Analysis of Multiple Birth Rates in Japan.
II. Secular Trend and Effect of Birth Order, Maternal Age, and Gestational Age in Stillbirth Rate of Twins

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Stillbirth rates of MZ and DZ twins in Japan gradually decreased during the period 1960–1967 and in 1974. The stillbirth rates of MZ and DZ twins were 0.270 and 0.224 in 1960, respectively, whereas the corresponding figures in 1974 were 0.135 and 0.099. The stillbirth rate was higher in MZ than DZ twins, in males than females, and in the second- than in the first-born. In both zygosities, the rates were higher in the first birth order than in the second, and then increased with birth order except in the sixth birth or more for MZ twins and for DZ twins born to mothers aged 35–39 years. The shorter the gestational age, the higher the stillbirth rate in both MZ and DZ twins, as expected. Mean gestational age was slightly shorter in MZ than in DZ twins. The decrease of the stillbirth rates can be explained partly by the reduction of twins with higher birth order, where high stillbirth rates of MZ and DZ twins are seen, and the reduction of older mothers.

INTRODUCTION

Among previous studies on the stillbirth rates of twins, Eriksson et al [2] reported that the rate in Sweden during the period from 1901 to 1960 remained constant up to 1940 and decreased gradually thereafter. Yerushalmy and Sherar [11] reported stillbirth rates among monozygotic (MZ) and dizygotic (DZ) twins in New York during the period 1936–1937. They found that the second of a pair of twins is exposed to a greater risk of a stillbirth than the first twin. The stillbirth rate of twins is more than three times as high as those of single births, and it was higher in MZ than in DZ twins. Barr and Stevenson [1] reported the stillbirth rate among total deliveries separately for MZ and DZ twins in England and Wales during the period 1949–1950. It was higher in MZ than in DZ twins in each sex, and was higher in male twins than in female twins in this population.

Imaizumi and Inouye [4] reported in the first report of the present series that stillbirth rate in Japan is high in young and old maternal age groups in both MZ and DZ twins. The present study deals with secular change of stillbirth rate of twins. It also deals with the effects of birth order, maternal age and gestational age on stillbirth rate of twins.

MATERIALS AND METHODS

There were two sources of data available for the present analysis: The annual volumes of Vital Statistics of Japan for the years 1951–1968 and 1974 [5] and the "Survey on Socio-Economic Aspects of Vital Events–Plural Births in 1975" [6]. In the first data, sex of the children and maternal age are listed from 1960 to 1967 and in 1974. Second data were derived from two surveys, A and B. Survey A was made on birth or stillbirth certificate records in 1974 on 25,189 children or fetuses born in plural deliveries to mothers of Japanese nationality, where the fetal death is defined as that which occurred after the beginning of 13th week of gestation. The survey B was conducted on a part of children included in survey A, and was not availed in the present analysis. Details of the surveys have been reported elsewhere [4]. Items used in the present analysis are sex of children, birth order of twins, live birth or fetal death, maternal age, gestational age, and the numbers of previous pregnancies and live births.

RESULTS

Secular Change of Stillbirth Rate of Twins

Table 1 shows the number of twin deliveries according to survival states of twins during the period from 1951 to 1968 and in 1974. In the following analysis, the stillbirth rate of twins was taken among twin deliveries, where total number of stillborn twin individuals was taken as numerator. The stillbirth rate of twins thus computed is also shown in Table 1. The rate increased significantly with the years up to 1961, and decreased thereafter.

Table 2 shows secular trends of the stillbirth rates of MZ and DZ twins during the period from 1960 to 1967 and in 1974. In computing the stillbirth rate separately for MZ and DZ twins, the numbers of twin individuals (live birth or stillbirth) were obtained after the numbers of MZ and DZ twins were estimated by Weinberg's method for each category of survival state of twins, two live-born, one live-born and one stillborn, and two stillborn.

In 1960, the stillbirth rates of like- and unlike-sexed twins were 0.260 and 0.224, respectively, the difference being significant ($P < 0.001$). Corresponding stillbirth rates of MZ and DZ twins were 0.270 and 0.224 in 1960, respectively. The rates gradually decreased with the years both in MZ and DZ twins, and the figures in 1974 are less than one half of those in 1960. Figure 1 shows secular trends of the stillbirth rates of MZ, DZ, and total twins including unknown sex. Similar decrease of stillbirth rates in the general population is seen from 1961 (Fig. 1), but the stillbirth rate of twins remained more than 2–3 times as high as that of the general population.

Table 3 shows secular trends of the stillbirth rates of twins according to sex during the period from 1960 to 1967 and in 1974. In both sexes the stillbirth rates are gradually decreased with the years in parallel to the decrease of stillbirth rates of MZ and DZ twins. In every year, sex difference of the stillbirth rates is statistically significant.

Stillbirth rates of twins in 1974 were analyzed according to zygosity, sex, and birth order of twins (Table 4). The stillbirth rate was higher in males than females in MZ twins, but this trend was not remarkable in DZ twins. The stillbirth rate was higher in MZ than DZ twins for both sexes. The stillbirth rate was lower for the first twin (0.112) than for the second (0.127), the difference being significant ($P < 0.001$).

Effect of Birth Order, Maternal Age, and Gestational Age on Stillbirth Rate of Twins

In the following analysis, the birth order concerns the numerical order of all children and fetuses (live-born and prenatally dead in the 21st week of gestation or later), where a delivery of twins was counted once. Table 5 shows the number of twin deliveries in 1974 according to survival state, sex, and the birth order, from which was computed the stillbirth rate of MZ and DZ twins according to birth order. Table 6 shows the result, in which the number of fetal deaths and stillbirth rates are shown according to maternal age. In MZ twins the stillbirth rate decreased from the first to the second birth, then increased but again decreased in higher birth orders in most maternal age groups. In DZ twins, the same pattern is seen in the maternal age group of 35–39 years, and in maternal age groups of 25–29 and 30–34 years are seen a decrease from the first to the second and an increase to the fourth.

As to the effect of maternal age in MZ twins, the lowest stillbirth rate is seen in the maternal age group of 25–29 years in the first birth order. As the birth order increases, the lowest rate shifts to the higher maternal age groups. Similar but less clear tendency is also seen in DZ twins.

Table 7 shows the number and frequency of deliveries of twins by zygosity according to survival state and gestational age. Gestational age of MZ twins tended to be shorter than DZ twins in the total of all survival states, which reflects the shorter gestational age of MZ twins than DZ twins in two live-born and one live-born categories. In the two-stillborn category, the frequency is higher in MZ twins than DZ twins in most gestational age groups.

TABLE 1. Number of Twin Deliveries According to Survival States of Twins and Stillbirth Rates Among Twins, 1951–1968 and 1974

Year	2 Live births	1 Live birth, 1 fetal death	2 Fetal deaths	Total	Stillbirth rate per 100 twin individuals
1951	10,600	1,888	2,655	15,143	23.77
1952	9,822	1,682	2,503	14,007	23.87
1953	8,952	1,621	2,480	13,053	25.21
1954	8,727	1,415	2,513	12,655	25.45
1955	8,221	1,447	2,374	12,042	25.72
1956	8,023	1,364	2,338	11,725	25.76
1957	7,762	1,331	2,314	11,407	26.12
1958	8,027	1,332	2,458	11,817	26.44
1959	7,907	1,280	2,392	11,579	26.19
1960	7,701	1,149	2,309	11,159	25.84
1961	7,855	1,178	2,361	11,394	25.89
1962	8,110	1,043	2,301	11,454	24.64
1963	8,304	979	2,355	11,638	24.44
1964	8,993	1,035	2,140	12,168	21.84
1965	9,338	901	2,027	12,266	20.20
1966	7,333	691	1,824	9,848	22.03
1967	10,483	844	1,885	13,212	17.46
1968	9,931	660	1,756	12,347	16.89
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1974	10,418	645	1,187	12,250	12.32

TABLE 2. MZ and DZ Twin Deliveries According to Survival States of Twins and Stillbirth Rates Among Twins, 1960–1967 and 1974

Year	MZ twin deliveries					DZ twin deliveries				
	2 LB	1 LB, 1 FD	2 FD	Total	Stillbirth rate per 100 twin individuals	2 LB	1 LB, 1 FD	2 FD	Total	Stillbirth rate per 100 twin individuals
1960	4,865	723	1,576	7,164	27.04	2,836	416	670	3,922	22.39
1961	4,871	720	1,649	7,240	27.75	2,984	448	628	4,060	20.99
1962	5,154	677	1,673	7,504	26.81	2,956	354	558	3,868	19.00
1963	5,288	661	1,694	7,643	26.49	3,016	312	580	3,908	18.83
1964	5,639	676	1,547	7,862	23.98	3,354	352	514	4,220	16.35
1965	5,868	618	1,469	7,955	22.35	3,470	272	470	4,212	14.39
1966	4,803	484	1,351	6,638	24.00	2,530	196	392	3,118	15.72
1967	6,893	560	1,408	8,861	19.05	3,590	268	398	4,256	12.50
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1974	6,954	459	889	8,302	13.47	3,464	186	298	3,948	9.90

LB = live birth; FD = fetal death.

TABLE 3. Stillbirth Rates of Twins for Males and Females, 1960–1967 and 1974

Year	Males	Females
1960	0.2777	0.2291
1961	0.2755	0.2297
1962	0.2643	0.2173
1963	0.2609	0.2155
1964	0.2299	0.1951
1965	0.2137	0.1777
1966	0.2383	0.1874
1967	0.1859	0.1518
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1974	0.1349	0.1133

TABLE 4. Stillbirth Rates of Twins According to Sex, Zygosity, and Birth Order, 1974

	Male			Female			Total	
	MZ	DZ	Total	MZ	DZ	Total	1st-born	2nd-born
Stillbirth rate	0.1494	0.1029	0.1349	0.1194	0.0953	0.1133	0.1118	0.1266

TABLE 5. Survival States and Sex of Twins According to Birth Order, 1974

Survival states of twins	Sex of twins	Birth order						
		1	2	3	4	5	6+	Total
2 live births	MM	1,887	1,565	571	101	17	17	4,158
	FF	1,970	1,518	563	96	21	11	4,179
	MF	735	628	232	33	13	8	1,649
1 live birth, 1 fetal death	MM	123	122	43	11	0	1	300
	FF	112	84	40	12	1	1	250
	MF	44	32	11	6	0	0	93
	Unknown	9	6	2	0	0	1	18
2 fetal deaths	MM	249	105	135	48	25	6	568
	FF	182	104	84	35	15	12	432
	MF	56	27	38	13	5	5	144
	Unknown	52	27	22	8	6	4	119

Table 7 also shows mean gestational ages of MZ and DZ twins according to survival state. It is seen that the means are lower in MZ twins than DZ twins in two or one live-born categories as well as in the total of all survival states.

DISCUSSION

The present analysis indicated that stillbirth rate of twins in Japan increased up to 1961, and decreased thereafter. A similar pattern was seen in the stillbirth rate of the general population (Fig. 1). In every year analyzed, the stillbirth rate was higher in MZ than DZ

TABLE 6. Stillbirth Rates of MZ and DZ Twins According to Maternal Age and Birth Order, 1974

Birth order	MZ						DZ					
	Under 25	25–29	30–34	35–39	Over 40	Total	Under 25	25–29	30–34	35–39	Over 40	Total
1	0.1347	0.1174	0.1343	0.2065	0.2273	0.1276	0.0944	0.0797	0.1264	0.1458	0.5000	0.0934
2	0.1255	0.0893	0.0850	0.0882	0.3333	0.0957	0.0958	0.0479	0.0710	0.0625	0.2500	0.0626
3	0.4491	0.1955	0.1172	0.1989	0.3333	0.1879	0.2308	0.1652	0.1208	0.1724	0.5000	0.1548
4	0.8333	0.4143	0.2325	0.1625	0.1667	0.3127	0	0.2500	0.3333	0.4545	0	0.3077
5	0.5000	0.7778	0.6111	0.4667	0.5000	0.5820	—	0.2000	0	0.5000	1.0000	0.2778
6+	—	0.6250	0.2857	0.2813	0.6250	0.4000	0	1.0000	0.7500	0.3333	0	0.3846

TABLE 7. Frequency of Twin Deliveries of MZ and DZ Twins According to Survival State and Gestational Age

|	Survival state	Gestational age (weeks)							Mean gestational age (weeks)
		12–23	24–27	28–31	32–35	36–39	Over 40	Total	
MZ twins	2 live births	0	0.0037	0.0264	0.1476	0.6513	0.0069	0.8359	37.0
	1 live birth, 1 fetal death	0	0.0017	0.0071	0.0130	0.0346	0.0006	0.0570	35.8
	2 fetal deaths	0.0519	0.0276	0.0139	0.0056	0.0080	0	0.1070	25.0
	Total	0.0519	0.0330	0.0474	0.1662	0.6939	0.0075	0.9999	35.7
	Stillbirth rate	1.0000	0.8640	0.3539	0.0726	0.0363	0.0417	0.1355	
DZ twins	2 live births	0	0.0053	0.0265	0.1151	0.7216	0.0058	0.8743	37.2
	1 live birth, 1 fetal death	0.0005	0.0016	0.0058	0.0058	0.0355	0	0.0492	36.0
	2 fetal deaths	0.0387	0.0260	0.0080	0.0021	0.0016	0	0.0764	23.9
	Total	0.0392	0.0329	0.0403	0.1230	0.7587	0.0058	0.9999	36.1
	Stillbirth rate	0.9934	0.8203	0.2688	0.0396	0.0243	0	0.1010	
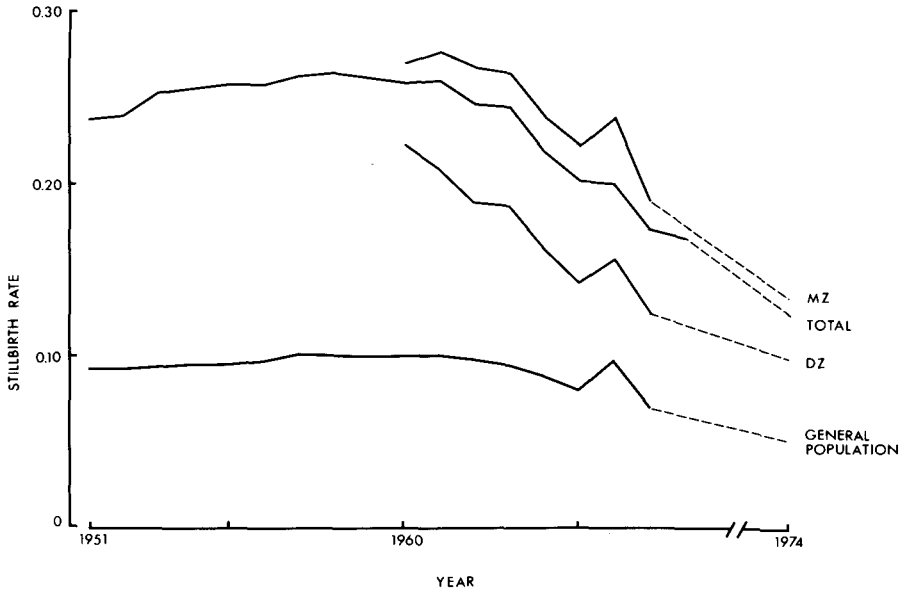
Fig. 1. Secular change of stillbirth rates of MZ twins, DZ twins, total twins, and the general population (1951–1968 and 1974).

twins and higher in males than females, except in 1974 where sex difference in DZ twins was not seen. A higher stillbirth rate of twins was seen in the second-born than in the first-born (Table 4). According to Yerushalmy and Sheerar [11], the stillbirth rate of MZ twins decreased, but that of DZ twins increased with birth order. In the present study, ignoring the classes with small numbers of subjects, the stillbirth rates of MZ twins are higher in the first birth order than in the second; and the rates increased with birth order up to the fourth birth order for maternal age groups under 34 years (Table 6). The same pattern is seen in DZ twins for maternal age groups between 25 and 34 years. As to the effect of maternal age, Yerushalmy and Sheerar reported that the stillbirth rates of MZ and DZ twins increased in old maternal age groups, but in the present study, a higher stillbirth rate of twins was seen in young and old maternal age groups both in MZ and DZ twins, as was reported by Imaizumi and Inouye [4] and is seen in Table 8.

According to Karn [7–9], mean gestational age was slightly shorter in same-sex twin pairs than in opposite-sex twin pairs, but Fraccaro [3] obtained the opposite result. In the present study, the mean gestational age was slightly shorter in MZ than in DZ twins (Table 7).

The decline of the stillbirth rate of twins in Japan seems to be partly due to a decline of children with higher birth order and a decline of maternal age, as indicated below. Stillbirth rates of MZ and DZ twins in 1974 are less than a half of those in 1960 (Table 2). Assuming the stillbirth rates of the fourth birth or more in 1974 (0.369 for MZ twins, 0.313 for DZ twins from Table 6) equal to a half of those in 1960, the stillbirth rates of MZ and DZ twins in the fourth birth or more are expected to decrease by 0.06 in MZ twins and 0.05 in DZ twins, since the proportion of the fourth birth or more was 9.8% in 1960 and 3.1% in the general population in 1974 (from vital statistics in 1960 and 1974). Similarly, the

TABLE 8. Stillbirth Rates in MZ and DZ Twins According to Maternal Age, 1960–1967 and 1974

	Year	Maternal age						
		−19	24−24	25−29	30−34	35−39	40+	Total
MZ	1960	0.5079	0.2984	0.2420	0.2599	0.2979	0.4235	0.2704
	1961	0.4252	0.2879	0.2556	0.2706	0.3622	0.4063	0.2775
	1962	0.4565	0.2813	0.2337	0.2759	0.3743	0.5300	0.2681
	1963	0.5042	0.2792	0.2261	0.2636	0.4388	0.5723	0.2649
	1964	0.4350	0.2486	0.2243	0.2259	0.3186	0.4127	0.2398
	1965	0.4286	0.2360	0.1953	0.2271	0.2952	0.5077	0.2235
	1966	0.4145	0.2462	0.2096	0.2442	0.3159	0.5183	0.2400
	1967	0.4201	0.1979	0.1678	0.1855	0.2640	0.4744	0.1905
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	1974	0.3247	0.1497	0.1216	0.1262	0.1738	0.2925	0.1347
DZ	1960	0.4333	0.2282	0.1921	0.2361	0.2527	0.3108	0.2239
	1961	0.4643	0.2215	0.1989	0.2024	0.2197	0.3600	0.2099
	1962	0.3529	0.2138	0.1562	0.1984	0.2766	0.3333	0.1900
	1963	0.3889	0.2029	0.1658	0.1887	0.2197	0.4750	0.1883
	1964	0.5000	0.1571	0.1508	0.1502	0.2464	0.3800	0.1635
	1965	0.3810	0.1401	0.1184	0.1602	0.2028	0.3611	0.1439
	1966	0.1250	0.1984	0.1257	0.1462	0.2402	0.3571	0.1572
	1967	0.1667	0.1457	0.1091	0.1187	0.1791	0.2222	0.1250
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	1974	0.3182	0.0943	0.0809	0.1122	0.1792	0.3214	0.0990

stillbirth rates of male and female twins in 1960 were 0.278 and 0.229, respectively (Table 3), whereas the respective rates in 1974 were 0.135 and 0.113, a decrease to a half during the past 14 years. Assuming the stillbirth rates of the fourth birth or more in 1974 (0.366 for males and 0.334 for females from Table 5) equal to a half of those in 1960, the stillbirth rates for males and females are expected to decrease by 0.06 in male twins and 0.05 in female twins in the fourth birth or more. As to the effect of maternal age, it is seen in Table 8 that the stillbirth rates for MZ and DZ twins decreased with the years in mothers under the age of 35, whereas in mothers over 40 the decline of the rates was least marked. In maternal age groups of 20–34 years, the stillbirth rates of MZ and DZ twins in 1960 are approximately two times as high as those in 1974, but the rates in maternal age groups less than 20 years and 35 years or more in 1960 are between 1.44 and 1.71 times (MZ twins) and between 0.97 and 1.41 times (DZ twins) as high as those in 1974. The proportion of mothers over 35 years of age was 6.7% in 1960 and 4.4% in the general population in 1974 (from vital statistics in 1960 and 1974). A diminished proportion of old mothers over 35 years of age during 14 years was only 2.3%, and the stillbirth rates in the same maternal age group in 1960 are more than 1.69 (0.321/0.190) times for MZ twins and 1.56 (0.305/0.196) times for DZ twins as high as those in 1974 from Table 8. Therefore, expected decreases of the stillbirth rates are only 0.013 for MZ twins and 0.012 for DZ twins in mothers over 35 years, and the cause of the decrease of stillbirth rate of twins should not be entirely attributed to the reductions of older mothers and higher birth orders. Other factors may also be important, including improvement in medical care.

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