On the Standardisation of the Twinning Rate

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In many studies the twinning rate, being strongly dependent on maternal age (and parity), has been standardised according to the maternal age distribution. The direct method requires very informative twinning data for the target population. The indirect method is used when the data for the target population is not sufficiently informative or when the target population is small. We have earlier introduced an alternative indirect technique for standardising the twinning rate. Our technique requires even less of the twinning data. Besides maternal age, parity is an influential factor, and should, if possible, be taken into account. In this study we present the traditional standardisation methods based on both maternal age and parity, we propose a new direct standardisation method and we develop our standardisation methods so that they take into account both maternal age and parity. We apply these standardisation methods to data from Finland, 1953–1964, from St. Petersburg, Russia, 1882–92, from Canada 1952–1967, and from Denmark, 1896–1967. These methods all give results very similar to those for the Finnish data, but the effect of parity is strongest with the direct methods. This may be due to the fact that, among extramarital maternities, parity has a strongly increasing effect on the twinning rate. This may be attributed to a higher reproduction capacity among unmarried mothers. Standardisations of the Canadian and the Danish data also give reliable results. With the St. Petersburg data, however, the different standardisations show notable discrepancies. These discrepancies are compared with Allen's findings.

The twinning rate is strongly dependent on maternal age and therefore, standardisation of the twinning rate according to the maternal age distribution is common in the literature. The purpose of standardisation is to eliminate the effect of maternal age and/or parity, in order to identify the effects of other socio-economic factors. There have been two main standardisation techniques, the direct and the indirect. These were in detail discussed by Hill (1971). The direct method requires very informative twinning data for the target population. Particularly, the age-specific twinning rates of the target population must be known. Sometimes this information is not available or the target population is so small that the age-specific twinning rates are subject to large random fluctuations, resulting in inaccurate estimates. These shortcomings are eliminated by the indirect standardisation method, which requires only that the age-specific twinning rates are available for a reference population and of the target population, only the age distribution of the general maternities and the total twinning rate need to be known. In Fellman and Eriksson (1990) we discussed these techniques, stressing the advantages of the indirect technique. In that paper we also introduced a new technique for indirect standardisation of the twinning rate according to maternal age. The advantage of our technique is that it requires even less informative data; for the target population only the total twinning rate and the mean maternal age.

However, Allen (1984, 1987), for example, has proposed that parity (the number of previous maternities), being an influential factor, should also be taken into account. In the following, we will study this problem. First, we present the traditional indirect and direct standardisation methods based on both maternal age and parity. Secondly, following our ideas (Fellman & Eriksson, 1990) we present our indirect method and propose an alternative direct standardisation method. We build our standardisation methods so that they take in account both maternal age and parity. Finally we apply these standardisation methods to the empirical data from Finland, 1953–64, from St. Petersburg, Russia, 1882–92, from Canada, 1952, 1957, 1962 and 1967 (in short denoted 1952–67), and from Denmark, 1896–1967.

The Indirect Standardisation Method

If we have to standardise the twinning rate according to one factor (usually maternal age) the data of the reference and target populations have to be grouped accordingly. For the reference population, we use the following notations:

$$N_j^R \, (j = 1,\ldots,c)$$

is the number of maternities in the different age groups,

$$T_j^R \, (j = 1,\ldots,c)$$

is the number of twin maternities in the different age groups and

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$$R_j^R = \frac{T_j^R}{N_j^R} \; (j = 1,\ldots,c)$$

are the corresponding twinning rates.

The notations

$$N_{\cdot}^R, T^R \text{and } R^R = \frac{T^R}{N^R}$$

a are the corresponding values for the entire reference population. The twinning rates are usually given per 1000. If so, the rates in every formula in this study should also include the factor 1000. Table 1 gives the layout of the reference population.

For the target population we have Table 2, where

$$N_j^T (j = 1,\ldots,c)$$

is the observed number of all maternities for the class number j and

$$\hat{T}_j^T = R_j^R * N_j^T \; (j = 1,\ldots,c)$$

is the estimated number of twin maternities if the group-specific twinning rates in the target population are the same as in the reference population.

We introduce the expected total twinning rate

$$R_e = \frac{\hat{T}^T}{N^T} \tag{1}$$

and obtain the indirectly standardised rate

$$R_{IS} = \frac{R^R}{R_e} R^T, \tag{2}$$

where R^T is the observed total twinning rate of the target population. In this context it is not necessary to know the number of twin maternities in the subgroups of the target population. The ratio in (2) measures how the difference between the two maternal age distributions influences the total twinning rate when the age-specific twinning rates of the reference population hold for both populations. This ratio transforms the observed total twinning rate (R^T) of the target population into the standardised rate (R_{IS}). The standardised total twinning rate, R_{IS}, indicates what the total twinning rate in the target population would be if the target population has the same maternal age distribution as the reference population. The difference between the observed twinning rate, R^T, and R_{IS} measures the extent to which standardisation has changed the total twinning rate; that is the effect of the difference in maternal age distribution. This standardisation method can as well be applied when the grouping factor is parity.

If the data of the populations are grouped according to two factors, e.g. both maternal age and parity, we can go one step further and standardise the twinning rate according to both factors. Now, we have to consider a two-dimensional grouping of the data. We use analogous notations and the layout for the reference population is presented in Table 3.

In Table 4 we present the target population. Let N_{ij}^T be the observed number of maternities in cell (i, j). Assuming that the group-specific twinning rates of the reference population hold, then the expected number of twin maternities is

$$\hat{T}_{ij}^T = R_{ij}^R * N_{ij}^T$$

and, consequently,

$$\hat{T}_{i.}^T = \sum_j \hat{T}_{ij}^T$$

is the row sum,

Table 1

Layout of the Reference Population According to One Factor

Factor levels (age)	f_1	…	f_j	…	f_c	Total
Number of maternities	N_1^R	…	N_j^R	…	N_c^R	N^R
Number of twin sets	T_1^R	…	T_j^R	…	T_c^R	T^R
Twinning rate	R_1^R	…	R_j^R	…	R_c^R	R^R

Table 3

Layout of the Reference Population According to Two Factors (e.g. Maternal Age and Parity) (Twinning Rates are defined as $R_{ij}^R = \frac{T_{ij}^R}{N_{ij}^R}$ $(i = 1,\ldots,r)$ $(j = 1,\ldots,c)$.

Factor levels (age and parity)	f_1	…	f_j	…	f_c	Total (rows)
g_1	N_{11}^R	…	N_{1j}^R	…	N_{1c}^R	$N_{1.}^R$
	T_{11}^R	…	T_{1j}^R	…	T_{1c}^R	$T_{1.}^R$
	R_{11}^R	…	R_{1j}^R	…	R_{1c}^R	$R_{1.}^R$
	:	…	:	…	:	:
g_i	N_{i1}^R	…	N_{ij}^R	…	N_{ic}^R	$N_{i.}^R$
	T_{i1}^R	…	T_{ij}^R	…	T_{ic}^R	$T_{i.}^R$
	R_{i1}^R	…	R_{iJ}^R	…	R_{ic}^R	$R_{i.}^R$
	:	…	:	…	:	:
g_r	N_{r1}^R	…	N_{rj}^R	…	N_{rc}^R	$N_{r.}^R$
	T_{r1}^R	…	T_{rj}^R	…	T_{rc}^R	$T_{r.}^R$
	R_{r1}^R	…	R_{rj}^R	…	R_{rc}^R	$R_{r.}^R$
Total (columns)	$N_{.1}^R$	…	$N_{.j}^R$	…	$N_{.c}^R$	$N_{..}^R$
	$T_{.1}^R$	…	$T_{.j}^R$	…	$T_{.c}^R$	$T_{..}^R$
	$R_{.1}^R$	…	$R_{.j}^R$	…	$R_{.c}^R$	$R_{..}^R$

Table 2

Layout of the Target Population According to One Factor

Factor levels (age)	f_1	…	f_j	…	f_c	Total
Number of maternities	N_1^T	…	N_j^T	…	N_c^T	N^T
Est. number of twin sets	$\hat{T}_1^T = R_1^R * N_1^T$	…	$\hat{T}_j^T = R_j^R * N_j^T$	…	$\hat{T}_c^T = R_c^R * N_c^T$	$\hat{T}^T = \Sigma \hat{T}_j^T$

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Table 4
Layout of the Target Population According to Two Factors.

Factor levels (age and parity)	f_1	…	f_j	…	f_c	Total (rows)
g_1	N^T_{11}	…	N^T_{1j}	…	N^T_{1c}	$N^T_{1.}$
	$\hat{T}^T_{11} = R^R_{11} * N^T_{11}$	…	$\hat{T}^T_{1j} = R^R_{1j} * N^T_{1j}$	…	$\hat{T}^T_{1c} = R^R_{1c} * N^T_{1c}$	$\hat{T}^T_{1.} = \sum_j \hat{T}^T_{1j}$
	:	…	:	…	:	:
g_i	N^T_{i1}	…	N^T_{ij}	…	N^T_{ic}	$N^T_{i.}$
	$\hat{T}^T_{i1} = R^R_{i1} * N^T_{i1}$	…	$\hat{T}^T_{ij} = R^R_{ij} * N^T_{ij}$	…	$\hat{T}^T_{ic} = R^R_{ic} * N^T_{ic}$	$\hat{T}^T_{i.} = \sum_j T^T_{ij}$
	:	…	:	…	:	:
g_r	N^T_{r1}	…	N^T_{rj}	…	N^T_{rc}	$N^T_{r.}$
	$\hat{T}^T_{r1} = R^R_{r1} * N^T_{r1}$	…	$\hat{T}^T_{rj} = R^R_{rj} * N^T_{rj}$	…	$\hat{T}^T_{rc} = R^R_{rc} * N^T_{rc}$	$\hat{T}^T_{r.} = \sum_j \hat{T}^T_{rj}$
Total (columns)	$N^T_{.1}$	…	$N^T_{.j}$	…	$N^T_{.c}$	$N^T_{..}$
	$\hat{T}^T_{.1} = \sum_i \hat{T}^T_{i1}$	…	$\hat{T}^T_{.j} = \sum_i \hat{T}^T_{ij}$	…	$\hat{T}^T_{.c} = \sum_i \hat{T}^T_{ic}$	$\hat{T}^T_{..} = \sum_i \hat{T}^T_{i.}$

$$\hat{T}^T_{.j} = \sum_i \hat{T}^T_{ij}$$

is the column sum and

$$\hat{T}^T_{..} = \sum_i \hat{T}^T_{i.} = \sum_j \hat{T}^T_{.j}$$

is the total sum of the expected number of twin maternities.

Accordingly, we introduce the expected total twinning rate

$$R_e = \frac{\hat{T}^T_{..}}{N^T_{..}} \qquad (3)$$

and obtain

$$R_{IS} = \frac{R^R_{..}}{R_e} R^T_{..}, \qquad (4)$$

where R^T is the observed total twinning rate of the target population. It should be noted that it is not necessary to know the number of twin maternities in the subgroups but only the numbers of all maternities in the subgroups and the total number of twin pairs.

The Direct Standardisation Method

When the direct standardisation method is applied, one calculates the expected number of twin maternities for the reference population, on the assumption that the twinning rates are those of the target population. Mathematically, we have to interchange the populations considered in the earlier section and calculate the expected rates in (2) and (4). In the two-factor case we obtain

$$R_{DS} = \frac{\hat{T}^R_{..}}{N^R_{..}} = \frac{\sum_i \sum_j R^T_{ij} N^R_{ij}}{\sum_i \sum_j N^R_{ij}}, \qquad (5)$$

where, R^T_{ij} is the observed group-specific twinning rate of the target population in the cell (i, j) and N^R_{ij} is the number of all maternities of the reference population in the cell (i, j).

The Fellman-Eriksson Standardisation Methods

Indirect Standardisation

The traditional indirect standardisation method outlined above demands rather much informative data concerning the target population, that is, knowledge of the distribution of the maternities over the different age-parity groups and the total twinning rate. In situations where the data concerning the target population are less informative, the method proposed by us can still be applied. In earlier studies, we have noted that the twinning rate is linearly dependent on maternal age up to 40 years (Figure 1). The births among mothers aged over 40 years form a very small part of the data set and their effect can be ignored (Fellman & Eriksson, 1990). The twinning rates also show, especially for the legitimate maternities, a close linear relationship to parity (Figure 2).

The basis of our standardisation method of the twinning rate is a regression model technique. Concerning the target population, this method requires only the total twinning rate and the mean maternal age and, within this framework, the mean parity. Following the ideas in Fellman and Eriksson (1990), we generalise our initial standardisation formula and obtain the formula for our indirectly standardised twinning rate (R_{IFE})

$$R_{IFE} = R^T \frac{\beta^R_O + \beta^R_a \mu^R(AGE) + \beta^R_p \mu^R(PARITY)}{\beta^R_O + \beta^R_a \mu^T(AGE) + \beta^R_p \mu^T(PARITY)}, \qquad (6)$$

where both the numerator and the denominator contain the regression function for the twinning rate, with the regressors maternal age and parity based on the data from the reference population. In formula (6), $\mu^R(AGE)$ and $\mu^R(PARITY)$ are the mean maternal age and the mean parity for the reference population, respectively. The corresponding means for the target population are $\mu^T(AGE)$ and $\mu^T(PARITY)$. As a consequence of the use of regression models based on the reference population, formula (6) corresponds to the indirect standardisation method. In fact, assuming that the group-specific twinning rates for the

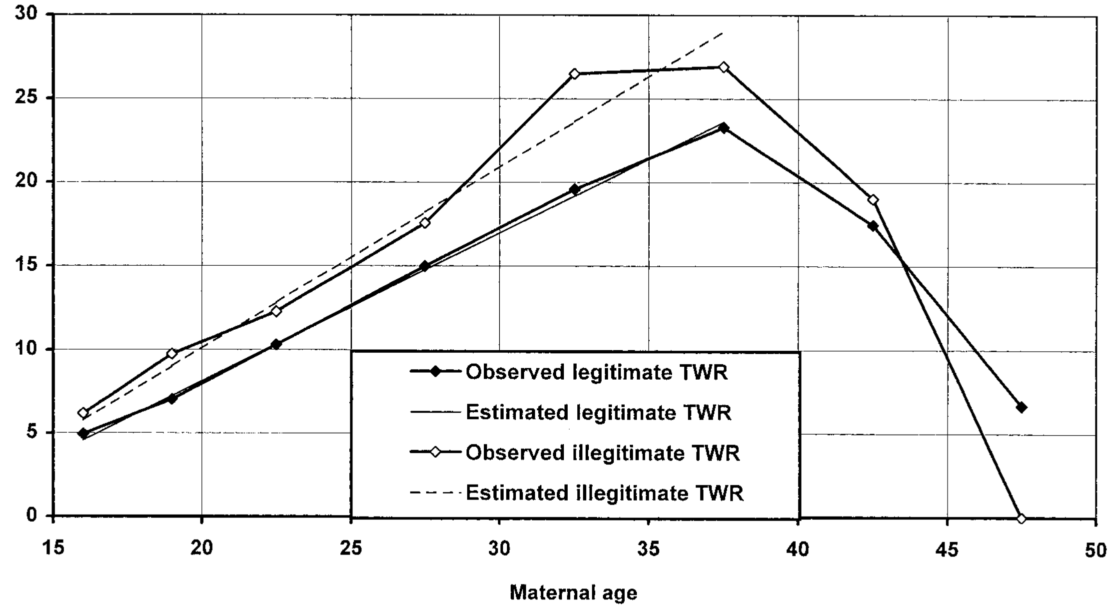

Figure 1

Twinning rate in Finland, 1953–64, according to maternal age and marital status.

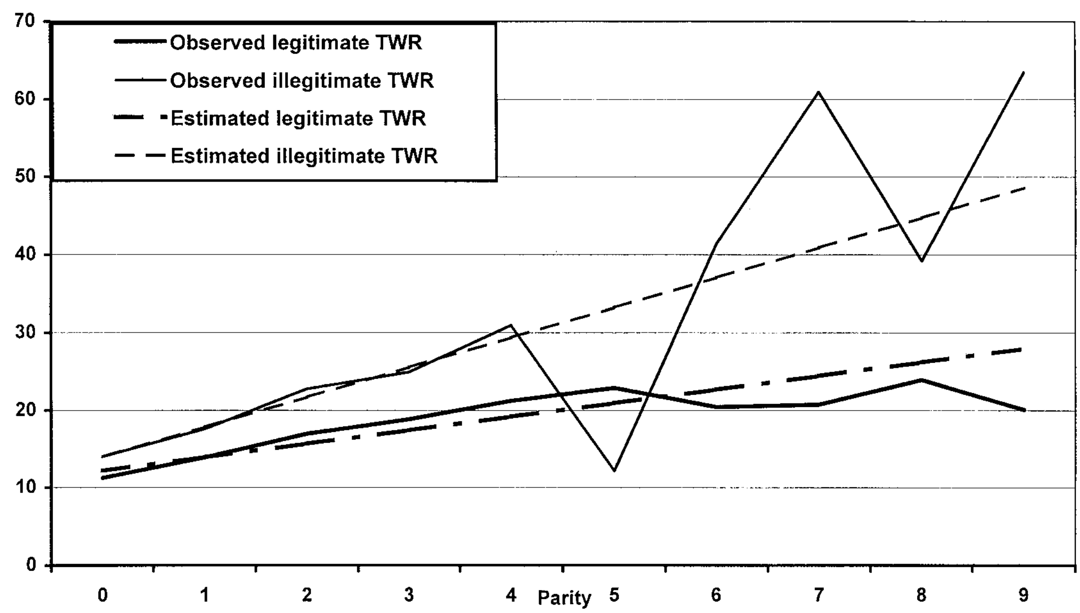

Figure 2

Twinning rate in Finland, 1953–64, according to parity and marital status.

reference population are linearly dependent on maternal age and parity, formula (6) follows from formula (4).

Direct Standardisation

An alternative to the indirect standardisation method is obtained when we use the regression models corresponding to the target population. Hence we obtain a direct standardisation formula for the twinning rate

$$R_{DFE} = \beta_O^T + \beta_a^T \mu^R\,(AGE) + \beta_p^T \mu^R\,(PARITY) \qquad (7)$$

where the the regression function for the twinning rate is based on the target population data and and μ^R (AGE) and μ^R $(PARITY)$ are, as above, the mean maternal age and the mean parity for the reference population. Analogously, if linearity is assumed, (7) follows from (5).

Applications

Comparison of the presented methods needs very informative data sets. Such sets are not common in the literature. In this study we have chosen four sets. The first is the twinning

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data from Finland, 1953–1964, grouped according to maternal age, parity and marital status of the mother, given in Eriksson and Fellman (1967a). In all our studies we use as the reference population the data for legitimate maternities from Finland, 1953–1964. In the study of the Finnish data the target population is the illegitimate maternities for the same period. The marital data consist of *976613* maternities and *14795* twin maternities, resulting in a total twinning rate of *15.15* per mille and the corresponding data for the illegitimate births are *43249*, *673* and *15.56*, respectively. In the second application the target population is twinning data from St. Petersburg, Russia, 1882–92, grouped according to maternal age and parity and given by Bertillion (1898). The St. Petersburg data consist of *311422* maternities and *4381* twin maternities, resulting in a total twinning rate of *14.07* per mille. The reference population is still the legitimate maternities in Finland, 1953–1964. Our third application is based on data, first given by Elwood (1978), from some cities in Canada in four years between 1952 and 1967. The initial data were not published but we have estimated them from the tables. These data consist of about *237409* all maternities and 2474 twin maternities, resulting in a total twinning rate of *10.42* per mille. The fourth data set was obtained from a preliminary study of Danish twinning data for the period 1896–1967.

The Finnish Data

We apply all four standardisation techniques presented above and compare the results when they are based on both parity and maternal age, on maternal age alone and on parity alone.

For the Fellman-Eriksson indirect standardisation method, the estimated regression models are

- using maternal age only:
  $TWR = -9.57991 + 0.88883\ AGE$
- using parity only:
  $TWR = 11.777276 + 2.158801\ PARITY$
- using maternal age and parity:
  $TWR = -6.57881 + 0.730516\ AGE + 0.90970\ PARITY$

In the simple models, in comparison with the full model, the parameter estimates exaggerate the effect of the chosen factor. This is a consequence of the strong correlation between maternal age and parity. Using the grouped data for legitimate maternities, we obtain the correlation *0.5455*. When we use the observed averages of the maternal age and the parity, we obtain Fellman-Eriksson indirect standardisation.

For the Fellman-Eriksson direct standardisation method, the estimated regression models based on the target population (illegitimate maternities) are

- using maternal age only:
  $TWR = -10.01274 + 1.013047\ AGE$
- using parity only:
  $TWR = 14.034606 + 3.966216\ PARITY$
- using maternal age and parity:
  $TWR = -9.029034 + 0.9528533\ AGE + 1.770606\ PARITY$

In these, we also observe the effect of the correlation (*0.2799*) between maternal age and parity. When we use the observed averages of maternal age and parity for the legitimate maternities noted above, we obtain the Fellman-Eriksson direct standardisation. The results of the four standardisation methods are given in Table 5.

If we use only one factor, it reflects some of the effect exerted by the other factor when the two factors are used simultaneously. This is a consequence of the strong correlation between the factors (see above). It is of great interest in this example that parity shows more proneness to reflect the effect of maternal age than does maternal age to reflect the effect of parity. One reason for this is that the marital and extramarital data differ more markedly according to parity distribution than to maternal age distribution. For married mothers the mean age is *28.57*, but for unmarried mothers it is *25.60*. The corresponding figures for the mean parity are *1.69* and *0.40*, respectively. In addition, parity has a much stronger effect on the twinning rate among unmarried mothers than among mothers who are married (See again, Figure 2).

The St. Petersburg Data

Our second application is based on data from St Petersburg, Russia, 1882–1892, first given by Bertillion (1898). These data consist of *311422* maternities and *4381* twin maternities, resulting in a total twinning rate of *14.07* per mille. The data set is grouped according to maternal age and parity. Consequently, it is well suited for the standardisations presented above. The maternal mean age is *28.47* and the mean parity is *2.51*. In comparison with the refer-

Table 5

Comparison of the Results of the Four Alternative Standardisation Methods for the total Twinning Rate for Illegitimate Maternities (FE = the Fellman-Eriksson Methods)

		Standardisation method			
Twinning rates (TWR)	Standardising factor(s)	Direct	Indirect	FE direct	FE indirect
Obs. leg. TWR		15.149	15.149	15.149	15.149
Obs. illeg. TWR		15.561	15.561	15.561	15.561
Stand. illeg. TWR	Maternal age	18.436	18.309	18.926	18.678
Stand. illeg. TWR	Parity	20.401	18.912	20.719	18.977
Stand. illeg. TWR	Age and parity	20.566	19.740	21.175	19.721

Table 6

Comparison of Results of Standardisation by the Two Alternative Methods on the Twinning Rate in Data from St. Petersburg, 1882–92 (FE = the Fellman-Eriksson Methods)

		Standardisation method	
Twinning rates (TWR)	Standardising factor(s)	Indirect	FE indirect
Observed TWR (reference population)		15.149	15.149
Observed St. Petersburg TWR		14.068	14.068
Standardised St. Petersburg TWR	Maternal age	14.447	14.994
Standardised St. Petersburg TWR	Parity	12.868	12.614
Standardised St. Petersburg TWR	Age and parity	14.050	14.116

Table 7

Comparison of the Results of Standardisation by the Two Alternative Methods on the Twinning Rate in Data from Canada in the Years between 1952 and 1967 (FE = the Fellman-Eriksson Methods)

		Standardisation method	
Twinning rates (TWR)	Standardising factor(s)	Indirect	FE indirect
Observed TWR (reference population)		15.149	15.149
Observed Canada TWR		10.421	10.42
Standardised Canada TWR	Maternal age	10.968	11.319
Standardised Canada TWR	Parity	10.641	10.888
Standardised Canada TWR	Age and parity	10.912	11.362

ence population the maternal mean age is almost the same (for the reference population *28.57*) but the mean parity is higher (for the reference population *1.69*). These figures indicate that the reproductive period is almost the same but that the intervals between consecutive maternities for individual mothers were markedly shorter in St Petersburg. When the traditional standardisation method is applied to the St. Petersburg data, there is a shortcoming. The age grouping in the St. Petersburg data differs from the age grouping in the Finnish data. The differences are one year (e.g. 21–25 versus 20–24). No adjustment of the grouping for the St. Petersburg data is possible. Consequently, when the traditional standardisation methods are applied, the results may include a small error. This grouping difference has no effect on our standardisation result, because our method needs only the mean maternal age and this is obtainable. We observed in the general analysis and in the first example that indirect standardisation methods can be assumed to be more reliable than direct methods. Therefore, we present only the result of the indirect standardisation (Table 6).

In Table 6 we observe that, on the basis of both maternal age and parity, the two methods give very similar results but with our standardisation method they are slightly higher. In comparison with the standardisation according to both maternal age and parity, maternal age alone gives quite similar values but parity alone gives lower values. This is a consequence of the marked difference in the mean parity, discussed above, between the reference population and the target population. This holds for both standardisation methods. In addition, we stress that in this study our method, which is based only on the mean maternal age and the mean parity, is more straightforward to use. Similar discrepancies were found by Allen (1987). See Discussion for further comparisons.

Canadian Data

The third population we studied is from Canada in the years between 1952 and 1967, first given by Elwood (1978). These data consist of about *237409* all maternities and *2474* twin maternities, resulting in a total twinning rate of *10.42* per mille. Elwood presents his data grouped according to maternal age and parity. However, he gives a reduced set of the single maternities. In this study we have recalculated the data presented with the factor *47.38*, in order to estimate the full set of maternities. The maternal mean age is *27.16* and the mean parity is *1.38*. The maternal mean age and the mean parity are slightly below the corresponding means for the reference population (*28.57* and *1.69*). The results of the standardisations are given in Table 7.

We observe that if both factors are used the standardised rate increases very slightly from *10.42* to *10.91* (to *11.36* for the FE method). The parity alone gives the standardised rate *10.64* (*10.89*), which is between the observed rate and the standardised rate when both factors are included. The standardisation according to the maternal age alone gives *10.97* (*11.32*), quite close to the results based on the maternal age and parity. In general, the discrepancies between the results according to the two methods are small.

The Data for Denmark

For this study we have chosen two twin data sets from Denmark, 1896–1930 and 1931–67. The first data set is subdivided according to maternal age (the age groups below 20 years, 20–24, 25–29, 30–34, 35–39, 40–44 and 45 years and over) and marital status (married and unmarried mothers). This data set was earlier analysed by Eriksson and Fellman (1967b). The second data set, not analysed before by us, includes information about the year of birth, maternal age in one-year age groups, parity, the marital status of the mother, the sex of the child in single births and the sex combination in the twin births. In this study we pooled our data according to the periods 1896–1930, 1931–40, 1941–50, 1951–60, 1961–67, and considered the parity groups and the maternal age groups below 20 years, 20–24, 25–29, 30–34, 35–39, 40–44 and 45 years and over. We standardised the twinning rates in order to solve two problems. The first was to study the effect of marital status on the twinning rate. The second was to study whether there were other temporal trends in the twinning rates than changes in parity and in maternal age distribution. Rachootin and Olsen (1980) have studied secular changes in the twinning rate in Denmark, 1931–77. They performed direct standardisation according to maternal age and according to maternal age and parity. Especially they considered dizygotic twinning. Although we are mainly interested in the effect of marital status of the mothers comparisons between their and our results will be considered later.

The effect of marital status. The observed twinning rates for illegitimate maternities were markedly below the corresponding curve for legitimate maternities but this was mainly a consequence of the lower mean maternal age and mean parity. In order to study the effect of marital status for each period we used the legitimate maternities as the reference population and standardised the twinning rate for the illegitimate maternities for the corresponding period. This standardisation was performed for the periods 1896–1930, 1931–40, 1941–50, 1951–60, and 1961–67. For the period 1896–1930 the standardisation had to be based on maternal age alone (cf. above). Comparison between the standardised twinning rates and the twinning rates of the reference population indicates the strength of the effect of marital status. The results are given in Figure 3. We observe that, whether we standardise according to both maternal age and parity or according to maternal age alone, the results are the same. However, standardisation according to parity alone gives markedly lower results. After standardisation, the extramarital twinning rates show levels markedly higher than the marital rates for the periods 1896–1930 and 1931–40. This indicates that, during these periods, unmarried mothers were more twin-prone than married mothers. This result is in good agreement with our earlier findings (Eriksson & Fellman, 1967a, b). For the later periods the standardised twinning rates are very similar to the twinning rates for the reference populations. These findings correspond well with our observation that, in recent times, the effect of the marital status of the mothers is diminishing (Fellman & Eriksson, 1987). In all the periods, however, standardisation according to parity alone does not wholly eliminate the difference between the twinning rates for marital and extramarital maternities (Figure 3).

Temporal trends. In order to study the temporal trends, we used the legitimate maternities for the period 1931–40

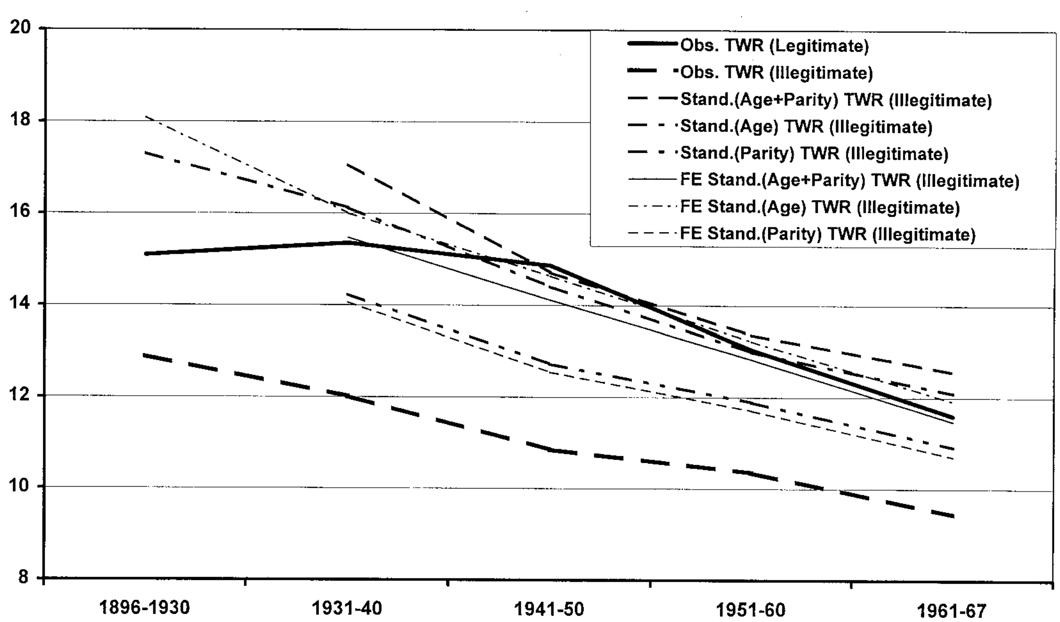

Figure 3

The effect of marital status on the twinning rates for Denmark, 1896–1967. The observed twinning rates for illegitimate maternities are markedly below the corresponding rates for legitimate maternities. After indirect standardisation (FE = the Fellman-Eriksson method) the extramarital twinning rates show levels markedly above the marital ones for the periods 1896–1930 and 1931–40. After that, the standardised curves show no marked differences. Thus, the relatively higher twinning rates among unmarried than among married mothers fade out after 1940. Standardisation according to parity alone cannot wholly eliminate the difference between the twinning rates for marital and extramarital maternities.

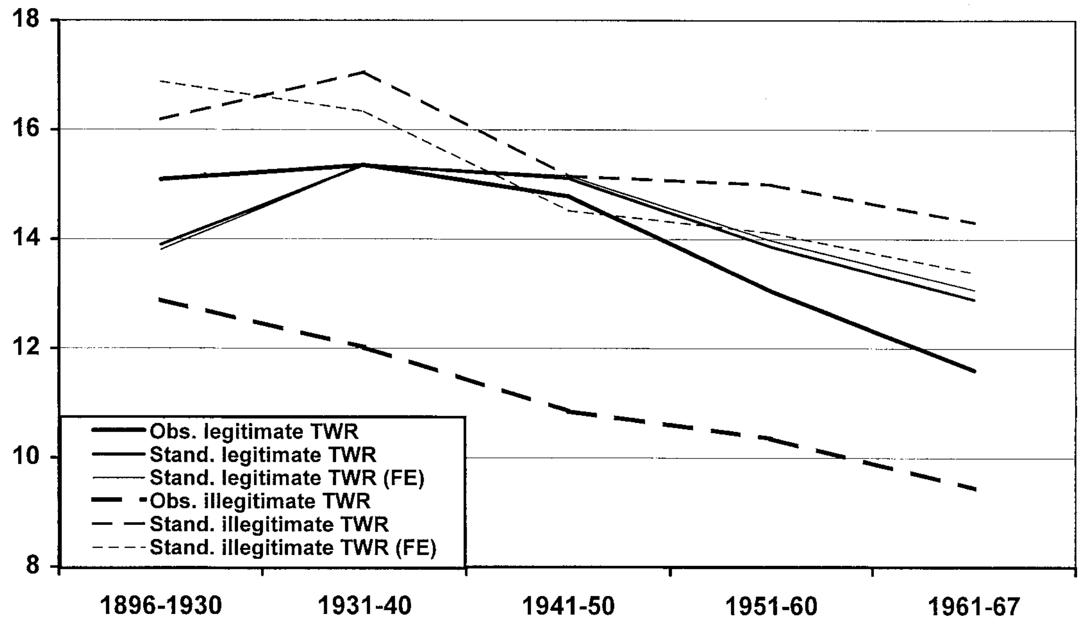

Figure 4

Temporal trends in the observed and standardised twinning rates for Denmark, 1896–1967. The observed twinning rates for illegitimate maternities are markedly below the corresponding curve for legitimate maternities. For both legitimate and illegitimate maternities a decreasing trend is noted. After indirect standardisation (FE = the Fellman-Eriksson method), this trend is reduced although still discernible. For the period 1896–1930, standardisation is based on maternal age alone. The extramarital twinning rates show levels markedly higher than the marital ones for the periods 1896-1930 and 1931–40. After that, the standardised curves show no marked differences

as the reference population and standardised the twinning rates of both legitimate and illegitimate maternities for the different periods as target populations. This standardisation was performed for the periods 1896–1930, 1931–40, 1941–50, 1951–60 and 1961–67. For the period 1896–1930, the standardisation was based on maternal age alone (cf. above). For both legitimate and illegitimate maternities, a decreasing trend in the observed twinning rate is noted. After standardisation, these trends were reduced but still discernible. Furthermore, the extramarital twinning rates were markedly higher than the marital rates for both the periods 1896-1930 and 1931-40. After that, the standardised curves show no marked differences (Figure 4). A decreasing trend in the observed twinning rate in Denmark and a reduced trend in the standardised twinning rates were also noted by Rachootin and Olsen (1980). Thus, our results are in good agreement with theirs.

Discussion

Allen (1984, 1987) discussed the standardisation problem in detail. He stated:

> In the best-known tables of twinning rates by maternal age and birth order, age groups have more effect than parity groups on twinning rates. This would seem to mean that when maternal age has little effect on the rates, the effects of birth order can be ignored. Quite the contrary with these data [US, 1964–1983]; birth order makes a much larger difference than maternal age. The seeming paradox disappears when one considers that mean parity can change drastically when mean age hardly changes at all; they can even change in opposite directions, and have done so in US.

In our study we observed that these methods all give very similar results. When the Finnish data were analysed, the effect of maternal age was almost the same. However, of the direct methods, the effect of parity was strongest. This is due to the fact that parity has an extremely strong influence on the twinning rates in illegitimate maternities and the direct standardisation methods use the group-specific twinning rates of the extramarital series. Furthermore, we note that, when parity is included as a factor, the Fellman-Eriksson indirect method gives values between those obtained by traditional methods. Finally, we observe that the Fellman-Eriksson direct method gives the most extreme result. Therefore, we state that the indirect method based on a reliable reference population should be used and that, in twin studies, our indirect method is a noteworthy alternative. In our study of the Finnish data, standardisation according to both maternal age and parity gives reliable results. This is due to the clear differences in the maternal age distribution (Figure 5) and in the parity distribution (Figure 6) between the legitimate and the illegitimate maternities. Furthermore, we observe that, for the Russian data, our standardisation method gives slightly higher results. In comparison with standardisation according to both maternal age and parity, maternal age alone gives very similar values but parity alone gives lower values. This holds for both standardisation methods. In addition, we stress that in this study our method, which is based only on mean maternal age and mean parity, is consequently not vulnerable to differences in the grouping of the data sets and is therefore more straightforward to use.

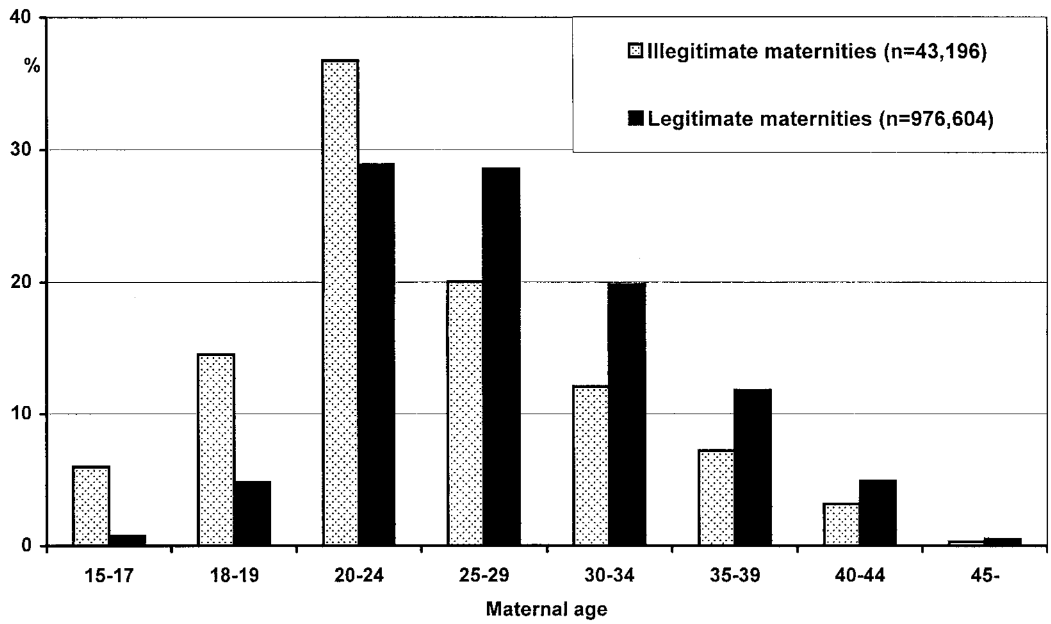

Figure 5
Distribution of the maternities in Finland, 1953–1964, according to maternal age and marital status.

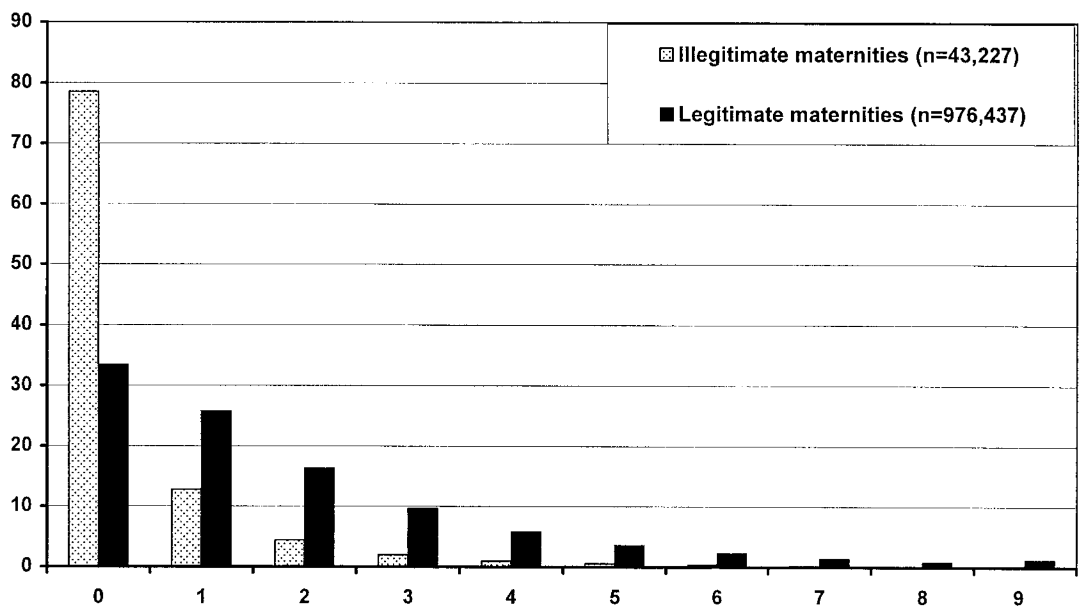

Figure 6
Distribution of the maternities in Finland, 1953–1964, according to birth order and marital status.

We agree with Allen's warnings concerning the superficial use of standardisation according to maternal age and parity. Our opinion is that one has to choose the reference population with great care. It must be closely related to a well-defined statistical problem. Such problems, for instance, are a study of the secular changes in the twinning rate in a specific population (e.g. Denmark in this study) or a cross-sectional study of the twinning rate in different subsections of a population in order to observe the effects of other social factors (e.g. the effect of marital status in the Finnish and Danish data sets in this study). Standardisation is intended to eliminate the effect of maternal age and/or parity, in order to identify the effects of other socio-economic factors on the twinning rate. Such additional factors can be determinants of fertility (e.g. coital rate, the probability of conceiving, given that coitus has occurred in the fertile interval, and the probability that spontaneous abortion does not occur), the proportion of unmarried mothers, etc. However, standardisation is valuable only if these factors are measured at the population level. Within a given

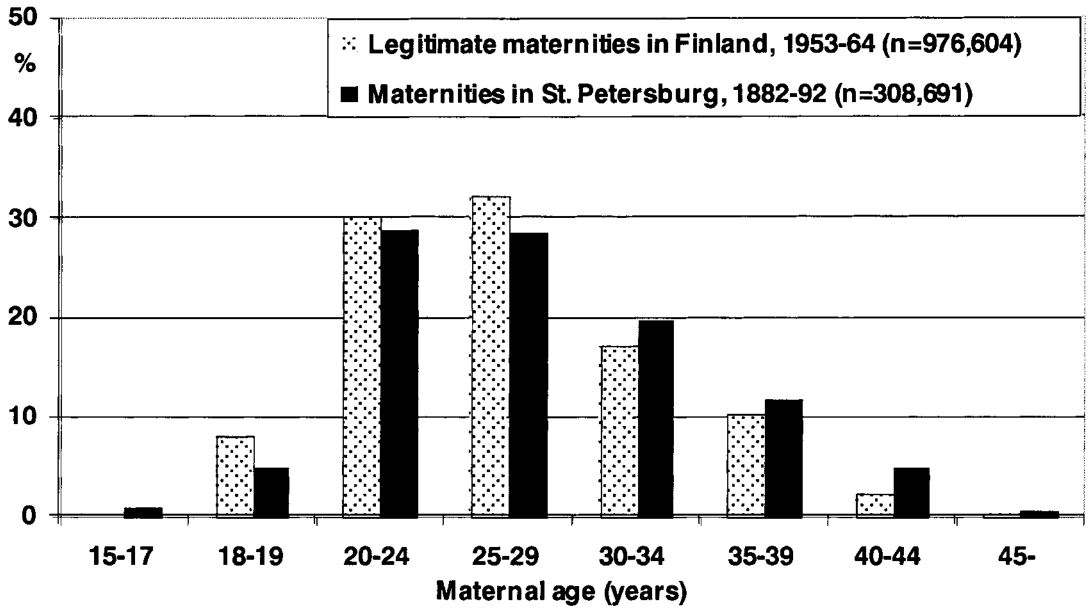

Figure 7

Distribution of the maternities according to maternal age in St Petersburg, 1882–92, and among legitimate maternities in Finland 1953–64.

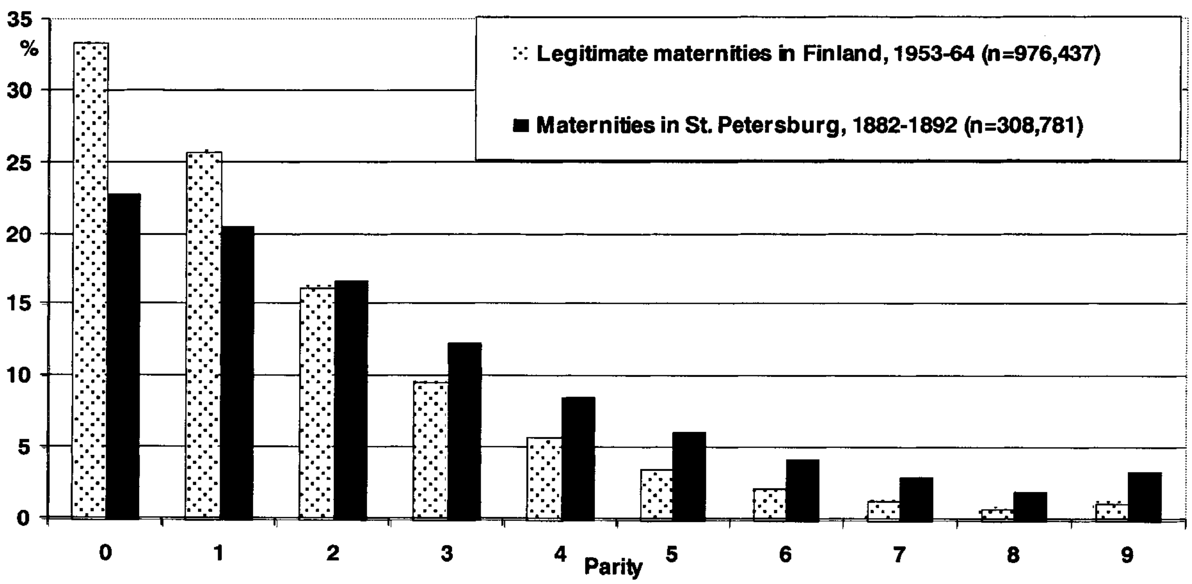

Figure 8

Distribution of the maternities according to parity in St Petersburg, 1882–92, and among legitimate maternities in Finland 1953–64.

population there is, as a rule, a strong correlation between maternal age and parity, but this relation may be quite different in another population or at another period. Therefore, standardisation methods should be based on both maternal age and parity. This reasoning is in good agreement with the conclusions obtained by Allen (1984, 1987).

The analysis of the Bertillion data is a good example of the standardisation problems stressed by Allen. Comparison between the reference population and the target population shows that the age distribution of the mothers is closely similar (Figure 7) but that parity differs markedly (Figure 8). In spite of the fact that the maternal mean age is slightly lower (*28.47*) in the target population than in the reference population (*28.57*), the mean parity is markedly higher, *2.51*, in the Russian data for the period 1882–92 as compared with *1.69* in the Finnish reference population for the period 1953–64. For interpretation of this phenomenon, we refer to our comments in the presentation of the St. Petersburg data.

In previous studies (Eriksson & Fellman 1967a, b) we have discussed the higher levels of twinning among unmarried than among married mothers. We are still convinced that, at least during the earlier periods, there are real differences. Our opinion is that unmarried women who give birth to extramarital children in spite of a less regular rate of coitus and a desire to avoid pregnancy, have a higher fertility than average. Hence, the unmarried mothers are a selected group of highly fertile women. The married mothers, on the other hand, cover all levels of fertility more completely. Today these differences are less noticeable. We noted (Fellman & Eriksson, 1987) that, according to the data from Denmark, 1973–1984, the differences between married and unmarried mothers faded out in parallel with the increasing proportion of unmarried mothers. The main explanation was that in Denmark, especially among younger couples, there has been an increasing tendency to cohabit without a formal wedding and the classification "marital status" has lost its original meaning.

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