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Birth Rates and Bones

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Skeletal biologists attempt to reconstruct populations using the techniques of palaeodemography. While the emphasis has been on mortality, a consideration of fertility may provide useful information on past societies. The cultural and biological determinants of fertility in modern and historical societies provide the context for an examination of Huron fertility in the seventeenth century based on ethnohistorical sources. The value of palaeodemographic estimators of fertility, derived from childhood ages-at-death, is tested using data from three Ontario ossuaries dating from 1500 AD to 1636 AD. The estimators provide credible fertility rates, changing through time. Interpretation of the data in terms of mortality would not accord with information derived from ethnohistory of the Huron.

Anthropologists who work with skeletons think more about death than about birth. Nevertheless, there are reasons why it is worthwhile for anthropologists to turn from death to birth:

(1) The reconstruction of populations and their mortality rates based on the study of skeletons (palaeodemography) has been strongly criticized in the last decade or so and there have been several suggestions that fertility can be more accurately estimated from the study of skeletons than can mortality.

(2) Fertility is a very important aspect of demographic reconstruction: fertility can be regarded as basic to the age structure of a human population and, because it is sensitive to a variety of factors, it may tell us a great deal about a population.

All human populations have biological constraints. These are simple with regard to mortality. There is a "shape" to mortality, a curve that describes the general pattern of human death. It is well-established that there is a certain minimum rate of death in the period around the time of birth, because of congenital defects. Male mortality before 12 months of age is higher than female mortality and thus the sex ratio, which is in favour of males at birth, comes closer to 1:1. The sex ratio stays about even, with female deaths in childbirth matched by deaths in young males because of accidents or violence. Cultural practices may alter this near equality: female infanticide in the past in China and the continuing bias in favour of males in southern Asia causes female mortality rates to be very high in early childhood. But there are also instances of populations in which daughters are favoured, including the Huron who inhabited parts of Ontario up until 1649 (Tooker, 1964:122). In later adult life the sex ratio is in favour of females.

After the first year or two of an individual's life, it becomes less likely that death will occur, although children aged 1–4 are very susceptible to infectious diseases and to famine. Older children (of around 10–15 years) generally have the lowest probability of death. Death becomes increasingly probable as one reaches maturity and, as people get older, they become more susceptible to infection and to degenerative diseases. In fact, the human organism has a time-limit on it. The great majority of people will die before 100 years of age. In spite of claims of great age in the Caucasus area, it seems that the oldest attested individual was 113 years (an American woman who died in 1928; Garson, 1991).

We can assume that, in general, human mortality has had the same "shape" throughout history and that slight modifications in the general shape of the curve will arise only under very particular conditions (war, or certain diseases that may increase the death rates of young adults: tuberculosis is the major disease in this category). Although it is often considered that there must have been variations in mortality levels in the distant past, attempts to demonstrate alterations in mortality at periods of great change in human history, such as the transition from hunting and gathering to agriculture, have not been convincing (Jackes, 1993).

In this chapter we will consider two questions: (a) can fertility be a sensitive indicator of certain population characteristics; and (b) can fertility be accurately estimated from the age at death distribution of a cemetery?

The age structure of a population has a great influence on its levels of fertility and mortality. In a population with many elderly people, the overall birth rate would be low in comparison with the death rate; in a population with many young adults, the overall birth rate will be high. In the past, such age distribution variants in a population were determined by fertility. Fertility is primary in determining the age structure of the population. If each adult woman has 2.1–2.5 children (depending on levels of medical care), then the human population would remain stationary because two children surviving to reproductive age constitute "replacement-level fertility". Under this circumstance, there would be an almost equal number of individuals at each age. The "population pyramid" with many young and fewer elderly individuals, would become a "population rectangle". In the past, however, any variations would probably have been around a level of slight increase.

A rise or fall in fertility may have been the determining factor in the age distribution of a population in the past. The twentieth-century increase in world population is a result of reduced mortality, brought about by mass vaccination programmes, the availability of antibiotics, and improvements in water supplies. But even in the twentieth century, the fertility rate is an important factor in mortality levels: since the probability of death is highest among infants, reduction in infant mortality reduces the overall rate of mortality.

There is a very complicated relationship between infant mortality and fertility. The death of an infant increases the probability that the bereaved mother will become pregnant sooner. But a decline in fertility has a tendency to reduce the level of infant mortality. The very fact that women have fewer children means that those children are more likely to survive. When the interval between the birth of two children is short, the older child is at risk of death from poor nutrition and the younger sibling is more likely to be premature and of low birth weight.

Modern fertility reductions in developed countries result from an interplay of medical, social and economic factors. But there is reason to doubt that all countries of the developing world today will immediately follow the path taken by the developed countries in the past (Trussel et al., 1989), and we can take it for granted that, if there has been family limitation in the past, it was not based on the same criteria that have altered family life in developed countries so drastically within the last century.

Van de Walle (1992) has pointed out the extraordinary difference between a society in which every marriage potentially results in 15 children or fewer, as "fate" decides, versus a society in which most marriages involve a conscious choice to limit the number of children, on the grounds that limitation is both possible and desirable. It is very difficult for most people in the developed world to realize that even questions about the ideal number of children are irrelevant and unanswerable for societies within the "natural fertility" regime. It is clear, however, that when we try to determine fertility rates for past populations, we should not expect people to have been "numerate" with regard to ideal family size. This is true now even in African populations in which birth spacing by sexual abstinence is a well-established practice.

NATURAL FERTILITY

Natural fertility is the term used for rates of fertility achieved in groups that do not practise any method of birth control. The North American Hutterites are generally used as an example of ferility without contraception, and therefore an indicator of uncontrolled fertility. A better example of natural fertility may be provided by Old Order Mennonites who migrated from Manitoba to Mexico in the 1920s (Felt et al., 1990). The women marry at about 20 years of age and have an average of 9.5 children. Only 3% of women are childless. The first child is born after 18 months of marriage and subsequent births follow every 25 months or so until the woman reaches age 40–41.

MEASUREMENT OF FERTILITY

When a modern census is taken, we get a reasonably accurate idea of how many live births have occurred each year, relative to the nümber of women in the reproductive years (usually considered to be 15 to 44 years of age). A number of demographic statistics are published by governments so that we know what the various fertility rates are. When we have a group of skeletons we can, theoretically, arrive at very good estimates of the same fertility rates. The estimates are not based on examination of innominates because there is no foolproof method of determining fertility directly from female pelves: palaeodemographers have to use the age at death distributions as the basis for studies of past populations that had no adequate registers of births and deaths.

This is done by the use of the life table, a relatively simple set of columns of arithmetic that makes it possible to determine from the numbers of dead in each age group how many people were alive in each age group.

The *total fertility rate*, the completed family size of the average woman at the end of her reproductive period, can be estimated from the life table column that gives figures on the age distribution of the living population. The estimation is relatively accurate except when a population is increasing rapidly.

The *crude birth rate* (CBR) is the number of live births per 1,000 people per year. Anthropologists have used this statistic for skeletal samples because it is very simple: it can be estimated from 1/mean age at death.

PROBLEMS IN PALAEODEMOGRAPHY

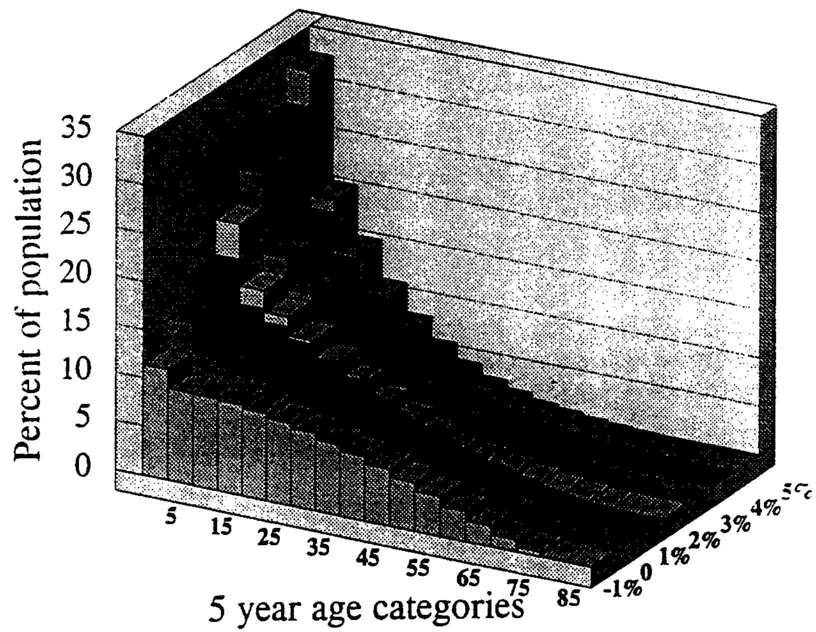
Problems occur with both sorts of demographic statistics when they are applied to skeletal samples, whether based on women of reproductive age, or a group of 1,000 people. You have to be sure that the collection of skeletons from the cemetery includes every single person who died in a given area over a certain length of time and you have to be sure that you know their ages accurately to within a few years. In fact, the buried bones of the very old and the very young do not preserve as well as the bones of active and healthy young adults. Added to this, cultural practices often give a different burial to very young babies than to older children or adults. And it is very unlikely that we can give very accurate ages at death to every single skeleton in a cemetery.

A CBR of 50 would be extremely high, yet this is the sort of birth rate that samples of archaeological skeletons often give. This may often be the result of the methods of estimating adult ages that we use: these commonly give adult ages that are too young (Figure 5 gives an example of this), and the result may be that the mean age of death is around 20 years: (1/20)*1000 = 50).

The crude birth rate and the *crude death rate* (CDR) are equal when a population is stationary, that is, when the population is neither decreasing nor increasing. When the population is increasing the birth rate is higher than the death rate. In order to understand why this happens, we can examine Figure 1. Figure 1 is based on the work of Coale and Demeny (1983), who used 326 reliable sets of mortality data from all over the world to provide us with models of human demographic statistics. We use their "West" family of tables because these represent general human mortality, rather than very specific patterns. Figure 1 employs the West 1 tables, illustrating the highest level of mortality with a CDR (and

CBR, when the population is stationary) of 50 or so. We use this high level of mortality because it illustrates what we know of archaeological mortality (Jackes, 1992) and of early mortality in Europe from historical sources (Loschky and Childers, 1993). We plot the age distribution of the West 1 model living population at seven different levels of fertility, beginning with fertility so low that the population is declining by 1%. When the rate of natural increase (r) is 0, then the population is stationary. As the birth rate rises above the death rate, the population increases (here from 1% to 5%). Figure 1 shows that an increasing population has a greater number of young people. As the distribution of ages in the increasing population changes, the mean age at death of the population as a whole falls.[1]

Figure 1. The Age Distribution of Living Populations Based on West 1 Model Data from Coale and Demeny (1983:55, 105).



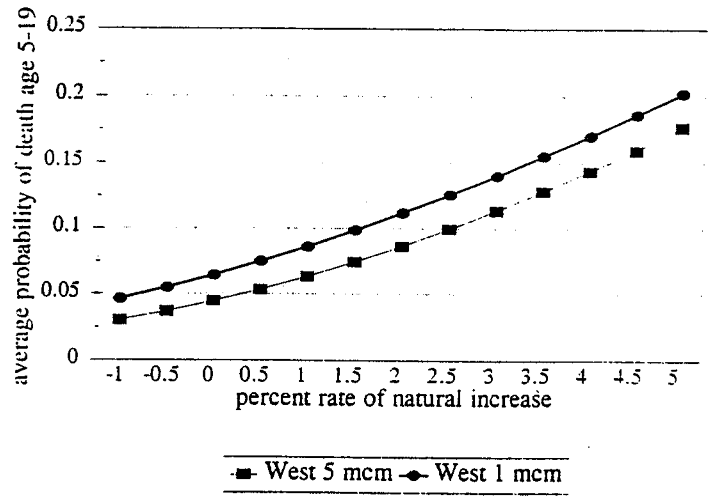
West 1 data (males and females combined) shows how the percentage of children in a population increases when the birth rate is greater than the death rate.

Variations in the mortality or fertility of different groups, in different times, places, and economies, can only be demonstrated if we have a good method of comparison that allows us to avoid the difficulties presented by infant underrepresentation. But, to repeat, this is not the only problem that may confront skeletal biologists. All anthropologists, and especially skeletal biologists, may be dealing with very incomplete data. The data could be inadequate: (1) because the ages of adults and children may not be accurately known; or (2) because a very short time period within a small community may provide unrepresentative figures; or (3) because not everyone living in the community within that time period is represented in the figures, or some combination of all three. For these reasons, which apply to both skeletal and living samples, methods may have to be devised that paint a broad picture rather than a close view accurate in every detail.

One possible method of comparison of the age structures of archaeological groups is based on the assumption that there is a relationship between juvenile and adult mortality, and that age-at-death data within very broad age categories will carry some information about the age structure, and hence, the fertility rate of the population. Since infant mortality rates (that is, the rate of death in the first 12 months of life) are variable and difficult to assess accurately (whether working from skeletons, documentary evidence or interviews), we should not try to estimate overall mortality from infant mortality. But it is useful to compare the levels of mortality after one year of age between different groups and reasonably accurate estimates of age-at-death can generally be made for the skeleton of an individual under 25 years. Figures 2 and 3 demonstrate the relationship between the age at death distribution and fertility. In Figure 2 we plot the average probability of dying from age 5 to age 19 against the figures that show whether a population is declining (by .5% or 1%), is stationary (0) or is increasing (by .5% to 5%). The data used come from the West model tables 1 and 5. It is clear that, as a population increases, as the birth rate exceeds the death rate, the dead will include a greater number of people aged 5 to 19. Figure 3 gives a demonstration of the great difference in the age at death distribution between a population that is in decline (-1%) and a population that is rapidly increasing (5%). The importance of the level of fertility to the ages of skeletons found in a cemetery is very clear.

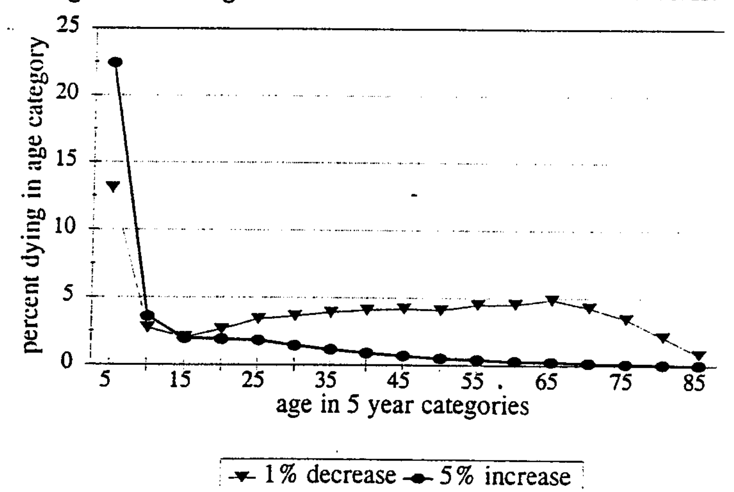
Variations in fertility are, however, based on an extremely complex series of factors and we have to look at some of these factors before we can decide whether we can make reasonable estimates of past fertility.

Figure 2. Deaths in Childhood From 5 to 19 Years.



As the rate at which a population increases changes, the average probability of death for individuals aged 5 to 19 increases, based on Coale and Demeny (1983) West 1 and West 5 tables of mortality.

Figure 3. The Age Distribution of Deaths From 5 to 90 Years.



At the same level of mortality (West 1), the age pattern of mortality is altered. Here deaths in populations declining by 1% and increasing by 5% are compared.

DETERMINANTS OF FERTILITY

Demographers have emphasized the importance of what have been called the proximate determinants of fertility (Bongaarts and Potter, 1983). The four determinants identified as of primary importance are: (1) the rate of non-marriage, (2) contraception, (3) lactational amenorrhoea/sexual abstinence, and (4) abortion. Four less important factors are: (1) frequency of intercourse, (2) intrauterine mortality, (3) natural sterility, and (4) involuntary sterility caused by sexually transmitted diseases.

More recently Reinis (1992) has said that it is essential to consider also what is called "stopping behaviour". This means that at a certain point before she reaches menopause, a woman may decide "enough is enough", or social convention may decree that a woman who is a grandmother should not have more children, as, for example, in West Africa. Under some kinship systems, confusion of ages between generations may be undesirable. Such a system would enforce sexual abstinence on women in middle-age.

All people understand the relationship between coitus and conception. It was at one time considered that Australian Aborigines were ignorant of this relationship, a measure of the low esteem in which native Australians were held by 19th-century Englishmen. In truth, Aborigines must have been quite aware of the facts of life, otherwise the control of female sexuality would hardly have been such a key element of social organization. The major error with regard to conception among populations without access to accurate knowledge of reproduction was that the period of menstruation was the time of greatest fertility. This error, and the sequestration of women around the time of menstruation as "unclean", would serve to increase coitus during the most fertile period of the female cycle, the several days around the time of ovulation.

Even under fertility regimes that might be regarded as "natural", that is non-contracepting, there may be practices that limit the size of families. *Coitus interruptus* is accepted as a method of fertility limitation in the Koran, and crude drugs derived from plants probably acted as contraceptives or abortifacients in many regions in the past (Riddle and Estes, 1992). The word "condom" had already entered the written English language by 1700, referring to dried sheep's gut. While condoms may have been used primarily to avoid infection, it can hardly be doubted that contraceptive practices were current during periods demographers describe as times of "natural fertility".

Even under a "natural fertility" regime, variations in fertility rates

may be quite broad. Bongaarts and Potter (1983) have suggested, based on American Hutterites, that 15.3 children is the mean family size. But the Hutterites may well be models of exceptional, not general, human fertility. Nutrition is of great importance and the Hutterites may simply be too well-nourished with too much animal fat and protein in their diet to serve as models for pre-industrial humanity.

The role of nutrition in fertility

The age of menarche (the age of first menstruation) is partly controlled by nutritional levels (Danker-Hopfe, 1986). The length of the period of adolescent sub-fecundity may also depend on nutrition, since there is evidence that the age of fertility is controlled by the fat level. The amenorrhea (non-menstruation) and anovulatory (non-fertile) cycling of adolescents suffering from anorexia nervosa has led to a clear understanding of the importance to fertility of weight gain in young females. Amenorrhoea may occur with as little as a 10% reduction in weight. The importance of fat is underlined by the consideration that female athletes, with a high body weight based on muscle, rather than fat, may become amenorrheic. Peak fertility in females occurs when about one-third of body weight consists of fat (Frisch, 1988). While there have been criticisms of the details of Frisch's work (see Ellison, 1990), there is no doubt that a certain level of fat is needed to allow ovulation every 28 days and to support 9 months of pregnancy and several months of lactation. The amount of subcutaneous fat also has an influence upon the age of menopause (Kirchengast, 1993).

The effect of nutrition on fertility and lactation has been demonstrated by the records of past famines: in eighteenth-century Iceland; South Asia in the nineteenth and twentieth centuries; Sudan in recent years; Japan in the last century; and the war time experiences of women in Holland and Russia. The Dutch experience (Hart, 1993) showed that previously well-nourished mothers could bear healthy children during famine. The major effect was the great reduction in conceptions during the period of greatest distress. This is true of all recorded famines: female fecundability is reduced; protein deficiency can affect male fertility; male mortality in famines is high and occurs before the peak of female mortality; famine brings with it diarrhoea and increases susceptibility to diseases like measles; lactation may be prolonged; and there may be migration and spousal separation. Many factors function together to reduce fertility.

Although famines show the effect of sudden and extreme nutritional stress, chronic undernutrition may have more general effects on fertility.

Well-nourished mothers produce infants at term with good birth weights who grow up to produce healthy children themselves, since maternal body size and composition is more important than diet during lactation. Furthermore, the transferral of immunity to nursing infants is most effective in well-nourished mothers so that infant mortality from infection is more likely when the mother herself is ill-nourished. Despite some controversy on the topic, Huffman et al., (1987) show that less milk with a lower fat content is produced by thin than by fat women: this results in intense and constant suckling by infants, which has the effect of reducing fertility. A low level of dietary fat increases the length of menstrual cycles, further reducing overall fertility, and there may be increased intrauterine mortality (fetal loss) with the resultant lowering of overall fertility.

We must not assume, however, that food alone will determine fertility levels. Pennington (1992) has shown that low !Kung Bushman fertility did not alter with a transition to sedentary life.

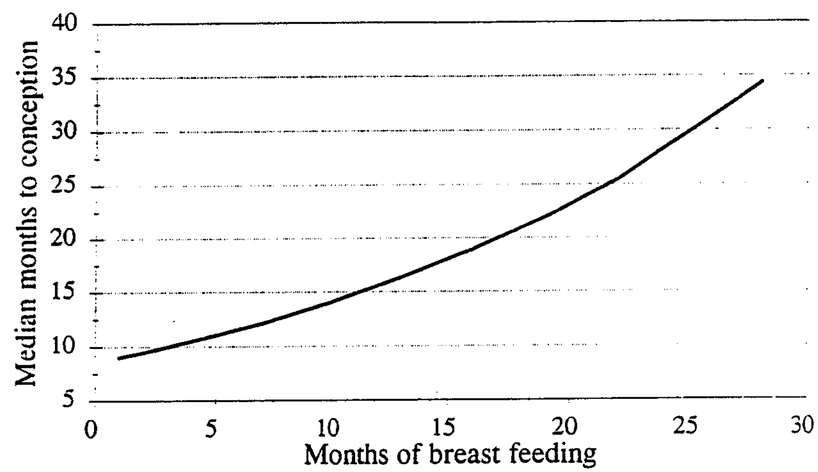
Cultural determinants of fertility

Whether contraceptive practices and/or abortion are available obviously effects fertility. Even in the absence of effective contraception or abortion there have been practices that function in a similar manner. Infanticide rates of 43.6% among the Yanomama (Early and Peters, 1990); the high infant mortality recorded as caused by "overlaying" in the crowded beds of the poor in eighteenth-century London; the astounding death rates among babies sent away to wet nurseries on the outskirts of cities in France and Russia; all attest to lack of contraception, and paradoxically, such practices serve only to increase the likelihood that the mother will conceive again.

The reason for making this statement is that most evidence shows that prolonged breastfeeding reduces fertility. Although some argue against this proposition (e.g., Fitzgerald, 1992), and post-partum taboos or pressure towards sexual abstinence during breast feeding are relevant (Trussel et al., 1989), lactational infecundity does seem a major factor in increasing birth intervals. Figure 4 gives a clear demonstration that the waiting time to a second or later pregnancy increases as the period of lactation lengthens. As the length of time a mother breastfeeds increases, so does the length of time before the mother again becomes pregnant. Ovarian function is suppressed by the hormone prolactin and prolactin levels are directly related to the intensity and frequency of suckling by an infant: it

is clear that questions of maternal nutrition, type and extent of supplemental feeding, and provision of an infant with objects to suck on, will make a difference here. But the data presented by Goldman et al. (1987), and reworked here as Figure 4, give us data with strong predictive value. If we have information on cultural norms for nursing, we have a basis for estimating the number of children the average woman in that culture will bear.

Figure 4. Time of Waiting for Conception of Second and Subsequent Children in Months.



Exponential curve based on months of breastfeeding (r = .9081; se = .08). Data from Goldman et al., 1987:138.

The social-cultural norms of human groups have a great influence on rates of fertility. All human societies have social controls on sexual intercourse. Since copulation can result in pregnancy and pregnancy has a high likelihood of adding another member to a group, a new member who must be fitted in to the complex web of biological, social, religious and economic relationships that govern the interaction of human beings and facilitate physical survival, no human society permits unregulated intercourse. The regulations partly determine fertility patterns.

The northwestern European pattern of marriage has been described by Hajnal (1982) and shown to have reduced levels of fertility by half the potential maximum. In the area of Europe west of an imaginary line drawn from Trieste to St. Petersburg in the period up to the industrial revolution: (1) mean age of women at first marriage was 23 years or older (men over 26); (2) the couple was in charge of their own household (with the male, although not much older than the wife, as the head); (3) young people were employed outside their homes as servants before marriage; (4) at least 10% of women never married.

In conjunction with religious influence, the requirement of economic self-sufficiency before marriage (Secombe, 1990), led to slower population growth than in southern or eastern Europe. The extreme example here is Ireland where celibacy rates and the average age of marriage were both very high, especially because marriage was delayed until one son could inherit the family land.

Fertility reduction can, however, result from other, very different scenarios. Just as Ireland has been of interest to anthropologists and demographers for its delayed marriage and celibacy, so there are a number of studies of Jamaica as a system involving delayed marriage without celibacy (e.g., Wright, 1988). A woman in Jamaica is likely to be involved in three types of relationships: visiting unions, common-law unions and marriage. At all ages, visiting unions are most common and marriage is the least common form of relationship. This system reduces fertility quite markedly even though the great majority of girls enter unions as adolescents. The "time lost" through changing partners means that even women who have had 5 or more partners have an average of only 2.63 children, although it might be expected that a women would desire a child within each union.

Another form of fertility reduction that has been widely discussed is polygyny, which is the marriage of one man to many women. We would expect high fertility under this regime because women marry young and they remarry quickly in the case of divorce or widowhood. But fertility reduction will occur because the husband's older age is important in reducing the fertility of his junior wives and because polygynous wives may be poorly nourished. The West African pattern (Caldwell et al., 1992) of early female marriage, delayed and polygynous marriage by men and long periods of sexual abstinence by women (during pregnancy: three

years post-partum, unless the baby died, in which case one year; upon becoming a grandmother) served as an efficient fertility check and the breakdown of this system has contributed to the high fertility of late twentieth-century Africa.

Even within populations in which there might seem to be no reins on fertility, it is unlikely that fertility will reach its maximum. India has not been characterized by high fertility in spite of having had virtually universal nuptiality. In Uttar Pradesh, a province in north central India, the average age of female marriage is still under 9 years and the average age of consummated marriage is 14 years (Basu, 1993). Yet, the first birth is delayed until the woman is nearly 19, and in the past the first live birth did not occur until the woman was an average of 21 years old. This long first birth interval occurs because Uttar Pradesh has exogamous villages and patrilocal marriage. The young wife is isolated and of low status in her new home and she is very likely to return to her parents for months at a time until she becomes pregnant (Basu, 1993).

Long periods of breast feeding are the norm in south Asia and long term post-partum sexual abstinence may be enforced. In fact, women may return to their parents for up to a year after the births of their first one or two children (Chaudhry, 1990). While divorce has a very low rate, widowhood occurred in the past at a very early age. In the 1930s women were commonly widowed in their late twenties and Hinduism traditionally forbids remarriage.

A TEST CASE FOR FERTILITY ESTIMATES IN PALAEODEMOGRAPHY

It is quite obvious that human fertility is the result of a complex interplay of physiological, environmental and economic/cultural factors. How can we hope to estimate fertility for past populations based only on skeletal collections? There is one case that provides us with an almost unique opportunity for testing whether this is possible. The Huron who lived in southern Ontario in the sixteenth and seventeenth centuries provide us with an opportunity to test the value of palaeodemography based on skeletal collections. The reasons for this are: (1) burial in ossuaries and (2) detailed reports by French missionaries.

Ossuaries, as found in Ontario, are large communal burial pits that have been filled with the disarticulated and mingled bones of the dead (Jackes, 1994). On the basis of the French accounts, it is believed that the Ontario ossuaries contain the bones of almost all the dead from a limited number of communities within a limited period of time. They therefore should provide information that is much more biologically meaningful than that from most archaeological sites for which we have no such assurance that the dead represent a biological population from a certain time span.

We will consider the ethnohistorical accounts in conjuction with information from Ossossané Ossuary, which is believed to be the site of the burial witnessed by the French Jesuits in 1636 (Kidd, 1953). Here we have an unprecedented opportunity to test the validity of information derived from skeletons, since the French wrote extensive descriptions of Huron life.

THE HURON

Our knowledge of the Huron is based on French descriptions of a period of change, after the introduction of European trade and diseases had probably caused alterations to the way of life, particularly to the patterns of trading, hunting and warfare. By 1580, European trade goods were not uncommon in southern Ontario, and within a short time all the Huron had settled in Simcoe County, probably to take advantage of proximity to a major trading route. Yet Trigger (1986:163, 220) argues that the basics of Huron life would have been maintained in the face of these changes. We will be discussing the period up to 1636, when traditional life still prevailed. By 1649, Huron life in Ontario had come to an abrupt and tragic end and there is no possibility of understanding the Huron past based on modern Huron people living under comparable conditions.

The Huron group we will be examining had probably been settled in Huronia for at least 200 years. They were members of the Attignawantan Nation, the people among whom the French Jesuits lived almost exclusively until 1640. The records of the Jesuit Fathers, the *Jesuit Relations,* upon which we will base our study, are therefore most accurately viewed as a description of life around Ossossané, the largest town of the Attignawantan or Bear Nation. At Ossossané lived the man who was not only the chief of the Bear Nation, but of the whole Huron Confederacy. In the town there were 1500 to 2000 people living in more than 40 longhouses and the town was fortified and surrounded by small satellite villages, probably eight.

Nutrition

A very large proportion of the Huron diet consisted of maize. Heidenreich (1971:163) estimated that 65% of the calories in the Huron

diet would have been derived from corn and Schwarcz et al. (1985:201) have calculated a 52% corn contribution to the diet based on stable isotope data. Beans, squash and gathered foods were also important, but Schwarcz et al. (1985) find no evidence that beans were a major source of protein. Fish caught in the autumn and meat from hunting must have rounded out the diet. However, ethnohistorical evidence suggests that fish and especially meat were not important components of the diet. Their major contribution was to feasts. Dogs were eaten but they cannot have provided much fat; probably less than 1% of their body weight consisted of fat. The dogs survived on scraps around the Huron villages and these were not rich pickings (Heidenreich, 1971:148).

It is clear that the Huron diet was low in fat. Animal fat would have been available only in late October when hundreds of men hunted white-tailed deer that had fattened on autumn acorns. However, considering the number of men involved, the time taken, and the distances travelled, the yield from deer hunting was very low. Vegetable oils were available: although oil was not extracted from corn, sunflowers were grown for seeds. However, sunflower oil was used chiefly to dress the hair, and vegetable or fish liver oil and animal fat (deer or bear) were smeared on the skin. Though oil and fat were poured on corn, this normally occurred only on ceremonial occasions (Tooker, 1964:69).

Work

During the 1620s and 1630s the Huron were working extremely hard. European iron axes must have helped the men to clear more land and the women must have worked harder to produce surplus corn meal to trade for furs. Beavers became extinct in Huronia around 1630 and so the trade with the French could be maintained only by the women tilling, planting, harvesting, and pounding the corn meal to trade for beaver pelts and to store against crop failure. The women's horticultural work must have taken all the spring and summer. The spring often required replanting if late frosts occurred, and was also the time for collecting and carrying firewood. The women and children might spend their summers in cabins near the fields weeding and protecting the crops. The women also made pottery, collected hemp and made twine for nets, made reed mats and baskets and prepared skins.

Men fished in the autumn and hunted in October and March (fasting for a week to ensure success in hunting). The men went far to the south and east on hunting trips, possibly involving 300 to 500 men for over a month.

Determinants of fertility

It is immediately clear that the age at menarche among the Huron might have been quite late. Young girls helped with the hard agricultural work and their diet is unlikely to have allowed them rapid adolescent fat development. Nevertheless, corn does provide a good deal of food energy for the amount of effort expended (corn provides more fat and starch+sugar than other grains). Furthermore, there is evidence for an Amerindian adaptation favouring the maximization of body fat in the context of a low fat diet (see e.g., Beizer, 1990).

Sexual activity apparently began at quite an early age. The French priests found this difficult to accept, but we should not interpret the Jesuits' statements to mean that Hurons were complete libertarians. Embracing in public was not permitted and it seems likely that the Huron, whether unmarried or married, tended to have sexual intercourse outside the village in private (Trigger, 1987:440 n.29) except during certain curing ceremonies (Tooker, 1964:106). Since the Huron lived in longhouses in which two families shared a number of central hearths, and the sleeping arrangements involved all family members huddling together by the fire within an area about 14 X 11 feet (Heidenreich, 1971:117–118), it is indeed very likely that the Huron insistence upon self restraint extended to intercourse within the village. Many men were absent from the village for long periods from March to December, and much of the winter was taken up with elaborate feasts and ceremonies. The snowy woods of January and February in northern Ontario cannot be conducive to dalliance, so the frequency of intercourse was probably low.

Sexual abstinence was required before prisoners were tortured and before games of lacrosse between villages. Sexual abstinence was required of lactating females. The premarital sex may have seemed entirely free to the Jesuits, but the adolescents must have chosen their partners from those in marriagable kinship categories. The eight Huron clans were exogamous and people could not marry within three degrees of consanguinity on both maternal and paternal sides. For this reason the initial relationships, whether visiting unions or common-law unions, would have to be with marriageable partners because any of the relationships could lead to marriage upon pregnancy. With the permission of the girl's father a necessary precondition, the pregnant girl more or less chose whom she wished to say was father of the child. It appears that marriages could occur before a pregnancy but, without children, divorce and rapid remarriage was common.

Fertility after the first child

Once a child was born marriages became very stable and adultery was uncommon. If there was a death, marriage to a dead brother's widow or a deceased wife's sister was normal. Remarriage required a wait of one year (Trigger, 1987:52).

Lactation commonly lasted for 2 to 3 years (Tooker, 1964:123), although supplements of prechewed meat might be given. Weaning or the feeding of a child whose mother had died was based on a thin soup of cornmeal boiled in water. Supplemented breastfeeding for such a long period would mean that ovulation was suppressed to some extent, but wide spaces between births was ensured by a post-partum taboo that lasted for the whole period of nursing, the child sleeping between the parents (Tooker, 1964:123).

Marital separation was very common, although the expeditions of the men out of the village were planned so that not all men were away at once, leaving the village unprotected (Tooker, 1964:49).

The Arendahronon Nation originally dominated trade with the French from 1611 on when the Huron began to oust the Algonkian middlemen. Later the Attignawantan Nation with its capital at Ossossané probably took over. Each year in the 1620s a trading expedition was sent to the St. Lawrence, taking a month for travel each way. By 1633 the trading party consisted of 500 men.

Trading corn for the furs, meat and dried fish of the Algonkians to the north was important to the Huron diet, but autumn fishing and winter hunts were crucial. Beginning in 1636, when the autumn fishing was disrupted by epidemics, lack of fish contributed to the crisis. The Huron had already overhunted the local deer and were forced to go on long hunting trips in October and November to find the acorn-fattened deer far to the east and south. Again in March, the Huron set out to hunt when the deer, facing late winter starvation, congregated in clearings searching for food.

Warfare was another cause for marital separation. Every spring and summer 500 or 600 young men went to raid Iroquois territory. They might be away from six to eight weeks, return when their cornmeal ran out and then go out again (Tooker, 1964:29-30).

Altogether, it is hardly surprising that the French said "the women... are far from being fruitful with long suckling and not cohabiting with their husbands all that time" (Charlevoix, 1761:2:80). To this they could have added the hard physical labour and restricted diet of the women and the fact that many of the men were away from home for large parts of the year.

Health of the Attignawantan Nation

The French considered the Huron to be healthy in comparison with the inhabitants of northern France in the first half of the seventeenth century, but we have minimal basis for assessing even the most fundamental factors, such as infant mortality. French Canadian infant mortality rates, perhaps around 183 per 1000 live births in the late seventeenth century (Nault et al., 1990), were low for Europeans of that period. While we have no idea of the proportion of Huron infants dying before age 1, Ontario ossuaries must be assumed to have an underrepresentation of infants among the dead since credible levels of infant mortality (approaching 180 out of each 1000 live born babies dead by 12 months of age) are not reached at any site in historic Huronia. Nevertheless, one of the chief causes of childhood illness and mortality (bad drinking water) can be excluded from consideration since the French stated that the Huron only drank water that had been used to boil corn. Furthermore, long suckling and wide birth spacing must have reduced infant mortality.

The hygiene in the crowded, smokey and lice- and flea-infested longhouses did not impress the French (though they cannot have been models of hygiene themselves). Hands were not washed but wiped on hair or on dogs' coats. Children urinated in the longhouses, although the French commented on the "decency and modesty" of the adults (Heidenreich, 1971:148), and dogs were given free range. The longhouses must have been ideal situations for the transmission of respiratory infections, lungs and eyes irritated by the smoke of the hearths, sweat lodges and tobacco. Huron sinus cavities exhibit marked bone changes indicative of constant infections, and middle ear disease certainly affected the children (Varney, 1994). Pulmonary TB must have been common in Huron villages (Pfeiffer, 1984) increasing young adult mortality. Low level infection deriving from the very high rates of dental pathology beginning in early childhood, with many teeth lost to caries and abscessing, must have been universal. Although it is considered that the most serious diseases among the Huron were introduced from Europe, not only tuberculosis but syphilis was already present (Larocque, 1991), lowering fertility.

Periodic crop failure occurred, leading no doubt to diarrhoea and increased mortality levels among children under five (there were droughts in 1628 and 1635). But even in good years the diet may have

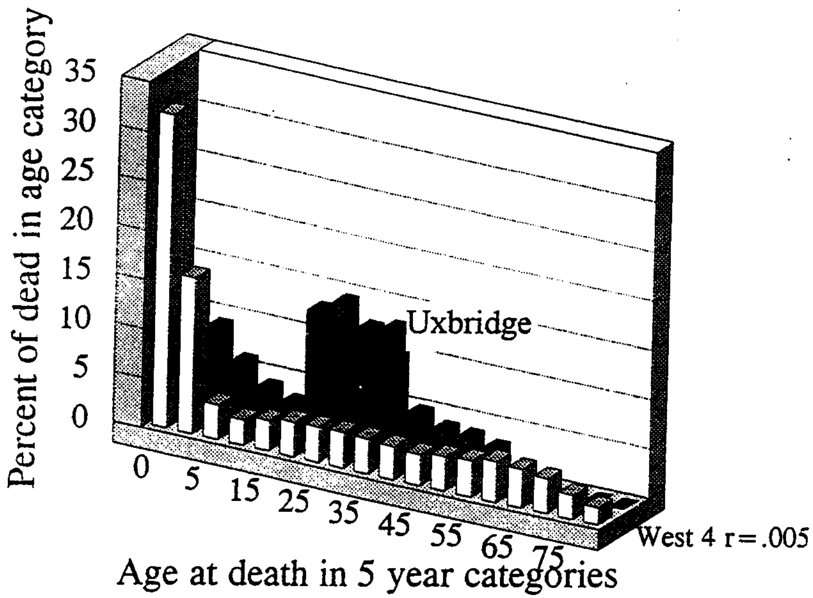
been quite marginal. Vitamin C may have been deficient during part of the year, and dependence on maize may have reduced iron and zinc levels, since these minerals are not easily absorbed in a high-fibre diet. A maize-based diet may lead to pellagra as a result of niacin deficiency. Mild pellagra symptoms include emotional instability, hallucinations, diarrhoea and a rash on any part of the body exposed to sunlight. Beans or meat and fish must be consumed in quantity to compensate for the absence of niacin in corn. Furthermore, corn should be cooked in water that has had lime added to it in order to increase the relative amounts of essential amino acids. Heidenreich (1971:165) has suggested that the calcium carbonate in the water in Huronia might have increased the slightly deficient calcium in the Huron diet; it might also have made the water sufficiently alkaline to avoid pellagra. But the greater dependence on corn and the reduction in hunting and gathering because of increased emphasis on trade with the French, and the concentration of population within historic Huronia, might well have tipped the balance, leading to some of the unexplained illness recorded by the French.

From 1634, the French began to record a series of bad years with illness of an indeterminate nature starting in the summers, culminating in an outbreak of smallpox in 1639. Estimates of mortality by the end of 1639–40 indicate a drop in the Huron population from about 30,000 in the early 1620s to about 10,000 in the early 1640s (Trigger, 1986:233). Is the fall in population to be attributed only to increased mortality, or does Ossossané give evidence of falling birth rates in the period up to 1636, when there is no record of severe epidemics?

Analysis of Huron demography up to the early summer of 1636

The method used in this analysis of Huron fertility from skeletal data ignores children under 5 years of age because of the documented burial of Huron infants outside the ossuaries (see e.g., Saunders and Spence, 1986). All adults are grouped into a single category because our present techniques of adult age estimation, together with preservational bias, tend to place too high a proportion of the population within the reproductive years. This is illustrated in Figure 5, which compares the age at death distributions for the site of Uxbridge from skeletal data and model life table data. The method is therefore a substitute for the more usual fertility statistics because those statistics depend on good estimates of the number of children dying before 12 months of age and of the number of women of reproductive age (Jackes, 1988).

Figure 5. Comparison of Age at Death Distributions for Uxbridge Ossuary and Coale and Demeny West Model Table Level 4 mortality r = .005.



The two distributions have equivalent mean childhood mortality and similar juvenile adult ratios. Archaeological samples commonly show increased young adult deaths, which may result from age assessment techniques.

We need first to establish some idea of Huron demographic parameters before contact with the French. For this we will use Uxbridge, a completely excavated and systematically analysed Huron ossuary (Pfeiffer, 1986). Ossuaries, by definition, are secondary burials, so that an ossuary contains large numbers of disarticulated skeletons, buried after the flesh has decomposed or been removed. For this reason it is very difficult to arrive at a completely accurate count of the number of individuals buried. Bones are mixed and broken, and many will also have suffered post-mortem damage. On the basis of mandibles, Pfeiffer (1986) has determined that the minimum number of individuals (MNI) at Uxbridge is 457,

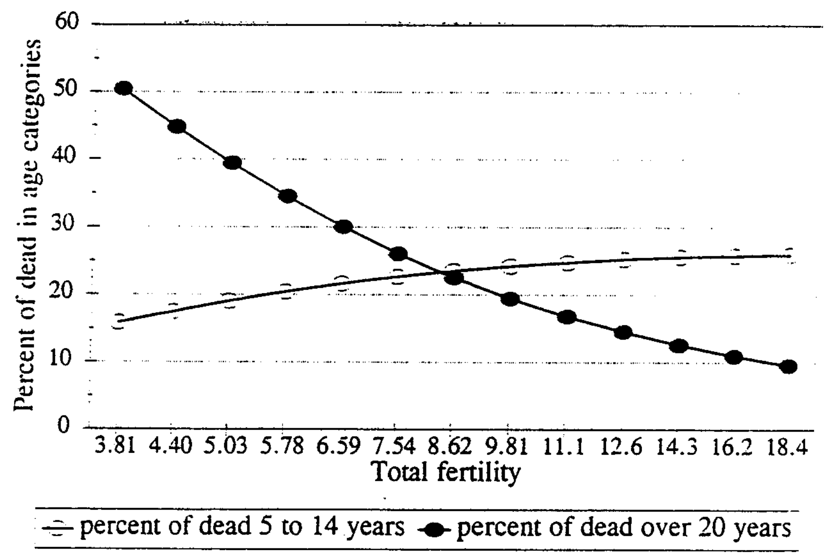
with 312 adults of 18 years and over and 145 sub-adults under about 18 years of age. The method of subadult age estimation used was Ubelaker's reworking (1989) of the Schour and Massler dental eruption schedule.

Based on Pfeiffer's age-at-death distribution, we determine values for two "estimators" (see Jackes, 1992 for discussion). These estimators are:

(1) the juvenile adult ratio (JA) proposed by the French palaeodemographers Masset and Bocquet-Appel (e.g., Bocquet, 1979), which is calculated on the basis of the ratio of children 5 to 14 years old to adults 20 years and over;

(2) the mean childhood mortality (mcm: Jackes, 1986), which is the average probability of death between age 5 and age 19 using the probability of death values calculated in a life table.

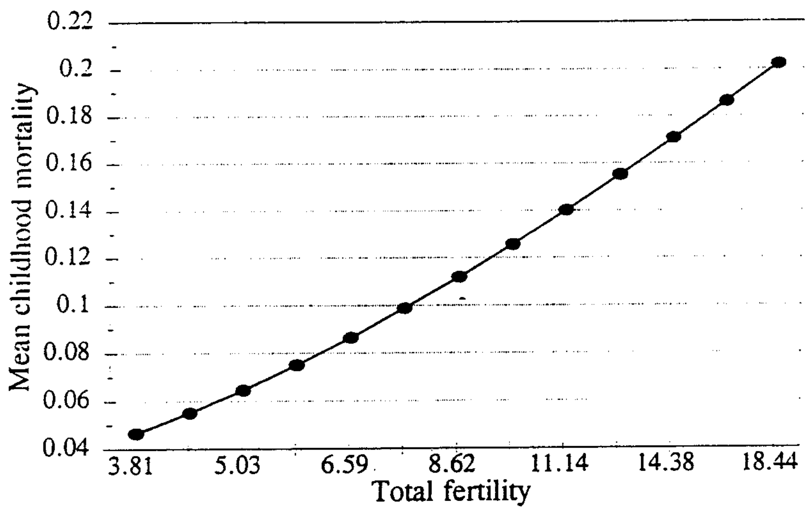
Figure 6. The Ratio of Juveniles to Adults Among the Dead (West 1, Males and Females Combined)



The mortality level is constant but, as the level of fertility changes, the West 1 model data demonstrates that the number of 5 to 14 year-old children increases relative to adults over 20.

Figure 6 shows how the proportions of adults and sub-adults among the dead change as the total fertility of a population changes. The total fertility is calculated here from the combined male and female age distribution of the living, provided by Coale and Demeny (1983) for West model table 1. Figure 7 shows the relationship between total fertility and the average probablity of death between ages 5 and 19 based on West 1. It is clear that the relationship between the estimators and fertility is so close that fertility can be predicted from the estimators. As demonstrated in Figures 1 to 3, if mortality levels are held at about the same level, but fertility levels increase or decrease, then the age structure of the population changes, thereby altering the age distribution of the dead.

Figure 7. The Mean Probability of Childhood Death (aged 5 to 19) Increases as the Fertility Rate Increases, although the Mortality Level (West 1) is Kept Constant.



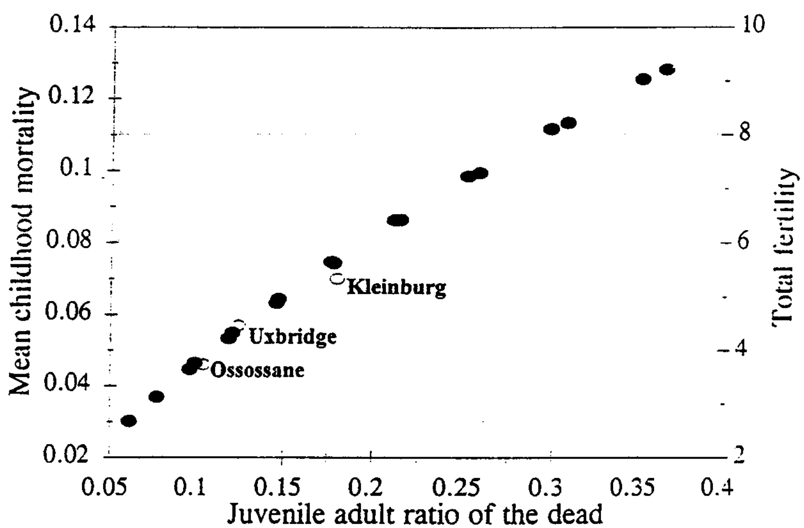
Thus, it is possible to use these two estimators to get an idea of fertility based on the age distribution of the dead. We will use model data as the source of fertility figures, so the only question is to determine the best

set of data to use for the analysis. There are many levels of West mortality tables, and there are also a number of model tables published by the United Nations. Here we will use West model tables 1 and 5 because they encompass the levels of mortality exhibited by the Ontario ossuaries and give data on non-stationary populations. We could predict fertility from model table data by regression analysis, but, as in Figure 8, we can simply plot mean childhood mortality, juvenile adult ratio of the dead and total fertility on the one graph and from that get an idea of the fertility levels in archaeological populations. The relationship of the juvenile adult ratio and mean childhood mortality in archaeological samples has been established in a number of analyses which have also shown that the method can give us information about whether the samples are biased or from non-stationary populations (e.g., Jackes, 1993). The total fertility figures are calculated from Coale and Demeny (1983) population data for West 1 and West 5, as (the number of male and female children under 12 months divided by the number of females aged 15 to 44) multiplied by 30, which represents the 30 years between 15 and 44. We exclude the data for populations increasing at more than about 3.5% per annum as irrelevant to the present research.

Uxbridge, which we are using as an exemplar of pre-contact Huron demography, would fall a little way off the line in Figure 8 that expresses the relationship of the juvenile adult ratio (JA) and mean childhood mortality (mcm). This indicates that the Uxbridge Ossuary may represent a population that was not stationary. It is important to know whether the Uxbridge population was non-stationary, and to determine this we can test whether the calculation of the life table with an adjustment for an increasing population will bring the point closer to the line (Jackes, 1986). In fact, calculating the life table for $r = .005$ ($r =$ the rate of natural increase, here 0.5% per year) allows the Uxbridge estimators to accord with model data. A valid adjustment to the Uxbridge sample might also be the addition of more adults since the French clearly stated that people who died by drowning, freezing or violence were excluded from ossuary burial (Tooker, 1964:132). The point will be lowered slightly on the line by such an addition, meaning that the fertility estimates that we will make will be the maximum, not the minimum estimates.

Using information based on model life tables (Coale and Demeny, 1983) with equivalent values for JA and mcm, we can estimate that total fertility was less than 5. That is, a Huron woman living around 1500 AD who survived to age 45, would most likely have had 4 live born children.

Figure 8. Trend Line Derived from Decreasing, Stationary and Increasing Model Populations (West 1 and 5) Shows the Relationship Between Childhood Mortality, the Ratio of Juvenile to Adult Deaths and Total Fertility in Huron Ossuaries.



Kleinburg (adjusted for 1% population increase) and Uxbridge and Ossossané (adjusted for .5% population increase) Ossuaries are plotted to allow an estimation of fertility levels.

It is not a simple matter to establish the demographic parameters for later Huron sites. Kleinburg, dated at around 1580-1600 AD, should provide good information on the Huron at the very beginning of contact, direct or indirect, with Europeans. Ossossané, probably dated to 1636 (in fact, to the seventh Monday after Easter that year; Kidd, 1953), should tell us about the period just before the most devastating epidemics and famines recorded by the Jesuits, and before the introduction of firearms to the Mohawks intensified the wars with the Iroquois.

Despite the possibility that Huron ossuaries provide the best data available to palaeodemographers (Jackes, 1986; Sutton, 1988), age estimation for skeletons from ossuaries is particularly problematic because the

ages must be based on isolated bones. Ages based on different skeletal elements, even different methods for the same skeletal elements, may give inconsistent results (e.g., Sullivan, 1990; Jimenez and Melbye, 1987).

It is absolutely essential that the minimum number of individuals (MNI) be reliable: reduction in the MNI will bias the results of our analyses very strongly, increasing the estimator values. Since underrepresentation of adults is known to be a factor because adults who died violently were excluded from ossuary burial, maximum estimates must be used. The best estimates available at present are as follows: (1) 617 people were buried at Kleinburg and around one third of these died before age 15 (Pfeiffer, 1986); (2) 681 individuals were buried at Ossossané and just over 20% of these died before age 15 (Katzenberg and White, 1979; Saunders and Melbye, 1990).

Larocque's (1991) age estimates for Kleinburg and Ossossané will be used for comparison with Uxbridge since the same technique of observing children's tooth development was employed by Larocque as by Pfeiffer (1986).[2] The data plotted on Figure 8 strongly suggest that the Huron population continued to increase until about 1600 AD, perhaps flowering under the impetus of early trade with Europeans, perhaps responding to the passing of a wave of tuberculosis that had affected the Huron the previous century (Jackes, 1988:64). The best estimate for Kleinburg is that the people living there had a total fertility rate of five, and that the population was increasing by slightly under 1% per annum.

During the period just before the recorded epidemics and wars of 1639–1649 the increase appears to have slowed. While the Ossossané population was not stationary, and certainly not declining, the average number of live born offspring seems to have been quite low, at about three. In the face of the epidemics, famines and warfare that were to strike the people within a few months, the fertility rate could not sustain the population.

CONCLUSION

The French stated that long periods of lactation and sexual abstinence were practised by the Huron. Sexual activity for 30 years without contraception, combined with up to three years of nursing per child, might well be expected to lead to birth intervals of four years.[3] Assuming 30 years of unrestricted sexual activity, the maximum Huron total fertility rate would be seven, meaning that the average Huron woman must have had fewer than seven children. The Kleinburg data are in accord with this and illustrate Huron life under ideal conditions. The Uxbridge Ossuary, which is earlier in time, is likely to have had a lower total fertility rate as a result of the high incidence of tuberculosis (Pfeiffer, 1984). Increased population density, intensification of trade, and probable worsening of the diet in the sixteenth century, led to reduced fertility rates and a decline that could not be reversed in the face of epidemics and warfare.

Huron ossuaries provide some of the best palaeodemographic evidence available, and when analysed in detail they may well give us a clear understanding of the decline of the Huron. In the interim, the interpretation of estimators in terms of fertility, rather than mortality, makes good sense. While the estimators cannot be used for the extreme cases in which the population was undergoing rapid decline leading to immediate extinction (Jackes, 1988), the method seems generally applicable. The Huron buried at Kleinburg lived about 50 years earlier than those buried at Ossossané: before the disruptions caused by the intensification of trade with the French, and in a rich agricultural area with a longer growing season. It makes good sense to interpret Ossossané as exhibiting lower fertility, not lower mortality, than Kleinburg.

In sum, we can indeed estimate fertility from past populations based only on skeletal collections, and the results of our analyses accord with known history. We have shown that the age at death distribution for a population known only from skeletons can be used in very specific ways to arrive at a clear idea of fertility. We are able to test the validity of this approach because seventeenth-century Ontario offers us the almost unique combination of (1) reasonably detailed and accurate written records with (2) the burial of almost all the dead of a community over a short period of time in an ossuary. It is important to note that fairly accurate ages at death are required only for the sub-adults, so that we can avoid the problems of age assessment of adult skeletons. The age assessment methods for sub-adults used in the studies cited here are all based on well-established techniques of observing the eruption of children's teeth (recently shown to be generally accurate: Liversidge, 1994). The method of determining fertility that has been used here is straight forward. It involves no more than plotting the average number of children an average woman would bear between the ages of 15 and 44 in a model population equivalent in its level of childhood mortality to the Huron of sixteenth- and early seventeenth-century Ontario.

The fertility estimates allow us to conclude that there was pressure on the Huron population even before the worst of the recorded devastating

epidemics, famines and wars that marked the final years of the existence of the Huron Confederacy in Ontario. If we were to interpret the estimators derived from juvenile mortality as indicating overall death rates, we would have to conclude that mortality was falling and that the population was increasing. Unfortunately for the Huron, nothing could have been further from the truth. As history makes clear, the few starving survivors of the Huron who had buried their dead in the Ossossané Ossuary in May 1636, were forced to abandon their country only thirteen years later.

ENDNOTES

1 The value 1/mean age at death now does not accurately estimate the death rate. Since any natural increase in populations requires that births must outnumber deaths in a population, 1/the mean age of death can logically no longer estimate both the CDR and the CBR. For this reason, it has been claimed that 1/mean age of death accurately estimates the CBR in archaeological populations (e.g., Sattenspiel and Harpending, 1983), rather than the CDR. However, estimates of the CBR derived from 1/mean age of death in increasing populations are too high (Jackes, 1992). Furthermore, we cannot rely on the CBR whenever there is any possibility that infants were buried differently than older children and adults or when adult ages might have been estimated inaccurately.

2 Larocque's data are smoothed by redistributing the sub-adults over the possible age ranges for each stage of the tooth eruption sequence, using probabilities under the normal curve. The percentage of the dead falling within each five year age category is the basis for determining the number of Kleinburg and Ossossané sub-adults dying between 5 and 15 years of age, the figures required to determine the JA and the mcm. As with Uxbridge, we use adjusted figures for Kleinburg ($r = .01$) and for Ossossané ($r = .005$), because the relationship of the mcm and JA values suggests that the two samples did not come from stationary populations.

3 Figure 4 suggests that a mother would not become pregnant again for almost 40 months after giving birth, if she breastfed her child for 30 months or more.

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