



Acta Genet Med Gemellol 35: 61-76 (1986)
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Received 10 December 1985
Final 31 January 1986

The Secular Trend of Twinning in Australia, 1853–1982

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Abstract. The incidence of twinning in Australia from 1853 to 1982 is described. The overall trend was determined by changes in the dizygotic rate and, for more than a century, it has been similar to that found in Finland and the South of Italy. It is not explained by demographic changes and there is no clear relationship with industrialisation or psychosocial factors. Monozygotic twinning has increased, most markedly in the 1970s. No adequate explanation has been given for this increase, so continuing surveillance in many different populations is necessary.

Key words: Twinning incidence, Australia, Secular trend, Demography

INTRODUCTION

Unexplained world-wide changes have occurred in the pattern of twinning in recent years. To gain a proper perspective, these changes should be seen in their historical context. It may be that interest in these recent developments has led to the neglect of the longer view, as most studies are limited to the last few decades.

In presenting their 110 years series based on Italian data, Parisi and Caperna [39] noted that the term secular (Latin, saeculum) was generally held to indicate a century or more. Their study was thus the first truly secular series outside Scandinavia, where long term studies have been conducted dating back to the eighteenth century [15-17]. Trends over shorter periods of time have been described from the United States [1,2, 21,30], Scotland [35], Hungary [10], Ireland [11], Denmark [37,44,45], Czechoslova-

kia [56], Canada [13,14], Poland [47], Germany [32] and Japan [23,25]. Long term studies of small population groups have been reported for a community in Quebec [41], an endogamous isolated Romanian village [49], and a parish in East Germany [46]. James [26,29] has twice surveyed twinning rates throughout the world. Trends with time have already been examined in Australia by Knibbs [8], MacArthur [34], Pollard [43] and over fifty years by Brackenridge [5].

No constant pattern is seen. The initially high twinning rate in Sweden started to decline in the nineteenth century, but in Finland not until the 1960s. The difference cannot be explained by changes in maternal age and parity. Lower twinning rates were found in industrialised urban areas than in rural areas. Most, but not all, of the other countries show a marked decline in the incidence of twins beginning at various times in the last fifty years. Where zygosity can be ascertained the monozygotic twinning rate (MZTR) is usually remarkable for its constancy. The overall declining incidence of twinning is therefore attributed to a fall in the dizygotic twinning rate (DZTR).

When they analysed the Italian data on a regional basis Parisi and Caperna [40] found a sharp contrast between the North, where industrialisation was early and rapid, and the South, where it was delayed until the 1950s. In the North the DZTR has been falling since the 1880s whereas in the South it increased up to a peak about 1950 and then declined. The authors describe how psychosocial factors associated with the breakdown of traditional agricultural society might be mediated through a hormonal mechanism to influence reproduction. Demographic changes have only accounted for part of the decline in any of the countries which have been surveyed. As the decline appears to be a concomitant of industrialisation, several environmental factors have been suggested as causative agents [26,29].

MATERIALS AND METHODS

All the data in this study were obtained from the vital statistics published annually by the Australian Bureau of Statistics (ABS) and its predecessors, the Commonwealth Bureau of Census and Statistics and the State (Colonial) Statistical Offices. Australia comprises six States and two Territories. In the early years, publication of the details of multiple births was sporadic in their annual statistical report. All available publications were searched to identify the earliest issues containing these details. The search was made in the library of the New South Wales Office of the Australian Bureau of Statistics. The original volumes were consulted for New South Wales and microfiche copies for the other States. Copies of missing years were kindly supplied by the ABS libraries in Melbourne and Canberra.

Even though twins were not tabulated every year, it was possible to build continuous series as they were frequently shown in quinquennial and decennial summaries. From 1908 all registered Australian births were included, apart from full-blood aboriginals who were excluded from official statistics prior to 1966. In the first reports, the statistical year ran from 1 July to 30 June but, from summary tables in subsequent years, it was possible to allocate the number of twin confinements to the appropriate calendar year. From 1908, the annual "Population and Vital Statistics Bulletin, Commonwealth Demography" of the Commonwealth Bureau of Census and Statistics contained increasing detail on twin confinements, including parental age. (This serial was continued as "Australian Demography" then "Demography Bulletin".) From 1916, the sex combination of twin pairs was added.

Incidence rates for twins are expressed as the number of twin confinements per thousand confinements (not births). The words are used in the sense that one twin confinement, or maternity, results in two births. Monozygotic and dizygotic twinning rates are also expressed per thousand

confinements and refer to the number of pairs of twins of that zygosity, not the number of births. Weinberg's differential method [54] was used to estimate zygosity.

Twinning rates vary considerably with maternal age in Australia as elsewhere [43,53]. To allow for this factor, direct standardisation for maternal age, as described by Fleiss [19], was carried out. There are no precise rules governing the choice of the reference year, except to avoid demographically unusual periods [4,42]. The choice of year will alter the calculated values of the standardised rates but should not significantly affect comparisons over time. The reference year used was 1955. The strata used were 5-year maternal age groups from 15 years. Age-group specific rates were calculated and plotted to contrast them. If only the age-adjusted rate is given, then differences across the various strata will be masked. The figures were computer-drawn with single-year intervals.

RESULTS

Trend 1853-1982

The secular trend in twin births is described from 1 July 1853, when compulsory registration of births was introduced in Victoria and multiple births were tabulated. New South Wales (including Queensland) followed in 1857 and from that date more than 80% of Australian births in any one year are included. When data from Tasmania in 1895 and Western Australia in 1897 are added, the proportion is increased to 91%. From 1908, when South Australia and the Northern Territory published data on twins, all registered Australian births are included. A total of 171,860 twin confinements, out of 16,442,748 total confinements, were registered by 1982 (an average rate of 10.45 per 1,000 confinements).

The number of twin confinements from 1853 to 1915 is shown in Table 1. In the last six months of 1853, 12 cases of twins were registered in Victoria from a total of 1,482 confinements. Completeness of registration increased and by 1856, from a total of 14,278 confinements, there were 140 cases of twins. The number of confinements more than doubles, to 29,583 with 291 sets of twins, when New South Wales is added in 1857. From 1858 onwards, more than 340 cases of twins and more than 33,000 confinements were recorded in any one year. The population of Australia was increasing rapidly at this time from a combination of high birth rate and immigration. In New South Wales and Victoria it doubled to 1,452,017 between 1857 and 1877. There was a marked preponderance of men, but the ratio of males to females in the population fell from 1.4:1 to 1.2:1 over the same period of time. By 1897, when the twin data for Tasmania and Western Australia were available, the Australian population had increased to over 3.5 million and was over 4 million by 1907. The number of twin confinements increased steadily so that in 1915 there were 133,444 out of a total of 4,421,527 confinements, an average rate of 9.72 per 1,000.

The variation in the incidence of twin births over the period 1853-1982 is shown in Fig. 1. In the first 25 years there were rapid fluctuations, when registration was still incomplete and sampling variation would be greater due to smaller numbers. As shown in Table 1, the rate varied between 11.03 per 1,000 (1861) and 7.47 per 1,000 (1875). The long-term trend appears to be an increasing twinning rate from 1875 to 1953. The fluctuations about the trend were initially large but became progressively smaller. Over this period, the rate increased from 7.47 to 12.36 per 1,000. After 1953, the rate declined until 1977, when it fell to 9.01 per 1,000 (Table 2), but then increased again to 10.29 per 1,000 by 1982.

Fig. 1 - Trends in Twin Births – Australia, 1853-1982

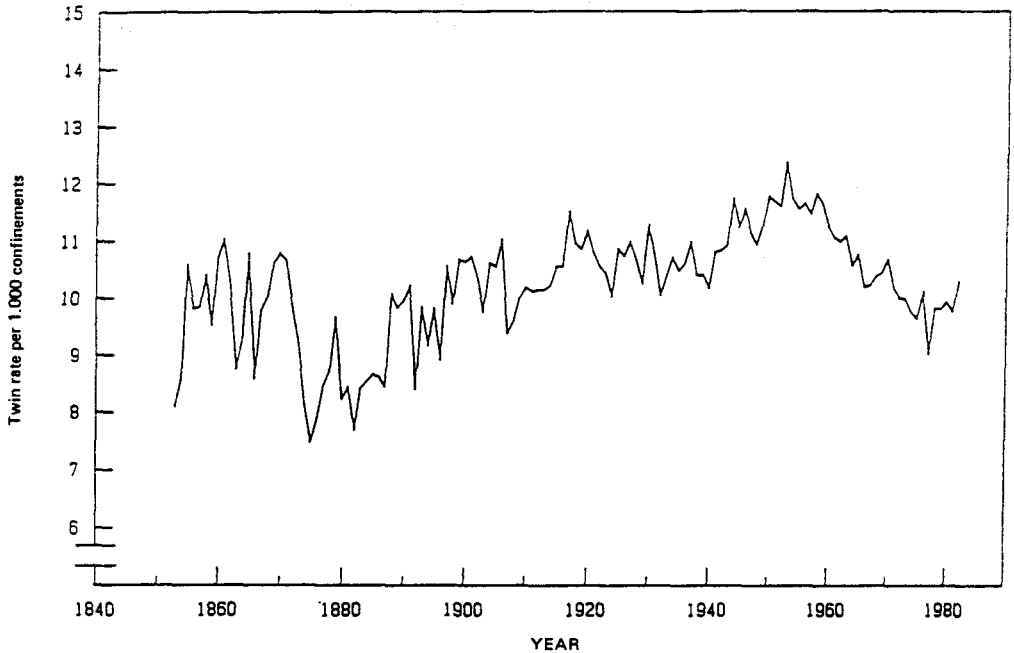


Table 1. Twin Confinements – Australia, 1853-1915

Year	Total confinements	Twin confinements	
	(N)	N	N/1000
1853	1,482	12	8.10
1854	7,476	64	8.56
1855	11,810	125	10.58
1856	14,278	140	9.81
1857	29,583	291	9.84
1858	33,376	347	10.40
1859	36,155	344	9.51
1860	36,683	393	10.71
1861	37,720	416	11.03
1862	39,416	403	10.22
1863	39,238	343	8.74
1864	42,159	392	9.30
1865	42,681	460	10.78
1866	41,595	357	8.58
1867	43,497	425	9.77
1868	45,265	453	10.01
1869	44,859	476	10.61
1870	46,294	499	10.78

Table I. *Contd.*

Year	Total confinements	Twin confinements	
	(N)	N	N/1000
1871	47,012	501	10.65
1872	47,132	465	9.87
1873	49,084	452	9.21
1874	48,574	394	8.11
1875	48,879	365	7.47
1876	49,669	392	7.89
1877	49,439	418	8.45
1878	51,455	448	8.71
1879	53,246	514	9.65
1880	53,867	443	8.22
1881	63,818	538	8.43
1882	64,069	493	7.69
1883	68,135	573	8.41
1884	72,832	621	8.53
1885	76,026	658	8.65
1886	79,009	680	8.61
1887	83,085	700	8.43
1888	86,393	869	10.06
1889	87,195	856	9.82
1890	91,030	905	9.94
1891	91,734	937	10.21
1892	91,980	772	8.39
1893	90,379	888	9.83
1894	86,384	790	9.15
1895	91,225	885	9.81
1896	86,526	771	8.91
1897	90,614	955	10.54
1898	88,993	879	9.88
1899	90,244	962	10.66
1900	92,057	978	10.62
1901	92,826	994	10.71
1902	92,852	960	10.34
1903	89,060	867	9.74
1904	93,973	996	10.60
1905	95,060	1,001	10.53
1906	97,867	1,078	11.01
1907	100,161	938	9.36
1908	110,491	1,059	9.58
1909	112,921	1,128	9.99
1910	115,609	1,176	10.17
1911	120,957	1,222	10.10
1912	131,726	1,334	10.13
1913	134,343	1,361	10.13
1914	136,576	1,395	10.21
1915	133,444	1,407	10.54
1853-1915	4,421,527	42,968	9.72

Table 2. Twin Confinements by Zygosity – Australia, 1916-1982

Year	Total confinements (N)	Twin confin.		DZ		MZ	
		N	N/1000	N	N/1000	N	N/1000
1916	130,031	1,371	10.54	972	7.48	399	3.07
1917	128,452	1,477	11.50	1,038	8.08	439	3.42
1918	124,361	1,362	10.95	914	7.35	448	3.60
1919	120,956	1,311	10.84	970	8.02	341	2.82
1920	134,875	1,505	11.16	1,138	8.44	367	2.72
1921	134,727	1,453	10.78	1,020	7.57	433	3.21
1922	136,056	1,432	10.53	1,042	7.66	390	2.87
1923	133,832	1,394	10.42	952	7.11	442	3.30
1924	133,583	1,337	10.01	926	6.93	411	3.08
1925	134,343	1,458	10.85	1,020	7.59	438	3.26
1926	131,756	1,412	10.72	922	7.00	490	3.72
1927	132,226	1,452	10.98	1,034	7.82	418	3.16
1928	132,678	1,412	10.64	988	7.45	424	3.20
1929	128,179	1,311	10.23	980	7.65	331	2.58
1930	126,969	1,431	11.27	1,022	8.05	409	3.22
1931	117,258	1,261	10.75	800	6.82	461	3.93
1932	109,848	1,102	10.03	692	6.30	410	3.73
1933	110,137	1,143	10.38	818	7.43	325	2.95
1934	108,329	1,159	10.70	748	6.90	411	3.79
1935	110,249	1,153	10.46	770	6.98	383	3.47
1936	114,917	1,218	10.60	822	7.15	396	3.45
1937	117,899	1,294	10.98	876	7.43	418	3.55
1938	119,247	1,239	10.39	830	6.96	409	3.43
1939	121,657	1,265	10.40	834	6.86	431	3.54
1940	125,130	1,271	10.16	886	7.08	385	3.08
1941	133,141	1,438	10.80	954	7.17	484	3.64
1942	135,282	1,465	10.83	958	7.08	507	3.75
1943	147,741	1,612	10.91	1,044	7.07	568	3.84
1944	151,624	1,778	11.73	1,236	8.15	542	3.57
1945	158,839	1,782	11.22	1,190	7.49	592	3.73
1946	174,431	2,014	11.55	1,316	7.54	698	4.00
1947	180,449	2,008	11.13	1,338	7.41	670	3.71
1948	176,105	1,923	10.92	1,250	7.10	673	3.82
1949	179,296	2,021	11.27	1,360	7.59	661	3.69
1950	188,437	2,217	11.77	1,472	7.81	745	3.95
1951	191,155	2,230	11.67	1,574	8.23	656	3.43
1952	199,424	2,310	11.58	1,526	7.65	784	3.93
1953	199,860	2,470	12.36	1,718	8.60	752	3.76
1954	199,954	2,344	11.72	1,678	8.39	666	3.33
1955	205,365	2,369	11.54	1,670	8.13	699	3.40

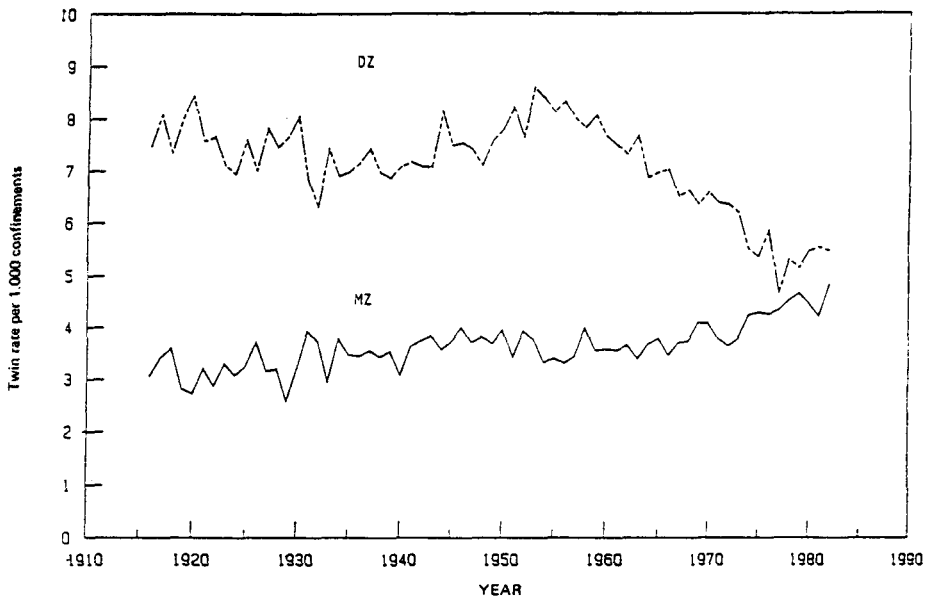
Table 2. *Contd.*

Year	Total confinements (N)	Twin confin.		DZ		MZ	
		N	N/1000	N	N/1000	N	N/1000
1956	209,745	2,442	11.64	1,748	8.33	694	3.31
1957	217,896	2,495	11.45	1,746	8.01	749	3.44
1958	219,929	2,599	11.82	1,722	7.83	877	3.99
1959	224,424	2,611	11.63	1,814	8.08	797	3.55
1960	227,833	2,564	11.25	1,748	7.67	816	3.58
1961	237,425	2,623	11.05	1,780	7.50	843	3.55
1962	234,530	2,575	10.98	1,716	7.32	859	3.66
1963	233,157	2,584	11.08	1,794	7.69	790	3.39
1964	226,793	2,393	10.55	1,558	6.87	835	3.68
1965	220,512	2,371	10.75	1,536	6.97	835	3.79
1966	220,344	2,310	10.18	1,548	7.03	762	3.46
1967	226,983	2,319	10.21	1,478	6.51	841	3.71
1968	238,456	2,472	10.37	1,580	6.63	892	3.74
1969	247,625	2,586	10.44	1,572	6.35	1,014	4.09
1970	254,810	2,718	10.67	1,678	6.59	1,040	4.08
1971	273,642	2,779	10.16	1,746	6.38	1,033	3.78
1972	262,366	2,622	9.99	1,666	6.35	956	3.64
1973	245,246	2,448	9.98	1,518	6.19	930	3.79
1974	242,829	2,367	9.75	1,338	5.51	1,029	4.24
1975	230,777	2,223	9.63	1,234	5.35	989	4.29
1976	225,565	2,281	10.11	1,322	5.86	959	4.25
1977	224,269	2,020	9.01	1,046	4.66	974	4.34
1978	221,991	2,181	9.82	1,178	5.31	1,003	4.52
1979	220,968	2,165	9.80	1,136	5.14	1,029	4.66
1980	223,318	2,219	9.94	1,222	5.47	997	4.46
1981	233,535	2,278	9.75	1,294	5.54	984	4.21
1982	237,454	2,443	10.29	1,298	5.47	1,145	4.82
1916-1982	12,021,221	128,892	10.72	84,314	7.01	44,578	3.71

Dizygotic Rate

From 1916 it is possible to divide the total twinning rate into MZ and DZ fractions by use of Weinberg's method. The separate rates have been plotted graphically in Fig. 2. Between 1916 and 1982 there were 128,892 twin confinements, of which 84,314 (65.4%) were DZ, an average rate of 7.01 per 1,000 with a range of 4.66 (1977) to 8.60 (1953). It is clear that the major part of the changes in rate since 1916 has been due to changes in the DZTR. Both inter-year fluctuation and long-term change are largely accounted for by DZ changes. The 1953 peak is a peak in the DZTR which fell 46% from 8.6 (1953) to 4.66 (1977) (Table 2).

Fig. 2 - Twinning Rates by Zygosity – Australia, 1916-1982



Monozygotic Rate

Between 1916 and 1982 there were 44,578 MZ twin confinements, corresponding to 34.6% of all twin maternities (Table 2), with an average rate of 3.71 per 1,000 confinements (range 2.58 to 4.82). Over the period, the MZTR increased 57%, from 3.07 to 4.82 per 1,000. Figure 2 shows that the MZTR and DZTR have converged and have not been greatly dissimilar since 1974. Since then, the MZTR has been above 4.2 per 1,000, whereas before then it had only reached 4 per 1,000 in one year, 1946. The trend has been of a gradual increase of the MZTR, more pronounced since 1970. The 1982 MZTR (4.82 per 1,000) exceeded the 1977 DZTR (4.66 per 1,000).

Age-Specific Twinning Rates, 1907-1982

To examine the effect of changes in maternal age on twinning rates, age-specific rates were calculated in 5-year age groups from 1907 to 1982. The rates are given in Table 3 and illustrated in Fig. 3. The importance of the role of maternal age is clearly demonstrated. The lowest rate was found in teenage mothers and each successive age group up to 40 years had a higher rate, then the rate was lower. Sampling variation causes large fluctuations, due to small numbers in the strata, especially in the earlier years and at the extremes of age. The decline from the peak level in 1953 was steeper in mothers over 25 years and most marked in those over 30. (For clarity, the rate for mothers 40 and over is not included in Fig. 3).

Table 3. Twinning Rates: Age Specific, Crude and Age-Standardised – Australia, 1907-1982

Year	Twin confinements per thousand in each maternal age group						Twinning rate per 1,000 confinements	
	15-19	20-24	25-29	30-34	35-39	40-44	Crude	Age-Standardised
1907*	4.01	5.14	7.63	12.10	15.69	12.64	9.36	8.57
1908	4.44	6.11	8.41	12.13	14.79	11.94	9.58	9.01
1909	3.44	6.67	9.20	13.07	14.09	10.90	9.99	9.47
1910	3.85	6.46	9.76	12.07	15.69	11.83	10.17	9.59
1911	4.34	7.03	8.95	12.57	14.94	12.37	10.10	9.57
1912	5.44	6.47	9.03	13.25	15.56	11.07	10.13	9.53
1913	3.38	6.20	9.70	12.65	15.68	13.53	10.12	9.64
1914	3.51	6.88	9.17	13.42	14.90	12.06	10.12	9.71
1915	4.72	6.94	10.05	12.84	16.34	11.03	10.54	10.07
1916	6.46	6.36	10.23	12.87	15.64	12.36	10.54	10.04
1917	4.44	8.21	10.20	13.44	17.22	14.29	11.50	10.78
1918	4.92	7.23	9.85	14.19	15.13	11.11	10.95	10.26
1919	4.34	8.42	9.05	12.37	16.01	14.27	10.84	10.11
1920	4.48	7.13	11.66	12.24	16.21	13.79	11.16	10.56
1921	4.41	6.47	9.39	13.98	16.11	14.95	10.78	10.04
1922	6.66	7.38	9.49	12.53	15.16	12.53	10.53	9.96
1923	5.45	7.21	9.13	13.41	14.26	12.50	10.42	9.86
1924	5.18	6.35	9.85	12.66	13.63	10.10	10.01	9.53
1925	6.18	7.44	10.00	13.03	14.79	14.90	10.85	10.29
1926	5.19	7.19	9.86	12.67	17.17	11.15	10.72	10.15
1927	4.65	7.83	10.04	12.81	17.07	13.27	10.98	10.45
1928	5.00	7.33	9.56	13.09	16.53	13.24	10.64	10.18
1929	3.39	6.25	10.34	12.86	15.59	12.89	10.23	9.88
1930	7.22	8.08	9.80	14.46	16.79	13.06	11.27	10.90
1931	6.84	8.29	9.73	13.60	14.74	12.58	10.75	10.51
1932	4.34	7.10	9.31	13.03	15.62	10.22	10.03	9.78
1933	4.01	6.52	10.61	14.07	15.62	9.55	10.38	10.22
1934	5.45	8.32	9.43	13.55	15.67	13.12	10.70	10.45
1935	5.31	7.29	10.44	12.64	16.41	11.36	10.46	10.31
1936	6.82	7.62	10.04	12.76	16.22	13.30	10.60	10.43
1937	7.50	7.87	9.77	15.27	15.76	12.53	10.98	10.90
1938	6.38	7.66	9.58	13.35	15.49	12.23	10.39	10.29
1939	6.37	6.73	10.04	13.44	16.20	12.87	10.40	10.28
1940	5.66	7.61	10.39	11.90	14.31	12.45	10.16	10.06
1941	5.79	8.10	10.20	13.87	15.38	13.79	10.80	10.72
1942	3.90	8.52	10.05	14.31	14.64	14.44	10.83	10.72
1943	6.16	8.06	10.75	13.35	15.71	12.82	10.91	10.78
1944	4.88	8.66	11.11	14.67	16.45	13.70	11.73	11.37
1945	5.61	8.48	10.86	13.60	14.98	13.02	11.22	10.92

Tab 3. *Contd.*

Year	Twin confinements per thousand in each maternal age group						Twinning rate per 1,000 confinements	
	15-19	20-24	25-29	30-34	35-39	40-44	Crude	Age-Standardised
1946	5.46	8.95	11.29	13.68	15.38	15.53	11.55	11.29
1947	6.23	7.96	11.30	13.84	16.02	10.33	11.13	11.00
1948	5.48	7.88	11.18	13.66	14.97	12.38	10.92	10.82
1949	6.91	8.98	10.50	13.81	16.27	14.12	11.27	11.21
1950	6.48	8.92	11.74	14.63	16.36	13.47	11.77	11.71
1951	6.83	9.03	11.56	13.76	17.49	12.88	11.67	11.62
1952	5.06	8.98	11.11	15.05	16.54	13.08	11.58	11.54
1953	7.52	8.68	12.21	16.02	17.58	14.56	12.36	12.29
1954	7.02	8.67	11.61	14.81	16.66	13.38	11.72	11.68
1955	4.83	9.13	11.42	14.22	16.10	15.78	11.54	11.54
1956	5.90	8.73	12.22	14.29	16.56	11.44	11.64	11.67
1957	5.88	8.27	11.78	15.02	16.43	10.01	11.45	11.50
1958	6.98	8.31	11.91	15.81	17.36	11.03	11.83	11.91
1959	6.83	8.17	12.07	15.52	16.53	12.66	11.63	11.58
1960	5.40	8.43	11.83	13.77	17.55	12.73	11.25	11.42
1961	6.17	9.18	11.33	12.89	16.65	10.88	11.05	11.23
1962	5.16	8.74	10.87	14.46	17.06	10.69	10.98	11.27
1963	6.83	9.34	10.86	14.05	15.13	14.87	11.08	11.38
1964	5.81	8.01	10.63	14.01	17.01	11.31	10.55	10.95
1965	6.04	8.87	11.41	13.35	15.82	12.53	10.75	11.22
1966	6.13	8.51	11.38	13.01	16.07	11.73	10.48	11.03
1967	7.13	8.19	10.01	14.51	15.30	12.27	10.22	10.84
1968	6.09	8.82	10.74	13.74	15.70	11.39	10.37	11.04
1969	6.22	8.07	11.69	14.62	14.03	13.16	10.44	11.12
1970	5.45	8.61	10.67	15.27	15.95	12.80	10.67	11.31
1971	5.77	8.91	10.78	13.54	14.00	12.48	10.16	10.89
1972	6.05	9.04	10.74	11.86	14.30	13.49	9.99	10.64
1973	6.34	8.13	10.57	13.81	16.38	9.75	9.98	10.82
1974	6.20	8.84	10.17	11.77	15.11	11.82	9.75	10.40
1975	5.35	8.10	10.10	13.22	15.44	10.85	9.63	10.42
1976	6.59	8.06	11.18	12.70	15.01	12.62	10.11	10.73
1977	5.70	7.52	9.20	12.00	13.39	10.87	9.01	9.54
1978	6.09	7.71	10.81	12.49	12.91	9.49	9.82	10.14
1979	6.42	8.21	10.28	12.46	11.77	8.57	9.80	10.00
1980	5.83	8.35	10.13	12.82	14.19	5.83	9.94	10.17
1981	5.89	8.42	10.28	11.40	13.33	8.90	9.75	9.96
1982	6.55	8.95	10.28	12.13	14.32	16.43	10.29	10.65

* 1907 excludes South Australia

Fig. 3 - Age Specific Twinning Rates – Australia, 1907-1982

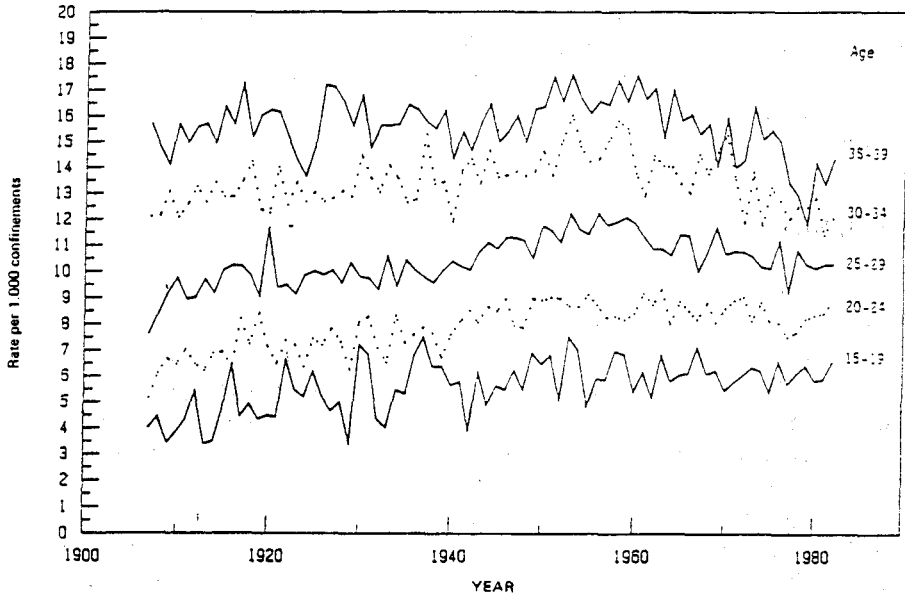
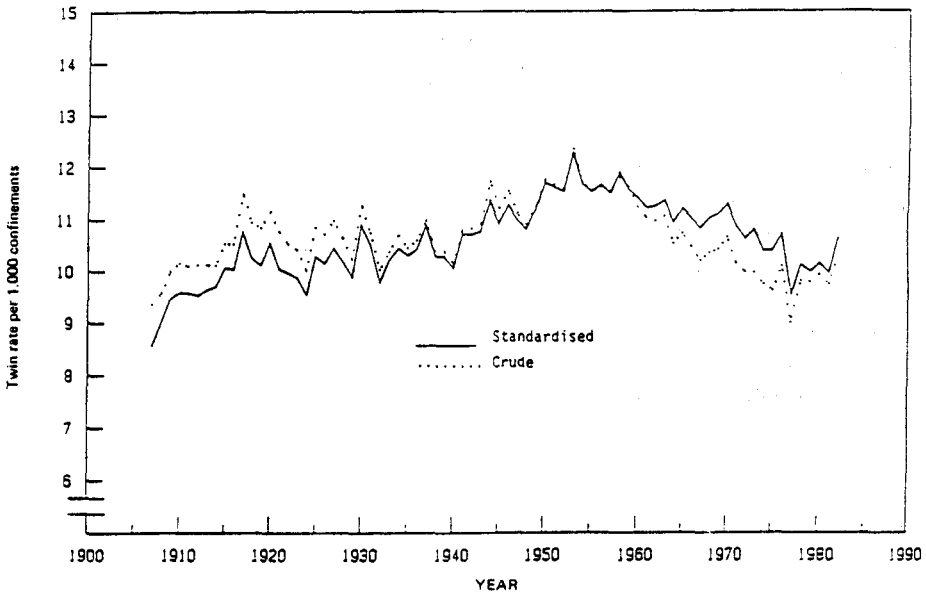


Fig. 4 - Twinning Rate, Standardised for Maternal Age – Australia, 1907, 1982



Age-Standardised Rate, 1907-1982

As the trend across the age strata was broadly similar, the twinning rate directly standardised for maternal age was calculated. The result is shown in Table 3 and illustrated in Fig. 4. The general picture is the same as the crude rate, except that the slope of the long-term rise up to the 1953 peak is slightly increased and the slope of the decline from 1953 is slightly decreased.

DISCUSSION

This study reports on the variation in the incidence of twinning in more than 16 million confinements in Australia over 130 years. It is the longest such historical series based on national data outside Scandinavia. Inspection of Fig. 1 confirms the importance of considering periods of at least several decades before inferring the existence of trends. The pattern is of wide variation in the middle of the nineteenth century and then of a gradually increasing incidence, though with large fluctuations, until the 1950s, when the well documented [26,29] decline began.

Twinning rates vary with maternal age and parity [38]. The only country which routinely classifies twin confinements simultaneously by the sex of the twins, maternal age and birth order is Italy [27]. Parisi and Caperna [39,40] showed that simultaneous adjustment for age and parity does not substantially change the crude twinning trend in Italy. Standardisation for maternal age of the Australian data does not greatly alter the trend and the parity effect would be expected to be smaller.

Twinning varies considerably with race. The already very low rate in the Japanese is declining [25], while the exceptionally high rates in Nigeria may be increasing [38]. Until after the second World War, migration to Australia was predominately from the United Kingdom and Ireland and full-blood aboriginals were not included in the data before 1966, so racial composition of the population is unlikely to have been a significant influence in the long-term trend. The demographic variables of race, age and parity would seem to account for only a small part of the variation in twinning rates in Australia.

The secular trend is similar to the pattern in Finland [17] and the South of Italy [40] over the same period. Remarkably, Finland is in closer concordance with Australia than with Sweden over this time. Most attention has focused on the DZ decline of the last few decades and the wide range of hypotheses put forward to account for it attests to their inability to explain it. Hormones in food, pesticides, coital rates and oral contraceptives have been implicated amongst other factors [26,29]. But not only the decline since the 1950s should be explained, but also the variation during and since the last century. Comparisons between the North and South of Italy show a clear link with socioeconomic change and industrialisation [40]. Parisi and Caperna offer the resultant psychosocial stress as a plausible explanation. The trend in Australia has been shown to be geographically homogeneous across the States and Territories from 1920 to 1969 [43]. From 1870 onwards, the trends in Australia and the South of Italy are very closely concordant. But Australia was a rapidly developing country, its population undergoing the psychosocial stress of recent mass inter-continental migration over this period.

This indicates that different types of social upheaval may have different reproductive consequences. A uniform response to diverse psychosocial stresses would predicate concordance between Australia and the North of Italy not the South.

McArthur [34] has analysed the Italian and Australian data between 1922 and 1950. She found that there was essentially no difference in the frequency with which Italian and Australian women of the same age and parity gave birth to twins. She followed birth cohorts of women by calculating their age-specific twinning rates at different ages and concluded that, compared with the effects of age and parity, environmental factors played a very small role. A possible explanation of this finding is that from 1920 to 1950 the twinning rate was relatively stable in both Italy (national data) and Australia, and that the Italian data were analysed as a whole: if birth cohorts were followed separately for the North and South, a different outcome might be found. Also, a thirty-year period may not be long enough for adequate appraisal of trends.

What then can be concluded from the long-term rise and fall in the DZTR in Australia? It closely resembles the trend in Finland and the South of Italy, but Sweden and the North of Italy show an earlier fall in DZTR and the United States is between them. The decline generally took place in the 1950s and 1960s in Western Europe and was also seen, but more unevenly, in Eastern Europe. There is no simple fit with the spread of industrialisation, affluence or social disruption. Further insight may be gained when longer trends are published from countries where the data are available and, in particular, when regional comparisons can be made which highlight differences in relevant social and environmental factors.

The decline in twinning rates appears to have ended. This has also been reported from Hungary [9], Canada [14] and Denmark [44]. This has been due to a stabilisation in the incidence of DZ twins in both Australia and Denmark, while no zygosity breakdown was given for Hungary and Canada. If the increasing incidence of MZ twins is a more general phenomenon, then it is likely that nearly half of the twins being born in the developed world are MZ.

The etiology of MZ twinning is unclear. There is an excess of congenital malformations in twins [12,22,33,36,55] entirely due to their increased incidence in MZ twins [48]. There may be a common factor in the causation of both [6]. Working with the eggs of trout and *Fundulus*, Stockard [52] was able to produce MZ twinning by lowering the temperature or reducing the oxygen supply, and so arresting development. Arey [3] postulated that inflammatory changes in the Fallopian tube or uterus might cause similar effects in the human through inadequate or delayed oxygen supply, so pelvic infection may be implicated. In Queensland, an increasing incidence of ectopic pregnancies has been linked with a concurrent rise in gynaecological infections in women during the 1970s [51]. Vitamin A, dimethyl sulfoxide and urethan have caused conjoined twins in the golden hamster [18]. Vincristine sulphate causes MZ twinning in the mouse [31]. Could there be a toxic or infective exposure in mothers of MZ twins? The incidence of MZ twinning increases slightly with maternal age and is unaffected by parity and race [6]. Falling maternal age, as has occurred in Australia, would therefore produce a lower incidence. MZ twins have higher perinatal mortality and stillbirth rates than DZ twins [7,20,23,24]. Since this form of twinning can itself be regarded as a developmental malformation, an unexplained increase in incidence requires further investigation. The increase has been most marked since the early 1970s and does not

appear to be related to the changes in DZ twinning. A rise in MZTR is also evident in data from Poland [47], Germany [32] and England [28]. The increased incidence is not necessarily due to a malign influence. It may be an artefact from a defect in Weinberg's method or a reflection of improved maternal health and a consequent decline in spontaneous abortions. However, it merits close monitoring.

Acknowledgments. This work was undertaken at the School of Public Health and Tropical Medicine, University of Sydney. The study formed part of a thesis submitted by JDH Doherty for the degree of Master of Public Health of the University of Sydney while on special leave for study and research from FAO. The National Perinatal Statistics Unit is funded by the Commonwealth Department of Health in Australia.

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