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Twinning in New England in the 17th–19th Centuries

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Abstract. Vital records of Saybrook and Plymouth in New England from the 17th century were investigated. Among 8,562 maternities 81 twin maternities were found, the twinning rate being 0.95%. Twinning rate was low at the 1st and 2nd births as compared with the 3rd or later births, and was highest at the 7th and 8th births (1.6%). Twin maternity seemed to be a strong risk factor to terminate reproduction, particularly after 6 or more children had been delivered. The rate of mothers who had any other child ("fertile" mothers) at the 7th or later birth order was significantly lower for twin (13%) than for singleton maternities (63%). Twinning rate also varied by the size of offspring of a mother, and those mothers who had 5 or 6 children showed the highest twinning rate (1.3%). Those fertile mothers who had 7 or more children showed the lowest twinning rate (0.74%), although an exceptionally higher twinning rate was seen at their last births. Elongation of the last birth interval was observed for each group of every family size, and higher twinning rates were generally observed at their last births. Reduction in fecundity and rise in twinning rate seem to have occurred simultaneously at the last stage of the reproductive period of mothers, regardless of their family size.

Key words: Twinning rate, New England, Birth order, Family size, Birth interval, Parish records, Fecundity

INTRODUCTION

Effects of birth order or maternal age on the incidence ot twinning have been almost established [1,10,11]. The twinning rate has been shown to increase with maternal age up to a peak at 35–39 years, and to increase with birth order, independent of maternal age [10,12]. Recent decrease in the family size by the prevalence of birth control in deve-

loped countries limits the possibility of further studies on the incidence of twinning among maternities with higher birth orders.

In a series of our investigations using old baptism records, some records were found to include the data grouped for each family by which the information of birth order was available. In the present paper, we report the effects of birth order and family size on the twinning rate in the 17th-19th centuries in New England.

MATERIALS AND METHODS

Vital records of Saybrook [5] and Plymouth [8] in New England were investigated. These records generally included the names of a married couple, followed by the dates of births of their children. Except for the cases in which the date of death of the mother was described, the completion of reproduction, for each couple could not be confirmed from these data. Therefore, the records, especially with a smaller family size, may include families with an apparently smaller family size. We confined the data, in a part of analysis, by using only the families with a larger family size.

Table 1 shows the distribution of the number of births by the birth year of children. Among 8,562 maternities used in the present analysis, most children were born until the 18th century.

Calculations were performed with the aid of SPSS-X package programmes on M-240D (Hitachi Co. Ltd.) at Teikyo University.

Table 1 - *Distribution of the number of births according to birth year and place*

Year periods	Place		Total
	Saybrook	Plymouth	
- 1650	31	19	50
1651 - 1700	416	571	987
1701 - 1750	1041	444	3485
1751 - 1800	600	1921	2521
1801 -	247	1062	1309
Unknown	33	177	210
Total	2368	6194	8562

RESULTS

Among 8,562 maternities 81 twin maternities were found, with a twinning rate of 0.95%. Table 2 shows the variation of the twinning rate of all births according to birth order (starting from 1). The twinning rate was low at the 1st or 2nd births (24/3,564 = 0.67%) compared with the 3rd or later births (57/4,998 = 1.14%; $\chi^2 = 4.84$; $P < 0.05$) and was highest at the 7th or 8th births (12/740 = 1.6%). The rate among the 9th or later births was reduced to 0.9% (4/451), but this decrease was not statistically significant compared

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Table 2 - Twinning rate by the birth order (all births)

Birth order	Number of births		Twinning rate (%)	
	Singleton	Twin		
1	1942	15	0.77	0.67 *
2	1598	9	0.56	
3	1278	18	1.39	1.19
4	1039	10	0.95	
5	813	7	0.85	0.90
6	624	6	0.95	
7	449	6	1.32	1.60 *
8	291	6	2.02	
9	189	2	1.05	0.89 ns
10 +	258	2	0.77	
Total	8481	81	0.95	

* $P < 0.05$ by the chi-square test; ns, not significant.

with the rate at the 7th or the 8th births. When the families with less than 6 children were excluded, the remaining 630 mothers also showed the birth order effect: the twinning rate at 1st and 2nd births was 0.2% (3/1,260) and the rate at the 3rd to 6th births was 0.87% (22/2,520; $\chi^2 = 4.23$ with Yates' correction, $P < 0.05$).

Mean number of children to be delivered after each birth order was calculated for singleton and twin births, respectively (Table 3). The mean number of children to be deli-

Table 3 - Number of children remaining to be delivered after each birth order

Birth order	Type of birth	
	Singleton	Twin
1	3.38 (1942)[a]	2.87 (15)
2	3.12 (1598)	1.00 (9)
3	2.86 (1278)	2.50 (18)
4	2.53 (1039)	2.90 (10)
5	2.25 (813)	0.86 (7)
6	1.92 (624)	1.17 (6)
7	1.66 (449)	0.17 (6)
8	1.54 (291)	0.33 (6)
9	1.38 (189)	0 (2)
10 +	1.06 (258)	– (0)

[a] Mean number of further children to be delivered (N of mothers).

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vered was nearly equal, or greater for singleton than for twin maternities. Its difference was small at lower birth orders and increased among higher birth order groups.

The rate of mothers who had at least one more child ("fertile" mothers) was 82% at the 1st birth order and decreased with the birth order, down to 54% at the 10th or later births (Table 4). After twin delivery, the rate was smaller than that after singleton delivery. The decrease in the rate after twin delivery was highly significant at the 7th or later birth orders; the rate of fertile mothers was 13% after twin (2/16) in contrast to 63% after singleton (746/1,187) deliveries ($\chi^2 = 14.9$ with Yates' correction, $P < 0.01$).

Table 4 - The rate of mothers who did not terminate reproduction after each birth order

Birth order	Type of birth (%)		Total (%)
	Singleton	Twin	
1	1595/1942[a] (82)	12/15 (80)	1607/1957 (82)
2	1291/1598 (81)	5/9 (56)	1296/1607 (81)
3	1034/1278 (81)	15/18 (83)	1049/1296 (81)
4	813/1039 (78)	7/10 (70)	820/1049 (78)
5	626/813 (77)	4/7 (57)	630/820 (77)
6	452/624 (72)	3/6 (50)	455/630 (72)
7	296/449 (66)	1/6 (17) *	297/455 (65)
8	190/291 (65)	1/6 (17) *	191/297 (64)
9	119/189 (63)	0/2 (0)	119/191 (62)
10 +	141/258 (55)	0/2 (0)	141/260 (54)
1-6	5811/7294 (80)	46/65 (71)	5857/7359 (80)
7 +	746/1187 (63)	2/16 (13)**	748/1203 (62)

[a] No. of "fertile" mothers/No. of all mothers.
* $P < 0.05$; ** $P < 0.01$.

The twinning rates also varies by the size of offspring from a mother. Table 5 shows the variation of the twinning rate of all births according to family size. Those mothers who had 5 or 6 children showed the highest (26/2,000 = 1.3%) and those who had 7 or more children showed the lowest twinning rate (29/3,933 = 0.74%).

Breakdown of the twinning rate by birth order and family size (Table 6) shows a general increase in the twinning rate at the last births for every family size, and the increase was more conspicuous among the groups with family size 7-9. Although these fertile mothers having 7-9 children had a lower twinning rate in total, they showed an extremely high twinning rate at their last birth: while the rate at birth orders other than the last was 0.44% (10/2,266), the rate at the last birth order was elevated up to 3.6% (12/336). But among the most fertile mothers having 10 or more children, the increase of the twinning rate at the last birth had a tendency to become less (last, 2/119, 1.7%; non-last, 5/1,209, 0.41%). The mothers with a smaller family size, in contrast, experienced more twin maternities at lower birth orders, and showed a slight rise at their last births. Among mothers of family size 2-6, the twinning rate was 1.1% (33/3,127) at the non-last births and 1.4% (16/1,152) at the last births.

Table 7 shows mean birth intervals calculated for each family size. In general, the higher the size and the lower the order of birth interval, the shorter the interval. From Table 7, the last interval is seen to have been elongated, rather abruptly, for every family

Table 5 - Twinning rate by the family size (all births)

Family size	Number of births		Twinning rate (%)
	Singleton	Twin	
1	347	3	0.86
2	615	7	1.13
3	734	7	0.94
4	907	9	0.98
5	936	14	1.47
6	1038	12	1.14
7	1098	8	0.72
8	839	9	1.06
9	643	5	0.77
10 +	1324	7	0.53
Total	8481	81	0.95

1.03, 0.97, 0.99, ns, 1.30, *, 0.87, 0.74, 0.61

* $P < 0.05$ by the chi-square test; ns, not significant

size. Even those mothers with family size less than 6 (less fertile mothers), for example, experienced sudden elongation of the last birth interval, as the more fertile mothers did.

DISCUSSION

Parish records have limitations in that they may not represent the whole population, may not include the information of all the family members, and may not include all the data or stillbirths or perinatal deaths which would have appeared more frequently in twin than in singleton maternities. In spite of these limitations, they have the advantage that there was virtually no artificial birth control and include the information on fertile mothers under natural conditions.

In the present paper, the increase of the twinning rate with birth order was confirmed for the data in two parishes in New England from the 17th century, though the confounding maternal age effect could not be excluded. Twinning rate has been noted to increase with birth order, while the effects of maternal age had a peak around the age 40 [12], and a small trough at the age around 30 years [10]. The authors confirmed the elevation of twinning rate up to the 7th or 8th birth order from the present data, but a further increase at the 9th or later births was not found. This may be explained by the maternal age effects at the age of 40 years or higher. We propose, in later discussion, a possibility that this decline was caused by the reduced twin-prone nature of highly fecund women.

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Table 6 - Variation in the twinning rate by birth order and family size

Birth order	Family size									
	1	2	3	4	5	6	7	8	9	10+
1	3/350[a] (0.9)	3/311 (1.0)	3/247 (1.2)	0/229 (0.0)	3/190 (2.6)	2/175 (1.1)	0/158 (0.0)	0/106 (0.0)	0/72 (0.0)	1/119 (0.8)
2		4/311 (1.3)	1/247 (0.4)	4/229 (1.7)	0/190 (0.0)	0/175 (0.0)	0/158 (0.0)	0/106 (0.0)	0/72 (0.0)	0/119 (0.0)
3.			3/247 (1.2)	2/229 (0.9)	5/190 2.6)	3/175 (1.7)	2/158 (1.3)	2/106 (1.9)	1/72 (0.5)	0/119 (0.0)
4				3/229 (1.3)	3/190 (1.6)	1/175 (0.6)	0/158 (0.0)	0/106 (0.0)	0/72 (0.0)	3/119 (2.5)
5					3/190 (1.6)	3/175 (1.7)	0/158 (0.0)	1/106 (0.9)	0/72 (0.0)	0/119 (0.0)
6						3/175 (1.7)	1/158 (0.6)	0/106 (0.0)	2/72 (2.8)	0/119 (0.0)
7							5/158 (3.2)	1/106 (0.9)	0/72 (0.0)	0/119 (0.0)
8								5/106 (4.7)	0/72 (0.5)	1/119 (0.8)
9									2/72 (2.8)	0/119 (0.0)
10+										2/260[b] (0.8)
Non-last		3/311 (1.0)	4/494 (0.8)	6/687 (0.9)	11/760 (1.4)	9/875 (1.0)	3/948 (0.3)	4/742 (0.5)	3/576 (0.5)	5/1209 (0.4)
Last		4/311 (1.3)	3/247 (1.2)	3/229 (1.3)	3/190 (1.6)	3/175 (1.7)	5/158 (3.2)	5/106 (4.7)	2/72 (2.8)	2/119 (1.7)
Total	3/350 (0.9)	7/622 (1.1)	7/741 (0.9)	9/916 (1.0)	14/950 (1.5)	12/1050 (1.1)	8/1106 (0.7)	9/848 (1.1)	5/648 (0.8)	7/1331 (0.5)

[a] Twin births/total births (twinning rate, %).

[b] Non-last births included.

The present study pointed out that the delivery of twins at higher birth orders (7th or later) made a strong risk factor to terminate further reproduction. Among 23 mothers who delivered twins in the parishes of Saybrook, five were actually described to have died soon after that delivery. Physical overload by the twin pregnancy and delivery seemed to have exhausted the maternal reproductive potential to have another baby, particularly if the mothers had delivered 6 or more children.

It is also possible, however, that the mothers who had suffered from some reduction in the reproductive functions, in consequence, tended to conceive twins. In fact, the last births were associated with a higher twinning rate for each family size, and simultaneously, with an elongation of the last birth interval. Since direct effects of the twin maternity on the determination of reproduction are limited for the mothers having delivered twins, it is conceivable that some general dysfunction in reproductive functions may have occurred concurrently or prior to the twin maternity.

Table 7 - Variation in birth intervals according to birth order and family size

Interval order	Family size								
	2	3	4	5	6	7	8	9	10 +
1st-2nd	32.7[a] (299)	31.3 (238)	30.9 (226)	28.3 (186)	26.5 (172)	24.3 (152)	24.4 (100)	23.3 (72)	22.5 (117)
2nd-3rd		36.1 (233)	31.2 (221)	31.8 (187)	28.4 (172)	27.2 (153)	27.7 (103)	23.7 (71)	23.3 (111)
3rd-4th			37.5 (217)	32.4 (184)	29.3 (167)	29.3 (154)	26.8 (102)	26.4 (70)	23.6 (111)
4th-5th				37.7 (184)	31.3 (167)	30.2 (155)	28.9 (102)	28.5 (71)	24.8 (113)
5th-6th					35.1 (168)	32.2 (152)	30.5 (98)	27.2 (72)	25.3 (112)
6th-7th						37.8 (149)	32.3 (95)	28.6 (70)	25.7 (111)
7th-8th							35.1 (95)	28.9 (68)	25.1 (110)
8th-9th								36.5 (67)	26.2 (112)
9th-10th or later									27.8[b] (241)
Non-last		31.3 (238)	31.1 (447)	30.8 (557)	28.8 (678)	28.7 (766)	28.4 (600)	26.6 (494)	24.7 (1017)
Last		36.1 (233)	37.5 (217)	37.7 (184)	35.1 (168)	37.8 (149)	35.1 (95)	36.5 (67)	30.1 (121)
Total	32.7 (299)	33.7 (471)	33.2 (664)	32.5 (741)	30.1 (846)	30.1 (915)	29.3 (695)	27.8 (561)	25.2 (1138)

[a] Mean interval in month (number of intervals).

[b] Non-last birth intervals included.

This last birth phenomenon, or the abruct elongation of birth interval and increase of twinning, seem to be considered as a result, not as a cause, in almost all groups of mothers. The authors made the following working hypothesis on the fecundity and twin-proneness of women (schematically illustrated in the Figure). Those mothers with a smaller family size ("Unhealthy" in the Figure) had some troubles in their reproductive functions and showed a higher twinning rate at younger ages. At these younger ages or lower birth orders, however, more fertile mothers kept good reproductive abilities and showed a low twinning rate. At the higher age or birth order, however, most of these fertile ("Healthy") mothers also suffered from a reduction in reproductive functions, in a rather abrupt manner, and showed a higher (the highest) twinning rate. Only a small portion of mothers, who had 10 or more children, showed a rather constantly low twinning rate through their reproductive period ("Ideally healthy" in the Figure). These discrete groups of mothers, as a mass, would show a gradual decline in fecundity and an increase and decrease in the twinning rate, according to maternal age or birth order (at the bottom of the Figure).

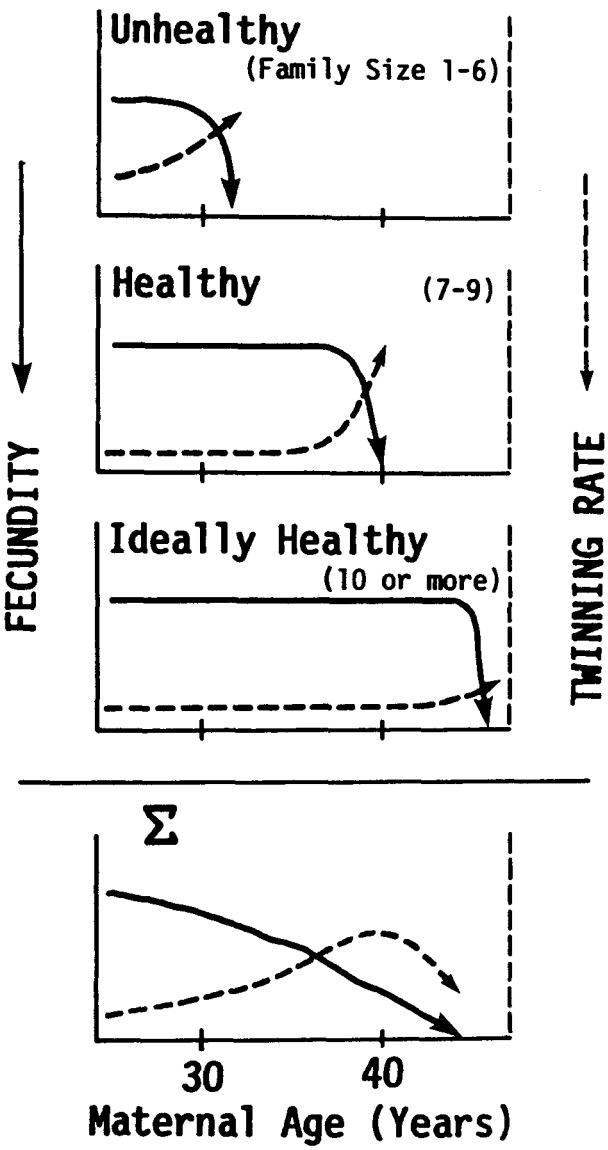

Figure - Diagrammatical illustration of the hypothesis on the fecundity (solid lines) and twinning rate (broken lines) are shown in three groups of mothers, noted as unhealthy, healthy, ideally healthy. These three discrete groups of mothers are supposed by the observation of twinning rates and birth intervals according to family size and birth order (Table 6 and Table 7). At the bottom, the figure shows the trend in all mothers, as a mass.

Apparent decline among the mothers with higher maternal age or birth order, then, could have been derived from the less twin-prone nature of the most fecund women.

Of course the validity of the above hypothesis should be checked by other data. As far as we know, the last-birth effects have not been so much discussed. In the prospective hospital data analysed by Allen [1], one can possibly see this last-birth effects in the Table showing the twinning rate by the family size and birth order, though the author's intention seems to be elsewhere. Although the family size cannot imply fecundity directly among recent birth data biased by the effects of birth control, the last birth phenomenon, specific

at the last stage of a maternal reproductive period, may present a new clue to consider the problem of the fecundity of twin-prone women [2].

Changes in maternal endocrinological conditions at the last stage of reproductive period could have given rise to irregular ovulations as natural biological aging: functional reduction of the aged ovary may cause delayed or no ovulation at the menstrual cycle. This could imply less fecundity, but simultaneously give a higher opportunity of multiple ovulation by the stimulation of gonadotropins elevated through negative feedback. Nylander [12] reported higher level of FSH in women having delivered twins. For the cause of the dysfunction in the endocrinological system, one could also suppose some active environmental factors, other than natural aging. Hypothetical epidemic factors which might cause the reduction of luteal functions [9] could have played a role in making an infertile state through abortion and, simultaneously, in making a twin-prone state by the elevated FSH level through a negative feedback mechanism. Burch [4] suggested actions of microorganisms as a trigger to multiple pregnancies in cattle. As for the regularity in menstrual cycles. Hémon et al [7] reported lower percentage of women with irregular cycles among mothers having delivered unlike-sexed twins, and Wyshak [13] showed shorter cycles among mothers having experienced twin maternities. Although these results appear to contradict our hypothesis, we think only the latest part of menstrual cycles should be separately studied.

Under ideally healthy conditions, human reproductive ability can remain nearly constant up to the menopausal age, though this phenomenon was actually observed only in particular populations such as the Hutterites [6]. Those mothers with a smaller family size, therefore, should have been deprived of their fecundity by some substantial reason, not only by probabilistic variation of biological aging. How and why were these less fertile mothers deprived of their reproductive abilities, and what characteristics and dispositions they might have, cannot be determined from the present data. Paternal factors, if possible, should also be considered in future studies.

To know the natural and healthy potential of human reproduction, data on mothers of a larger family size without artificial birth control are necessary. We hope some other old parish records, which include mothers with 10 or more children, may present the information on fertile as well as less fertile mothers under natural conditions.

CONCLUSION

Fertile mothers showed a low twinning rate in general, and an abrupt increase in the twinning rate was seen at the last births for every family size. We suppose from these observations that fecundity of women was negatively correlated with the twinning rate, and that individual women lost their fecundity abruptly at the last stage of their reproductive period.

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