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Abstract

Temporal variations in the sex ratio or the ratio of boys over girls at birth have been widely studied and variously attributed to social changes, conditions of war, and environmental changes. Recently, Mathews, Johnson and Neil (2008) studied the direct evidence of individual pregnancies and established an association between the sex at birth and the mother's preconception diet. We examined the hypothesis using new evidence from the wartime famine in Holland in 1944/45 and failed to show an association between maternal diet in pregnancy and the sex ratio. This makes a causal link highly improbable.

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Introduction

In most human populations there is a small excess of boys over girls at birth, or a sex ratio slightly over 1 (Russel 1936). In several industrialized countries this sex ratio has been falling over a long period (Parazzini, La Vecchia, Levi et al 1998, James 2000) and the reasons for this are not well understood. Trends in Denmark since 1850 and in the Netherlands since 1950 have been interpreted in terms of increasing reproductive hazards, such as environmental estrogens, but long-term developments in Germany have been attributed to other factors like nutrition or social changes (Moller 1996, van der Pal, Verloove-Vanhorick and Roeleveld 1997, Broman and Jockel 1997). Then there are a number of studies that suggest an increase in male births in conditions of war (Graffelman and Hoekstra, 2000; and for the Netherlands, van den Broek 1997). A recent report by Matthews, Johnson and Neil (2008) that links the sex ratio to the maternal preconception diet is therefore of particular interest, the more so as the authors make use of direct evidence from individual pregnancies.

Matthews, Johnson and Neil have interviewed women attending an antenatal clinic in the south of England in the 1990s and collected 721 retrospective reports of the usual diet prior to conception, using a food frequency questionnaire. The preconception dietary intake of women delivering a boy were higher than of women delivering a girl (with averages of 2413 and 2283 kcal/day respectively), and 45% of women in the lowest third of food intake had boys against 56% in the highest third. These differences are statistically significant. There was no association with the diet in early pregnancy. The authors interpret this association as a causal link, and suggest *inter alia* that the secular decline in the sex ratio in industrialized countries may be due to slimming diets of young women.

We here examine the hypothesis that a mother's diet around conception and in pregnancy has a direct effect on the sex ratio with new data for the Dutch famine during the winter of 1944/45.

Data and methods

We use new data for the Dutch hunger winter of 1944/45, viz. the monthly birth statistics for the city of Amsterdam from January 1938 to December 1948, as published by the Municipal Bureau of Statistics of that city (Gemeente Amsterdam 1938-1948). The data represent a large population living under uniform (but varying) conditions; with between 1,000 and 1,200 monthly births in normal years, and about 600 in the worst months of the famine. The study period includes the war years, and in particular the famine of the 1944/45 winter, during the last months of the German occupation, when food rations in Amsterdam dropped dramatically to a level of only 500 kcal/day (Trienekens 2000).

In order to trace the effects of war and famine, we examine the monthly births in Amsterdam for five distinct periods of conception, reflected by births nine months later. These are the prewar period, the war period without famine, the war period with famine, and the early postwar and later postwar periods. The period of war without famine starts with the German invasion of the Netherlands in May 1940, the famine period in Amsterdam starts in November 1944, the early postwar period starts with liberation in May 1945, and the later postwar period starts six months thereafter. The precise delimitation of these periods is given in Table 1.

The monthly data on fertility and the sex ratio are shown in Figures 1 and 2, and the mean values for the five periods in Table 1.

Results

Figure 1 shows a dramatic decline in fertility during the famine and an equally dramatic increase after the end of the war and of the German occupation. While it is known that in the course of the war conceptions responded to major events and the mood of the population (van den Brink 1948), the present famine also caused widespread amenorrhoea among women (Burger, Drummond and Sanstead 1948, Stein, Susser, Saenger et al 1975).

But while the sex ratio is quite variable from month to month (as Figure 2 shows), its average level stays remarkably constant (as Table 1 shows) and is not affected by the condition of war, nor by the severe malnutrition of the famine months. It is easy to test the hypothesis that the sex ratio or the proportion of male births is the same for all five subperiods that we have distinguished. In each subperiod sample, given in the third column of Table 1, the number of male births has a binomial distribution, and this permits a likelihood ratio test of the hypothesis that the proportion of male births is the same for all five. This gives a test statistic $LR = .64$ for a chi-square distribution with 4 degrees of freedom. The hypothesis is maintained with flying colours.

Discussion

Our results confirm the findings from two previous studies of the effects of the Dutch hunger winter, viz. the analysis of monthly birth data for six cities (Stein, Susser Saenger *et al* 1975, Appendix Table 1) and the study of 3,300 selected births in three birth clinics (Stein, Zybert and Lumey 2004). These results are also in line with recent findings from Africa (Stein, Barnett and Sellen 2004). In all these studies, the sex ratio is not affected by famine, in contradiction to Matthews' hypothesis. Neither is there any evidence of a 'war effect', as postulated by van den Broek 1997 for annual births in the entire Netherlands. We can

therefore dismiss the hypothesis that potential effects of malnutrition towards a lower sex ratio could be offset by a contrary effect of war conditions.

These results do not invalidate the finding of Matthews, Johnson and Neill (2008) that in their data there may be an association between maternal nutrition and the sex of the child. They do however contradict any causal interpretation of that association.

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Table 1. Amsterdam 1938-1948, monthly births by selected conception periods

<i>Period</i>	<i>Date of conception</i>	<i>Total # of births</i>	<i>Births per diem</i>	<i>Mean sex ratio (s.d)</i>	Mean % male (s.d)
Prewar	1937:4 - 1940:4	38 175	34.41	1.056 (.011)	51.3 (.3)
War no famine	1940:5 - 1944:10	62 500	38.06	1.065 (.009)	51.5 (.2)
War and famine	1944:11 - 1945:4	4 860	26.41	1.077 (.029)	51.8 (.7)
Early postwar	1945:5 - 1945:10	12 479	68.94	1.073 (.013)	51.8 (.3)
Later postwar	1945:11 - 1948:3	46 677	52.86	1.058 (.008)	51.4 (.2)
Entire period	1937:4 – 1948:3	165 231	41.15	1.061 (.005)	51.4 (.1)

Mean sex ratio and mean % male are means of monthly values for the indicated period; the standard deviations of these means have been derived from the variation of the monthly values.

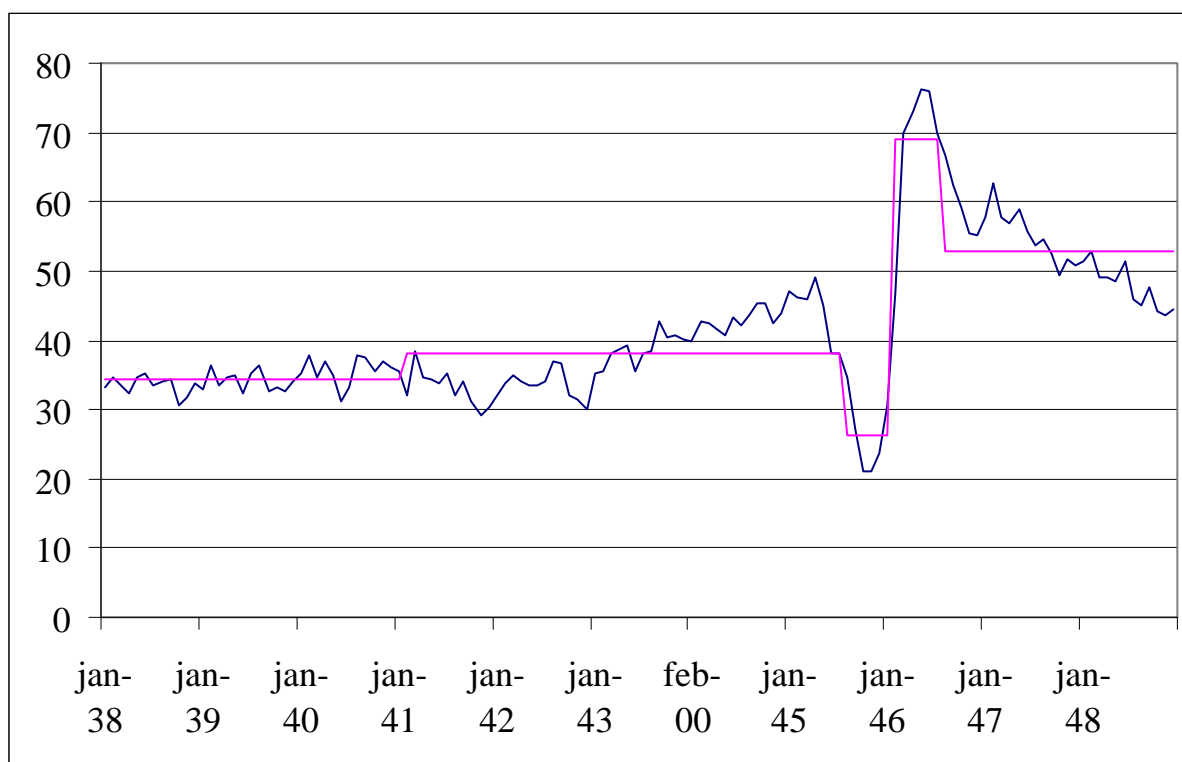


Figure 1. Amsterdam 1938-1948: daily number of births by month for five periods of conception (see Table 1).

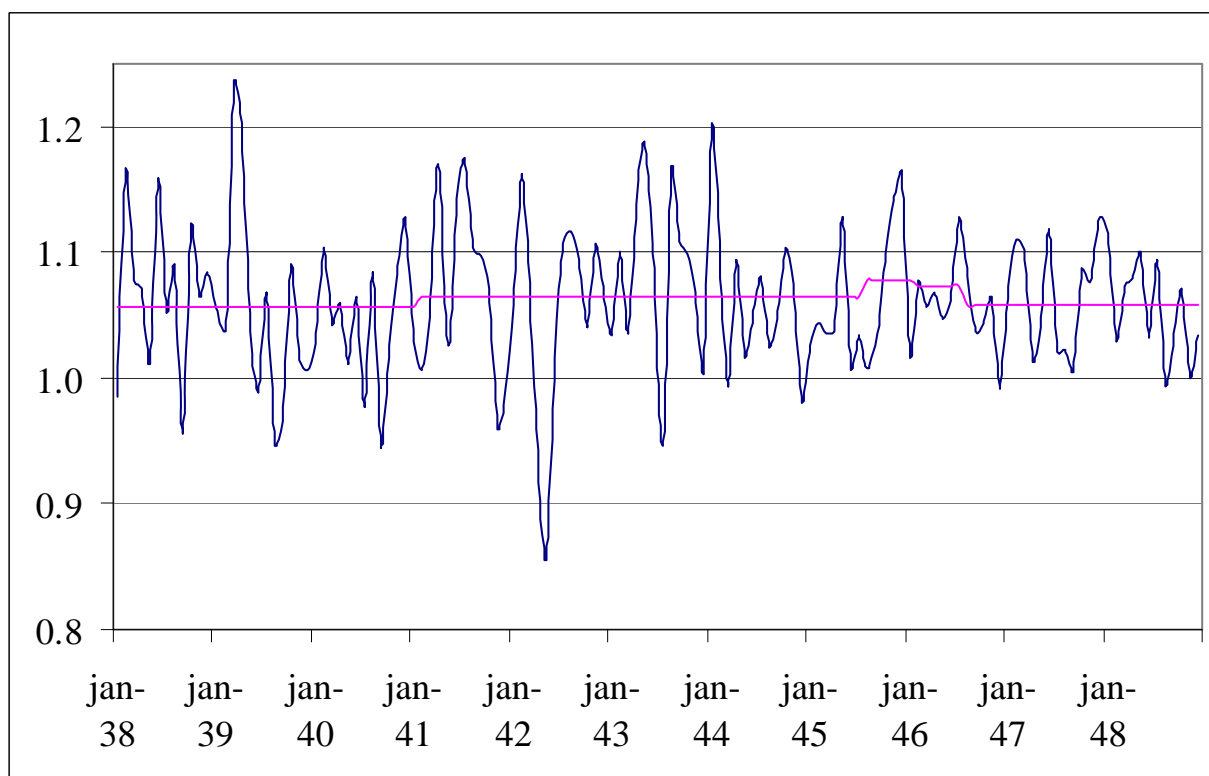


Figure 2. Amsterdam 1938-1948: sex ratio by month for five periods of conception (see Table 1).