CRITICAL EFFECTS OF MALNUTRITION DURING PREGNANCY

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We read with interest in the recent issue of Local Population Studies the account of the current work of the Cambridge Group concerning the steady and substantial rise in marital fertility during the period c.1680 to c.1810 which was, surprisingly, most marked in older women who had been long married. It is concluded that it is probable that this change was not due to any change in the rate of conception but rather to a reduction in the numbers of stillbirths associated with the loss of life in the third trimester of pregnancy.

We look forward to reading the detailed arguments on which this hypothesis is based. We have no direct information about the frequency of stillbirths during the long eighteenth century, but these findings are in accord with our work on the effects of an inadequate nutrition during pregnancy. Penrith, lying in the Eden Valley, Cumbria, was a community living under marginal farming conditions which was susceptible to mortality crises in the late sixteenth and early seventeenth centuries. We have completed a family reconstitution study for this parish\(^1\) and have shown that the average marital fertility ratio over the period 1557-1812 was lower than that recorded for other historical populations. The distinguishing characteristic of fertility at Penrith is the marked subfecundity of women aged below 25 years and we have suggested that this is indicative of nutritional deprivation.\(^2\) A late age at menarche, a higher amount of pregnancy wastage, a longer period of premenopausal subfecundity and an earlier age of menopause are associated with a longer period of adolescent sterility, and a higher frequency of nutritional amenorrhoea is found when food supplies are marginal.\(^3\) This pattern is common among poor populations of many developing countries today.\(^4\)

Conditions at Penrith gradually ameliorated during the seventeenth century and the population enjoyed a halcyon period during 1700-1750, with a population boom after 1750.\(^5\) Table 1 shows that, overall, the low fertility rates varied little with time, but the age-specific marital fertility for women of 40 to 49 years did rise quite markedly during 1700-1749 (in comparison with 1650-1699) although, paradoxically, it fell again during the population boom after 1750. We have shown that this marked rise in population at Penrith was primarily linked to a progressive improvement in infant (and later in child) mortality and not to any change in fertility, as shown in Table 1.\(^6\)

We have explored in detail the subtle effects of malnutrition during pregnancy by an analysis of the mortality crisis of 1623 at Penrith\(^7\) which was caused by the coincidence of high wheat and low wool prices.\(^8\) Cycles in infant mortality were significantly correlated with cycles in wheat prices, which are regarded as a
Table 1  Age-specific marital fertility at Penrith (per 1,000 women-years lived)

<table>
<thead>
<tr>
<th>Age groups</th>
<th>15–19</th>
<th>20–4</th>
<th>25–9</th>
<th>30–4</th>
<th>35–9</th>
<th>40–4</th>
<th>45–9</th>
<th>Total marital fertility rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1557–1599</td>
<td>187</td>
<td>319</td>
<td>312</td>
<td>309</td>
<td>256</td>
<td>77</td>
<td>93</td>
<td>7.8</td>
</tr>
<tr>
<td>1600–1649</td>
<td>186</td>
<td>270</td>
<td>321</td>
<td>263</td>
<td>201</td>
<td>112</td>
<td>34</td>
<td>6.9</td>
</tr>
<tr>
<td>1650–1699</td>
<td>196</td>
<td>320</td>
<td>321</td>
<td>230</td>
<td>229</td>
<td>94</td>
<td>14</td>
<td>7.0</td>
</tr>
<tr>
<td>1700–1749</td>
<td>234</td>
<td>299</td>
<td>317</td>
<td>301</td>
<td>249</td>
<td>164</td>
<td>64</td>
<td>8.1</td>
</tr>
<tr>
<td>1750–1812</td>
<td>211</td>
<td>269</td>
<td>286</td>
<td>272</td>
<td>223</td>
<td>128</td>
<td>35</td>
<td>7.1</td>
</tr>
<tr>
<td>1557–1812</td>
<td>211</td>
<td>291</td>
<td>307</td>
<td>275</td>
<td>230</td>
<td>114</td>
<td>45</td>
<td>7.4</td>
</tr>
</tbody>
</table>

measure of the availability of food to this community and to pregnant and nursing mothers in particular. Analysis of events around 1623, using the family reconstitution study, support the hypothesis that neonatal mortality was related to malnutrition during pregnancy, whereas post-neonatal mortality was primarily dependent on exogenous causes (particularly inadequate levels of nutrition) during the first year of life.9 The interesting fact to emerge from this study is that malnutrition exerted the most severe effects during the last trimester of pregnancy, a finding that agrees with the study of the effects of famine during the well-documented Dutch hunger winter between September 1944 and May 1945.10

A sharply fluctuating food supply could produce another exacerbating and paradoxical effect on infant mortality, particularly in the poorer classes. A large and potentially beneficial placenta could be built up early in pregnancy with good nutrition following a good harvest but, if this were rapidly followed by a sharp reduction in food supply, the large placenta would deprive the developing foetus of adequate nutrition.11 This would imply that, under these particular conditions with a large placenta, the foetuses exposed to inadequate nutrition during the second and third trimesters would be more severely disadvantaged than those that were exposed during the first three months in utero.

Studies of Third World countries have shown that where maternal undernutrition prior to and during pregnancy is compromised, rates of low birthweight infants and stillbirths tend to be high.12 An analysis of the affect of the mean weight gain in pregnancy has shown that women in three developing countries (Thailand, Philippines and the Gambia) gained the least weight in pregnancy and had the lowest birthweight infants when compared with women of developed countries (Scotland and the Netherlands).13 Women, in Bangladesh, who are among the most poorly nourished in the world, had a significantly lower mean weight at all stages of pregnancy when they had either a stillbirth or an infant death compared with women in Britain, Kenya and India.14 Of particular interest, is the observation that women who themselves were born with a low birthweight had a 2.5 times greater risk of an abnormal pregnancy.15
This suggests that a reduction in the rate of infant mortality and in the risk of stillbirths for historic populations might not be expected until there was a sustained improvement in the nutritional status and in weight gain prior to and during pregnancy of mothers of the preceding generation. We believe that this may have occurred in Penrith when, during the period 1700 to 1750, an amelioration in the effect of high wheat prices, led to better nutrition for mothers who conceived during this period and, consequently, in the birthweight of their daughters who then produced the next generation who experienced a marked reduction in the rate of infant mortality.

We conclude that fluctuating nutritional levels, particularly during the third trimester of pregnancy, could make a major contribution to stillbirths in historic populations, as reported by the Cambridge Group, even when these were not living under marginal conditions.

Recent work, again in Third World countries, has also highlighted the importance of a recuperative interval for the mother between the end of lactation and the beginning of a subsequent pregnancy. When the two overlap, there is a risk of depletion of nutrient stores for the mother and of growth retardation of the foetus. A longer period between pregnancies is often found for older women and is assumed to be the response to a reduction in coital frequency as the result of marriage duration and the level of sexual activity. Data from the Demographic and Health Surveys of women of 18 countries in the late 1980s has found that coital frequency was stable for ages 15 years to the mid-30s but then declined substantially to age 49. The longer the period of recuperation between births, the greater would be the reduction in the risk of maternal depletion and of foetal malnutrition and of low birthweight infants and stillbirths.

These studies have led us to investigate the effects of short birth intervals on infant mortality at Penrith, 1600 to 1800, and our current work has emphasised another effect of maternal depletion. There is a significantly increased risk in the first or second year of life of children whose mothers quickly had another pregnancy which probably impaired breastfeeding of these earlier offspring.

Malnutrition in pregnancy had other subliminal, and hitherto undetected, effects on deaths from infectious diseases in very young children. Time-series analysis of mortality records, show that cycles of deaths from measles (London, 1647 to 1837), scarlet fever (England and Wales, 1847 to 1880) and whooping cough (London, 1701 to 1812) were significantly correlated with cycles in wheat prices but with a lag of two years and we conclude that an inadequate diet during pregnancy, particularly among the poorer classes, produced a greater susceptibility and increased the likelihood of dying in the next epidemic in the subsequent children.

NOTES

2. S. Scott and C. J. Duncan, 'Marital fertility at Penrith, 1557-1812 — evidence for a malnourished
6. Scott, Duncan and Duncan, 'Interacting effects of prices'.
11. D. J. P. Barker, personal communication