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SEASONALITY OF BIRTH IN INDIA

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Summary. The conception rate in Baroda and Manipal, India, is lowest during the hottest weather. The greatest extremes are found in Baroda and, following high summer temperatures, there is a prolongation of low conception rates which may indicate that part or all of the effect is mediated through an effect on scrotal temperature. However, other factors may also be involved and a reduction of coital frequency is likely at extremes of temperature. Seasonal changes in abortion, stillbirths and prematurity are also observed. Changes in spontaneous abortion could be due to heat stress in the mother or possibly to abnormal sperm production at high temperature or to less frequent coitus, leading to embryonic defects.

Introduction

Seasonal fluctuations in human conception rates have been studied for almost a century and among one of the earliest papers was that by Hill in 1888, concerning births in India. The present study compares seasonal variations in conception in two different parts of India (Baroda and Manipal). It uses data from the maternity ward and relates findings to statistics from the whole community and explores variations in abortion, prematurity and stillbirths as well as in deliveries. We attempt to use epidemiological clues to distinguish between the various biological and social factors which could account for the changes found and we discuss the administrative implications of the observed (23·5–45%) variations from the annual mean.

Materials and methods

Geography

Baroda and Manipal are both situated almost at sea level on the west coast of India. Baroda is approximately 250 km north of Bombay (22°N of the Equator and 73°W) and lies in the 'wet and dry' tropical belt. The summers are extremely hot, reaching 37·5–43°C by day and only falling to 21·5–32°C at night. Manipal lies 650 km south of Bombay (13°N of the Equator and 75°W) in the 'rainy tropical' area of south India and seasonal variation in temperature is less. The maximum seasonal difference in mean monthly temperature in Manipal is 3·5°C compared with 11·3°C for Baroda.

In both places, the monsoon extends from mid-June to mid-September, but Manipal has rain all the year round (annual rainfall 300 cm and the humidity never falls below 69–75%—April/May). In Manipal, the monsoon coincides with the coolest part of the year. In Baroda, May is a dry, hot month and the monsoon brings the hottest, most humid and uncomfortable weather.

Baroda (population 450,000) is an industrialized city, producing, for example, 20% of the total Indian pharmaceutical production. There is a university. Manipal (population 30,000) has a great many educational institutions and some sophisticated but relatively small scale industry—the town serves the surrounding *taluk* of Udupi (population 350,000). Both Baroda and Udupi are over 90% Hindu.

Data sets

The clinical records for Baroda come from the General Hospital which serves the city and some adjoining rural areas. Ninety per cent of deliveries are believed to take place in the General Hospital or small nursing homes. In Manipal the Medical College Hospital and five satellite maternity homes form the Manipal Maternity Complex (MMC) which attends to about 20% of the deliveries in the area. Birth registration in India is compulsory but uneven in quality. In Baroda and Manipal it is thought to be good. The local population, even in the rural areas, is quite well educated and aware that birth registration is necessary to enter a child for school and to obtain a ration card.

The following data sets are analysed in this paper:

Registered births for Baroda City: 1968–73, by month of occurrence ($N=$ 78,709).

Registered births for Udupi Taluk: 1967–74, by month of occurrence ($N=$ 63,912).

Temperature °C for Baroda: 1968–73, maxima and minima, by month.

Temperature °C for Mangalore: 1967–74, maxima and minima, by month.

Records of abortion admissions from Baroda General Hospital and MMC: 1966–73.

Records of abortion admissions from MMC: 1965–74, by month of occurrence ($N=766$).

Records of prematurity (below 2500 g) from Baroda General Hospital: 1966–74, by month of occurrence ($N=8665$).

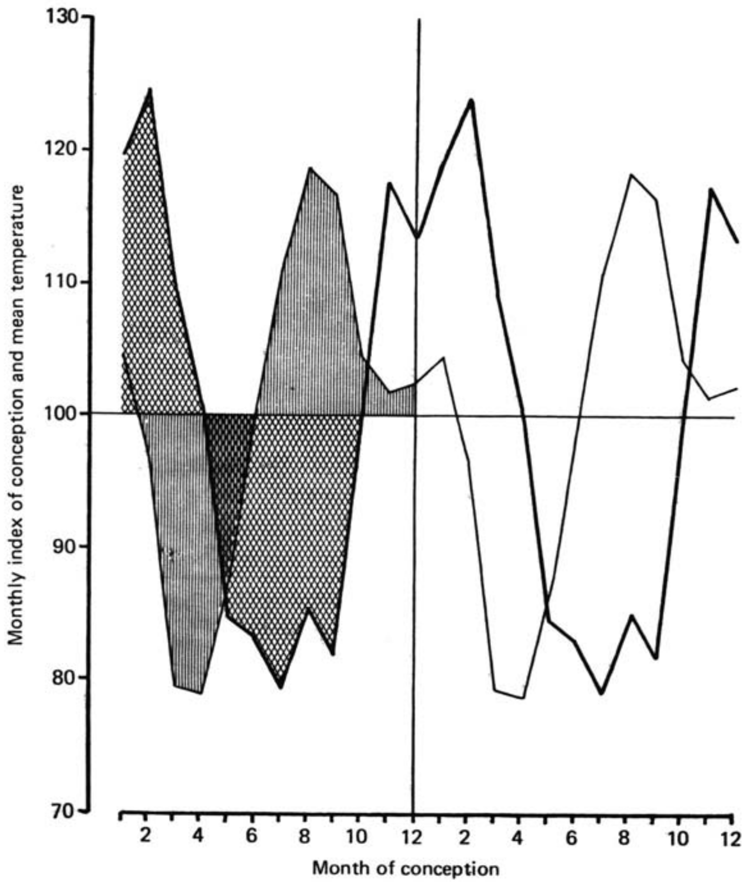
Records of prematurity (below 2500 g) from MMC: 1965–74 by month of occurrence ($N=2715$).

Stillbirths from Baroda General Hospital: 1966–73, by month of occurrence ($N=1425$).

Stillbirths and neonatal deaths from MMC: 1965–74, by month of occurrence ($N=920$).

Results

Table 1 gives a step-by-step sequence of the treatment of the data for both pregnancy outcome events and temperature. The number of births in each month were aggregated for the period under review (6 years for Baroda and 8 years for Udupi Taluk) and adjusted to standard months of 30 days (cols. 1–3), from which an aggregate annual mean was calculated (3a). This leads to the calculation of a monthly index of birth (col. 4) which is taken to be synonymous with the index of conception when the month scale is shifted by 9 months. Mean monthly maxima and minima in temperature were aggregated for the period under review and then an average taken (col. 5) from which an aggregate annual mean temperature was derived (5a). This enables the calculation of a monthly index of temperature (col 6). The indices were then charted in two identical 12-month sequences for Baroda (Text-fig. 1) and Udupi Taluk (Text-fig. 2). The monthly indices of temperature were made to correspond with the monthly indices of conception. In order to stress the association with regard to (a) amplitude and (b) phasing of the curves,



Text-fig. 1. Seasonal variation in conception (——) and temperature (——) in Baroda, 1968–73.

Table 1. Monthly indices of birth (conception) and temperature for Baroda and Udupi

Time	Births			Temperature		Time
Month of birth (1)	No. of births (2)	Mean no. of births in 30-day month (3)	Index of birth (4)	°C (Max − Min)/2 (5)	Index of temperature (6)	Month of conception (7)
*City of Baroda**						
1	6720	1083·9	100·7	22·3	79·0	4
2	5165	911·6	84·7	24·8	87·9	5
3	5560	896·8	83·3	27·8	98·4	6
4	5118	853·0	79·3	31·4	111·2	7
5	5712	921·3	85·6	33·6	118·8	8
6	5276	879·3	81·7	32·7	115·7	9
7	6713	1082·7	100·6	29·5	104·3	10
8	7844	1265·2	117·6	28·7	101·5	11
9	7312	1218·7	113·3	28·9	102·3	12
10	7972	1285·8	119·5	29·5	104·5	1
11	8026	1337·7	124·3	27·4	96·9	2
12	7291	1176·0	109·3	22·5	79·5	3
1–12	78709	12911·9	1200·0	339·0	1200·0	
*Udupi Taluk**						
1	4748	574·4	87·6	26·3	97·9	4
2	4588	609·0	92·8	26·9	100·0	5
3	5563	672·9	102·6	27·9	103·7	6
4	5642	705·3	107·5	29·2	108·5	7
5	5605	678·0	103·4	28·8	106·9	8
6	5614	701·8	107·0	26·5	98·3	9
7	6119	740·2	112·8	25·5	94·6	10
8	5247	634·7	96·8	25·6	95·1	11
9	5209	651·1	99·3	25·8	96·0	12
10	5201	629·2	95·9	26·6	98·7	1
11	5224	653·0	99·5	26·9	99·9	2
12	5152	623·2	95·0	27·0	100·5	3
1–12	63912	7872·8	1200·0	322·9	1200·0	

* The two data sets cover an experience of 6 and 8 years for the City of Baroda and Udupi Taluk, respectively.

Notes: (1) Calendar month.

(2) Birth registration by occurrence.

(3) Adjustment for 30-day month.

(3a) Baroda 12911·9/12 = 1075·99 (6-year annual mean); Udupi 7872·8/12 = 656·06 (8-year annual mean).

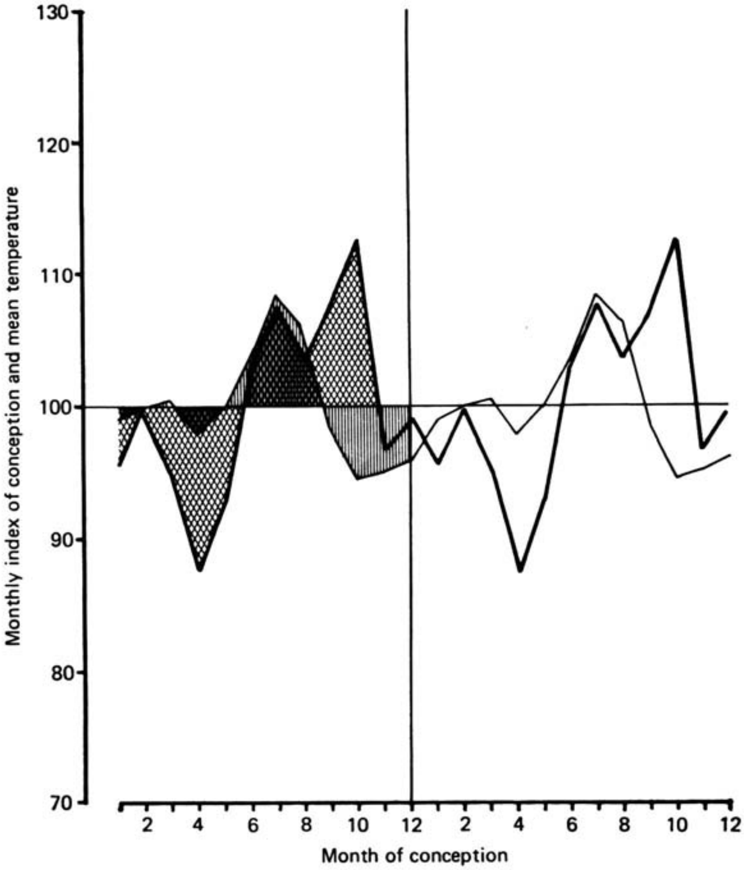
(4) Index of birth (or conception): (3)/(3a). The monthly index covers the 6- and 8-year span for each month.

(5) Official temperature readings in Baroda and Mangalore.

(5a) Baroda 339·0/12 = 28·25 (6-year annual mean); Udupi 322·9/12 = 26·91 (8-year annual mean).

(6) Index of temperature: (5)/(5a). The monthly index covers the 6- and 8-year span for each month.

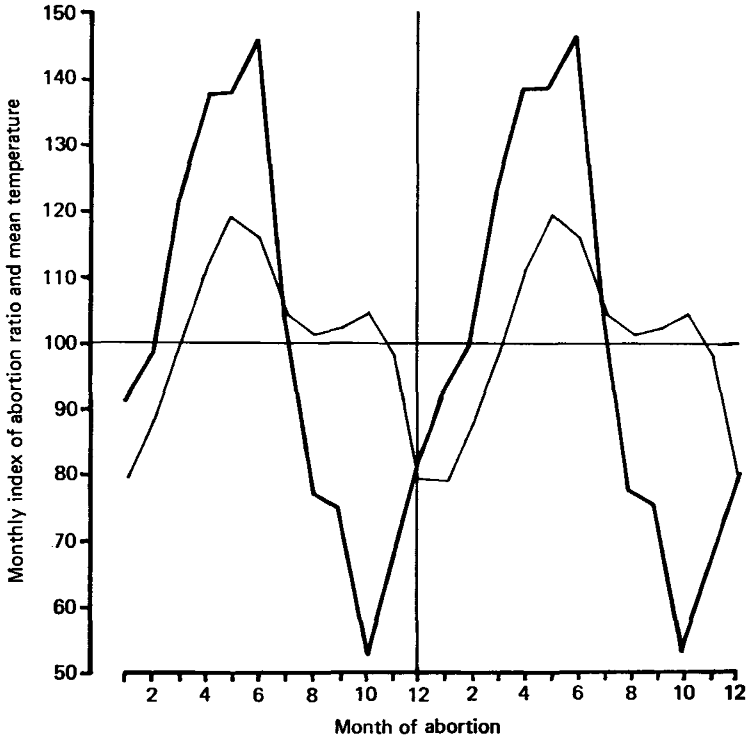
(7) Calendar month minus 9 months is defined as the statistical conception month.



Text-fig. 2. Seasonal variation in conception (——) and temperature (——) in Udupi Taluk, 1967–74.

the deviation from the mean has been shaded for both temperature and conceptions. Records on institutional admissions for abortions, stillbirths and records of premature deliveries have been analysed in the same way and monthly indices plotted (Text-figs 3–5). The following relationships are apparent.

1. At both places conceptions correlate inversely with temperature.
2. The amplitudes of the opposite deviation from the mean of temperature and conception are large for Baroda (around 20%) and moderate for Udupi Taluk (around 10% level).
3. The inverse association between ambient temperature and conception rate shows a protracted period of low conception after the peak of maximum temperature in Baroda against an instant reversal towards a high incidence of conception after the lower temperature peak in Udupi.
4. Abortions are highest in the hottest weather in both Baroda (Text-fig. 3) and Udupi.
5. Stillbirths are most common in the hottest weather (Text-fig. 4).
6. In Baroda the maximum prematurity rate occurs 5 months after the hottest weather, but in Udupi no such correlation was found (Text-fig. 5).



Text-fig. 3. Seasonal variation in abortion to confinement ratio (——) and temperature (——) in Baroda, 1966–73. (Note the index scale is half that in Text-figs 1, 2, 4 and 5.)

Discussion

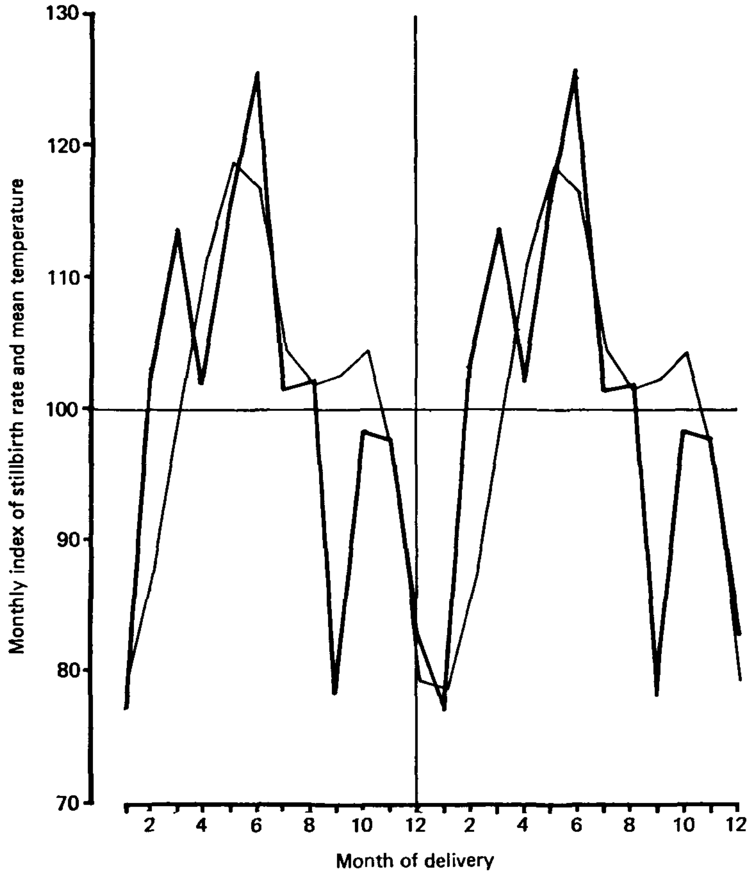
The reflectiveness of community data in institutional records

Ex hypothesis, it might be thought that the availability of beds and other extraneous factors might mask the seasonal variations in deliveries at the hospital level. Therefore, seasonal variations in deliveries for hospital records (21,000) in Baroda were compared with the City (107,000) for the years 1966–70. It was found that the institutional records reflected, with great accuracy, the seasonal changes apparent in the whole area. It is of interest that the same reflectiveness of the community data in the maternity ward sample has been confirmed in Manipal, even though the percentage of births within the MMC, in relation to the community as a whole, is less than in Baroda.

It is assumed that clinical events, such as abortion and prematurity, in institutional records also empirically reflect events in the community and, in the light of this finding, the numerator analysis presented of the hospital data seems reasonable.

Seasonal variation in conceptions

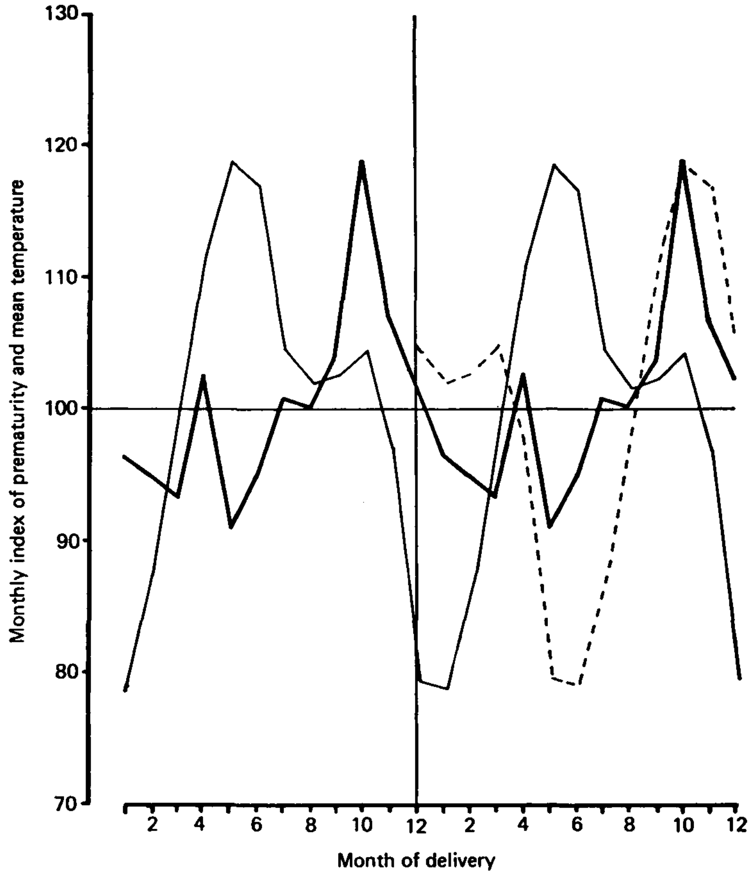
Seasonal variations in conceptions are known from many places (Cowgill, 1966), but the exact links between the weather and variations in human reproduction



Text-fig. 4. Seasonal variation in stillbirth rate (——) and temperature (——) in Baroda, 1966–73.

are sometimes in dispute. Seasonal variations in some of the other parameters of human reproduction, such as abortion, have not been so consistently studied.

Hill (1888) observed that conceptions in United Provinces, India, were highest in December and lowest in September, 'when malarial influences are rapidly increasing to a maximum, the food supply is nearly exhausted and there is the greatest tendency to suicide'. Madras hospital records (42,206 deliveries between 1920 and 1933) were studied by Nair (1935), who found the lowest conception rate to be in April/May, during the hottest weather. Kosambi & Raghavachari (1957) made a thorough analysis of seasonal variations in births from several parts of India, using data from the weekly birth records given in the *Gazette of India* (which are of irregular quality and probably registrations lag behind the events recorded) cross referenced with some municipal data. They also suggested that in urban areas the maximum temperatures were associated with the lowest conceptions but, in the rural areas the time of harvest, with its long tiring work in the fields, appeared to be the most important factor influencing the conception rate.



Text-fig. 5. Seasonal variation in prematurity rate (——) and temperature (——) in Baroda, 1966–73. Shift of temperature by 5 months (----).

In temperate Europe, peak conceptions occur in June and July, while in New Zealand, they are most numerous in December and January. However, the pattern is not consistent and, in the USA, January and December are also the months with the highest conception rate. Takahashi (1952) studied deliveries by month in Japan for the long series 1908–37 and found maximum conceptions in April and June. In Puerto Rico the season of maximum conception has shifted from summer to winter between 1940 and 1960. A number of factors would seem to be at work, although where very hot summers (e.g. Queensland, Flòrida, Hongkong) do occur, the conception rate always appears to be low at times of maximum temperature (Parkes, 1976).

Seasonal fluctuations in reproductive performance also occur in other mammals over and above the changes that characterize seasonal breeding. Pennycuik (1969, 1972) conducted experiments in mice in which either day length or temperature was held constant, while the other variable was changed. She discovered that day length was the more important of the two and that the largest and most frequent litters occurred in 'summer'. Rhesus monkeys have fewer conceptions in summer (Hartman, 1931). In northern latitudes conception among cattle is lowest in the winter (Courot, Goffaux & Ortavant, 1968), but in tropical and subtropical areas, as in India, it is lowest in summer.

The observed changes could be explained by a number of biological and/or social factors which might overlap or interact.

Testicular temperature. A rise in testicular temperature can lead to oligospermia or abnormalities in sperm function. The biological mechanisms for maintaining the scrotum at a lower temperature than in the rest of the body are well understood and appear to be effective over a wide range of temperature. The cremaster muscle pulls the testicle nearer the abdomen when the temperature falls, the dartos muscle relaxes in hot weather, increasing the surface area of the scrotum and the pampiniform plexus acts as a counter current heat exchanger (Harrison & de Boer, 1977; Harrison & Werner, 1948).

In Baroda men usually wear a tight loin cloth drawn between the thighs, forcing the scrotum close to the abdomen. This is not found in Udupi and the maximum summer temperatures are lower. The greater degree of seasonal variations in births in Baroda than Udupi and the timing of the maximum depression of fertility is compatible with an explanation that high testicular temperature might be the cause of the fluctuation.

Higher external temperature (29–38°C) suppresses spermatogenesis in bulls and, at the most extreme, causes a reduction in semen quality (Johnston & Branton, 1953). Sperm changes take about 2 weeks to occur and 6–8 to return to normal and can be brought about by a single brief episode at high temperature or scrotal insulation. Glover (1956) found scrotal insulation in the ram reduced the spermatozoa in the ejaculate, but increased the amount of fructose (indicating raised hormone output). In the monkey, Venkatachalam & Ramanatham (1962) showed that scrotal immersion (44°C $\pm$ 1°C for 20 minutes daily for 6 days a week over 20 weeks) caused atrophy of the epithelium of the spermatic tubules, some loss of spermatogonia and total absence of epididymal spermatozoa. The sertoli and interstitial cells survived intact.

It would seem likely that the effect of temperature on the human testes is also limited to a reduction in sperm count unassociated with any change in hormone output. Several experiments involving men have been conducted. In one (Macleod & Hotchkiss, 1941), young, adult, American men were placed nude in humid, heated cabinets until the oral body temperature reached 40°C or over. The sperm count fell (usually to 60 million per ml or less) 25–55 days after a single exposure, and remained low for 15–20 days.

The extended interval of low conceptions after the highest summer temperatures in Baroda, which has the most extreme climate of the two localities, is most readily explained as an effect of temperature on sperm output.

Temperature related changes in physiology could also affect women. Both monkeys and women have most irregularities in menstruation during hot weather (Hartman, 1932; Engle & Shelesnyak, 1934). In temperate climates the human menarche occurs least often in the months of June, July and August. Maternal body temperature at the time of coitus can affect spermatozoa during their passage through the uterus. Incubation of rabbit spermatozoa *in vitro* at 40°C for 3 hours has no effect on fertilizing capacity, but does adversely affect embryo survival (Burfening & Ulberg, 1968). Alliston, Howarth & Ulberg (1965) attempted to distinguish between the possibility of heat stress acting directly on the embryo, or via changes in the female reproductive tract, by transferring fertilized rabbit eggs to pseudo-pregnant recipients after in-vitro culture at 40°C for 6 hours. They found a direct effect on the egg which was most vulnerable to heat stress during early cleavage. In the heifer, raised external temperature immediately after insemination prevents conception (Dunlap & Vincent, 1971). Circulating progesterone levels rise, but the biological mechanism of this effect in cows is not understood, nor is it known if the effect is species specific.

Frequency of coitus. This may be influenced by the climate and this in turn could alter the conception rate. Among married women aged 18–27 in the Lebanon, Yaukey (1961) found that the mean time taken to conceive approximately doubled (3·1 to 6·1 months) when the reported coital frequency was less than ten or more than 30 per month. Extremes of temperature may cause enough discomfort and irritation to depress the desire for intercourse and one would expect this effect to be greater in Baroda than in Udupi. Also, in Baroda, but not in Udupi, many families sleep on the open terraces of their houses during the hot dry months and this could be a further deterrent to intercourse. The data on seasonality of conception from the two localities is consistent with an effect of climate on coital rates.

In many parts of India certain months are preferred for the solemnization of marriage. In Baroda, they are April, May and December and in Udupi, May and June, with fewest marriages in February and April. But analysis of the data from Baroda and Udupi does not reveal any demonstrable concentration of first conceptions which might be related to the months of marriage.

Variation in abortion rate

The changes in abortion rate in Baroda are marked, virtually doubling between the high and low levels. In Udupi, abortions are also commoner in the hottest months, although the effect is not so marked as in Baroda. The maximum rate is within 1 month to 6 weeks of the highest mean monthly temperature, but the lowest rate occurs in October or November when the temperature is mid-way between extremes. The abortion rate climbs to near the mean at the time when the ambient temperatures are lowest.

There is no way of distinguishing between spontaneous and illegally induced abortions in either series. Therefore, the possibility must be considered that, either the whole of the variations might be due to changes in only one category of abortion, or that both are involved. Spontaneous and induced abortions are commonest in the first trimester of pregnancy, but the observed maximum abortion rate for hospital administrations in Baroda and Udupi falls approximately 7 months after the highest conception rate. There is no obvious factor that might cause a rise in induced abortions at this time, but a number of physiological factors that could alter the spontaneous abortion rate require review.

On the maternal side, heat stress may give rise to abortion. Unacclimatized rats kept at 35°C suffer high fetal wastage through reabsorption (MacFarlane, Pennycuik & Thrift, 1957). The control of body temperature is less efficient in women than men (Kawhata, 1960) and may be especially poor in the pregnant woman, although specific studies have not been conducted in this field. Lean individuals acclimatize to heat more effectively than those who are obese and the increase in body size during pregnancy could be detrimental. Women sweat less effectively than men and the threshold for sweating and sweat output is less than in men (Fox *et al.*, 1969). Haslay & Hertzman (1965) have demonstrated that heat regulation is less efficient during the post-ovulatory phase of the menstrual cycle. It should be noted that most Indian women cook the family meals twice a day squatting on the floor with the abdominal wall very close to the hot charcoal cooking fire.

An alternative explanation to heat stress in the woman causing abortion could relate to possible changes in the frequency of intercourse. Women ovulate spontaneously, unlike many other mammals which ovulate on coitus. The longer the interval between intercourse, the greater the chance that fertilization, if it does take place, will involve gametes that have been in the reproductive tract for some time. There is much evidence from animals that delay in fertilization is associated with serious embryological consequences both in the case of the aged spermatozoon (Tesh & Glover, 1966; Thibault, 1970, 1972), but especially in the case of the egg (Blandau & Young, 1938; Austin, 1961; Witschi, 1971). Butcher, Blue & Fugo (1969) found chromosomal changes following fertilization of 'overripe' ova in the rat.

The use of periodic abstinence as a method of family planning decreases the frequency of coitus at the expected time of ovulation and could have the same effect as the postulated decrease in coital frequency in Baroda associated with the very hot weather. Guerrero (1973) observed no change in the frequency of abortion among pregnancies conceived before the ovulatory temperature rise in couples using periodic abstinence, but a doubling of the rate among pregnancies conceived 3 days after the time of ovulation. A case control retrospective study of 59 mentally retarded children born to Catholic parents (Jongbloet, 1971) found the greatest number of abnormalities occurred to parents who limited intercourse to the post-ovulatory interval.

There are very few data on the seasonality of abortions from other parts of the world. In one series from Cincinnati, Ohio, USA, Miller (1934) found hospital admissions rose in the summer. Giving January an index of 100 he found rates of 109 and 113 in July and August. In this case, the highest rates occurred at the time of maximum conception, but the variation was small compared with that in Baroda, and may have some other explanation.

Variation in prematurity and stillbirth

In Baroda and Udupi the stillbirth ratio per 1000 deliveries reaches a peak in the hottest months. It is not known if most of these deaths occur antepartum or intrapartum. The simplest explanation would be that high temperature stresses the woman in labour and the most obvious specific factor would be dehydration.

A second rise in stillbirths occurs in Baroda during October/November when the temperature is below average. This peak may well be related to the maximum rate of prematurity. The seasonality of prematurity in Baroda is a novel observation.

A possible explanation might be heat stress at the time of conception or implantation adversely affecting placental development, but as yet undertermined factors are just as likely.

Administrative implications

The high conception rate during the cool monsoon weather may be relevant to the design of family planning services. The increased stillbirth rate in the hot weather suggests that further studies should be made to see if women are suffering from heat stress during the summer months.

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