The Comparison of Twinning Rates Between Urban and Rural Areas in China

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Based on the birth record data from the National Vital Statistics in the 1990 Census of China, the present study analyzed the differences between urban and rural areas on monozygotic (MZ) and dizygotic (DZ) twin rates by maternal age in 1989. The twins by zygosity were calculated with Weinberg's differential method. Results show that the MZ and DZ twinning rates in China were associated with maternal age and that there were substantial differences between urban and rural areas. The MZ twinning rates in urban and rural areas were 2.36 pairs and 2.11 pairs per 1000 deliveries respectively, significantly lower than that in most studied populations. Furthermore, our analysis indicated that MZ twinning rates remained relatively constant for mothers under the age group of 36 to 38 years, but rose over this age group in both areas, albeit with a different slope. The DZ twinning rates were strikingly affected by maternal age, but the age for peak DZ rates was found within the age group of 33 to 35 years. In all maternal age groups except for 24 to 26 years, the DZ twinning rates in urban areas were higher than in rural areas. It remains unclear as to why the DZ twinning rates reversed to reach higher values within the older maternal age groups in China, but it is almost certain that the high twinning rates had nothing to do with in vitro fertilization.

Monozygotic (MZ) and dizygotic (DZ) twins result from different biological mechanisms. Normally, the MZ twinning rate is rarely affected by hereditary and environmental factors, and keeps relatively constant, while the DZ twinning rate is affected by heredity, maternal age, parity, diet and assisted reproductive technologies, and is very different for various populations and periods (Vogal & Motulsky, 1997). After undergoing a progressive decline, the twinning rates reversed in the late 1970s and have increased significantly in industrialized countries, and this has raised considerable concern (Pison & D'Addato, 2006). These phenomena were possibly related to demographic features such as maternal childbearing age, birth control, and assisted reproductive technologies (Eriksson & Fellman, 2004; Olsen, 2001; Steinman, 2006; Wilcox et al., 1996). The influence of factors such as lifestyle, nutrition, and economic status on twinning rates remains poorly understood. Because twin births are rare, and the factors affecting twinning rates are complex, it is extremely challenging to obtain sufficient samples to analyze the influence of multiple factors on twinning rates in a single study. China has the largest population in the world. A lack of systematic historical vital records in the past prevented thorough studies on Chinese twinning rates. To date, only a few studies are documented, with a very limited number of twins, mostly obtained from hospital delivery records or school investigations. Consequently, the reported Chinese twinning rates range from 0.28% to 1.54% (Chen et al., 1987; Lauferm, 1920; Millis, 1959), and in the literature, the twinning rates in Mongoloid populations were usually cited from results in Japan. Gan and Zheng (2002) analyzed the geographical distribution of twinning rates in China. In the present paper, we use the annual data on twin births registered in the 1990 census of China to further analyze the influence of differences between urban and rural areas on twinning rates by maternal age.

Materials and Methods

The numbers of infants and twins born to mothers aged from 15 to 49 years, from urban and rural populations, from January 1 to December 31, 1989, were obtained from the National Vital Statistics in the 1990 Census of China (Population Statistics and Employment Department of National Statistics Bureau, 1993, 1994). The twin pairs were recorded in sex combinations. In order to reduce the random fluctuations of twin births, and to make the age dependence more clear, data for every 3-year age period was combined into one group (with the exception of ages 48 and 49 years, which were grouped).

The census data of births only recorded two types of deliveries, singletons and twins. Triplets or higher

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Table 1

Maternal Age Distribution and Total Twinning Rates in Urban and Rural Areas in China, 1989

Maternal age group	Number of mothers		Maternal age distribution (%)		Total number of twin pairs		Twinning rates per 1000 births	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
15+	15,917	148,608	0.34	0.79	76	524	4.77	3.53
18+	366,322	2,437,110	7.87	12.95	2345	10,756	6.40	4.41
21+	1,357,025	6,164,118	29.15	32.75	9830	35,540	7.24	5.77
24+	1,806,113	5,517,343	38.79	29.31	15,003	43,649	8.31	7.91
27+	526,330	1,878,782	11.31	9.98	5802	19,603	11.02	10.43
30+	317,184	1,293,745	6.81	6.87	4639	16,482	14.63	12.74
33+	170,722	776,685	3.67	4.13	2772	10,136	16.24	13.05
36+	65,783	361,445	1.41	1.92	1064	4552	16.17	12.59
39+	19,525	152,876	0.42	0.81	290	1801	14.85	11.78
42+	6393	60,336	0.14	0.32	101	675	15.80	11.19
45+	2967	23,182	0.06	0.12	102	319	34.38	13.76
48+	1407	8043	0.03	0.04	54	158	38.38	19.64
Total	4,655,688	18,822,273	100.00	100.00	42,078	144,195	9.04	7.66

order multiples were so rare that these were not recorded. The Weinberg's differential method was applied to the analysis of twins by zygosity (Fellman & Eriksson, 2006). The differential rate (DR) was used to express the differential degree in MZ or DZ twinning rates between urban and rural populations, that is, the formula of DR for MZ is

$$100^* \frac{\text{urban MZ} - \text{rural MZ}}{\text{rural MZ}},$$

and an analogous formula for DZ.

Results

Changes in Twinning Rates by Zygosity With Maternal Age

Figure 1 illustrates the MZ and DZ twinning rates by maternal age in the total, urban, and rural populations of China during 1989. Because the annual numbers of both mothers and twin births in China were much higher in rural areas than in urban areas within every maternal age group, the curves of MZ and DZ twinning rates by maternal age were smoother in rural areas than in urban areas. As shown in Figure 1, the MZ and DZ twinning rates were greatly affected by maternal age, and also by differences between urban and rural areas, but the trends of change with maternal age were congruous in both populations.

There are two distinctive features of the MZ twinning rates in China in 1989: the low MZ twinning rate, and the rising trend for the MZ twinning rate at an older maternal age. The total MZ twinning rates were 2.36 pairs per 1000 deliveries in urban areas and 2.11 pairs per 1000 deliveries in rural areas, both of which were considerably lower than the 3.5 to 4.5 pairs per 1000 deliveries typically found in many other countries, including Asian populations (Chen et al., 1992; Imaizumi & Nonaka, 1997). The MZ twinning rates were somewhat constant for the maternal age group of 36 to 38 years, with mean MZ twinning rates of 2.13 pairs in urban areas, and 2.06 pairs in rural areas per 1000 deliveries. However, over 38 years, the MZ twinning rates rose drastically with age, reaching 19.90 pairs in urban areas and 12.18 pairs in rural areas per 1000 deliveries within the oldest age group of 48 to 49 years.

For DZ twinning rates, maternal age was the most important nongenetic determinant. The DZ twinning rates increased monotonously with age for mothers under the 33 to 35 age group. The peak rates within the 33- to 35-year age group were 14.39 pairs in urban areas and 11.03 pairs in rural areas per 1000 deliveries, representing 4.76 and 6.89 times the DZ twinning rates from the youngest age group of 15 to 18 years in urban and rural areas respectively. These results were different from most previous findings that the maternal age for peak DZ twinning rates was 35 to 39 years.

The other particular phenomenon evidenced in the present study is that the DZ twinning rates reversed to increase with age at older maternal ages. The turning point ages were within 39 to 41 years in urban areas but 45 to 47 years in rural areas, being 6 years earlier in urban areas than in rural ones.

Comparisons of Twinning Rates Between Urban and Rural Areas

Figure 2 shows the effects of differences between urban and rural areas on the MZ and DZ twinning rates by maternal age in China in 1989. The MZ twinning rates were rarely affected by the differences between the two areas under the maternal age group of 36 to 38 years, and showed a random fluctuation. Over this age group, the discrepancy of MZ twinning rates in both populations expanded rapidly with maternal age.

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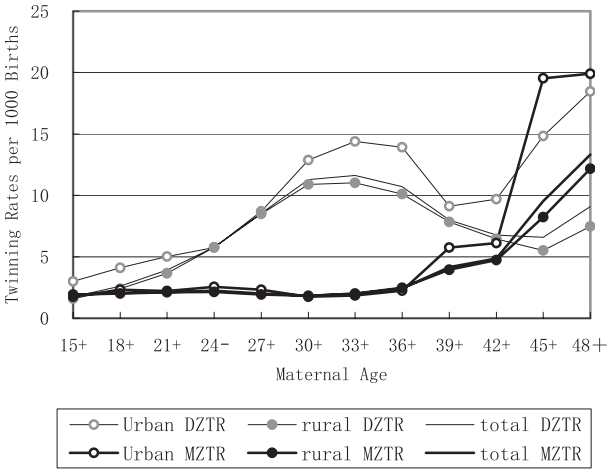

Figure 1

MZ and DZ twinning rates by maternal age in total, urban and rural populations.

Previous reports about the relationship between socioeconomic status and DZ twin births were not all consistent (Pison & D'Addato, 2006). According to the data analyzed in this study, the DZ twinning rates in China were higher in urban areas than in rural areas within all but the 24 to 26 years maternal age group. The differential rates in DZ twinning rates by maternal age showed a trough with the exception of an abnormal drop within the age group of 39 to 41 years. That is to say, the main differences in DZ twinning rates between both areas were within the younger and older maternal age groups, and the DZ twinning rates within the age groups 24 to 26 and 27 to 29 years were rather close in both areas.

Although maternal ages had obvious effects on the DZ twinning rate, there was nonetheless only a very minor difference in the mean maternal age between urban and rural areas: the mean maternal age was 25.0 years in urban areas and 24.7 years in rural areas. However, the distribution of mothers differed between both areas: distribution was more concentrated in urban areas. The proportion of mothers within almost all age groups, especially below the 24- to 26-year age group, was higher in rural areas than in urban areas. The only exceptions appeared to be within the age groups of 24 to 26 and 27 to 29 years.

Discussion

Biologically, MZ twins are the result of early division and segregation of a fertilized egg, while DZ twins result from the ovulation and fertilization of two different ova during a single cycle. Therefore, changes in twinning rates might reflect, to a certain degree, the influences of nongenetic factors on the early development of a fertilized egg and female reproductive physiology, for example, the level of follicle-stimulating hormone and the status of ovarian function.

Some researchers propose that a constant value for MZ twinning rates would be arbitrary, and that MZ rates vary between populations (Allen & Hrubec, 1987). The present study showed that stable MZ twinning rates in China were evidenced only under the maternal age group of 36 to 39 years. The rising MZ twinning rates at older maternal ages were usually ignored. Because MZ twin pairs born within the older maternal age groups accounted for a very small proportion of the total MZ twin pairs, and showed a greater fluctuation, its particularity was easily hidden. The high MZ twinning rates at the older maternal ages suggested a higher risk of anomaly at early embryo development for older mothers, especially mothers in urban areas, which might be associated with older female reproductive physiological features and industrial pollution.

In this study, the MZ twinning rates were much lower in China than in many other Asian populations studied to date, but the results were in accordance with Zeng's conclusion (Zeng, 1962). Zeng studied the natural twinning rates in Shanghai in 1962, and compared the twinning rates between Chinese and Japanese populations. He found that both populations had very close total twinning rates, but the rates by zygosity were significantly different — the MZ twinning rate was 2.65 per 1000 deliveries in Shanghai and 3.83 per 1000 deliveries in Japan (Inouyo, 1957; Zeng, 1962).

There could be numerous explanations for the variations in DZ twinning rates in various populations. The causes for the higher DZ twinning rates in urban areas might be complex in China. Under economic development plans before 1992, China had relatively strict binary social systems: urban population and rural population. Between the two populations, there were significant differences in economic opportunities, nutrition accessibility, environment, ways of work and lifestyles, family

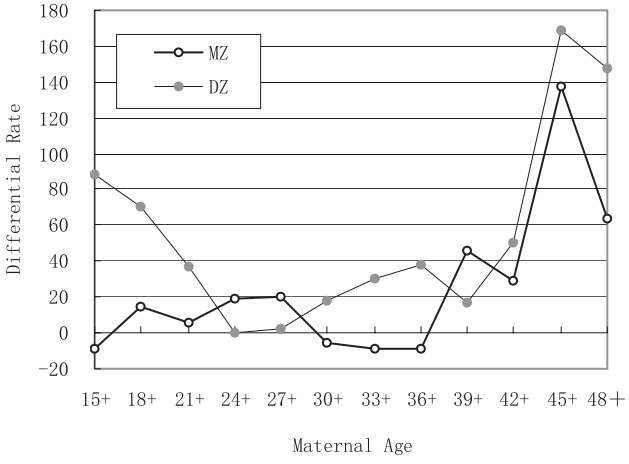

Figure 2

Comparison of MZ and DZ twinning rates between urban and rural areas.

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planning, physical development, life span, and so forth. In general, the economic and nutritional conditions were much more unfavorable in rural than in urban areas, but environmental pollution was more serious in urban than in rural areas. These differences might influence the reproductive physiology of the female population. Some studies indicate that although Chinese rural females show trends of advancing the mean of first menstruation age and prolonging the mean menopause age (14.40 ± 1.40 years and 47.5 ± 0.19 years respectively), they still have not reached urban females' mean first menstruation age or menopause age (13.50 ± 1.21 years and 49.5 ± 0.13 years respectively; Wang et al., 1990; Xi et al., 1987). These differences might be responsible for the higher DZ twinning rates in urban areas, as well as the differences in DZ twinning rates within the youngest and oldest maternal ages between both areas.

The difference in parity was also an important contributing factor to the discrepancy in DZ twinning rates for mothers under the age of 27 to 29 years between urban and rural areas. Although the twin birth records did not include information about parity, it can be speculated from the maternal age distribution to some degree. The policies in urban and rural areas were different with regards to family planning. In urban areas, a couple usually had only one delivery, but in rural areas, if a couple had a female at the first delivery, they were allowed to have a second delivery 5 years later. The mean first delivery age was younger in rural areas than in urban areas, which led to a higher proportion of young mothers under the age of 21 to 23 years in rural areas, and thus the more concentrative distribution of maternal ages in urban areas. The difference in parity between both populations increases as the maternal age rises. To some degree, the effects of parity might counterbalance the effects of urban and rural differences on DZ twinning rates. This might be an important reason why the differences in DZ twinning rates between both areas decreased when maternal age reached the 27- to 29-year age group.

The increased differences in DZ twinning rates between urban and rural areas at older maternal ages might be partly explained by the higher proportion of second marriages in urban areas, which led to the second or more deliveries. In addition, mothers in urban areas tend to receive fertility treatment more frequently than in rural areas, especially at older ages.

Almost all studies show that the peak DZ twinning rate is for mothers within the 35- to 39-year age group, and that the DZ twinning rates then decrease steadily. However, in the present study, the DZ twinning rates reach their peak values within the 33- to 35-year age group, and the second peak values occurred within the oldest maternal age. These phenomena need to be further studied. In fact, the DZ twinning rates for maternal ages between 35 and 39 years displayed a large fluctuation for the period 1981 to 2002 in South Korea, where during the middle 1980s, the twinning rates for the maternal age group 35 to 39 years were the lowest among all 5-year age groups (Hur & Kwon, 2005). In addition, although the twinning rates soar markedly for mothers aged 40 to 44 years and over in recent years in some countries (Martin & Park, 1999), it is almost certain that the high twinning rates within the oldest maternal age groups in China had nothing to do with in vitro fertilization (IVF), as the first child conceived from IVF was born in 1988.

Finally, it should be noted that China is a large blank spot on the map of twinning. Therefore every attempt to eliminate this lack of information is desired. Previously ignored data can be used to analyze the twinning incidence in China, the present study being an example, and findings from this research can serve as a background for future large-scale twin studies on the Chinese population.

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