandic data for the period 1856-1875 show strong seasonal variation, with one marked mortality peak in June. The standard deviation (SD) for the observed data is 21.4. The optimal regression model ($M = 3$) fits the data well [3].

During the period 1876-1930 the summer peak declined and the mortality in the winter and spring increased. A small peak is discernible in late autumn and $SD = 9.5$. As in the former case, the optimal model ($M = 3$) gives a good fit.

For the period 1931-1970 the mortality values are high during the spring and early summer (peaks in February, April and June). The autumn peak, albeit diminished, is discernible and $SD = 5.7$. This indicates further reduced seasonal variation. The simple regression model is optimal, but the *F* test is only slightly significant ($F = 5.65; P < 0.025$ with *2* and *9* degrees of freedom).

For the last period, 1971-1990, the seasonal variation has almost disappeared. The SD is 2.4, which is only about 11% of the SD for the first period 1856-1875. For the final period, no regression model gives significant results [3]. Iceland being an isolated island in the Atlantic has only minor seasonal variation in the climatic conditions, and consequently, the recent slight seasonal variations are logical.

As noted above, Fellman and Eriksson [3] connected their results with the theory of the epidemiological transition. The secular trends in mortality caused by different diseases are shown in Fig. 4. For comparison, the mortality caused by drownings among males is included. The available data start from 1911, and consequently they could only check the proposed turning points in 1930 and 1970. After the 1920s, they observed marked declines in the mortality caused by tuberculosis, infective and parasitic diseases, pneumonia and influenza. In the alternatives, cancer, ischaemic heart disease and cerebrovascular diseases, there is a slight increase. These findings are in good agreement with a turning point from the second to the third stage of the epidemiological transition. Around 1970, one cannot discern any marked changes. In addition, Fig. 2 shows no decrease in the total mortality level after the 1950s. Consequently, the findings given in [3] did not support the existence of a distinct turning point around 1970.

As we have already stressed, a specific aspect of the mortality pattern in Iceland in the 19th century is the high level of mortality caused by drownings. Being a cause of death restricted almost entirely to males (over 95% of the victims were males), it is an important factor when mortality in Iceland is studied. In Fig. 5, we present the mortality per 1000 for drowning and other accidents. The death rate from drowning has decreased from over 1.5 to about 0.06. The mortality from other accidents is fairly constant around 0.3 per 1000. Although the number of drownings had decreased markedly since the 19th century, drowning was still a notable cause of death for males in the first half of the 20th century (cf. Fig. 4).

3.2 Temporal Variation in Births

In earlier birth studies, we have concentrated on the variables twinning rate (TWR) [17-20]), still birth rate (SBR) [21-23] and secondary sex ratio (SR) [11,12,24,25]). To perform population comparisons, we study these variables and compare Iceland with Denmark and Norway, having populations most closely related to the Icelandic population.

In Fig. 6a, the TWR for Iceland is compared with the rates for Denmark and Norway. One observes high Icelandic TWRs for the period up to 1920. After that, the TWRs decrease in a similar manner in all countries. In Fig. 6a, the TWR for the Åland Islands (Finland) is included. Åland has no relation to Iceland, but the TWR on Åland is high and sometimes extremely high [26], and therefore, the rate is a good benchmark for high TWRs. We observe that the TWR in Iceland is below the TWR on the Åland Islands. The still birth rates in Iceland, Denmark and Norway are presented in Fig. 6b. For all countries, similar decreasing temporal trends are observed. Secondary sex ratios for Iceland, Denmark and Norway are compared in Fig. 6c. The sex ratios are similar for all countries, but for Iceland the temporal heterogeneity is markedly high. This is caused by the small data sets for Iceland [10].

In Table 2, the annual death rates for these countries are presented. The mean annual death rate for the countries is estimated as the intercepts given in [3]. In the Table is also included data for Iceland, 1856-1870. Note the decreasing geographic trend from south to north in the mortality rates and the extreme mortality rate for Iceland. The high death rate in Iceland is discussed above and in detail in [3].

Table 1. Optimal multiple regression models of monthly mortality indices (deaths per day) for Iceland in different periods. Boldface estimates are statistically significant. The missing estimates indicate that at different periods the optimal models consist of different numbers of terms ([3])

	Iceland							
Intercept	**1856-1975**		**1871-1930**		**1931-1970**		**1971-1990**	
	Est.	**SE**	**Est.**	**SE**	**Est.**	**SE**	**Est.**	**SE**
	100.03	2.32	**100.06**	1.27	**100.08**	1.21	**100.02**	0.65
A_1	**-19.54**	3.29	**-5.66**	1.80	1.49	1.71	1.37	0.93
B_1	5.42	3.28	**6.70**	1.80	**5.58**	1.72	0.76	0.92
R_1	**20.28**	3.29	**8.77**	1.80	**5.78**	1.72	1.57	0.93
A_2	**11.71**	3.29	4.02	1.80			0.53	0.93
B_2	**-8.58**	3.28	-3.36	1.80			1.36	0.92
R_2	**14.52**	3.29	**5.24**	1.80			1.46	0.93
A_3	**-9.69**	3.28	**-6.73**	1.80				
B_3	**8.48**	3.28	-0.23	1.80				
R_3	**12.88**	3.28	**0.30**	1.80				
R^2	0.936		0.902		0.558		0.438	
$\overline{R}^2$	0.859		0.785		0.460		0.117	
s^2	64.63		19.41		17.67		5.13	
DF	5		5		9		7	
F	**12.17**		**7.69**		**5.69**		1.36	

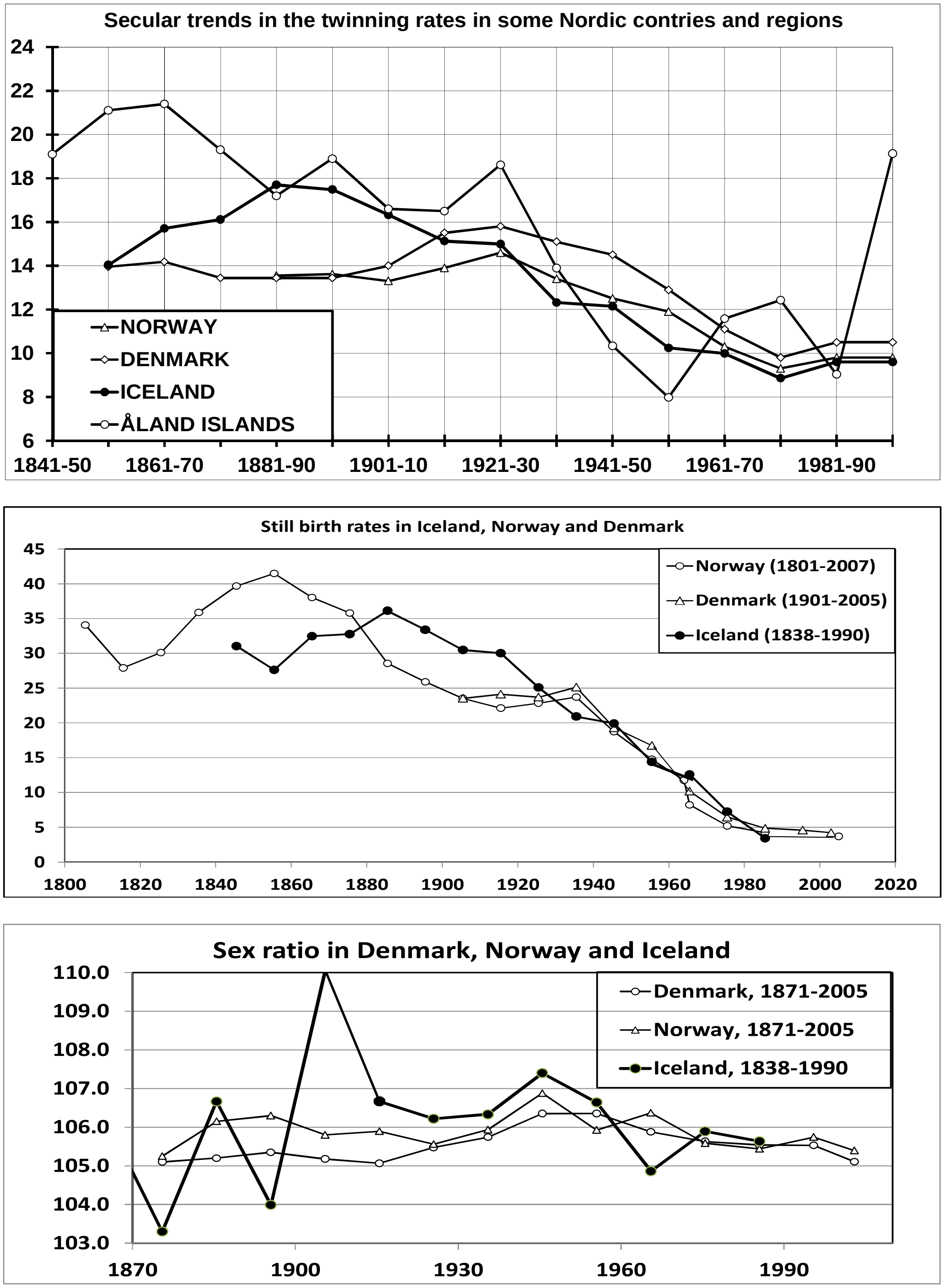

Fig. 6. Temporal trends in birth variables. Details are discussed in the text

(a) Twinning rates (TWRs) in Iceland, Denmark and Norway. Up to 1920, the TWR in Iceland is high. As a benchmark, the high TWR on the Åland Islands (Finland) is included.

(b) Still birth rates in Iceland, Denmark and Norway. All countries show similar decreasing trends.

(c) Secondary sex ratio in Iceland, Denmark and Norway. The marked variations in the sex ratio for Iceland are caused by the small data sets [10]

4. DISCUSSION

4.1 Comparisons between Iceland and Other Countries

In the 19th century, the Swedish statistician and demographer Sundbärg [27] analysed monthly mortality data for eight different European countries. Of these, we consider Italy (1863-1876), France (1853-1868, 1872), Germany (1872-1876), Scotland (1855-1875), Denmark (1835-1869), Norway (1841-1873) and Sweden (1861-1872). These data had been presented earlier by Berg [28]. Berg considered the monthly variations in mortality and used standardised indices. Sundbärg compared the mortality rates in the different countries at different periods and used death rates per 1000 in the population. To obtain monthly rates, he corrected the rates in relation to the whole year [3].

Table 2. Annual death rate per 1000 in different countries

Country	Mortality rate
Italy (1863-1876)	29.9
Germany (1872-1876)	27.2
France (1853-1868, 1872)	23.1
Scotland (1855-1875)	22.1
Denmark (1835-1869)	19.7
Sweden (1861-1872)	19.2
Norway (1841-1873)	17.4
Iceland (1861-1870)	31.6

For the countries in southern and central Europe (Italy, France and Germany), the seasonal pattern of deaths shows two marked peaks, one in the winter and one in the late summer. The countries in north-western Europe (Scotland, Denmark, Norway and Sweden) show only one peak in the spring. These differences indicated that a flexible method, such as multiple trigonometric regression, had to be applied. In addition, the resulting optimal trigonometric regression models for the different countries may differ markedly. Furthermore, the mortality level shows a marked decreasing trend from south to north [3]. The studies presented in [3] indicate that there were great regional and temporal differences in the seasonal pattern of the mortality and that the multiple trigonometric regression model reveals these differences. Consequently, the usual sinusoidal model and the corresponding Walter-Elwood method [4] are not applicable.

5. CONCLUSIONS

During the first stage of the epidemiological transition the seasonal variation in deaths and births was mainly a result of the living conditions. There are temporal variations in the seasonal pattern and consequently, multiple trigonometric regression models being more flexible than the simple sine curve should be used. In addition, years marked by severe famine or other crises have had strong effects on the seasonal pattern. Fellman and Eriksson [3] discussed especially the effect on the demographic variables in Finland caused by the severe famine in the 1860s. Such effects can also be seen in the data from Iceland during the 19th century (Figs. 2, 3, 4 and 5). For Icelandic males, the drownings during the first were an important indicator of the harsh living conditions. Until the 20th century, the sex ratio for the Icelandic population was low relative to the sex ratio for both Norway and Denmark, indicating the greater effect of the fluctuations in mortality from malnutrition and its sequelae on males than on females [16,3].

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Land KC, Cantor D. ARIMA models of seasonal variation in U. S. birth and death rates. Demography. 1983;20:541-568.

2. Fellman J, Eriksson AW. (Statistical analysis of the seasonal variation in the twinning rate. Twin Res. 1999b;2:22-29.
3. Fellman J, Eriksson AW. Regional, temporal and seasonal variations in births and deaths: The effects of famines. Social Biology. 2002;48:86-104.
4. Walter SD, Elwood JM. A test for seasonality with a variable population at risk. Brit. J. Prev. Soc. Med.1975;29:18-21.
5. Diggle PJ. Time series a Bio-statistical introduction. Oxford Science Publications Clarendon Press Oxford. 1996;1-257.
6. Omran AR. The epidemiologic transition. A theory of the epidemiology of population change. Milbank Mem. Fund Quart. 1971; 49:509-38.
7. Olshansky J, Ault AB. The fourth stage of the epidemiologic transition: The age of delayed degenerative diseases. Milbank Mem. Fund Quart. 1986;64:355-391.
8. Rogers RG, Hackenberg R. Extending epidemiologic transition theory: A new stage. Soc. Biol. 1987;34:234-243.
9. Hawley AH. Population composition. In the study of population: An inventory and appraisal. Ed. Hauser PM, Dudley O. Duncan. Chicago, University of Chicago Press. 1959;361-382.
10. Visaria PM. Sex ratio at birth in territories with a relatively complete registration. Eugen. Quart. 1967;14:132-142.
11. Fellman J, Eriksson AW. Secondary sex ratio in multiple births. Twin Research and Human Genetics. 2010;13(1):101-108.
12. Fellman J, Eriksson AW. Temporal trends in the secondary sex ratio in Nordic countries. Biodemography and Social Biology. 2011;57(2):143-154.
13. Fellman J, Eriksson AW, Forsius H. Sex ratio and proportion of affected sons in sibships with X-chromosomal recessive traits: Maximum likelihood estimation in truncated multinomial distributions. Human Heredity. 2002;53:173-180.
14. Icelandic historical statistics (Hagskinna Sögulegar hagtölur um Ísland) Eds. Guðmundur Jónsson and Magnús S. Magnússon. Reykjavík. 1997;957.
15. Fellman J, Eriksson AW. Secular changes in the seasonal patterns of births in Nordic countries. Perspect. Hum. Biol. 1999a; 4:203-212.
16. Tomasson RF. A millenium of misery: The demography of the Icelanders. Population Studies. 1977;31:405-427.
17. Eriksson AW, Bressers WMA, Kostense, PJ, Pitkänen KJ, Mielke JH, Jorde LB, Tas RFJ, Fellman JO. Twinning rate in Scandinavia, Germany and the Netherlands during years of privation. Acta Genet. Med. Gemellol. 1988;37: 277-297.
18. Eriksson AW, Abbott C, Kostense PJ, Fellman JO. Secular changes of twinning rates in Nordic populations. In populations of the Nordic countries human population biology from the present to the Mesolithic. Proc. of the Second Seminar of Nordic Physical Anthrop. Lund 1990. University of Lund, Institute of Archeology Report Series No. 1993;46:113-135.
19. Fellman J, Eriksson AW. Variations in the maternal-age effect on twinning rates: The Nordic experience. Twin Research and Human Genetics. 2005;8:515-523.
20. Fellman J, Eriksson AW. Spatial variation in the twinning rate in Sweden, 1751-1850. Twin Research and Human Genetics. 2009;12(6):583-590.
21. Eriksson AW, Fellman J. Factors influencing the stillbirth rates in singleton and multiple births in Sweden, 1869 to 1967. Twin Research and Human Genetics. 2006;9:591-596.
22. Fellman J, Eriksson AW. Stillbirth rates in singleton, twins and triplets in Sweden, 1869 to 2001. Twin Research and Human Genetics. 2006;9:260-265.
23. Fellman J, Eriksson AW. Maternal age and temporal effects on stillbirth rates. Twin Research and Human Genetics. 2008; 11:558-566.
24. Fellman J. Sex ratio at birth. In International Encyclopedia of Statistical Science, (Ed. Miodrag Lovric) Part. 2011; 19:1314-1316.
25. Fellman J. Temporal and regional trends in the secondary sex ratio: The Nordic experience. Submitted Early Human Development Journal; 2015.
26. Eriksson AW. Human Twinning in and around the Åland Islands. Commentationes Biologicae. 1973;Suppl 64:159.
27. Sundbärg G. Dödligheten månads- och årstidsvis i Sverige, 1861-80 (Monthly and

seasonal variation in mortality in Sweden, 1861-80, In Swedish). Statistisk Tidskrift. 1883;69:153-194.

28. Berg FT. Årstidernas inflytelse på dödligheten (The effect of the seasons on the mortality. In Swedish). Statistisk Tidskrift. 1879;56:87-121.

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