White Poison? The Social Consequences of Milk Consumption, 1850-1930

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SUMMARY. This paper seeks to adduce evidence on the social consequences of milk consumption in the period 1850-1930. It is shown that the poor quality of supply partly resulted from the nature of the marketing system, with adulteration and the use of chemical preservatives as other factors. Local authority regulation and central government legislation were very slow in controlling the cleanliness of production and sale. Milk was heavily contaminated with bacteria and was responsible for spreading a variety of diseases such as scarlet fever and tuberculosis. Infants not wholly breastfed were particularly vulnerable to diarrhoeal infections. Improvements such as pasteurization and bottling were slow to spread and are unlikely to have had much impact before the 1920s. Overall it is argued that ill-health caused by dirty milk was more serious, and its amelioration much later than previously documented.

KEYWORDS: bovine tuberculosis, breast feeding, diarrhoea, infant mortality, milk, London, pasteurization, scarlet fever.

Over the last 20 years or so nutrition has played an important if controversial part in the history of medicine.[1] The work of Thomas McKeown in particular has come to be associated with the view that a substantial proportion of the very significant fall in death rates in the nineteenth and early twentieth centuries was primarily the result of better nutrition, with a lesser contribution from improved sanitation and hygiene.[2] Medical intervention was relegated to a minor role. On the subject of milk McKeown found support in a paper by Beaver, which claimed that cleaner milk supplies were the main reason for reductions in infant mortality after 1900.[3] The forceful arguments of these writers have been a mixed blessing. There has been pedagogic value in their determination to alert us to the importance of nutrition in raising the health status of the population, but the effect of their crude arguments, at times in the case of McKeown bordering on the deterministic, has been to prompt a reaction which, if left unchecked, may veer too far in another direction.

The present author believes that food did indeed play a significant role, both positive and negative, in public health, but cannot identify with McKeown's dubious methodology of argument by exclusion. The simple aim of this paper is to present some data on milk which seem to suggest that the McKeown-Beaver hypothesis of nutrition's positive contribution to health oversimplifies a very complex web of forces. Improvements in milk quality before the First World War were limited and the data are consistent with a hypothesis that milk may have contributed substantially to the toll of foodrelated morbidity and mortality. The paper can, however, be no more than a preliminary step on a path of research which will require much detailed local archival work. Our current knowledge of variations in time and space of consumption patterns and their social consequences is at best fragmentary.

1850 has been chosen as a commencement date because of the local authority intervention in conditions of production which began in the City of London. By 193O the central state was fully involved. Most of the evidence cited starts in the later decades of the nineteenth century because of a delay in public and scientific awareness of the potential medical impact of milk.

I

London's milk trade was radically transformed in the nineteenth century from a small-scale, localized system to one with nationwide connections. This presented dairymen with a test of their ingenuity. For the last forty years of the century they struggled to assemble an industry capable of meeting the unique requirement of making daily deliveries of small quantities of a bulky, perishable liquid to a vast number of customers. Arguably they failed, with rapidly expanding urban demand running ahead of appropriate organizational structures. The sheer scale and intricate nature of that evolving system defeated traders and local authority regulators alike, with unfortunate, and at times tragic, results for public health.

Under the primitive technological conditions of the mid-nineteenth century, liquid milk, in order to be fresh on delivery, had to be produced in cowsheds actually in the large urban areas and their immediate suburbs, close to its market. In London the peak of this urban regime was reached in the 1850s and 1860s.[4] After that town milk gradually became too costly to produce. In the overcrowded cowsheds there was an expensive toll from endemic cattle diseases such as pleuro-pneumonia, and occasional epidemics of rinderpest and foot and mouth. To this was added the cost of meeting the sanitary requirements of the local authorities, starting with John Simon's 1853 rules in the City and gradually spreading throughout London.[5]

From the human health point of view one can readily appreciate the desire of urban administrators to be rid of the cowkeepers. The environmental hazard of the quarter of a million tonnes of manure produced by London's cows each year in the early 1860s was sufficient to make them the object of universal obloquy.[6] On the other hand London's producers were closely regulated in the last three decades of the century and their milk is therefore less likely to have been contaminated with dirt and disease than the output of their unregulated rural colleagues. Town milk was also fresher.

The competitive edge of rural comparative advantage was facilitated through the supply of milk by railway.[7] This started in a small way in London in the 1840s and grew rapidly in the 1860s and 1870s. The simple availability of rail transport was not enough to encourage dairy farmers to switch from their traditional butter or cheese manufacture. It was necessary first to arrange for the appropriate rolling stock and timetable adjustments, with urban-based wholesalers facilitating the. co-ordination and receiving the milk at specially designed platform facilities at the London termini.[8] Even then it took a depression in dairy product prices to make liquid milk sales attractive.[9]

This lengthening of distance between producer and consumer meant significant delays in delivery. To an average four to five hour rail journey to London was added the time

needed by the wholesaler to supply the trade, and the retailers to supply their customers.[10] Milk was then stored in the home before consumption. From cowshed to teacup could take over 24 hours, more than enough time in hot weather for the multiplication of pathogens.

Traders were at a loss to know how to cope with this logistical problem. The Lawrence refrigerator, a device which cooled milk to the temperature of the available water supply, was introduced in 1872 but took decades to become widely used. Another innovation of the 1870s was the addition to milk of chemical preservatives. These were popular and became one of the shaky foundations on which the system was built in the last twenty years of the century. Preservatives were dangerous for two reasons. Firstly, they inhibited the souring process but did not kill harmful bacteria, with the result that consumers wrongly thought that they were buying fresh milk. Secondly, the large doses of boracic acid, added sometimes at several points in the chain, were toxic in themselves.

Another trade response was to market tinned, condensed milks. These were first introduced on a commercial scale in the 1870s. The full cream variety was outsold in the 1880s by a sweetened 'machine skimmed' condensed milk which became popular because of its cheapness and keeping qualities. By 1892 all types of condensed milk accounted for 11.6 per cent of London's milk consumption, and a decade later there were 140 brands on the market, many imported. The Sale of Food and Drugs Act of 1899 insisted that tins containing the machine skimmed product should be clearly labelled as such, but it was not only illiterate mothers who remained unaware of the nutritional implications of using it as a food staple for their babies. Coutts found that 'in certain districts a really considerable proportion of babies are fed almost exclusively on this diet'.[11]

Some of the milk trade's solutions to the perishability problem seem then to have caused danger to health, and traders were unwilling or unable themselves to address the issue of clean production and handling. There was extensive public debate on the issue of pure milk, especially from the 1890s, but most of the radical suggestions came from outside the milk industry. Leslie Mackenzie, for instance, suggested the 'municipalisation' or public ownership of the milk supply, thereby eliminating the chains of middlemen who were thought to introduce delays and administrative inefficiency, leading to higher prices, and also abolishing the worst excesses of misleading advertising and fraud.[12]

The Nuisance Removals Acts had proved ineffective in controlling conditions of production, and were replaced by the Dairies, Cowsheds and Milkshops Orders in 1879, with amendments in 1885.[13] Implementation was left to local endeavour and, typically of this period, there was therefore a wide disparity of date between local authorities as to when they issued their own rules under the Orders.[14]

In London the Metropolitan Board of Works made regulations in 1862, 1879, and 1885. Sanitary Inspectors were encouraged to insist upon improvements in the amenities and even the structure of cowsheds in their various areas, and were at liberty to advise local magistrates against the renewal of the obligatory licence. These requirements added significantly to the costs of urban producers and almost certainly contributed to a decline

in their numbers in the last quarter of the century. Ironically, the choking off of this urban source increased the proportion of milk which came from less well regulated, rural cowsheds, such as those described in Cheshire by Vacher:

> The accommodation in shippens provided for cows, even in first class farms, rarely exceeds 400 cubic feet of air space per head, and often less than this [the Local Government Board recommended 800 cubic feet per animal]. In many districts no regulations have been made under the Dairies, Cowsheds and Milkshops Order; and without regulations it is impossible to ensure that the premises, cattle, and milk are kept clean.[15]

In 1907 a quarter of Rural District Councils had not made regulations under an Order by then over 20 years old (Table 1) and still more found them unenforceable.[16] Even the RDCs who complied were disadvantaged by comparison with the larger cities, which had greater resources to appoint inspectors. In consequence there emerged in the last two decades of the nineteenth century a discrepancy between the dwindling number of relatively well regulated urban cowsheds and a rapidly expanding number of rural producers who were subjected to weak constraints, or to none at all. The frustrated urban authorities had no right to inspect or influence their country suppliers, but their officials were well aware of the problem:

> Not long since the Medical Officer of Health [of Islington], being in the country within three miles of London, was invited by a farmer to inspect his cows. . . .He was taken to the cowshed, which to his horror he found to be at least three to four inches deep with filth, while the walls were splashed all over with cow dung and the flanks and teats of the cows themsleves were in an abominable state. Under these circumstances he contented himself with viewing the animals from the door of the byre.[17]

Table 1: The number of local authorities outside London which had made regulations under the Dairies, Cowsheds, and Milkshops Orders by April 1907

	Total	% with regulations
Borough Councils	326	88.96
Urban District Councils	810	84.44
Rural District Councils	658	74.92
	1,794	81.80

Source: Return Showing the Names of Borough and Urban and Rural Districts who have made Regulations under the Dairies, Cowsheds, and Milkshops Order of 1885, and the Number of each Class who have not made any such Regulations, (P.P.,1907, lxvii, 383-91).

This unsatisfactory state of sanitation at the point of production was emphasized by Mrs A. Watt-Smyth in her evidence to the Physical Deterioration Committee. 'The farms are in such a filthy condition that milk when it leaves the farm is already poisonous. I have been over many farms, and the conclusion one must come to is that at the bottom of the whole question is the filth of the farms.'[18]

II

Much milk production was insanitary. In St Pancras the bacteriological examination of 50 samples of milk in 1899 showed that only 32 per cent could be described as 'normal'. Of the rest, six per cent were 'dirty', 16 per cent contained an excess of microbes, 12 per cent were contaminated with leucocytes, 24 per cent had traces of pus, and in 10 per cent were found tubercle bacilli.[19] In Finsbury 32 per cent of milk contained pus from diseased udders.[20]

The commonest causes of contamination on the farm were reckoned to be:
1. Dirt falling into the open pail during milking;
2. The use of unsterilized milk pails, coolers, and churns;
3. Straining a large amount of milk through just one strainer;
4. The admixture of fresh milk with stale.[21]

Of 75 milk producers surveyed in Yorkshire, none ever washed their cows' udders.[22] In addition there were bacteria introduced in unsterilized milk vessels, from milk pails to cooling apparatus. Few dairy farmers even recognized that there was a problem. In the words of one wag quoted by Dodd: 'If the Almighty had intended that there should be no manure in the milk, he would have placed the udder at the other end of the cow'.[23] Producers resented the additional time and cost of producing clean milk, and few volunteered to improve matters until compelled.

Professor Delepine's research illustrated this hazard, although a declining one, for Manchester in the decade 1896-1906 (Table 2). In 1896 he estimated that Manchester annually received 26 tons of 'slime' in its milk supply, a gruesome cargo which was halved by 1906. He attributed the improvement to Manchester Corporation's regulatory 'Milk Clauses' (1899).

Table 2: Sediment in Manchester's milk supply, 1896-1906 (Classes by mm of sediment separated by centrifuge. n=3,650)

		Clean		Doubtful	Dirty
		0-6	7-8	9-10	>10
	Samples	%	%	%	%
1896-1900	454	4.2	35.3	48.0	12.5
1901-2	861	21.6	37.7	32.6	8.1
1903-4	857	19.1	34.5	38.0	8.4
1905	764	24.9	36.2	31.6	7.3
1906	704	26.3	42.0	26.7	5.0

Source: S. Delepine, 'Report on Investigations in the Public Health Laboratory of the University of Manchester upon the Prevalence and Sources of the Tubercle Bacillus in Cows' Milk', Appendix B5 in Medical Officer of Health to the Local Government Board, Annual Report for 1908-9 (P.P.,1909, xxviii).

Producers were by no means the only culprits, however.[24] For Dodd the means of distribution were as bad as those of production, and these certainly presented several new opportunities for contamination.[25] In 1908, for instance, Orr reported that over seventy

per cent of the cans used for transport were of a type that admitted dirt and dust.[26] Refrigerated waggons were rarely used in the railway or road transport of milk before the First World War, and the long journey to the city increased the risk of deterioration.

Adulteration and 'toning' were very common. Farmers, wholesale dealers and retailers all boosted their profits by adding water and extracting cream, but few bothered about the cleanliness of'the cow with the iron tail'.[27] Table 3 shows 'purveyors' (small general shopkeepers and itinerant vendors) to have been particularly prone to selling highly contaminated milk.[28] Added, dirty water was one problem, and another was poor storage conditions.[29] Newman found that all of the 221 milk shops inspected in the Metropolitan Borough of Finsbury had one or more sanitary defects, including seventy-three per cent which had no cover for their counter pan.[30] Sykes noted that 'it is very difficult to get the keepers of small general shops to use any precaution to protect milk from contamination'.[31]

Table 3: Sediment in London's milk supply, 1904/5
(classes in parts per million by volume, measured by centrifuge)

	Samples	0-24	25-49	50-74	75-99	100-149	>150
Cows	20	100	-	-	-	-	-
Rail stations	20	45	35	15	5	-	-
Wholesalers	20	60	35	5	-	-	-
Dairy shops	20	40	40	10	-	-	-
Purveyors	20	40	25	15	5	5	10

Note: Houston regarded 50ppm as the upper limit for clean milk. A.C. Houston, A Report on Milk Contamination (London, 1908). Orr preferred a standard of 30-40ppm. T. Orr, Report on an Investigation.
Source: A.C. Houston, Report on the Bacteriological Examination of Milk (London, 1905), p.17.

In St Pancras a survey of 389 shops registered to sell milk showed that 52 per cent sold less than two gallons daily, of which 63 per cent were 'general' shops.[32] Of these general shops, half had floors that were not kept properly clean, and three-quarters did not have covered milk vessels. In Lambeth 47 per cent of retail milk outlets had sanitary defects and the bacteriological count was especially bad in 'poor class' shops (Table 4).[33]

These small purveyors were concentrated in poor areas, and it was also here that the risk of domestic contamination of milk was highest. Working class housing was rarely provided with facilities for the hygienic preparation or storage of food.[34] By contrast, those able to pay a premium could buy a better quality of milk from large concerns such as the Aylesbury Dairy Company, which by the turn of the century had imposed its own standards of cleanliness upon its suppliers and was profiting from an increasingly segmented market, a portion of which demanded extra rich milk from Channel Island cows or the supposedly safe 'nursery milk'.[35]

Table 4: The contamination of milk retailed in London, 1903-4
(Million bacteria per cubic centimetre of milk sampled)

	Good class shop	*Poor class shop*	*Street vendors*
Lambeth			
Inner wards	1.9	4.7	5.2
Outer wards	1.7	4.2	3.2
Finsbury	1.8	2.1	–
City of London	4.8	–	–
Islington	1.6	–	–
Westminster	1.6	–	–
Holborn	4.8	–	–

Note: "Good" milk was thought to contain 0.05-0.5 million bacteria per cc. Dodd, 'Municipal milk', p.11.
Sources: Newman, Report on the Milk Supply, p.40; Medical Officer of Health to the Metropolitan Borough of Lambeth, Annual Report (1904).

So far we have equated 'dirty' milk with an excessive sediment load or a general contamination with 'bacteria',[36] but stronger evidence of disease generating organisms is required to support a hypothesis that milk was a vector of specific infection. Tables 5 and 6 present some preliminary data of this nature, showing that the faecal bacteria enteropathogenic Escherichia coli (EPEC, formerly known as Bacterium coli communis) were present in large numbers in the supplies of Liverpool and London. E. coli are thought to play a major role in infantile diarrhoea, a theme we will pick up again in section IV.

Table 5: E. coli in Liverpool milk

	country milk by rail		*town produced milk*		*milk supplied to hospitals*	
	samples	*E. coli percentage*	*samples*	*E. coli percentage*	*samples*	*E. coli percentage*
1900	245	16.3	255	5.9	60	11.7
1901	246	72.4	254	43.5	66	65.1
1902	297	87.8	213	21.6	85	69.4

Source: Swithinbank and Newman, The Bacteriology of Milk.

Table 6: Bacterium coli in London milk

		Neg.	Positive results (%)						
	Samples	10cc	10cc	1cc	0.1cc	0.01cc	0.001cc	0.0001cc	0.00001cc
Cows	20	30	40	25	5	-	-	-	-
Rail stations	20	-	5	35	45	-	-	-	-
Wholesalers	20	-	-	20	15	40	20	5	-
Dairy shops	20	-	-	-	15	35	25	15	10
Purveyors	20	-	-	-	20	20	25	25	10

Source: Houston, Report on the Bacteriological Examination, p.17.

III

Fresh milk is an ideal medium for the growth of micro-organisms, containing all of the essential nutrients. This makes it potentially a key means of disease transmission. Viruses and bacteria such as Mycobacterium tuberculosis and brucella do not multiply in milk, however, and their infective power therefore depends upon the original load.[37] Table 7 lists a selection of milk transmissible diseases.[38]

Table 8: Diseases which can be caught from contaminated milk

Viral: Adenoviruses; enteroviruses (including polio); foot and mouth; infectious hepatitis.
Rickettsial: Q fever.
Bacterial: Anthrax; botulism; brucellosis; cholera; coli infections; diphtheria; enteritis; leptospirosis; listeriosis; paratyphoid fever; salmonellosis; shigellosis (dysentery); staphylococcal gastroenteritis; scarlet fever (streptococcosis or septic sore throat)); tuberculosis; typhoid fever.
Protozoal: Amoebiasis; balantidiasis; giardiasis; toxoplasmosis.
Helminths: Enterobiasis; taeniasis.
Other: Toxicoses from preservatives.

Source: Kaplan, 'Diseases Transmitted through Milk', p.15.

Before 1857 it was not fully appreciated that milk might be responsible for the conveyance of infectious disease. In that year Dr Michael Taylor, medical officer of health at Penrith, published the results of his investigations into an outbreak of typhoid, which he attributed to milk infected from a human subject.[39] This he followed with an analysis of an epidemic of scarlet fever (scarlatina) which in 1867 had affected fifteen people supplied by a single cowkeeper with a diseased child.[40] At the same time two other pioneers recognized the importance of milk in the spread of germs. In 1870 Dr Bell, Professor of Medicine at the University of St Andrews, attributed 26 cases of scarlet fever to milk drawn by infected milkers, and in the same year Dr E. Ballard, medical officer of health for Islington, found that all of the sufferers in a localized outbreak of typhoid in Holloway had consumed the milk of a single dairy.[41] By no means everyone accepted a 'contagionist' interpretation, however, many clinging stubbornly to the 'miasmic' theory of disease transmission, at least until the work of Pasteur and other

microbiologists came to be accepted. By 1903, the date of publication of Swithinbank and Newman's textbook on the Bacteriology of Milk, the case was proven, although the precise mechanism of diseases such as scarlet fever was not fully understood until the 1930s. In 1904 Newman reported that 160 outbreaks of typhoid in Britain, 70 of scarlet fever, and a few of diphtheria had been attributed to milk, and there were at least another 99 between 1912 and 1937.[42]

> One of the remarkable features of the outbreak [in Holloway] was that, with few exceptions, the persons who suffered were not of the class among whom fevers are most commonly observed, but were persons in very comfortable positions in society, attended by private medical men, and residing in some of the best houses in the parish.[43]

This was the first characteristic of milk-borne epidemics, that middle class families were often hardest hit, because they consumed more milk than other sections of society. Secondly, outbreaks were spatially localized to the delivery round of one dairy. Thirdly, the clinical effects were unusual. The incubation period was shorter, with sudden, explosive outbreaks which also declined rapidly, and the attacks tended to be mild, with a lower rate of mortality than normal.[44] Secondary infection was uncommon.

Of these various potentially milk-borne diseases, tuberculosis caused the greatest concern throughout the nineteenth century. It was the single greatest cause of death and disability.[45] In 1882 Koch announced that the tubercle bacillus was the causative agent but three decades of scientific investigation and argument elapsed before it was generally accepted that the bovine strain was both transmissible to humans and a threat to their health.

There are no reliable estimates of milk related morbidity and mortality for the nineteenth century.[46] Griffith and Munro found that 1.9 per cent of the 3,874 human biopsy/autopsy examinations carried out in England and Wales in the 1920s and 1930s showed signs of bovine infection, a figure which increased to 5.7 per cent of 2,769 cases in Scotland.[47] It seems likely that these proportions would have been higher before the introduction of a compulsory slaughter policy in 1925. There is more than a hint of this danger in the disturbingly high proportion of London's milk found to contain bacilli by London County Council inspectors (Table 8).

Table 8: Tuberculosis in London's milk, 1908-18

	Milk samples	*TB milk percentage*	*TB udders percentage*
1908	620	11.6	2.4
1909	2531	9.7	1.7
1910	2766	10.7	0.9
1911	3038	10.4	0.6
1912	2991	8.3	0.5
1913	2900	10.0	0.3
1914	2925	7.9	0.8
1915	–	–	–
1916	–	8.7	–
1917	–	10.3	–
1918	–	7.4	–

Source: London County Council, Annual Reports; Savage, The Prevention of Human Tuberculosis, p.49.

IV

As many of the infectious diseases of childhood came under control in the late nineteenth century, contrary to general trends infantile diarrhoea was actually increasing its incidence in the 1890s (Table 9), becoming a principal cause of morbidity and mortality in the first year of life. There were problems of diagnosis and definition, with a variety of conditions lumped under the syndrome of 'infantile diarrhoea', including enteritis, infective enteritis, gastro-enteritis, dysentery, 'English cholera', dyspepsia, gastric catarrh, and other diseases of the stomach and bowel. The attribution of causality was also a puzzle: the early weight of opinion suspected poor sanitation and gaseous effusions from ill-drained soil, but later there was a shift to the notion of airborne and foodborne infection.[48] As early as 1871 Dr Selby Norton argued that milk was likely to be a key factor, suggesting that ninety per cent of infantile diseases arose from neglect of proper precautions in its preparation.[49] Later Dodd spoke for many others when he confidently asserted that 'the milk supply is the main cause of this waste of [infant] life'.[50] The 1890s saw a number of papers in medical and public health journals identifying milk as a culprit, a suspicion which was widely canvassed as a certainty in the 1900s.

Table 9: Mortality from infantile diarrhoea in England and Wales, 1871/5-1916/20
(deaths under 1 year per 1,000 live births)

	all causes	*percentage of diarrhoea*
1871–5	153	12.42
1876–80	145	11.03
1881–5	139	10.07
1886–90	145	11.72
1891–5	151	13.25
1896–1900	156	19.87
1901–5	138	16.67
1906–10	117	15.38
1911–15	110	17.27
1916–20	90	10.00

Source: Annual Reports of the Registrar General

Not all contemporaries shared this view. While not dismissing milk as a factor, some preferred the eschew monocausal explanations of what increasingly was seen as a complex phenomenon. The series of official reports on infant mortality for the Medical Officer of the Local Government Board relegated milk to a minor role.[51]

One aspect of infant mortality which intrigued commentators was its very peaked seasonal distribution, dominated by 'summer diarrhoea'.[52] Newman interpreted the summer incidence in terms of the effect of air temperature upon bacterial growth and the breeding of flies.[53] Delepine blamed the contamination of milk at the point of production, but Newsholme saw the domestic setting, and particularly poor storage facilities, as crucial.[54] The latter claimed in his memoirs that his theory had prevailed, conveniently forgetting that by the 1930s cowsheds were better regulated and that pasteurization had become widespread.[55]

This issue has been re-examined recently by several authors, many of whom have been sceptical that cows' milk had much impact.[56] Woods, Watterson, and Woodward in their exhaustive study, for instance, model the infant mortality decline in the period 1861—1921 in the light of a wide range of variables. Breastfeeding remained high, they argue, and the health of weaned infants and small children was affected far more by poverty, the mother's education and employment outside the home, overcrowded housing, sanitary reforms and the fertility decline.[57]

There are, however, several reasons for suspecting that infected milk was strongly linked at least to diarrhoeal deaths, which accounted for 10—20 per cent of infant mortality throughout the period 1871—1920. It seems possible, pace Woods et al., that there was actually a decline in breast-feeding, either in the proportion of women using this method or a shortening of the period of breastfeeding.[58] Ann Roberts claims that 'commercial activity and contemporary comment indicate a steady trend away from breastfeeding throughout this period [1850-1900] in favour of the feeding bottle and artificial foods'.[59]

There will have been regional and social class variations to this trend, but it is clear that medical opinion supported the technical innovation of feeding bottles, the commercial introduction of proprietary farinaceous baby foods, and the increasing retail availability of relatively cheap cows' milk.[60] A massive advertising campaign made mothers aware of alternatives to breastfeeding and gave the impression that artificial foods were superior.[61] Many women with jobs outside the home found breastfeeding inconvenient, and there were others who were so malnourished themselves that their milk was absent or insufficient.[62]

A final conclusion on trends in the prevalence of breastfeeding will have to await the results of research currently being undertaken by Dr Valerie Fildes at the Cambridge Group for the History of Population and Social Structure. Meanwhile we may reflect on data available in the reports of Medical Officers of Health in 21 Local Authorities in the period 1894-1912.[63] These show, in a sample of 69,000 healthy infants, that 74 per cent were breastfed, 12 per cent were fed breast milk and supplements, and 14 per cent were solely artificially fed.[64] The diets of 3,600 dead infants showed the rather different proportions of 33 per cent, 18 per cent and 49 per cent respectively.[65]

Mother's milk contains substances which help protect the child against infection and its premature cessation must have increased the risk of infection. [66] The switch to a greater consumption of 'fresh' cows' milk and condensed milk at the end of the nineteenth century meant a greater convenience for working women, but their offspring may have suffered. The death rate among weaned infants was high, at least double that of those at the breast. Of deaths before the age of one, about half were of babies fully on artificial food, or 57 per cent for deaths from infantile diarrhoea. Woods, Watterson, and Woodward emphasized the high incidence of breatfeeding, but in a paper about infant mortality they curiously underplay the exposure to risk of the substantial minority who were wholly or partly fed artificially. Much of this infantile diarrhoea was probably caused by a group of microorganisms, including Bacterium welchii, Proteus morgani, and EPEC, which may be transmitted to the milk in dirt and dust.[67] E. coli was probably the main culprit, being typically derived from the manure and decaying organic matter associated with dirty milk production.[68]

Domestic contamination will have been important, not only of fresh milk but also the tinned, condensed milks which were introduced from the 1870s onwards. An opened can attracted flies and gave access to dust if not properly stored.[69] The use of condensed milk also had nutritional implications. The skimmed, condensed milk was low in vitamins A, C, and D, and calorie deficient. A child fed mainly on this would have been at risk of rickets, scurvy, and other diseases of malnutrition. Analyses of the food of dead infants in Brighton (1903—5) showed that the proportion on a diet of condensed milk alone was 33 per cent, a ten times higher proportion than for survivors.[70]

Condensed milk had a longer shelf-life than liquid milk. This was an attractive characteristic in hot weather when country milk was sometimes sour. There were other seasonal aspects to the trade which are worth noting. There was often a shortage of milk produced in the grass-based dairying areas when pasturage diminished in high summer,

and this tempted unscrupulous dealers to stretch their supplies with (possibly contaminated) water.[71] The use of preservatives would also have been at its peak in August. We cannot confidently assert that seasonal circumstances in the milk supply were a prime cause of the phenomenon of summer diarrhoea, but they are factors which must be taken into account.

For Woods, Watterson, and Woodward their 'urban-sanitary-diarrhoeal' effect was sufficient to set Britain's pattern of infant mortality in the period roughly 1881-1911 apart from the continental experience.[72] This they attribute to overcrowded and insanitary housing conditions, poor street cleansing and the climatic aberration of a series of hot summers. The urban-sanitarydiarrhoeal effect must have been mediated through some means of infection, perhaps airborne but more likely water/foodborne. It affected artificially fed infants most readily, and milk is therefore likely to have played its part.

V

We now turn to the developments of the early twentieth century and Beaver's widely quoted view that 'the fall in infant mortality was brought about by improvements in the safety of available infant foods'.[73] The argument will hinge on the timing and effectiveness of the innovations discussed.

First among these is the 'infant milk depot' movement, which was supported by a small number of local authorities and charities.[74] The pioneer opened in St Helens in 1899, modelled on the Goutte de Lait of Dr Dufour at Fecamp in Normandy. Others followed in Liverpool, Ashton-under-Lyne, and Dukinfield in 1901, Battersea in 1902, York (The York Health and Housing Association) in 1903, and Finsbury (Finsbury Social Workers' Association) in 1904. Depot organization varied but their common goal was the provision of sterilized or pasteurized milk at subsidized prices. The milk came from inspected and approved farms and was bottled to reduce contamination. Some schemes provided 'humanized' milk, chemically modified cows' milk closer to the formula of human breast milk. The Liverpool project was the largest, providing for 16,000 babies in the early 1900s.

The history of these depots is now well known. In Dwork's view their underlying premise was unsound, based as it was upon transplantation of an idea from a society with a very different tradition of infant feeding.[75] Three of the original thirteen pioneer depots closed before the First World War. They had found their operations costly and difficult to sustain without public funding.[76] As a result the numbers of beneficiaries was tiny against the size of the problem. In addition, the difficulty of guaranteeing a safe supply of milk had persuaded most depots that heat treatment was necessary to kill the bacteria, but the primitive technology of the day unfortunately made the milk less digestible and destroyed some of its valuable constituents. Above all the milk depot was in a sense treating the symptoms rather than the cause. Once off their subsidized milk, children returned to the conditions of poor hygiene and malnourishment which had been at the root of their illness.[77]

Milk for artificial feeding was one of the strongest early thrusts of the infant welfare.movement, but by 1920 it had fallen out of fashion. Lane-Claypon thought its use a fallacy, preferring instead the encouragement of breastfeeding and the education of mothers in child care.[78] The latter had been a feature from the outset in the Finsbury depot, the St Pancras School for Mothers (1907) and the Islington Infant Welfare Centre (1913), and spread after the First Wold War as multi-purpose child welfare centres came to supersede infant milk depots.[79] The funding problem was partially solved in 1915 when the government agreed to allocate 50 per cent grants for infant welfare centres, and by 1917 100 had been established in London alone (80 per cent were run by volunteers), increasing to 224 in 1928.[80]

McCleary (1935) shows that the nineteenth-century infant welfare movement was rudimentary and dependent on local enthusiasms. The early twentieth century saw symbolic developments in the Midwives Acts (1902, 1918), the Notification of Births Acts (1907, 1915), the Maternity and Child Welfare Act (1918), and an increasing number of health visitors, antenatal clinics, day nurseries, and nursery schools.[81] Quantifying their relative and overall significance is exceptionally difficult, but one might reasonably suggest that any major impact was delayed until the 1920s and after.

Voluntary improvements in the cleanliness of milk production were also delayed until after the First World War. The National Clean Milk Society, founded by Wilfred Buckley and others in 1915, was the publicity vehicle which persuaded the country, including the reluctant producers, that clean milk was desirable.[82] Their efforts led the government to introduce the Milk (Special Designations) Orders of 1922 and 1923 which started a voluntary bacteriological quality grading of milk, later enhanced by the Milk and Dairy Order (1926), which protected milk from contamination in transit, and the Sale of Milk Act (1927) which introduced licences for Grade A, 'Tuberculin Tested' milk.[83] By the 1930s milk had changed its image to that of a clean and healthy food, an image which has only recently been tarnished with our concern about the dangers of its fat content.[84]

A major event in the evolution of a safe milk supply was the introduction of sophisticated methods of final treatment and packaging before sale. In Copenhagen at least one company filtered its milk through layers of gravel and cloth to remove any sediment, but in Britain only the Manchester Pure Milk Supply Co. is known to have followed their example.[85] Heat treatment was a surer and cheaper way of eliminating harmful bacteria. Two methods became standard:
(1) Sterilization, which involved heating the milk to or beyond its boiling point for a sustained period to kill all organisms. This seriously altered the taste, at least until the invention of the homogenizer by Gaulin in 1904. The intense heat also caused the loss of the milk's vitamin B12, about 30 per cent of the thiamin, and about half of the antiscorbutic vitamin C.[86]
(2) Pasteurization, which was discovered in the 1860s by Louis Pasteur, but not advocated for milk until 1886. Commercial pasteurization, as defined by the Milk (Special Designations) Orders of 1936 and 1941, was either by the 'flash' or 'HTST' method, heating the milk to 162 degrees for 15 seconds, or the 'holder' method, -which sustained 145—50 degrees for 30 minutes.[87] It is possible that some earlier pasteurization

systems did not efficiently exceed the thermal death point of the Mycobacterium tuberculosis, and we know that 10-15 per cent of other micro-organisms would have survived.[88] The process destroys 20 per cent of the vitamin C in normal milk, but does not affect the vitamins A and D or riboflavin.

A small amount of heat-treated milk was sold in Britain from the 1880s, but the added cost of the product, and the lengthy controversy which surrounded its reduced nutritional value, limited its appeal for some time.[89] Several London dairy companies in London retailed pasteurized milk in bottles but, as Macewen observed cynically, the real motive behind this seems to have been to preserve old milk rather than to provide a genuinely germ-free product.[90] A fillip to demand was provided by the conclusions of the Royal Commission on Tuberculosis in 1911 which blamed an infected milk supply for the spread of certain types of the disease, and by 1921 it was estimated that about half of the capital's milk was heat treated.[91]

In London the delivery of milk in disc stoppered glass bottles seems to have begun in 1897.[92] The added expense made it unpopular with dairymen, but they were forced to adopt this innovation with the gradual introduction of graded milk in the 1920s.[93] Milk in bottles was sealed from contamination and also protected from adulteration.

A final early twentieth-century development of note was the manufacture of dried milk. Powdered milks such as the Glaxo brand were available in the 1900s but did not become popular until after the Great War. From the 1920s they represented 'something of a revolution in the practice of safe artificial feeding' because they were the most sterile milk product then available.[94]

In conclusion we cannot agree with Beaver that the period after 1895 saw a 'radical change' in milk quality.[95] The Manchester series in Table 2 is encouraging but does not show a 'safe' supply by 1906. Overall it seems that progress was slow and that for most people the consumption of raw milk remained a significant hazard until after the First World War and into the 1920s.

VI

In the second half of the nineteenth century we have a problem in disentangling the positive and negative effects of milk consumption. Milk quality was so abysmal that the damage caused by disease may have outweighed the nutritional benefits. Quantifying where the balance lay is not possible in our current state of knowledge but it is probably fair to conclude that cows' milk was an important source of morbidity and mortality, especially for infants. Woods, Watterson, and Woodward underestimate its role in diarrhoeal infections.[96]

The evidence presented, in section V and earlier sections is far from convincing of a shift to a clean and healthy milk supply by 1920. It is true that adulteration had been brought under control by then and chemical preservatives banned, but universal heat treatment and bottling was still many years distant and we have shown that contamination with tubercle bacilli and other disease organisms was still rife. The conditions of milk

production were still disgracefully filthy and ill-regulated, with those of transport and sale only marginally better. Domestic hygiene is unlikely to have improved much, despite educational initiatives, because of the desperate poverty of the most vulnerable groups in society. In short it is difficult to support Beaver's contention that improved quality milk was responsible for falling infant mortality. There must have been other, more timely factors at work. Woods, Watterson, and Woodward's excellent work on the decline in infant mortality has shown us a multi-factorial approach which is surely the way forward.[97] They conclude that artificial feeding with milk was a minor influence in the overall IMR decline. This may well be true, but our objective has been to show that milk was probably responsible for the stubborn persistence of some of that IMR and indeed of mortality and morbidity among other age groups.

This paper has adduced evidence which suggests firstly that milk caused more ill-health than some previous writers have allowed, and secondly that a significant, general improvement in its quality was incomplete as late as the 1920s. These conclusions amount to a readjustment in the balance of evidence rather than a radical re-interpretation. The intention has been to suggest that milk was one contributory factor, which should not be neglected, among the many necessary to explain ill-health during this period.

Notes

1 Portions of this paper have been delivered at a Joint Conference of the British Agricultural History Society and the Historical Geography Research Group, and at the Wellcome Unit for the History of Medicine, University of Oxford. I am grateful for the comments made by colleagues on these occasions, and to three anonymous referees for their constructive input, but the sole responsibility for the views expressed here remains mine.

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3 M. W. Beaver, 'Population, Infant Mortality and Milk', *Population Studies,* 27 (1973), 243-54.

4 P. J. Atkins, 'The London Milk Trade, *c.* 1792—1914' (unpublished Ph.D. thesis, University of Cambridge, 1977).

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' D. Taylor, 'Growth and Structural Change in the English Dairy Industry, c. 1860-1930', *Agricultural History Review,* 35 (1987), 47-64.

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12 L. Mackenzie, 'The Hygienics of Milk', *Edinburgh Medical Journal,* 5 (1899), 373-4.
13 Three Dairies, Cowsheds and Milkshops Orders were made in 1879 under the Contagious Diseases (Animals) Act, 1878. They were replaced in a new Order of 1885 made by the Privy Council, whose authority was transferred in the Order of 1886 to the Local Government Board. In the Order of 1899 tuberculosis was added to the schedule of cattle diseases. All were replaced in 1926 by the Milk^and Dairies Order.
14 Anon., 'The Milk Supply of Large Towns: Action and Inaction of Rural and County Authorities', *British Medical Journal,* 5 December (1903), 1488-92.
15 F. Vacher, Evidence to the *Royal Commission . . . into the Administrative Procedures for Controlling the Danger to Man Through the Use as Food of the Meat and Milk of Tuberculous Animals* (P.P., 1898, xlix, q. 4039).
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" Medical Officer of Health to the St Pancras Vestry, *Annual Report* (St Pancras, 1899).
20 G. Newman, *Report on the Milk Supply of Finsbury* (Finsbury, 1903).
21 Milk Control Board, *Memorandum on the Milk Supply* (London, 1919), p. 3.
22 T. Orr, *Report on an Investigation as to the Contamination of Milk Carried out on Behalf of the Councils of. . . Bradford, Hull, Leeds, Rotheram and Sheffield, and . . . the East and West Ridings of Yorkshire* (Beverley, 1908), p. 7.
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24 52 per cent of milk retailers' premises in Finsbury had one or more sanitary defects. Newman, *Report on the Milk Supply,* p. 23.
25 Dodd, 'Municipal Milk', p. 11.
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27 Anon., 'The Cow with the Iron Tail', *Household Words,* 9 November (1850), 145-51.
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30 Newman, *Report on the Milk Supply,* p. 23.
31 J. F. J. Sykes, *Annual Report of the Medical Officer of Health to the Metropolitan Borough of St Pancras* (St Pancras, 1911).
32 J. S. Higgins, *Annual Report of the Medical Officer of Health to the Metropolitan Borough of St Pancras* (St Pancras, 1913).

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"Jenkins, *Drinka Pinta.* By 1925 'most' of London's milk was pasteurized. F. J. Prewett, *Marketing of Farm Produce, II: Milk* (Oxford, 1927), p. 23. By 1933 the proportion was over 90 per cent. In 1939 92.7% of London's milk was pasteurized under licence, 2.3% sterilized, and 3.6% heat treated in some other way. 0.4% was sold as Tuberculin Tested, either raw or pasteurized. In the county boroughs 70.2% of milk was pasteurized by this date but no more than 50% nationally and in some rural areas hardly any. E. M. Hugh-Jones, 'Milk', in Llewellyn-Smith, *The New Survey,* vol. 2, p. 66; Wilson, *The Pasteurization of Milk,* p. 73; Bryder, *Below the Magic Mountain,* p. 138. This record was poor by comparison with the USA where 50% of milk

had been pasteurized by 1912, and 95% across the whole country by the 1930s. Raw, *The Control of Bovine Tuberculosis*, p. 91.
92 *Final Report of the Committee on the Production and Distribution of Milk*, (P.P., 1919, Cmd 483, xxv, 683).
93 Hugh-Jones, 'Milk', p. 68.
94 Dyhouse, 'Working Class Mothers', 256; Smith, *The Retreat of Tuberculosis*, p. 189; S. Delepine, 'Dried Milk', *Reports to the Local Government Board on Public Health and Medical Subjects*, new series 97 (1914).
95 Beaver, 'Population, Infant Mortality and Milk', p. 251.
96 Woods, Watterson and Woodward, 'The Causes of Rapid Infant Mortality Decline', pp. 120-1
97 Ibid.