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Did smallpox reduce height?

By PETER RAZZELL

Voth and Leunig's recent article in this journal presents detailed evidence for a correlation between smallpox and height, concluding that on average 'smallpox reduced height by at least 1 inch'.[1] The authors discuss the serious and destructive nature of smallpox in the eighteenth and nineteenth centuries, arguing that many young children were permanently stunted as a result of the impact of the disease in early life. Voth and Leunig have rightly pointed out the serious consequences of smallpox and it is probable that there were a number of secondary illnesses—including tuberculosis and bronco-pneumonia—which resulted from the disease.[2] It also led to physical deformity and permanent disfigurement, and in the late nineteenth century up to two-thirds of unvaccinated children attacked by smallpox were left significantly pock-marked.[3]

The authors are therefore undoubtedly correct in highlighting the possible significance of smallpox for average height. However, there are major problems with the quality of the data that they have used in their article, and these are so fundamental that a re-examination of their central conclusions is necessary.

Voth and Leunig have used the computerized dataset prepared by Floud, Wachter, and Gregory in their study of height for the period 1750-1980.[4] Part of this is based on boys recruited into the Marine Society for the period 1770-1873, and Voth and Leunig have used this for their analysis of smallpox and height. The data on height are derived from all boys recruited into the society, whereas those on smallpox are based on a sample of cases.[5]

Voth and Leunig have presented a diagram (their figure 6) summarizing the incidence of smallpox among recruits, plotting the proportion of boys 'who had experienced smallpox' against their 'year of birth', computed from stated age.[6] This diagram shows that just over 40 per cent of boys born in the middle of the eighteenth century had had smallpox, a proportion rising to nearly 100 per cent by 1760, and staying at that level (with one or two minor fluctuations) until about 1820, dropping dramatically to zero by the end of the 1820s, and staying at that level until 1859, the end point of the diagram.

[1] Voth and Leunig, 'Did smallpox reduce height?', p. 542.
[2] See Razzell, *Conquest of smallpox*, pp. 107, 108.
[3] See, e.g., Collins, *St Pancras*.
[4] The dataset is deposited in the ESRC archive, ESRC SN 2134. For the origins of the dataset, see Floud, Wachter, and Gregory, *Height, health and history*.
[5] See Floud, Wachter, and Gregory, *Height, health and history*, p. 133.
[6] Voth and Leunig, 'Did smallpox reduce height?', p. 547.

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The boys recruited into the Marine Society came predominantly from London, the proportions varying, according to Floud, Wachter, and Gregory, between 71.7 per cent and 88.9 per cent.[7] The incidence of smallpox given by Voth and Leunig for the eighteenth and nineteenth centuries thus essentially describes the experiences of boys living in London.

I

There are two major problems with the data as presented by Voth and Leunig. First, smallpox is known to have been endemic in London since at least the sixteenth century, and was probably a disease of childhood from that period onwards.[8] Lettsom, who had treated over 6,000 smallpox cases in London between the years 1773 and 1776,[9] stated that 'most born in London have smallpox before they are seven',[10] and this is consistent with the endemic nature of the disease. We would therefore expect virtually all boys to have experienced smallpox before they were recruited into the Marine Society at the average age of about 14 years—casting doubt on the authors' conclusion that only about half of boys born in the 1750s and recruited in the 1770s had experienced the disease.[11]

Even more unexpected is Voth and Leunig's depiction of a more-or-less constant, nearly 100 per cent, level of smallpox incidence in boys born between 1760 and 1820, followed by a dramatic decline for those born in the 1820s, and culminating in a zero level for the 1829 to 1859 cohorts. This pattern of smallpox incidence is not consistent with what is known about smallpox mortality in London. The authors themselves cite Landers's figures of smallpox deaths as a proportion of total burials, falling from 10.5 per cent in the 1760s to 7.3 per cent in the 1800s, and 3.5 per cent in the 1820s, and this pattern of mortality is confirmed by detailed statistics which I have published elsewhere.[12]

Voth and Leunig explain this significant decline of smallpox mortality by citing Kunitz's argument that the 'growth of population and increasing integration of national economies led to a change in the human crowd diseases, notably measles and smallpox, transforming them into more benign childhood diseases'.[13] This thesis is flawed on a number of counts:

[7] Floud, Wachter, and Gregory, *Height, health and history*, p. 105, n. 9. The original registers often distinguish between parish of origin and current parish, but the majority of boys appear to have both originated and lived in London.

[8] See Razzell, *Conquest of smallpox*, p. 113.

[9] Ibid., p. 106.

[10] Creighton, *Epidemics in Britain*, p. 554.

[11] It is possible that some of the boys born outside London escaped the disease before entering the Marine Society, but an examination of the original registers indicates that most of these boys came from seaports such as Chatham, Portsmouth, and Plymouth, where smallpox was probably endemic and therefore a disease of young children. (See Razzell, *Conquest of smallpox*, p. 114.) In any event, the majority of boys came from London itself, where most children had contracted the disease before the age of seven.

[12] Voth and Leunig, 'Did smallpox reduce height?', p. 557, n. 74. See also Razzell, *Conquest of smallpox*, p. 148.

[13] Voth and Leunig, 'Did smallpox reduce height?', p. 557.

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smallpox was probably always a childhood disease in London; the weight of evidence is that smallpox in childhood was just as fatal as it was in adulthood; and smallpox probably increased sharply in virulence during the eighteenth and nineteenth centuries.

To support their argument that smallpox was less fatal in childhood than in adulthood, the authors quote figures from my work on case fatality by age for Aynho in Northamptonshire,[14] based on a sample of 132 cases. I present two other tables on the same and an adjacent page, one for Berlin for the period 1865-74 and the other for London for 1870-83, the Berlin table covering 6,123 cases, and the London one 2,159.[15] Both these tables show that smallpox fatality was higher for children under the age of 10 than for any other age group, with the London figures indicating that smallpox fatality was particularly high for children under the age of three—a case fatality rate of 66.0 per cent, compared with 43.0 per cent for adults over the age of 40.[16] This higher level of smallpox fatality is consistent with a general pattern of greater vulnerability of infants and young children to infectious diseases.

There is also no evidence for the reduction in the virulence of smallpox during the period under discussion. On the contrary, the average case fatality of smallpox increased steadily throughout the eighteenth and nineteenth centuries, probably peaking at the end of the nineteenth century. When the Royal Society conducted censuses of smallpox epidemics in the 1720s, it found that the average case fatality rate of 32 epidemics in different parts of the country was 16.5 per cent.[17] According to a series of local censuses, this rate climbed steadily to over 40 per cent by the early 1890s,[18] providing evidence for McVail's conclusion that 'natural smallpox gradually became throughout the eighteenth century, and up to the epidemic of 1870-73, a more virulent and fatal disease, its maximum fatality being on a large basis of facts 45 per cent'.[19]

Average case-fatality rates do not, of course, simply reflect levels of virulence. They are also strongly influenced by age and, probably to some extent, by environmental conditions. However, the scale of change in average case fatality—nearly trebling in 150 years—indicates that there was a marked increase in virulence. Literary evidence also supports this conclusion; for example, Lettsom, writing in 1805, stated that 'the malignity [of smallpox] even in London is augmenting. When I practised here, 35 years ago, one in ten was the calculation, but I think one in six is now a fair proportion.'[20] This increase in the virulence of smallpox is consistent with what is known about the nature of the virus: the more virulent the strain the more infectious the disease,[21] and with the develop-

[14] Ibid., p. 556; Razzell, *Conquest of smallpox*, p. 126.
[15] Razzell, *Conquest of smallpox*, pp. 126, 127.
[16] Ibid., p. 127.
[17] Ibid., p. 131.
[18] Ibid., p. 133.
[19] Ibid., p. 127.
[20] Ibid., p. 135.
[21] Ibid., pp. 34, 35.

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ment of world trade, more virulent strains were probably imported from India, China, and elsewhere.

There is therefore a fundamental inconsistency between the pattern of smallpox incidence as presented by Voth and Leunig, and the known facts about changing smallpox mortality and case-fatality rates. The latter two factors indicate that in London smallpox was a universal disease of childhood increasing in virulence, not consistent with a sharp rise in incidence in the 1750s and a sudden disappearance in the 1820s. That pattern is also not consistent with what is known about the impact of inoculation and vaccination on smallpox mortality, but this will be discussed later.

II

In the light of this major contradiction, the original registers of the Marine Society deposited in the National Maritime Museum were re-examined. Only limited details of these registers are provided by Floud, Wachter and Gregory, and Voth and Leunig do not give any additional informtion making exact identification possible. However, they state that the dataset refers to the period 1770-1873, and there are two types of register with information on height and smallpox for this period, the 'Registers of boys entered as servants in the king's navy' and the 'Register of apprentices sent to merchant ships'. The first type starts in 1770 and ends in 1873, whereas the second begins in 1772 and finishes in 1835.[22] From these dates it is likely that the dataset analysed by Voth and Leunig is based on the first series—the royal navy registers—although there is some information in the merchant navy registers which might also have been used.

The royal navy registers give information on height and smallpox between 1770 and 1844, although, as we will see later, the quality of registration deteriorates sharply in the early 1840s. The merchant navy registers ostensibly give information on height and smallpox between 1772 and 1831. However, the pattern of registration is complex, and it is necessary to describe in detail the information recorded and how it changed over time.

The royal navy register starts on 25 September 1770, and initially there is no information recorded on smallpox. Then on 31 October (case number 170) a letter 'P' (= pox) appears in the column headed 'Reads Or Writes', which from 14 December includes the word 'Spox'. This composite heading of 'Reads Or Writes/Spox' is included from this date (14 December 1770) until 27 November 1844, which is the end of register no. 14. For the final register (no. 15), which runs from 1844 to 1873, the composite heading is replaced by the printed heading 'Reads Or Writes', and smallpox is no longer mentioned either in the heading or in the text of the register itself. It should be emphasized that 'no smallpox'

[22] See National Maritime Museum Library, Greenwich, documents MSY/O/1-15 and MSY/Q/1-6.

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is a residual category, in that it is the absence of a marking for smallpox (the letter 'P') that is the basis of the coding for this category.

In the first royal navy register a total of 638 boys are entered between 31 October 1770 and 17 April 1772, of whom 610 are listed as having had smallpox, i.e. have the letter 'P' entered against their name, giving a total of 95.6 per cent. Most of the 28 boys not listed as having had smallpox are to be found right at the beginning of this sequence (25 in the first 100 cases), and it is possible that this was due to poor registration before the system became fully established.

The second register in the royal navy series runs from 15 August 1772 to 2 February 1778, although there are no cases recorded during the year 1774, probably a result of an interruption in the operations of the Marine Society. This second register covers a total of 1,578 boys, of whom 1,414 (89.6 per cent) are listed with the letter 'P' against their names. But again, it is likely that the absence of smallpox was the result of poor registration, since most missing cases occur on blank column pages with no information on reading, writing, or smallpox. This suggests that the registration clerk simply omitted information on these pages, presumably out of negligence.

From 1778 through to 1824 (11 further registers in the royal navy series) virtually all boys (98 per cent and above) are marked as having had smallpox and the small minority of cases without smallpox are frequently on blank column pages. In register 14, which begins in 1824, there are only 18 boys without smallpox in the first 1,351 cases, but then there is a sharp deterioration in the quality of registration, with many blank column pages, and 80 of 341 cases between 29 August 1838 and 28 March 1841 are listed as without smallpox. From 28 August 1841, registration almost completely collapses, with only 3 cases out of a total of 324 listed as having had smallpox. The register at this time mirrors registration in the initial period in 1772: only information on reading and writing is recorded, and the registration of smallpox is abandoned. The final register (no. 15), starting on 27 November 1844, no longer has a column for smallpox, and no further information is given about the disease from that date onwards.

The merchant navy register begins on 3 July 1772, and includes the following two headings: 1. 'When appeared before the Committee—If he has had the Small Pox . . . P—If only supposed to have had it . . . S.' 2. 'When indentured—If has been inoculated by order of the Committee . . . I.' These headings are included in the first five registers in the series running from 1772 to 1831, and then disappear in the sixth and final register, beginning in 1832, although, as we will see, most of these registers in fact contain no information on smallpox.

The first merchant navy register runs from 3 July 1772 to 3 July 1778, and although it has headings for smallpox and inoculation on every page, no information on these topics is recorded in the body of the register. Likewise with the second register in this series, starting on 3 July 1778: the columns headed 'If has had the smallpox' and 'if has been inoculated by order of the committee' are completely blank until 16 November 1780.

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The number of blank cases between the start of the first register in 1772 and the first recorded case of smallpox in November 1780 is 799.

Information is recorded on smallpox in the second merchant navy register running from 16 November 1780 to 21 December 1787, with a total of 404 cases, of which 51 are listed as without smallpox. Nearly all these are on pages with complete blank columns and there is no mention of inoculation in the adjacent column—suggesting that many of those without smallpox are the result of under-registration. From 21 December 1787 there is no further information on smallpox, and although the headings on smallpox and inoculation are retained in the fifth register in the series, ending on 6 June 1831, there are no entries on smallpox in the text of the registers. Finally, the headings on smallpox and inoculation are dropped from the sixth register which starts on 23 February 1832, and there is no further mention of smallpox in the text of the register.

Voth and Leunig place a special emphasis in their analysis of smallpox and height on the two recruitment periods 1770-5 and 1820-40, and this is because these are the only two periods in their data where there are 'those with smallpox, and those without'.[23] In all other periods nearly 100 per cent of boys had had smallpox, and were therefore not suitable for analysis. However, when we compare the figures for smallpox incidence supplied by Voth and Leunig with those revealed by the original registers there is a fundamental inconsistency. Although they do not quote exact figures, from their figure 6 it would appear that approximately 60 per cent of boys recruited in both 1770-5 and 1820-40 had had smallpox. According to the first register in the royal navy series 95.6 per cent of boys recruited in 1770-2 had experienced smallpox—and this is a minimum figure because of the under-registration discussed earlier. The second register in this series covers the period 15 August 1774 to 2 February 1778, largely outside the 1770-5 period, and this indicates a figure of 89.6 per cent, but with an even greater degree of under-registration. The first merchant navy register starts in 1772 and runs through to 1778, but although there is a heading for smallpox, no cases are recorded in that register.

In the second period, 1820-40, there is again a basic contradiction between Voth and Leunig's figures and those revealed by the original registers. The royal navy series indicates a minimum smallpox incidence of 98 per cent up to 1824. From 29 March 1824 to 29 August 1838, there were 1,351 boys registered, of whom 1,333 (98.7 per cent) had experienced smallpox. From 29 August 1838 to 28 March 1841, 261 of 341 boys (76.5 per cent) had had smallpox—near to the estimated 60 per cent figure from Voth and Leunig's figure. However, most of the cases without smallpox are on blank column pages and therefore are almost certainly the result of under-registration.

[23] Voth and Leunig, 'Did smallpox reduce height?', p. 556.

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III

How do we account for the discrepancies between Voth and Leunig's data and information revealed by a re-analysis of the original registers? First, the former material is based on samples and therefore not strictly comparable to data from the complete set of registers, but the discrepancies are so great as not to be consistent with this explanation. A complete explanation will only be possible by comparing the ESRC computerized dataset with the original registers, but the most likely reason for the discrepancy lies in coding procedures. Many of the blank column page entries—probably all of the first 169 cases in the royal navy register for 1770 and possibly the whole of the first merchant navy register for 1772-8—may have been coded as 'no smallpox', simply because there was an absence of positively coded smallpox entries. The great majority of Voth and Leunig's 'no smallpox' cases in the 1770s consist of entries on blank column pages, with an absence of all information on reading, writing, and smallpox. In the later period of the 1840s, most of the 'no smallpox' cases are probably the result of the abandonment of smallpox registration in 1841. This is indicated by the zero level of smallpox incidence in Voth and Leunig's birth period 1830-59—a period when the incidence of the disease was no longer being registered by the Marine Society. Voth and Leunig make no reference to the original registers and it is likely that they worked only with the computerized dataset; this would explain why they were unfamiliar with the registration problems of the original source material.

The question arises as to whether there is any reliable information in the Marine Society registers which could be used for the analysis of smallpox and height. In the royal navy register before 1841, genuine cases of 'no smallpox' can possibly be recognized by their occurrence in individual entries with information on reading or writing. However, of 24,057 cases registered between 25 September 1770 and 31 August 1841, only 29 fell into this category. To analyse this small sample, these 29 cases were matched with ones immediately following which had identical information on reading and writing, but mentioned smallpox. The total height of the 29 boys in both groups was almost exactly equal—132.9 feet (average 54.99 inches) in the 'no smallpox' sample and 132.5 feet (average 54.82 inches) in the smallpox one. As the mean age of the two groups was almost identical, this would tentatively suggest that smallpox had no impact on average height.

There is one remaining major problem yet to be considered. Given the decline of smallpox mortality in London charted by Landers and by Razzell, why did the incidence of smallpox continue at such a high (almost 100 per cent) level until the late 1830s? The probable explanation is one referred to by Voth and Leunig in their footnote 30. In the eighteenth and nineteenth centuries, contemporaries viewed inoculation as a type of smallpox, believing it was just another form of the disease. The Marine Society was interested in the practical question of whether boys were vulnerable to smallpox when it sent them to royal navy or

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merchant navy ships, which is why it asked them whether they had previously had smallpox,[24] either in its natural or inoculated form—both preventatives against future attacks of the disease. It is also presumably for this reason that the society was concerned about inoculating boys who had not previously had smallpox, either naturally or by inoculation. Therefore the category 'has had the smallpox' would include boys who had smallpox both in its natural and inoculated forms. This is indirectly confirmed by the royal navy registers from 1822 onwards: a capital letter 'V' is sometimes marked in the smallpox column, presumably referring to vaccination as a surrogate for inoculation.

Inoculation became popular in London from the middle of the 1770s and after the beginning of the nineteenth century was practised widely, along with vaccination.[25] This explains why mortality from smallpox fell during this period, in spite of a severe increase in virulence. This is a further reason why Voth and Leunig's statistics of smallpox incidence are so implausible: they are not consistent with the history of inoculation and vaccination, both known to be effective in preventing smallpox.

IV

If the arguments of this comment are correct, what are the lessons to be learnt from the misinterpretation of the Marine Society's registers? If the basic problem derives from Voth and Leunig's exclusive reliance on the ESRC computerized dataset, it will provide a salutary lesson for economic history. No amount of sophisticated statistical analysis will supply a substitute for careful study of original sources. Because the new economic history is able to analyse data at a very sophisticated and abstract level, including computer modelling, there is a danger that insufficient attention will be paid to the reliability of the raw material on which such studies are based. The neglect of detailed empirical research on source material will inevitably lead to the problems associated with the study of the Marine Society registers. An example of this is the use of parish registers, which have formed the basis of much complex and sophisticated historical demographic work—registers which have not been properly evaluated through detailed empirical research.[26] Perhaps Voth and Leunig have provided the new economic history with an invaluable lesson—there is no substitute for the scrupulous study of original source material.

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[24] Hanway, writing an account of the Marine Society in 1770, stated that 'if any have not had the small pox, with their consent they are ordered to be inoculated': Hanway, *Marine Society*, p. 26.

[25] Razzell, *Conquest of smallpox*, pp. 71-3.

[26] See *idem*, *English population history*, pp. 173-216. Parish registers can be evaluated through the empirical method of 'triangulation', involving the comparison of registers with wills, poor law records, local censuses, apprentice indentures, newspaper reports, and other relevant documentary material. This process of nominal record linkage is a much more reliable method of assessing the quality of parish registers than abstract and general statistical analysis of parish register data.

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Footnote references

Collins, G. W., *St Pancras: vaccination and the smallpox epidemic of 1884* (pamphlet in the Office of National Statistics Library, London).
Creighton, C., *A history of epidemics in Britain*, vol. 2 (Cambridge, 1894).
Floud, R. C., Wachter, K. W., and Gregory, A., *Height, health and history: nutritional status in the United Kingdom, 1750-1980* (Cambridge, 1990).
Hanway, J., *The origin, progress and present state of the Marine Society* (1770).
Landers, J., *Death and the metropolis: studies in the demographic history of London* (Cambridge, 1993).
Razzell, P., *The conquest of smallpox* (Firle, 1977).
Razzell, P., *Essays in English population history* (1994).
Voth, H. J. and Leunig, T., 'Did smallpox reduce height? Stature and the standard of living in London, 1770-1873', *Econ. Hist. Rev.*, XLIX (1996), pp. 541-60.

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