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Trends in Monozygotic and Dizygotic Twinning Rates by Maternal Age and Parity

Further Analysis of Italian Data, 1949-1985, and Rediscussion of US Data, 1964-1985

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Abstract. The dizygotic twinning rate in Italy, adjusted for maternal age and parity, declined from 8.9/1000 in 1949-1953 to 6.0/1000 in 1978-81, but may have stabilized or recovered slightly in the early 1980s. The long decline was greatest in the oldest mothers, and the recent increase, if any, has been principally in first births and in women under 30. The monozygotic rate rose from 3.8/1000 in 1969-73 to 4.3/1000 in 1982-85, having been relatively stable prior to that period. No good explanation for these trends is apparent.

Key words: Twinning, Maternal age, Parity, Secular trends

Variations in twinning rates have continued to attract much interest in recent years, and it appears that the biology of twinning will continue to yield insights into reproductive biology. Until a few years ago the DZ twinning rate was observed to be declining in most industrialized countries, beginning shortly before or after World War II [9,12,14]. Because these were years of increasing birth control and falling birth rates, the most obvious explanation was changing demographic structure of the population, namely, reduction of maternal age and parity. This explanation proved inadequate, however [8, 11,14]. Alternative or additional hypotheses have been suggested, and analyses performed [1,5,13], but no consistent and adequate explanation has so far emerged.

Meanwhile, in recent years the DZ twinning rate appears to have stabilized and in some countries even to have increased [3,6], while the MZ rate, generally considered to be fairly stable, has also appeared to increase [7,15]. The DZ increase has been attributed by some to a "rebound effect" of oral contraceptives and/or to the use of ovulation

stimulants [4,10,16], while MZ twinning may have been increased by other after-effects of contraception [7].

The largest and most prolonged increase in twinning is reported from the US where it seems to have started about 1964, a year when all twin birth reports were extracted from birth records and analyzed. Since then, US twin statistics have been reported only in terms of live births in twin deliveries in a specified fraction of all births, without details of maternal age, birth order, or sex concordance. These data permitted examination of a 20-year span, interrupted in 1969-70 when twin births were not properly counted. After indirect adjustment or standardization for changes in maternal age and birth order, Allen [3] plotted curves as shown in Fig. 1 for twin births in the white and the black populations.

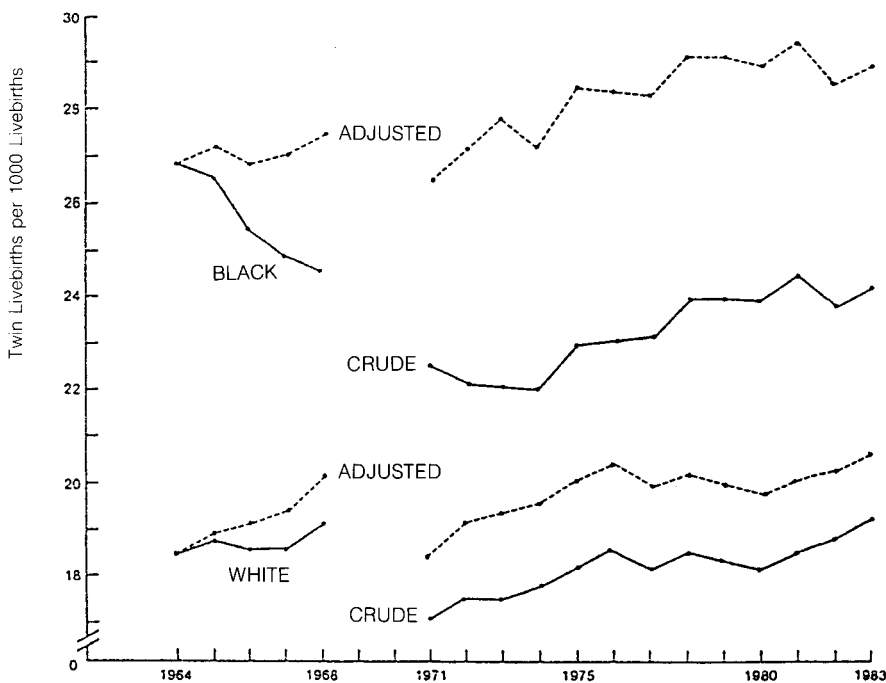


Fig. 1. The US total twinning rate, 1964-1983, crude and adjusted (standardized indirectly) for maternal age and birth order.

Several problems with these data require emphasis. First, between 1968 and 1971, when data were not published, there appeared to be a drop in twinning rates amounting to about 5% in the black and 10% in the white population. The 1969-70 suspension of published tables was dictated by an admitted loss of twin birth reports. One could speculate that the increase in twinning after 1971 was an artifact due to gradual recovery of the ascertainment system. Indeed, in the white population the adjusted rate increased only until 1976, then stabilized at a level close to that of 1968, which was not again exceeded until 1982. In the black population, however, the rise continued strongly after the rate passed the 1968 level.

A second problem is that, because twin birth reports were not tabulated by sex concordance, zygosity estimates are lacking. It cannot be excluded that the DZ rate continued to decline, as it did up to 1964, and that the observed increase in twinning was due to MZ twins.

Finally, indirect standardization for maternal age and birth order yields only tentative estimates of the true values. Exact adjustment requires fully specific rates by both age and parity or birth order. Such rates are only available for Italy and have already been studied for the years 1949-1979 by Parisi and Caperna [15]. Our purpose here is to extend that series to 1985 and to analyze it in more detail with respect to maternal age, birth order, and zygosity. Because of the unusual detail of the Italian data [15], the results of this analysis should be able to provide some insights into a better understanding of the US data and perhaps, more generally, of the recent trends in MZ and DZ twinning rates in industrialized countries.

METHODS

The data studied here refer to the whole of the Italian population over a series of 37 consecutive years, 1949-1985. That means a total of about 1,000,000 to 600,000 legitimate maternities per year, with some 12,000 to 6,000 twin pairs per year. These data are reported in six maternal age groups (under 20, 21-24, 25-29, 30-34, 35-39, 40 and over) and in five parity groups (0, 1, 2, 3, 4 and over), reported as live birth order (1 through 5 and over). The data are further broken down by twin zygosity, estimated through Weinberg's difference rule, twin sex combinations being known for all classes of maternal age and birth order. When the numbers of twins, especially MZ twins, are thus divided among the resulting 30 maternal-age-by-parity cells, very few cells yield stable rates, unless successive years are combined. Five-year periods have been adopted for the years 1949-1973, their use improving considerably the stability of the estimates and still revealing sufficient time detail. For the last twelve years, 1974-1985, where the new trends are of particular interest in this study and we did not want to discard data, we grouped the data in 4-year periods. The consequences of this arbitrary decision will be considered in the discussion.

To yield as much information as possible on the biology of twinning, it is desirable to study changes over years without interference from changing maternal age or changing birth order composition, and also to study the effects of time on these influences themselves. We therefore present three kinds of analysis. We have not analyzed the data by maternal birth cohorts, which might be possible and worthwhile.

First, we have studied secular change within single age-by-parity cells. This is useful for only the more frequent age and parity combinations.

Second, we have controlled both variables together, maternal age and birth order, by standardization. We applied age, and parity-specific rates from a given 5- or 4-year period to the numbers of births in corresponding cells for the 1949-53 period. The eight periods yield eight points to plot for each zygosity, giving curves covering the entire 37-year span free of the effects of secular changes in maternal age and parity.

The third method controls for one variable at a time in order to study the other one. This separates the confounding effects of maternal age and birth order while combining

enough data in each cell to yield stable estimates. Within all categories of one variable, the other is standardized to a constant distribution. This analysis might be undertaken with regression methods, but the result would be single coefficients instead of curves, giving little or no information about changes in rate-of-change or points of inflection.

To obtain six maternal age groups with nearly the same parity composition, we used the parity distribution of all 1949-53 births as proportions of the total, 0.347, 0.256, 0.146, 0.088, 0.163. These weights were applied to the five corresponding parity-specific rates in a single age group for, say, 1954-1958, and the products summed to yield a parity-standardized, age-specific rate for 1954-1958. Because the higher parities are not found in the youngest age group, the adjustment is only approximate for those cells. The rate for parity 0 was substituted for that of higher parities when births numbered less than 1000.

For age-standardized, parity-specific rates, the same procedure was applied, exchanging birth order and maternal age. Age group proportions for 1949-53 were 0.028, 0.215, 0.327, 0.212, 0.145, and 0.073. As before, for mothers under 20 the rate for parity 0 was used when total births at a given higher parity numbered less than 1000. The small proportion of births under age 20, 0.028, indicates that errors due to lack of higher birth orders in that particular group are not substantial. The problem is more general; the wide disparity at several birth orders between weights and the natural contribution of the different age groups. A similar problem exists, of course, in regression analysis of such data.

A word is needed about our terminology. When data from several years, say 1949-53, are added together and tabulated in a single cell, or plotted as a single point, we will refer to those years as a period; we do not attempt to study change within such a period except briefly in the discussion. When two adjacent cells or points are compared, say 1949-53 and 1954-58, the difference between the cells or the connecting plot will be called an interval.

FINDINGS

The total of live births in legitimate deliveries and the numbers of twin deliveries by sex combination are shown in Table 1, broken into the 5-year and 4-year periods used throughout the analysis.

Table 1 - Five- and four-year summations of legitimate live births in Italy from 1949 to 1985

Periods	Total deliveries	Twin deliveries		
		Male-female	Male-male	Female-female
1949-1953	4,297,488	19,083	17,959	17,199
1954-1958	4,292,611	18,892	18,080	17,157
1959-1963	4,571,181	18,589	18,209	17,146
1964-1968	4,794,065	17,304	17,914	17,604
1969-1973	4,416,405	13,799	15,201	14,910
1974-1977	3,128,777	8,667	10,458	10,287
1978-1981	2,530,618	6,532	8,280	8,178
1982-1985	2,261,058	5,909	7,624	7,467

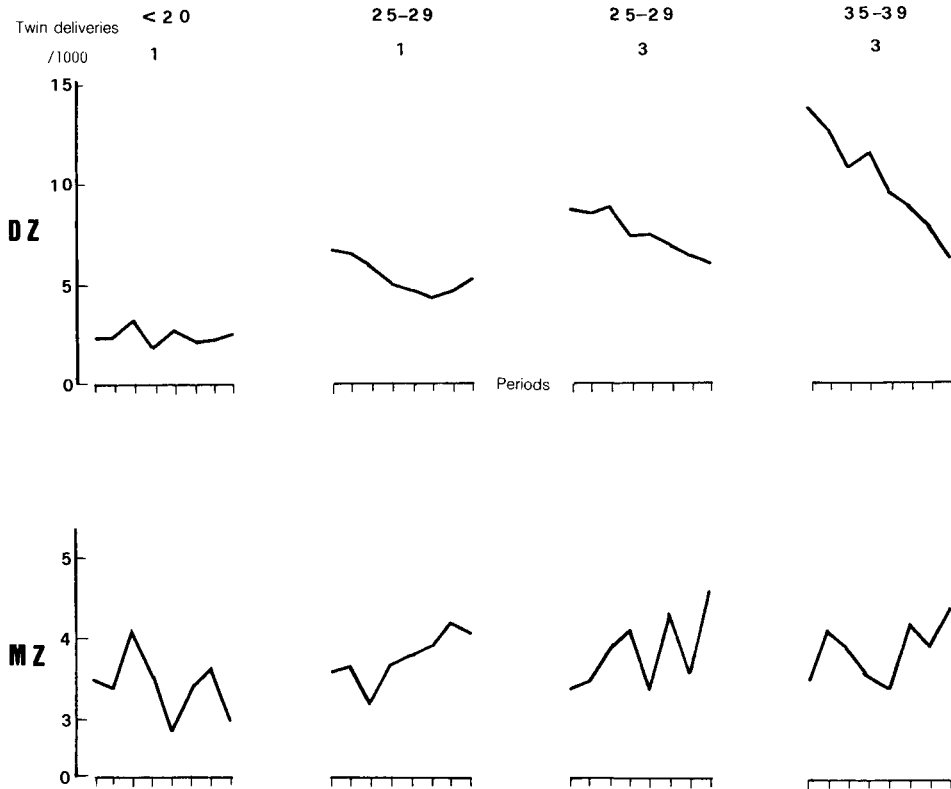


Fig. 2. Italian twinning rates from 1949 to 1985, DZ (above) and MZ (below), for representative age-by-parity categories: First births to mothers under 20; first births to mothers 25-29; third births to mothers 25-29, third births to mothers 35-39.

Table 2 gives the age-and-parity specific DZ twinning rates for the cells that have at least 100 opposite-sex twin pairs in each 4- or 5-year period. A few are graphed in the upper part of Fig. 2. The secular decline of the rates is evident throughout the table, but the exceptions may be significant. First births to mothers under 20 do not decline or show any meaningful trend. In other age groups, the early decline, between 1949-53 and 1954-58, was most consistent in the first birth order (see Table 2). First births also showed a consistent upturn in the last interval except mothers 20-24. In the period 1964-68 mothers 35 to 39 showed a small peak of twinning in all birth orders (except 5 and over, not reliable enough to include here). Following the 1974-77 period the rates tended to stabilize or to rise, but the decline continued in the oldest mothers and in the highest birth orders.

For MZ twins, shown in Table 3 and in the lower part of Fig. 2, a slight increase is seen with age, and at all ages over 20 an increase above earlier periods occurred at some time after 1969-73. Of fifteen age-by-parity rows, five reach the highest rate in the last period, and six others reach the highest rate in one of the last three periods. No period or parity stands out.

Table 2 - Estimated DZ twinning rates by maternal age and birth order: Legitimate Italian births from 1949 to 1985^a

Maternal age	Birth order	1949 to 1953	1954 to 1958	1959 to 1963	1964 to 1968	1969 to 1973	1974 to 1977	1978 to 1981	1982 to 1985
Under 20	1	2.4	2.4	3.2	1.9	2.7	2.2	2.3	2.5
	2	4.8	4.4	4.6	3.7	3.6	3.5	3.7	3.7
20-24	1	4.9	4.8	5.1	4.0	4.5	4.3	4.3	4.3
	2	6.8	6.6	5.9	5.1	4.8	4.4	4.7	5.3
25-29	1	7.2	7.0	7.1	5.7	5.4	5.4	4.9	5.0
	2	8.8	8.6	8.9	7.4	7.5	7.0	6.4	6.0
	3	9.3	9.0	7.4	6.8	6.5	6.1	6.7	7.1
30-34	1	9.7	9.2	8.2	7.7	7.0	6.6	6.2	6.0
	2	11.3	11.7	10.1	9.5	8.4	8.3	6.5	6.9
	3	13.1	13.6	12.7	11.7	10.6	9.7	9.3	8.1
	4	11.6	10.3	8.6	9.5	8.2	8.5	7.3	8.4
35-39	1	11.1	11.2	8.6	10.1	8.5	7.3	7.6	6.8
	2	13.7	12.7	10.8	11.4	9.6	8.9	7.8	6.2
	3	14.7	15.4	12.8	13.1	11.5	10.1	8.9	7.8
	4								

^a Categories are included that have over 100 opposite-sex pairs of twins in every period.

Table 3 - Estimated MZ twinning rates by maternal age and birth order: Legitimate Italian births from 1949 to 1985^a

Maternal age	Birth order	1949 to 1953	1954 to 1958	1959 to 1963	1964 to 1968	1969 to 1973	1974 to 1977	1978 to 1981	1982 to 1985
Under 20	1	3.5	3.4	4.1	3.6	2.8	3.4	3.6	3.0
20-24	1	3.4	3.3	3.6	3.7	3.5	3.6	3.6	3.9
	2	3.3	3.5	4.0	3.9	3.4	3.4	3.7	3.4
25-29	1	3.6	3.7	3.2	3.7	3.8	3.9	4.2	4.1
	2	3.5	3.4	3.6	4.1	3.8	3.9	3.9	4.0
	3	3.4	3.5	3.9	4.1	3.4	4.3	3.6	4.6
30-34	1	4.4	3.9	3.4	3.9	3.9	4.5	4.2	4.5
	2	3.7	4.1	3.4	3.7	3.8	3.8	4.2	3.9
	3	4.1	3.3	4.0	3.6	4.0	3.9	4.7	4.6
	4	3.3	3.6	3.7	3.3	4.0	4.8	3.6	3.8
35-39	1	4.3	4.7	3.6	4.2	3.9	3.8	3.8	4.6
	2	4.1	4.1	3.8	3.7	3.4	4.3	3.5	4.6
	3	3.5	4.1	3.9	3.6	3.4	4.2	3.9	4.4

^a Categories are included that have over 100 opposite-sex pairs of twins in every period.

Table 4 gives the estimated total DZ and MZ rates: crude, adjusted directly to the maternal age and birth order composition for 1949-53, and (for the DZ twins) adjusted indirectly as was done with the US data in Fig. 1. Figures 3 and 4 are graphs of the same data. Fig. 3 compares the secular changes in DZ and MZ twinning, adjusted. Fig. 4 com-

Table 4 - Estimated DZ and MZ twinning rates for Italy in five- and four-year periods: Crude, standardized directly for maternal age and birth order, and standardized indirectly (DZ only)

Periods	Crude rates		Standardized directly		Standardized indirectly
	DZ	MZ	DZ	MZ	DZ
1949-1953	8.88	3.74			
1954-1958	8.80	3.81	8.74	3.81	8.73
1959-1963	8.13	3.67	8.35	3.71	8.16
1964-1968	7.22	3.80	7.57	3.81	7.42
1969-1973	6.25	3.69	7.00	3.76	6.90
1974-1977	5.54	3.86	6.49	4.00	6.50
1978-1981	5.16	3.92	5.99	3.95	6.18
1982-1985	5.23	4.06	6.04	4.28	6.22

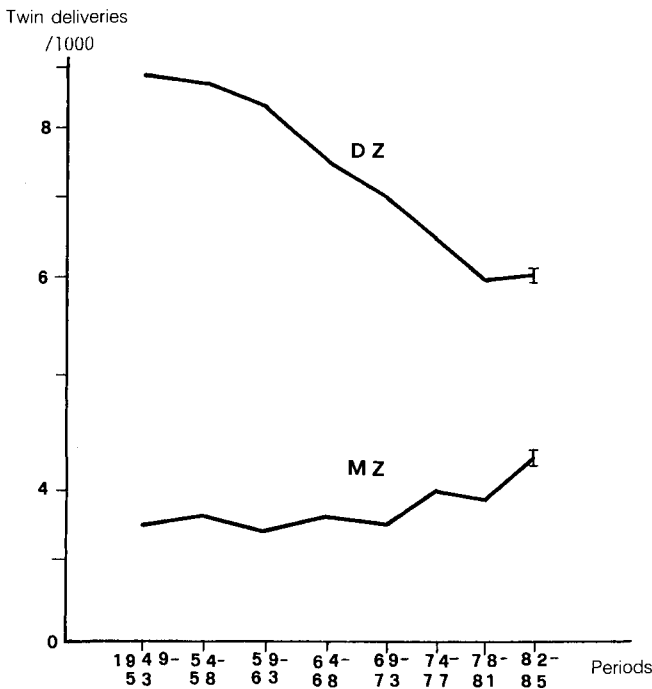


Fig. 3. Italian twinning rates from 1949 to 1985, DZ and MZ: Total rate within zygosity classes, adjusted (standardized directly) for maternal age and birth order. Length of vertical lines is 2 s.d.

compares the crude rates of DZ twinning with rates adjusted directly and indirectly. The slope of DZ twinning is almost uniform from 1959-63 through 1978-81, after which the curve rises slightly. The adjusted MZ rate is essentially level through 1969-73, and then rises sharply in two of the last three intervals.

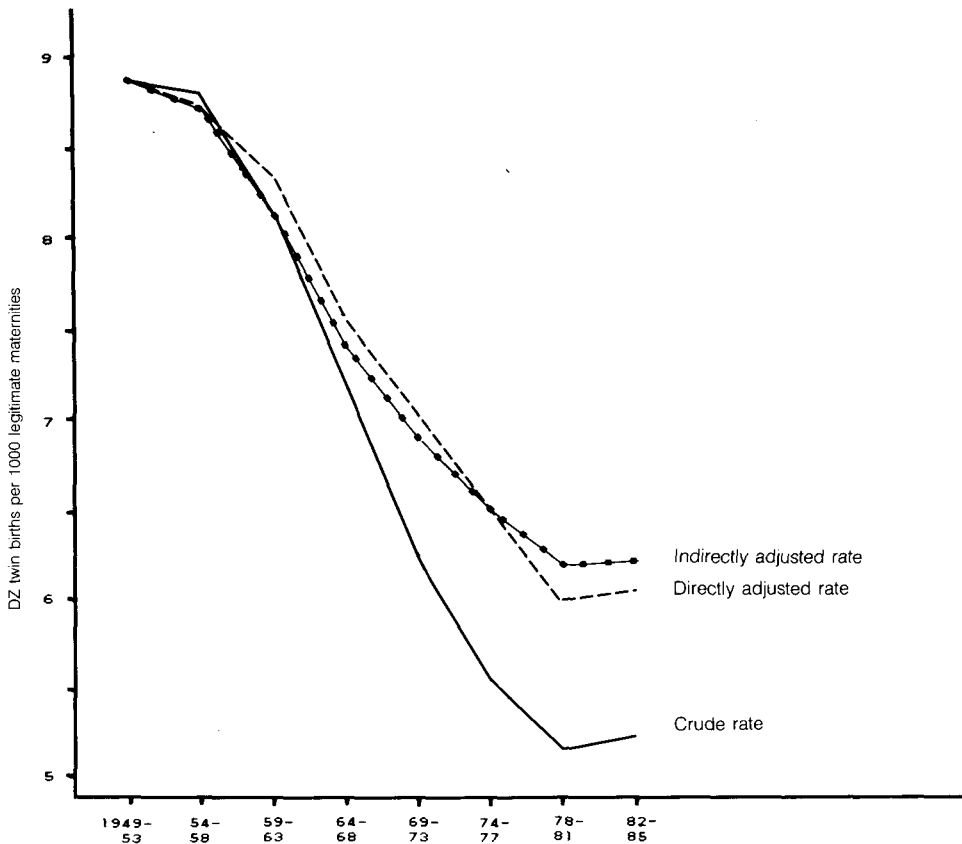


Fig. 4. Italian DZ twinning rate from 1949 to 1985: Comparison of crude rate with rate adjusted directly and indirectly for maternal age and birth order.

Table 5 and Fig. 5 show the changes in the maternal age effect over time, controlled for changes in parity. That is, the parity composition is adjusted to be the same for every point at every age, as nearly as possible. In DZ twinning the secular decline is greatest in the oldest mothers, and this is not merely due to plotting a logarithmic change on an arithmetic scale. The ratio of the 1949-53 rate to that for 1977-81 for each of the six age groups is as follows: 1.29, 1.48, 1.48, 1.48, 1.57, 1.70. It may also be of interest that under age 30, and particularly under age 20, the rate was higher in 1959-63 than in 1964-68, while above age 34 the difference is reversed.

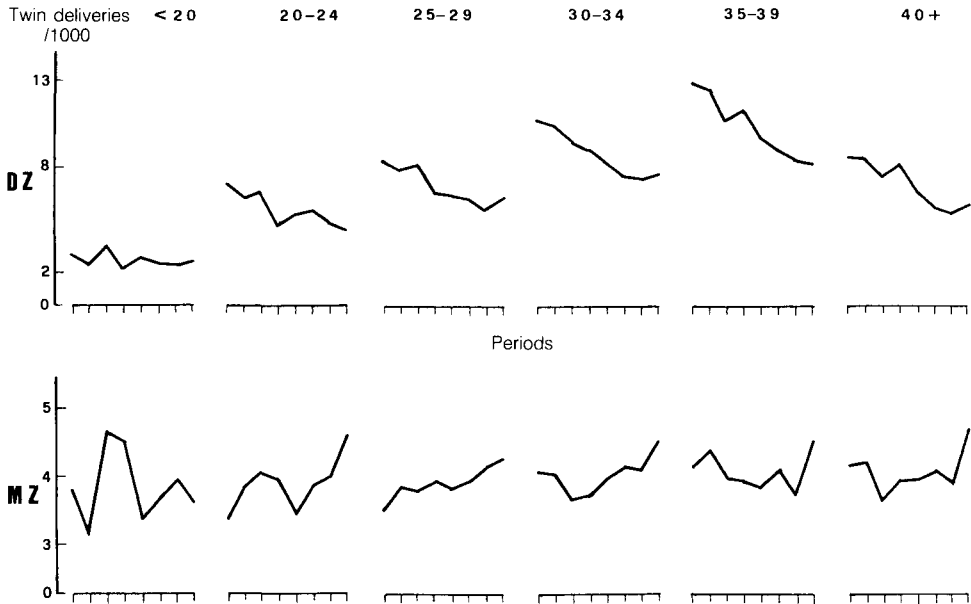


Fig. 5. Italian twinning rates from 1949 to 1985, DZ and MZ: Age-specific rates adjusted to a constant birth order distribution.

MZ twinning (Fig. 5) does not resemble DZ twinning except that, in general, the last interval shows a rise in both types of twins for most age groups. In DZ twinning the rise is restricted to the last interval, but in MZ twinning among mothers under 35 it is evident in the last three intervals.

By parity, shown in Table 6 and Fig. 6, there is no recent increase in DZ twinning except in first births, where it shows in the last two intervals, and in parity group 5 where

Table 5 - Birth-order-standardized, maternal-age-specific DZ and MZ twinning rates for Italy in five- and four-year periods. Birth order distribution taken from 1949-53 total births

Periods	DZ twinning rates by maternal age						MZ twinning rates by maternal age					
	<20	20-24	25-29	30-34	35-39	40+	<20	20-24	25-29	30-34	35-39	40+
1949-1953	3.1	7.1	8.3	10.8	12.9	8.7	3.8	3.4	3.5	4.1	4.1	4.1
1954-1958	2.4	6.1	7.9	10.6	12.5	8.5	3.1	3.8	3.8	4.0	4.4	4.2
1959-1963	3.5	6.6	8.1	9.6	10.7	7.3	4.6	4.0	3.8	3.6	3.7	3.6
1964-1968	2.1	4.7	6.5	9.0	11.3	8.0	4.5	4.0	3.9	3.7	3.9	3.9
1969-1973	2.9	5.2	6.5	8.1	9.7	6.7	3.3	3.5	3.8	4.0	3.8	4.0
1974-1977	2.5	5.4	6.2	7.7	8.9	5.8	3.7	3.8	3.9	4.1	4.2	4.3
1978-1981	2.4	4.8	5.6	7.3	8.2	5.1	4.0	4.0	4.1	4.2	3.7	3.9
1982-1985	2.7	4.3	6.1	7.5	8.0	4.8	3.6	4.6	4.2	4.5	4.5	4.7

Table 6 - Maternal-age-standardized, birth-order-specific DZ and MZ twinning rates for Italy in five- and four-year periods. Maternal age distribution taken from 1949-53 total births

Years	DZ twinning rates by birth order					MZ twinning rates by birth order				
	1	2	3	4	5+	1	2	3	4	5+
1949-1953	7.6	7.7	9.3	10.3	13.7	3.9	3.7	3.8	3.9	3.4
1954-1958	7.1	7.5	9.2	11.3	11.8	3.8	3.7	3.7	3.5	5.0
1959-1963	6.3	7.0	8.9	10.7	12.7	3.4	3.7	4.0	3.8	4.6
1964-1968	5.8	6.4	7.9	9.4	10.3	3.9	3.8	3.9	3.2	4.4
1969-1973	5.4	6.0	7.4	8.8	10.2	3.8	3.6	3.7	4.3	3.7
1974-1977	5.1	5.6	7.2	8.4	9.9	3.9	3.9	4.2	4.0	4.3
1978-1981	5.2	5.4	6.2	7.4	8.0	4.1	3.7	4.2	4.4	4.1
1982-1985	5.7	5.2	5.9	6.7	8.4	4.2	4.1	4.6	4.4	5.2

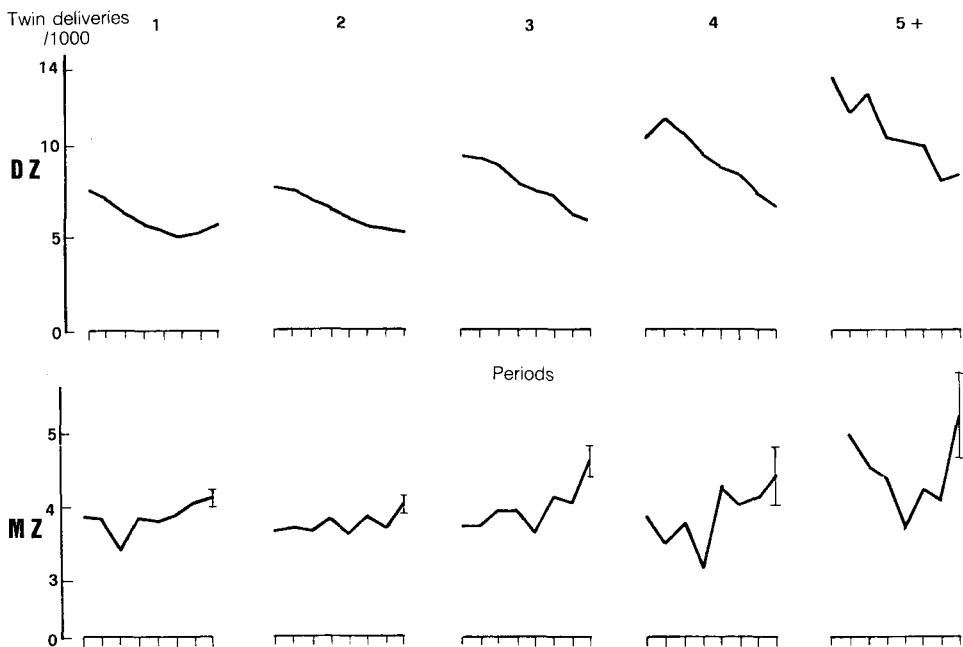


Fig. 6. Italian twinning rates from 1949 to 1985, DZ and MZ: Birth-order-specific rates adjusted to a constant maternal age distribution. Length of vertical lines is 2 s.d.

the rate rose only in the last interval. The increase of DZ twinning with parity holds true for all parities and all periods except in the last period, where the rate is higher for first births than for second births.

MZ twinning increased at all parities in the last interval, and at most parities in the last three intervals.

DISCUSSION

Different conclusions might be reached if the years had been grouped in other periods. In particular, the increase of DZ twinning between 1978-81 and 1982-85 was not found *within* the 1982-85 period; the 1985 rate, crude or adjusted, being lower than in any other single year after 1979. However, provisional data for 1986 and 1987 confirm that the rapid fall prior to 1978-81 was at least partly arrested in the 1980s.

While adjustment for age and parity is clearly desirable, its effect in the case of DZ twinning is small here compared with the true changes in the twinning rate. The indirect adjustment seen in Fig. 4 is not quite accurate, but is seen to be a satisfactory approximation to direct adjustment, giving credibility to the findings in US based on indirect adjustment (Fig. 1).

The data show a clearly rising trend in MZ twinning starting with the fifth interval, and this has continued (or recurred) in the 1980s, as also confirmed by provisional data for 1986 and 1987. This amply confirms earlier reports of increasing MZ rates [7,15] and overturns a long-held belief that significant changes in unspecified twinning rates could safely be attributed to the DZ component [2]. It also casts uncertainty on any inference from rising twinning rates in the US that the drop in DZ twinning was long ago reversed in that country.

The causes of the MZ increase might reasonably be linked to side effects of contraceptives or ovulation stimulants, but if this were true, it seems that DZ twinning ought to show direct effects of these agents. The only finding in DZ twins that matches expectation based on fertility agents is that, by parity, the largest and longest increase in DZ twinning is in first births, but age curves show that this increase is limited to women under 30.

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