Temporal Differences in the Regional Twinning Rates in Sweden after 1750

Johan Fellman and Aldur W. Eriksson
Folkhälsan Institute of Genetics, Population Genetics Unit, Helsinki, Finland

When twinning rates are studied, maternal age and parity should be considered. Data on parity are seldom available. We studied information about the mean parity, using the gross reproduction rate, the total fertility rate and the crude birth rate. These are strongly correlated with the mean parity. The crude birth rate is more readily available than the gross reproduction rate or the total fertility rate. Earlier studies have shown that it is difficult to model variations in the twinning rate with data for the macrolevel. In this study these findings are explained by theoretical analyses and illustrated by empirical data. Sweden, having the oldest continuous population statistics and high twinning rates, offers excellent possibilities for analyses of the twinning rate. We considered data for the counties of Gotland, Älvsborg and Stockholm and the city of Stockholm from 1749 to 1960 and for Sweden until 1996. For Älvsborg, the twinning rate was low for the whole period, showing no statistically significant decreasing trend. It is mainly about 11–14 per thousand, which is only 50–60% of the twinning rate in Gotland in the 18th century. In Gotland, in the county of Stockholm, in the city of Stockholm and in Sweden as a whole, the decreasing trends in the twinning rate were statistically significant. The decreasing twinning rates converge towards the low twinning rate of Älvsborg. After standardization of the twinning rate, the differences remained and the low rate in Älvsborg could not be explained by maternal age.

When temporal and regional differences in the twinning rate (TWR) are studied, maternal age and parity (the number of previous births), being the main influential factors, should be considered. Data on maternal age are often available in demographic registers but data on parity more seldom. When data on parity are not available, alternatives should be considered. In this paper we study the possibilities to use the crude birth rate (CBR), the gross reproduction rate (GRR) or, alternatively, the total fertility rate (TFR), instead of the unknown parity data. The CBR is usually defined as the number of live births per 1000 inhabitants. The GRR is defined as the expected number of live-born daughters per mother during her whole fertile period, on the assumption that the age-specific rates of the registration year hold constantly. The TFR is analogously defined as the expected number of live-born children. GRR, TFR and CBR are mutually correlated and are also strongly correlated with the mean parity. In regional and temporal studies, CBR is more readily available than GRR and TFR.

Earlier studies have shown that it is difficult to explain temporal and regional variations in the twinning rate by data on the macrolevel. In this study these findings are explained by theoretical analyses and illustrated by empirical data.

Sweden, having the oldest continuous population statistics for a whole nation, offers excellent possibilities for temporal analyses of the twinning rate. Furthermore, these possibilities are improved by the fact that the demographic data for Sweden are of high quality (Hofsten & Lundström, 1976) and show high twinning rates (Eriksson, 1973). The Swedish data have been collected from different official sources, some of them published in the middle of the 19th century. For the period 1849–1873, the county of Gotland (in short Gotland) has a high twinning rate and the county of Älvsborg (in short Älvsborg) a low twinning rate (Berg, 1880). Our interest in county of Stockholm and the city of Stockholm is based on the fact that they are two neighbouring regions, one rural and the other entirely urban. For details of the data set, see Table 1.

In the county of Älvsborg, the twinning rate is low for the whole period 1751–1960, and shows no statistically significant decreasing trend. The TWR is mainly around 11–14 per thousand: that is, only 50–60% of the twinning rate in Gotland in the 18th century (23.8 per thousand). In Gotland, in the county of Stockholm, in Stockholm city, and in the whole of Sweden strong decreasing trends in the twinning rates are noted. The decreasing twinning rates converge towards the low rate observed for Älvsborg since the 1750s.

Gotland, with the highest twinning rate in Sweden, has had the lowest birth rate for about 200 years (Wohlin, 1915) and western Sweden, including Älvsborg, has had, since the beginning of the 18th century, a low twinning rate but a high birth rate (Sundbärg, 1910 and Figure 1). The low level of the twinning rate in Älvsborg up to the 20th century cannot be explained by differences in the CBR, used as proxy variables for mean parity, or in the mean maternal age (MMA). After standardization of the twinning rates according to maternal age, the regional and temporal differences remain.

Address for correspondence: Professor Johan Fellman, Folkhälsan Institute of Genetics, Population Genetics Unit, POB 211, FIN-00251 Helsinki, Finland. Email: johan.fellman@shh.fi

Table 1

The Sources for Regional Data Concerning the Twinning Rate (TWR), the Crude Birth Rate (CBR) and the Mean Maternal Age (MMA), 1749–1960 (ST = Statistisk Tidskrift, SS = Statistics Sweden)

County	Variable	Period	Reference
City of Stockholm	TWR	1749–1858	ST, 1860–62:43–47
	TWR	1871–1960	SS
	CBR	1749–1858	ST, 1860–62:43–47
	MMA	1861–1900	SS
County of Stockholm	TWR	1749–1773, 1795–1858	ST, 1860–62:134–141
	TWR	1871–1960	SS
	CBR	1749–1773, 1795–1858	ST, 1860–62:134–141
	MMA	1861–1900	SS
Gotland	TWR	1759–1869	ST, 1870:221–231
	TWR	1871–1960	SS
	CBR	1759–1869	ST, 1870:221–231
	MMA	1751–1910	Wohlin (1915)
Älvsborg	TWR	1749–1773, 1795–1874	ST, 1875:127–136
	TWR	1871–1960	SS
	CBR	1749–1773, 1795–1874	ST, 1875:127–136
	MMA	1861–1900	SS

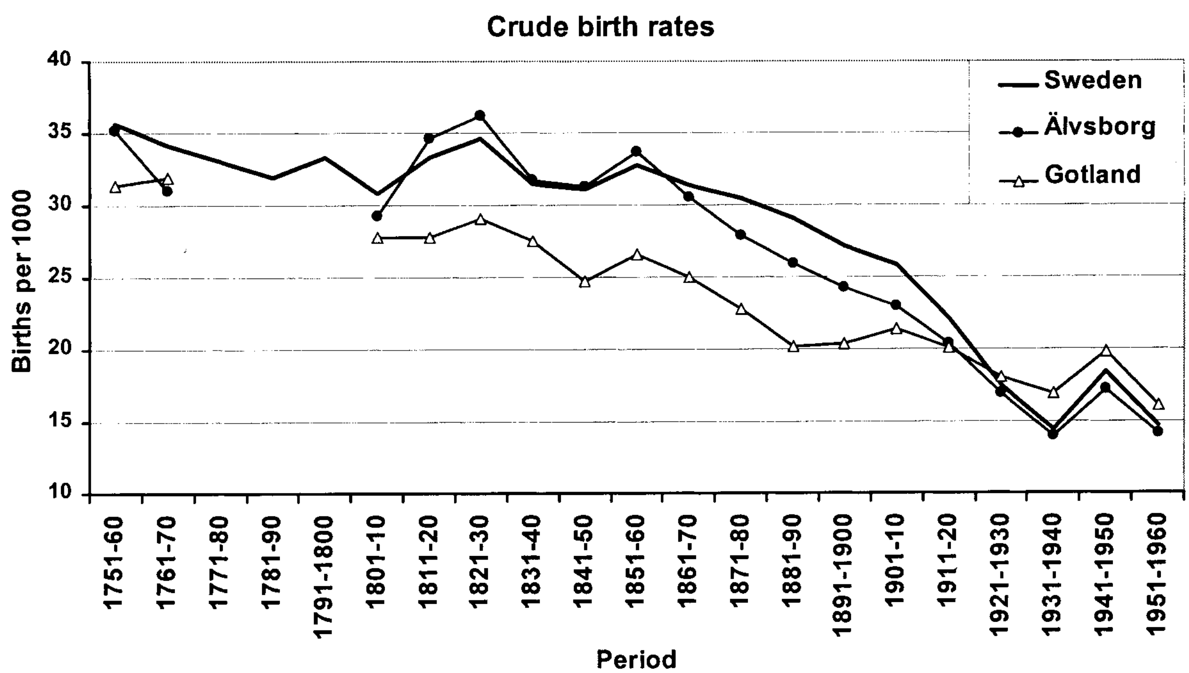

Figure 1

Temporal trends in the crude birth rates (CBR, the number of births per 1.000 inhabitants) for Gotland and Älvsborg, 1751–1770, 1801–1960, and for Sweden, 1751–1960. All the decreasing temporal trends are statistically significant.

Material

We analyzed demographic time series data from 1749 to 1996 in Sweden and to 1960 in the counties of Gotland, Älvsborg and Stockholm and the city of Stockholm. The data are pooled for 10-year periods collected from the official data published by Sweden. In the middle of the 19th century, Statistics Sweden published in "Statistisk Tidskrift" a long series of regional demographic data. The regional data are given for the counties. These time series started in 1749, the starting time for "Tabellverket" (the predecessor to Statistics Sweden). Depending on the time of the publication the time series ended in the period 1858–1874. Therefore, periods with available data vary somewhat from county to county. In most of the counties there is a gap between 1774 and 1794, because during that period the parish data were pooled according to the partition of Sweden into dioceses. We have used time series for the CBR and the TWR of the counties considered here.

An important source is Sundbärg (1907). However, he presented only the demographic time series for the whole of Sweden for 1751–1900. For this study, data for CBR and mean maternal age are of interest. The maternal age data for Gotland, 1750–1910, were given by Wohlin (1915). For the other counties, maternal age data have only been obtained for the period 1861–1900. In addition, the correlation between CBR and TFR in the Swedish 5-year data for the period 1751–1965 is based on the data given in "Historisk statistik för Sverige" (1969). Furthermore, we have used yearly official data from Finland for the period 1939–1994 in order to analyse the association between CBR and GRR and the mean parity. For details of the data set, see Table 1.

Methods and Results

Proxy Variables for Mean Parity

Empirical models are often misspecified because the researcher cannot obtain data for some of the variables in the theory. Regression analyses that ignore a relevant regressor may cause biased estimates. The estimates are still unbiased only if the regressors ignored are uncorrelated with those used. Therefore, one should try to replace the missing variables with alternative, available variables. Such variables are called *proxy* variables and if they are linearly dependent, stochastically or exactly, on the missing variables, the bias is eliminated. When one substitutes a proxy alternative for a true variable, one assumes that the proxy variable is strongly correlated with the true variable. This assumption is impossible to check, because the true variable is not observable. Consequently, the assumption must be based on theoretical arguments or on earlier studies.

In the literature there have been discussions concerning the use of proxy variables. On the basis of the bias criterion, McCallum (1972) and Wickens (1972) concluded that a proxy variable should be used even if it is a poor one. Maddala (1977, p. 158) and Frost (1975) advocated incorporating reliable proxy variables only. Ohtani (1981) presented predictors based on two misspecified models: one containing only one regressor from which the immeasurable variable was missing, and the other in which the immeasurable variable was replaced by a proxy variable — the result being a regression model with two regressors. In addition, he introduced a weighted predictor. His main conclusion was that none of these predictors dominated the others. Consequently, he deduced that indiscriminate inclusion of the proxy variable might lead to definite risks and he therefore proposed the use of the weighted predictor. Stahlecker and Trenkler (1993) generalized the results of Ohtani (1981) to apply to multiple regression models.

Maternal age and parity are strongly correlated and, if either of them is missing, proxy variable techniques would be desirable. Allen (1984, 1987), for example, proposed that the standardization of TWR should take into account not only maternal age but also parity, which is another influential factor. In our paper (Fellman & Eriksson, 2002) we have standardized the twinning rates, using maternal age alone, parity alone, and both together, and have observed discrepancies between the results obtained. In official statistics, historical information concerning parity data is rarely available. If parity data are missing, one possibility is to consider other demographic variables as proxy variables, giving information about the mean parity.

CBR as a Proxy Variable

In the absence of information about parity, an attempt to use proxy variables in studies on TWR seems to be desirable. One proxy variable could be the CBR. It is to be expected that the CBR and the mean parity are positively correlated. If the CBR is high, then the average number of births per mother may also be high, and conversely, if CBR is low then the number of births per mother may also be low. The CBR has an advantage as a proxy variable because it is usually easily obtainable from the recorded data, even from the data for sub-regions and sub-periods. One needs only the population size and the number of live births. Hofsten and Lundström (1976) commented that the CBR is a poor measure of fertility. However, in spite of its shortcomings, the CBR is often used as a measure of fertility and in this study we considered it to be an acceptable proxy variable for the mean parity in Sweden and its counties.

GRR and TFR as Proxy Variables

Both the GRR and the TFR, if available, may be used as proxy variables for the mean parity. They measure the expected total number of daughters (or alternatively offspring) of a mother. Therefore, one expects high (low) values to indicate high (low) mean parity. Hofsten and Lundström (1976) also stressed that the TFR, and consequently the GRR, are poor measures of fertility, especially for recent periods, owing to the introduction of stricter family planning. The possibility of spacing maternities means that their timing varies considerably. In this study, based mainly on historical data, the spacing of births has a minor influence and, to gain an impression of the mean parity, we could consider GRR or TFR as alternatives to CBR. However, they are seldom available for sub-regions.

Evidence from Finnish and Swedish data

To gain an impression of the correlation between the CBR and the mean parity, we studied the data from Finland (1939–1994) and Sweden (1751–1965). For Finland, we observed that there was no great difference in the associations between the mean parity and the variables CBR and GRR. Between the mean parity we obtained the correlation .842 for legitimate live births and CBR and between the mean parity for legitimate live births and GRR the correlation is .848. If, furthermore, we note that the correlation between CBR and GRR is as high as .974, we may conclude that they can be assumed to be equally good as a proxy variable for the mean parity. According to the correlations, there are no obvious arguments for a specific alternative. The final choice between CBR and GRR has to be based on the availability of data. The correlation between CBR and TFR for Sweden based on data for 5-year periods is .979. This finding is in good agreement with the results obtained for Finnish data and supports the use of the proxy variable technique suggested above. CBR, being the most easily obtainable from data registers, has been chosen for this study. The introduction of proxy variables has been connected with regression analyses, but in this study the proposed variables are considered to give at least qualitative information about the variation in the mean parity.

Mean Parity and CBR

Comparisons between the mean parities of the Swedish counties cannot be performed, but a study of CBR can give some indications about the temporal variation in the mean parity. The data considered are Gotland, Älvsborg, the county of Stockholm and the city of Stockholm, 1751–1770, 1801–1960 and Sweden as a whole, 1751–1960. Figure 1 shows that Älvsborg, for almost the whole period, has higher birth rates than Gotland. For both counties we observe markedly decreasing trends in the CBR. Similar trends can also be observed for the county of Stockholm and the city of Stockholm, as well as for Sweden as a whole. On average the CBR is lowest in Gotland. Regression analyses indicate that for all the counties and for Sweden as a whole the decreasing temporal trends in the CBR are statistically significant. If we assume that the CBR is strongly correlated with the mean parity, the temporal pattern of the unknown mean parity can be considered to be similar to the temporal pattern of CBR presented above. In addition, the low level of the CBR in Gotland indicates that the mean parity is low in Gotland too. Bernhardt (1971) has pointed out that about 75% of the women born in Sweden in the 1870s and 1880s were married at least once. The proportion then rose steadily to 90% of women born around 1920. One has also to take into consideration that 10–15% of couples are primarily sterile. In consequence, in earlier times children were distributed among a much smaller proportion of women than nowadays (after the strong decrease in twinning started in the 1930s in Sweden). Apparently, the mean parity has decreased more steeply than is implied by the curve for the number of children per mother. Rough estimates show that until the 20th century the average number of children per mother was between 6 and 7, but in relation to all women only between 4 and 5. The average number of children in fertile marriages in 1930 was 3.80 and in 1936 only 2.87 (Gyllensvärd, 1946). As a comparison we have performed an analysis of the temporal trend for the TFR in Sweden, 1751–1965, based on data obtained from "Historisk Statistik för Sverige" (1969), which showed a statistically significant decreasing trend.

Mean Maternal Age

The temporal trends in mean maternal age are shown in Figures 2 and 3. For the periods when the mean maternal age for Älvsborg is available it is markedly higher than in Gotland (Figure 2). In Sweden there are statistically significant temporal trends in MMA. We observed that the increasing temporal trend in MMA for Sweden ends about 1860. In 1861–1870 the maximum is 32.31 years. After that the MMA decreases markedly. This decrease is comparable in strength with the significant decreasing trend in Älvsborg and the (not significant) decreasing trends observed for the county of Stockholm and Stockholm City during the period 1861–1900 (Figures 2 and 3). After 1900 the mean maternal age for Sweden decreases even

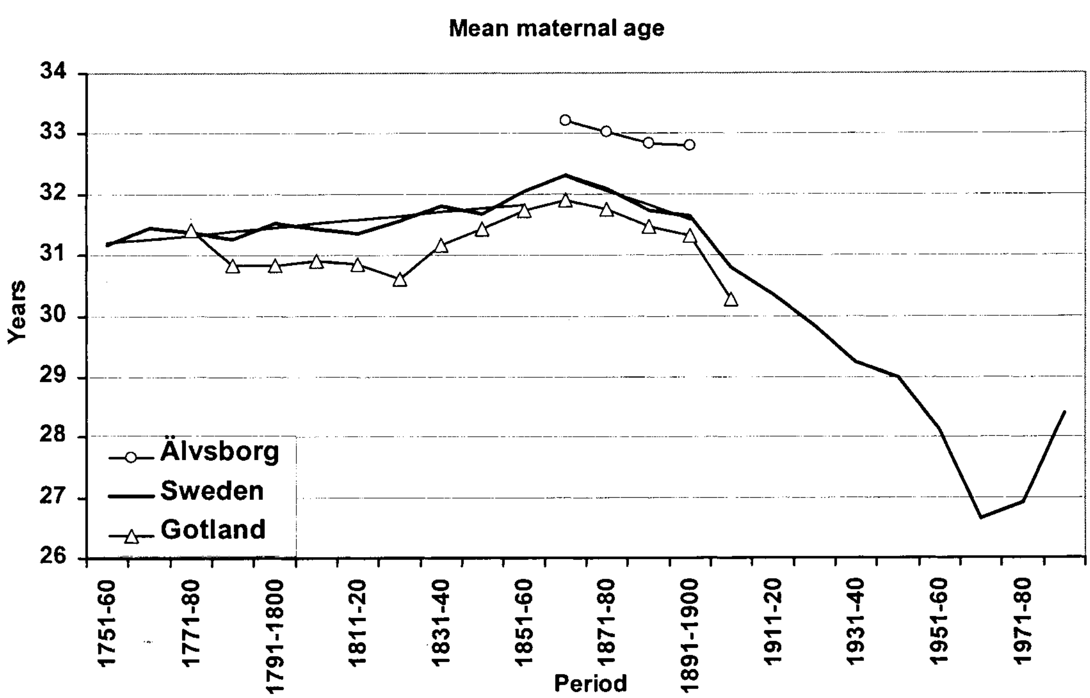

Figure 2

Temporal trends in mean maternal age (MMA), given in years, for Älvsborg, 1861–1900, for Sweden, 1751–1990, and for Gotland, 1778–1910. For Älvsborg, the decreasing temporal trend is statistically significant. For Sweden, there is a statistically significant increasing trend until 1860 and after that there is a statistically significant decreasing trend. In 1861–70, the maximum is 32.31 years. After that, the MMA decreases markedly. The decrease in Sweden during the period 1861–1900 is comparable in degree with the simultaneous significant decreasing trend in Älvsborg. After 1900, the mean maternal age decreases even more markedly, reaching a minimum, 26.65, in 1961–70. After that there is a slight increase.

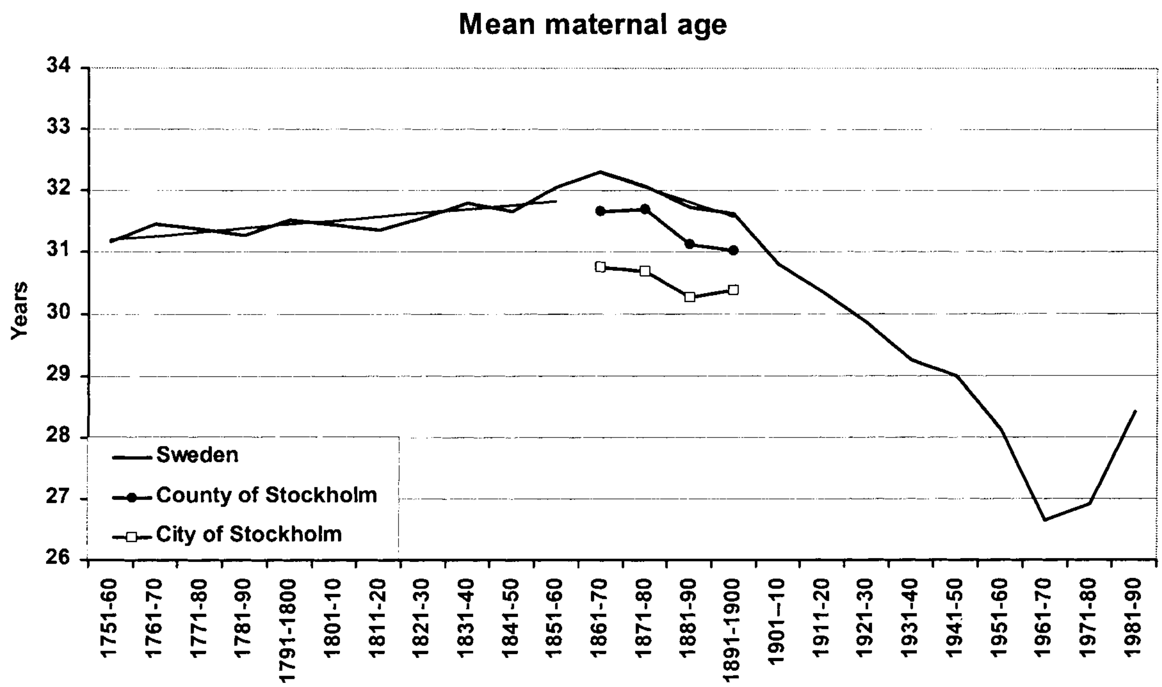

Figure 3

Temporal trends in mean maternal age (MMA), given in years, for Sweden, 1751–1990, the county of Stockholm and Stockholm city, 1861–1900. The decrease during the period 1861–1900 is comparable with the decreasing trends observed for the county of Stockholm and Stockholm city.

more markedly until 1961–1970, reaching a minimum 26.65. Then there is a slight increase.

Statistical Inference Problems with Demographic Macrodata

In an earlier paper (Fellman & Eriksson, 1987) we stressed that temporal and regional differences are hard to explain with factors on the macrolevel. In this paper we shall discuss this problem in greater detail and illustrate it with the influential factor of maternal age. Analogous reasoning can be applied to other influential factors, such as parity (the number of previous births), marital status (married or unmarried mothers) or degree of urbanization (urban or rural regions). However, these factors are discrete and presented in classes. Consequently, the integrals in the following formulae should be replaced by sums (cf. Fellman & Eriksson, 2002). In addition, we develop the analysis in order to make possible comparisons between several groups (e.g., sub-periods and/or sub-regions of a population). Therefore, from the beginning in our formulae we introduce an additional grouping index. In order to avoid several indices, we consider maternal age to be continuous and ungrouped. We introduce the following notations:

For the group number i ($i = 1,\dots, I$) let $N_i\,(a)$ be the number of general maternities among mothers of age a and $n_i\,(a)$ be the number of twin maternities among mothers of age a.

Then

$$r_i\,(a) = \frac{n_i(a)}{N_i(a)} \tag{1}$$

is the age-specific twinning rate for mothers of age a in group number i. Using these notations, we obtain the total number of general maternities

$$N_i = \int_{a_{min}}^{a_{max}} N_i(a)da. \tag{2}$$

The maternal mean age, m_i is

$$m_i = \frac{1}{N} \int_{a_{min}}^{a_{max}} aN_i(a)da \tag{3}$$

The total number of twin maternities is

$$n_i = \int_{a_{min}}^{a_{max}} n_i(a)da = \int_{a_{min}}^{a_{max}} r_i(a)N_i(a)da \tag{4}$$

and the total twinning rate is

$$R_i = \frac{n_i}{N_i}. \tag{5}$$

In Fellman and Eriksson (1990) we used these ideas when we developed our alternative standardization method. Furthermore, we stressed that r_i(a), for $a < 40$ years, is approximately a linear function of a. In that paper we also discussed the fact that there is only a small disturbing effect if we ignore mothers over 40 years old. Following this line of thought, we assume that

$$r_i(a) = \alpha_i + a\beta_i \tag{6}$$

Now we obtain from (4) and (6)

$$n_i = \int_{a_{min}}^{a_{max}} (\alpha_i + a\beta_i)N_i(a)da$$
$$= \alpha_i N_i + \beta_i \int_{a_{min}}^{a_{max}} aN_i(a)da = \alpha_i N_i + \beta_i m_i N_i \qquad (7)$$

Consequently,

$$R_i = \alpha_i + \beta_i m_i. \qquad (8)$$

Fellman and Eriksson (1987) used this linear relation between maternal mean age and the total twinning rate when the alternative standardization method was developed. When the goal of the study is analyses of temporal or regional differences and we know only the total twinning rate and the mean maternal age, equation (8) is without value. With this limited information, it is impossible to assume that the parameters α_i and β_i are the same for all groups, resulting in one common linear relation, $R_i = \alpha + \beta m_i$. If the parameters vary from group to group, then no regression technique can be applied. Figure 4 is a simple sketch of the problem and gives the explanation. If the parameters α_i and β_i vary from group to group, then (6) varies from group to group resulting in different lines. A regression analysis based only on the points (m_i, R_i) $(i = 1,\ldots, I)$ gives a line fitted to these points and the regression model obtained does not estimate the initial parameters (Figure 4). In fact, the line obtained may even have a negative slope. In addition, it is necessary to stress that, if the parameters α_i and β_i are the same for all regions, then the regression analysis gives unbiased estimates. However, usually there is very little variation among the mean maternal age values for the different regions, and an analysis based on the points (m_i, R_i) $(i = 1,\ldots,I)$ gives inaccurate estimates.

It is a well-known fact that TWR is higher in rural than in urban areas (see e.g., Eriksson, 1962, 1964, 1973; Eriksson & Fellman, 1973). In Fellman and Eriksson (1987), we tried to explain statistical significant regional differences in TWR for Finland, 1974–1983. We had information about MMA, mean parity, the percentage of illegitimate maternities and the urbanization level for 12 different counties. Earlier microlevel studies had identified the statistically significant effects of all these variables (Eriksson et al., 1973a). Particularly, the high twinning rate in illegitimate maternities was discussed in detail in Eriksson and Fellman (1967a, 1967b). However, Fellman and Eriksson (1987) observed no association between twinning rate and marital status for Denmark, 1973–1984. The suggested explanation was that the classification, marital status, had lost its original meaning. In Denmark today, younger couples, especially, live as married couples without formally wedding. However, they are classified as unmarried. James (1981) considered twinning rates in England and Wales, 1962–1966, and noted that the illegitimate DZ twinning rate is lower than the legitimate rate at the lowest maternal age (15–19) and is higher only at the higher maternal ages, resulting in a steeper slope. Also MacGillivray et al. (1988) have observed a decreasing effect of marital status on the twinning rates.

Our attempt to measure, on a macrolevel, the effects of maternal age, parity, urbanization and marital status almost failed. The only statistically significant effect was the level of urbanization. The corresponding regression coefficient was statistically significant and had the expected minus sign but the model was very poor. This finding is a good example of the estimation problem theoretically discussed above. In addition, as a consequence of the theoretical analysis, CBR and/or mean maternal age cannot explain the temporal variation in TWR. Regional and temporal heterogeneity in the parameters (α_i, β_i) is caused by heterogeneity in the age-specific twinning rates. This heterogeneity is independent of differences in the age distributions of the mothers. Therefore, further studies on correlations between different genetic, fertility and socioeconomic factors and the regional twinning rates in Sweden have to be performed and are in preparation (Eriksson & Fellman, 2003).

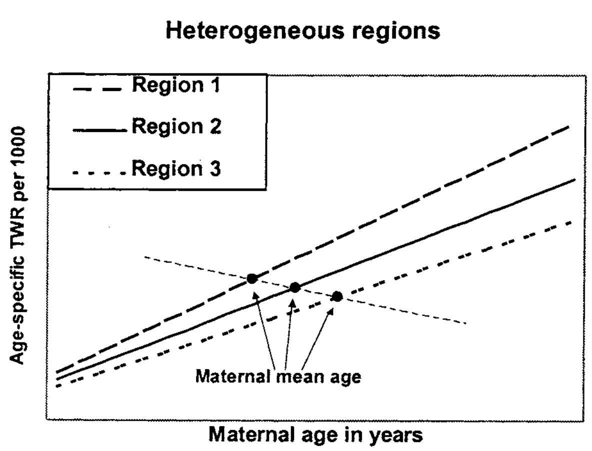

Figure 4

Graphical sketch of the estimation problem caused by regional heterogeneity in the age-specific twinning rates. For details see the text.

Secular Changes in the Twinning Rate

For the counties of Gotland, Älvsborg and Stockholm and for Stockholm City we considered the period 1751–1960. For comparison, we also considered the whole of Sweden for the period 1751–1996. The temporal variation in TWR for Sweden is presented in Figure 5. The data were pooled in 10-year periods and the temporal trends for all the series were analyzed statistically for the period 1751–1960. For Sweden, the data for the period 1961–1996 were not included in the regression analysis. The argument for this is that gonadotrophin and similar techniques for stimulation of ovulation were introduced in Sweden in the 1960s (Gemzell & Roos, 1966). The TWR for Sweden as a whole decreased from 14.87 in 1751–1760 to 10.98 in 1951–1960. Particularly, the decade 1781–90 showed the highest twinning rate for Sweden, 17.21 per thousand. The 95% confidence interval is CI = (16.90, 17.51). This notation is used later for 95% confidence intervals. After that there was a marked continuous decrease in the twinning rate to 13.55 CI = (13.33, 13.77) in 1841–50. The decrease, 3.66 per mille units (a 21.3% decrease) cannot be explained by a lower MMA or a lower CBR. For the period 1781–90, the

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MMA was 31.27 and the CBR 31.95 and for the period 1841–1850 the corresponding figures were 31.67 and 31.10. Moreover, a standardization does not eliminate the marked decrease (Figure 5). After standardization of TWR according to maternal age, we obtain the standardized rates of 15.19 for the period 1781–90 and 11.82 for the period 1841–50, resulting in a difference of 3.37 per mille units (a 22.2% decrease).

After 1850, a slight upward trend with national values between 14 and 15 per thousand are noted. The twinning rate after the 1920s falls steeply down to 8.74 per thousand CI = (8.55, 8.92) in the 1970s. This decline by 40% between the 1920s and the 1970s may have been still steeper but assisted reproduction techniques were introduced in Sweden as early as the 1960s (Gemzell & Roos, 1966). Only about 50–60% of this steep decline in the twinning rate can be explained by the changes in maternal age distribution and parity (Eriksson & Fellman, 1973; Fellman & Eriksson, 1990, 2002). See also Figure 5.

TWR in the Gotland series decreased from 24.52 in 1751–1760 to 12.79 in 1951–1960. In sharp contrast to that, TWR for Älvsborg was low for the whole period. It decreased from 12.37 in 1751–1760 to 10.60 in 1951–1960 and had an overall mean of only 13.29 compared with 14.42 for Sweden as a whole. Earlier studies have shown that Gotland and Älvsborg showed quite different levels of the twinning rate during the period 1849–1873 (Berg, 1880). Our study has confirmed that equally marked differences in TWR can also be noted before and after this period (Figure 6). For the county of Stockholm, TWR decreased from 17.15 to 10.35. For Stockholm city, the corresponding figures were 17.22 and 10.97. Based on regression analyses, decreasing temporal trends were statistically significant for Sweden, Gotland, and the county of Stockholm and for Stockholm City. For Älvsborg, TWR showed no statistically significant decreasing trend.

Standardization of TWR

We standardized TWR according to maternal age. Standardization according to parity, as suggested by Allen (1984, 1987), could not be performed. Parity data were not available and the proxy variables proposed are on a macrolevel and therefore impossible to use. We applied the method introduced in Fellman and Eriksson (1990, 2002). The regional twinning rates can be standardized only for periods with known mean maternal age. The reference population must be sufficiently informative. One has to know the age-specific twinning rates and the mean maternal age. In addition, it would be preferable for the reference population to be associated with the target populations (Fellman & Eriksson, 2002). In this study we used data from Sweden, 1971–1980, as the reference population. For this period, the TWR for Sweden attains its minimum, 8.74 per thousand. The observed and standardized TWRs are presented in Figure 5. Standardization of the TWR for Sweden, 1751–1900, reduces the TWR, but the minimum is 11.82 (for the period 1841–50), which is far from the value of 8.74 in 1971–1980. Observed and standardized twinning rates for Sweden are presented in Figure 5 and for

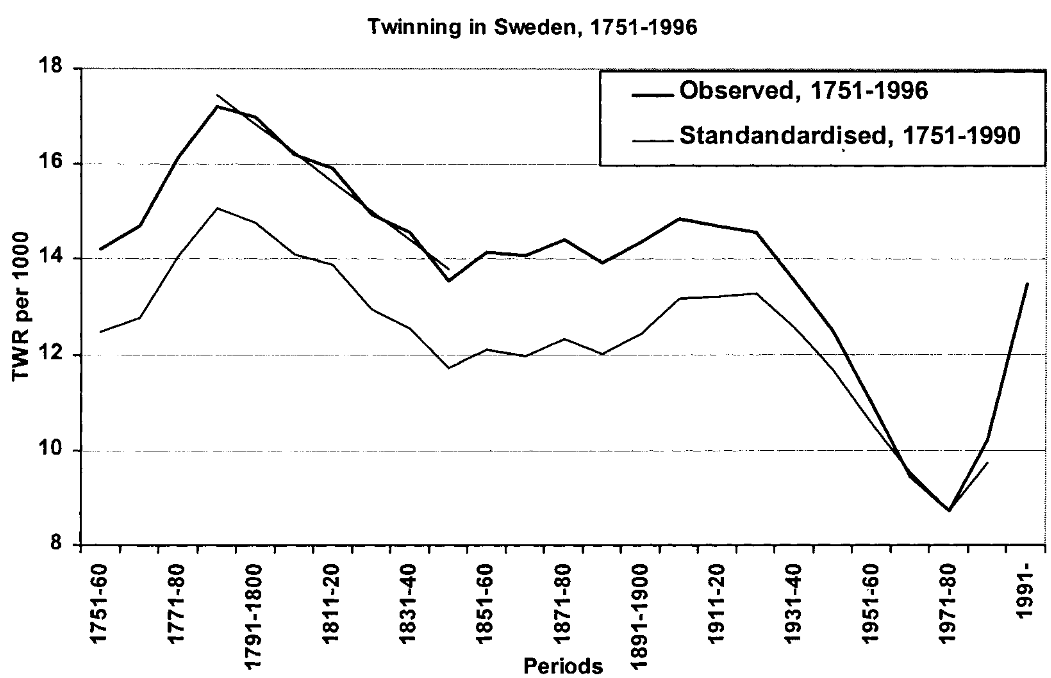

Figure 5

Temporal trends in the twinning rate in Sweden, 1750–1996. The decreasing trend is statistically significant. The steep fall during the period 1781–1850 is indicated with a trend line. The standardized TWR for the period 1751–1900 shows temporal fluctuations of similar strength to the observed TWR. The reference population for the standardization is Sweden, 1971–80. In the 19th century the standardized TWR obtained its minimum 11.82 for the period 1841–50, which is markedly higher than the observed TWR 8.74 for the period 1971–80.

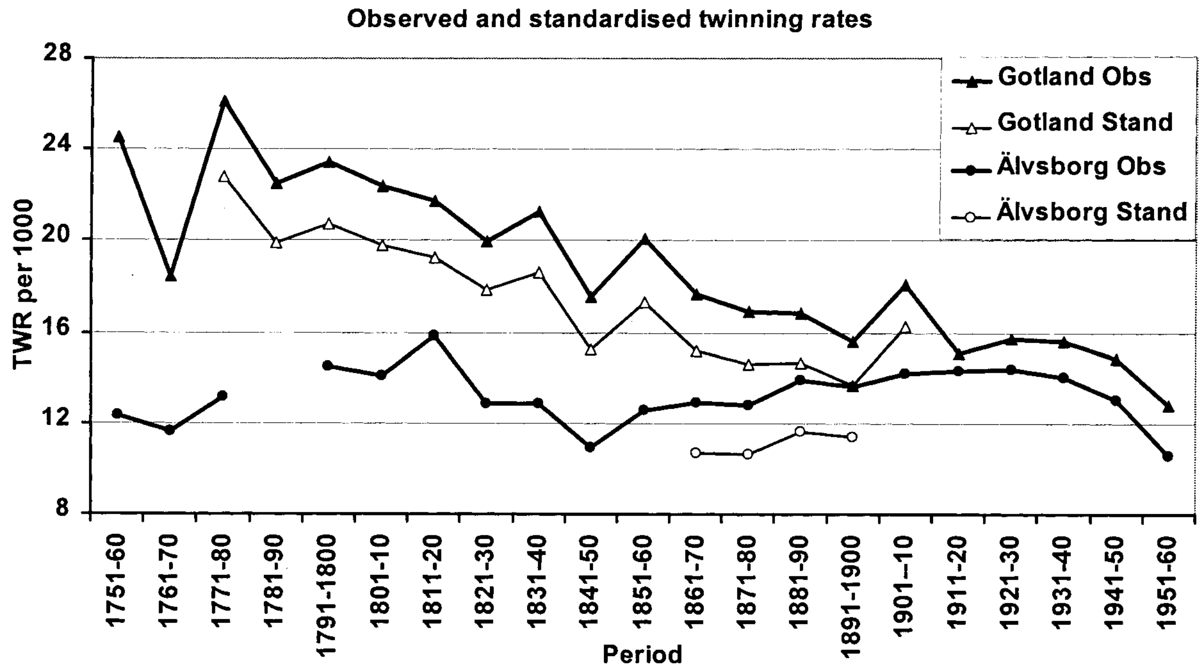

Figure 6

Temporal trends in the twinning rates in Gotland and Älvsborg, 1751–1960. For Gotland, the decreasing trend is statistically significant. For Älvsborg there is an *increasing* trend, but it is not statistically significant. After standardization, the relative difference between the twinning rates for Gotland and Älvsborg remains.

Gotland and Älvsborg in Figure 6. We observed that the relative differences remain. Particularly, the difference between the low level for Älvsborg and the high level for Gotland can still be observed. Furthermore, the strength of the decreasing trends remains. These results support the finding that the regional and temporal differences cannot be explained by differences in maternal age alone.

Discussion

Population Structure and Twinning

There are marked differences in population structure between Älvsborg and Gotland. The former has, for a long period, been a more or less "panmixed" region, while the latter is, up to recent time, a rather isolated island, with a population increasing from about 25000 in 1751 to 55000 in 1960. The high rates of multiple maternities (over 20 per thousand) also in Gotland's neighbouring insular isolates in the Baltic Sea, such as Åland and Åboland in south-western Finland, may well reflect the effect of inbreeding, accumulation of common genes or some common environmental factors (e.g., in food). The decline in the rates of multiple maternities is also matched by the decreasing pattern of regional endogamy at least in the Åland Islands (Eriksson, 1962, 1964, 1973; Eriksson et al., 1980).

In his detailed studies on the population of Gotland, Wohlin (1915) thoroughly analysed the demographic data from Gotland for the period 1751–1910. Although the goal of his study differs from ours, his results support our findings and conclusions. According to Wohlin, Wargentin noted already in the 18th century that in 1749–1782 the birth rate in Gotland was the lowest in all counties of Sweden (16 children born per 100 married couples per year against 17–27 in the other counties of Sweden). Wohlin noted that the birth rate in Gotland during the last part of the 18th century was 2–4 per mille units below the average for Sweden and during the 1840s and 1850s more than 6 per mille units below. During the 1860s and 1870s this difference was still more accentuated, being over 8 pro mille units. In the 1880s, the birth rate in Gotland was only 20.2 compared to 29.1 in Sweden. In Europe, only France had a birth rate lower than Gotland. Wholin (1915) could not find any explanation for the low natality in the age structure or civil status of the population. As a possible cause, the actual reproduction in marriages was analysed and discussed by Wohlin, who reached the conclusion that conscious attempts at birth control started at the beginning of the 19th century in Gotland. His explanation for this is that the farmers did not wish to split up the farms. In this respect there was a contrast between Gotland and the mainland of Sweden, because, according to Sundbärg (1910), the fertility of marriages in the other parts of Sweden did not decrease until the 1880s. As alternative causes Wohlin discussed late marriages and inbreeding. The mean maternal age does not support the first alternative (cf. Figure 2).

Högberg and Wall (1992) concluded that changes in parity and maternal age in Sweden accounted for the decline in the twinning rate from the 19th century to the middle of the 20th century. The authors concluded that the later decline in the twinning rate could not be explained by changes in maternal age and parity. At the diocese level, they noted no definite decline in the twinning rate during the first half of the 19th century. However, in our studies at the county level during the 18th century the island of Gotland showed the highest twinning rate noted in Sweden (23.55 per thousand) and a significant secular decrease during the 19th century to values around 16 per thousand (Figure 6).

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