

From Swill Milk to Certified Milk: Progress in Cow's Milk Quality in the 19th Century

Michael Obladen

Department of Neonatology, Charité University Medicine Berlin, Berlin, Germany

Key Words

Artificial feeding · Cow's milk · Infant formula · Milk-borne disease · Public health

Abstract

Background: Industrialization and urbanization jeopardized infant nutrition during the 19th century. Cow's milk was produced in the cities or transported long distances under suspect conditions. Milk was contaminated with bacteria or adulterated with water, flour, chalk and other substances. When distilleries proliferated in the metropolises, their waste slop was fed to cows which then produced thin and contaminated swill milk. **Summary:** Following a press campaign in the USA, the sale of swill milk was prohibited by law in 1861. Bacterial counts became available in 1881 and helped to improve the quality of milk. Debates on pasteurization remained controversial; legislation varied from country to country. Disposal of the wastewater of millions of inhabitants and the manure of thousands of cows was environmentally hazardous. It was not until 1860 and after several pandemics of Asiatic cholera that effective sewage systems were built in the metropolises. Milk depots were established in the USA by Koplik for sterilized and by Coit for certified milk. In France, Budin and Dufour created consultation services named *goutte de lait*, which distributed sterilized milk and educated mothers in infant care. **Message:** Multiple efforts to improve milk quality culminated in the International *gouttes de lait* Congresses for the Study and Prevention of Infantile Mortality.

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Introduction

During the industrial revolution in the first half of the 19th century, the European population doubled, and the proportion of city dwellers rose to 50%. Urbanization jeopardized infant nutrition in at least 3 ways: (1) mothers accepted paid work far from their homes, undermining breastfeeding; (2) cow's milk was either produced in the cities under questionable circumstances or was transported long distances and sold under likewise suspect conditions, and (3) working class neighborhoods usually lacked sanitation and rarely had access to clean water. The following article identifies actions taken during the second half of the 19th century to improve the quality of cow's milk in the metropolises.

Contaminated and Adulterated Milk

Although there was no knowledge of pathogenic microbes until 1841, Naples professor Filippo Baldini, a protagonist of artificial infant feeding, worried about dirty stables in 1786: 'One must take care that the goats do not lay down in their excrements or in humid places, and should be afraid if they absorb the volatile matter through the pores of their skin.' In London, the Commission on Adulterations painted a gloomy picture in 1855: 'He [Dr. Normandy] saw from thirty to forty cows in a most disgusting condition, full of ulcers, their teats diseased and their legs

full of tumours and abscesses – in fact, quite horrible to look at; and a fellow was milking them in the midst of all this abomination. This was by no means an exceptional case, a great many dairies being in the same condition. The milk, in consequence, is really diseased milk...’ [1].

John Mitchell published an entire book on ‘the falsification of food’ in 1848 [2], and the ‘cow with the iron tail’ became subject of a satirical poem in 1867: ‘For he won’t want milk, if the truth they talk, while he has his pump, and his lump of chalk’ [3]. Vernois and Becquerel described milk manipulation in France in 1853: ‘Milk is altered in Paris by the following substances, listed in the order of frequency: water, glucose, flour, starch, dextrine, infusion of amylaceous matter (rice, barley, bran), yolk of egg and white of egg, sugar, caramel, cassonade; gelatine, liquorice, boiled carrots, broken-down calves brains, serum of blood, several salts, bicarbonate of soda’ [4].

The situation was no better in Germany, and Carl Hennig, director of the Leipzig Children’s Hospital, stated in 1874: ‘Often the milk is diluted with water to raise profits. The conscientious landowners know that this occurs most frequently during transport and therefore send their products in sealed vessels’ [5]. All over Europe, a plethora of ‘lactometers’ was developed to detect falsifications. Martiny’s monograph on milk of 1871 devoted 51 pages to these devices [6], some of which are depicted in figure 1. Figure 1a–d and i shows hydrometers that measured the specific density at a defined temperature. The deeper the metered bulbs sink, the lower the specific gravity, which may reveal dilution. Figure 1b, g, and h depicts instruments that measured the percent cream layer that ascended after a defined time. Figure 1f shows an optical instrument that assessed the translucency of candlelight through a thin layer of milk, believed to indicate its fat content.

Swill Milk and Milk Transport

With the invention of the column distillery, mass production of cheap spirits became possible in the early 19th century, and hard liquors abounded in the growing suburbs [7]. The distillery waste slop was fed to cows which became sick and produced thin and contaminated swill milk. Robert Hartley, secretary of the New York Association for Improving the Conditions of the Poor, described the situation in his city in 1842: ‘During the winter season, about two thousand cows are said to be kept on the premises... All the cows are most inhumanly condemned to subsist on this most unnatural aliment... At the distill-

eries, the slop is drawn off hot into tanks, at short intervals through the day, and in this state is distributed and eaten by the cows on the premises, and also by those in the adjacent parts, as before it cools it may be transported to a considerable distance... cases have occurred where, owing to lameness from debility or disease, and sometimes by a paralysis of the limbs, the cattle, unable to stand, have been supported by straps passed under the body, and yet have been retained as milkers... Slop milk is naturally very thin, and of a pale bluish color. In order to disguise its bad qualities and render it saleable, it is necessary to give it color and consistence... Starch, sugar, flour, plaster of Paris, chalk, eggs, anatto, etc. are used for this purpose... more than three fourths of the infants born in our cities are sustained in whole or in part on artificial diet’ [8]. New York City Inspector David Reese agreed in 1857: ‘Distilleries in or near large cities... an intolerable nuisance and curse... wherever they exist, their slops will furnish the cheapest food for cows, the milk from which is more pernicious and fatal to infant health and life than alcohol itself to adults... So long as distilleries are tolerated in cities, cow stables will be their appendages, and the milk, fraught with sickness and death, will still perpetuate mortality...’ [9]. From May 1858, a series of 8 articles with a total of 36 drastic pictures (fig. 2) appeared in *Frank Leslie’s Illustrated Newspaper*, ‘exposing the milk trade of New York and Brooklyn’ [10]. The pictorial campaign prompted a law prohibiting the sale of swill milk in April 1861, and Leslie triumphed ‘a great victory won’ [11].

Cows fed on slop were not a specific US problem: city distilleries were described and opposed by authors in England, Germany, France and other countries. For Germany, Hennig complained in 1874: ‘In the large cities dairies and cowstables make room for distilleries, dyeing works, steam laundries, and cigar factories... Milk of cows fed spent corn, rape, distillery slop and the like is noxious for newborn infants’ [5]. Milk transport from the allegedly healthier countryside was no real alternative. In Detroit, Sutherland had patented a refrigerator railway car in 1867 [12]; nevertheless, in 1905 Fabian Society member Lawson Dodd observed: ‘The railway companies have no financial or other interest in the delivery of clean milk, and therefore very seldom provide proper vans for its conveyance. Fish, paint, petroleum, or other unsuitable goods are packed along with the milk. The churns from the farms are allowed to stand for hours on platforms of rural stations to be dealt with as ordinary goods, or to await the slow milk train. While thus waiting, the milk is often exposed to the hot rays of the sun and the dust of passing traffic, which both make for increased bacterial contamination’ [13].

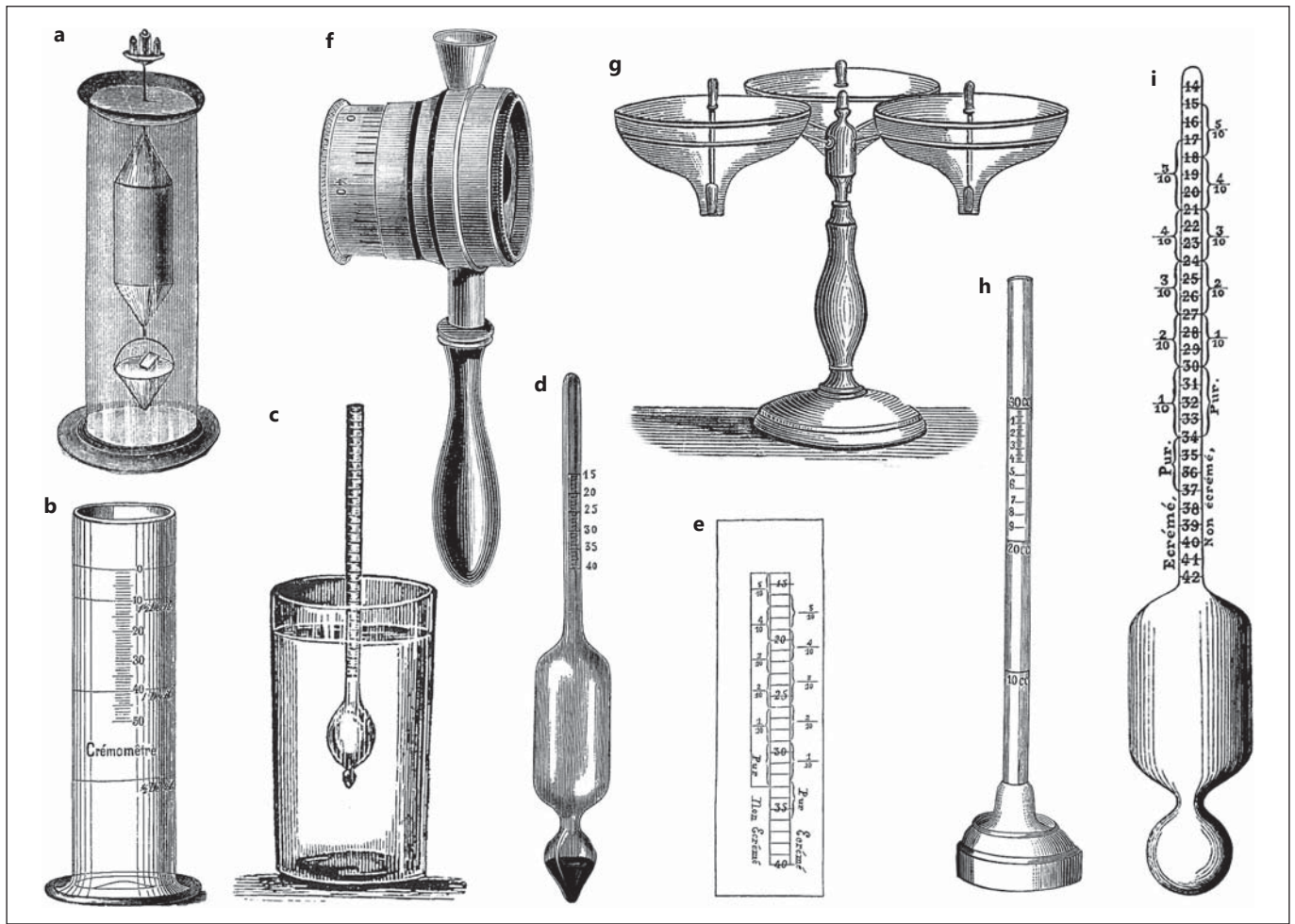


Fig. 1. Instruments used in the 19th century to prove milk falsification. **a** Hydrometer of Nicholson 1790. **b** Cremometer of Schübler 1817. **c** Lactometer of Hartley 1842. **d** Lactodensimeter of Quevenne 1842. **e** Quevenne's scales for full-cream and skim milk. **f** Lacto-

scope of Donné 1843. **g** Butyrometer of Krockner 1856. **h** Lactobutyrometer of Marchand 1854. **i** Galactometer of Bouchardat 1857. Figures modified from Martiny [6], 1871, and Krafft [49], 1885.

Milk-Borne Disease

The triumph of bacteriology contributed to improving the quality of milk. In 1881, Henri Fauvel, chemist in the Paris police headquarters, detected vast numbers of bacteria and cryptogams in 28 of 31 milk bottles used in 10 different nurseries [14]. At the turn of the century, cow's milk was known to be highly contaminated, and Dodd stated ironically: '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' [13]. For his review 'White poison', Peter Atkins carefully collected data on milk microbiology from Britain: in 1901, 10% of London samples were classified as 'dirty' and Liverpool samples contained

Escherichia coli in 72% when transported by rail, and in 44% when produced in the town; 10% of milk samples contained tubercle bacilli [15]. Concerning *Mycobacterium bovis*, Robert Koch stated in 1901: 'It is not decided whether man is susceptible to bovine tuberculosis... If such a susceptibility really exists, the infection of human beings is but a very rare occurrence... I therefore do not deem it advisable to take any measures against it' [16]. British scientists, especially Sir John McFadyen, contradicted Koch's view, which led to appoint the Royal Commission on Tuberculosis, ruling in 1907: 'A very considerable amount of disease and loss of life, especially among infants and children, must be contributed to the consumption of cow's milk containing tubercle bacilli' [17]. The ensuing acrimo-

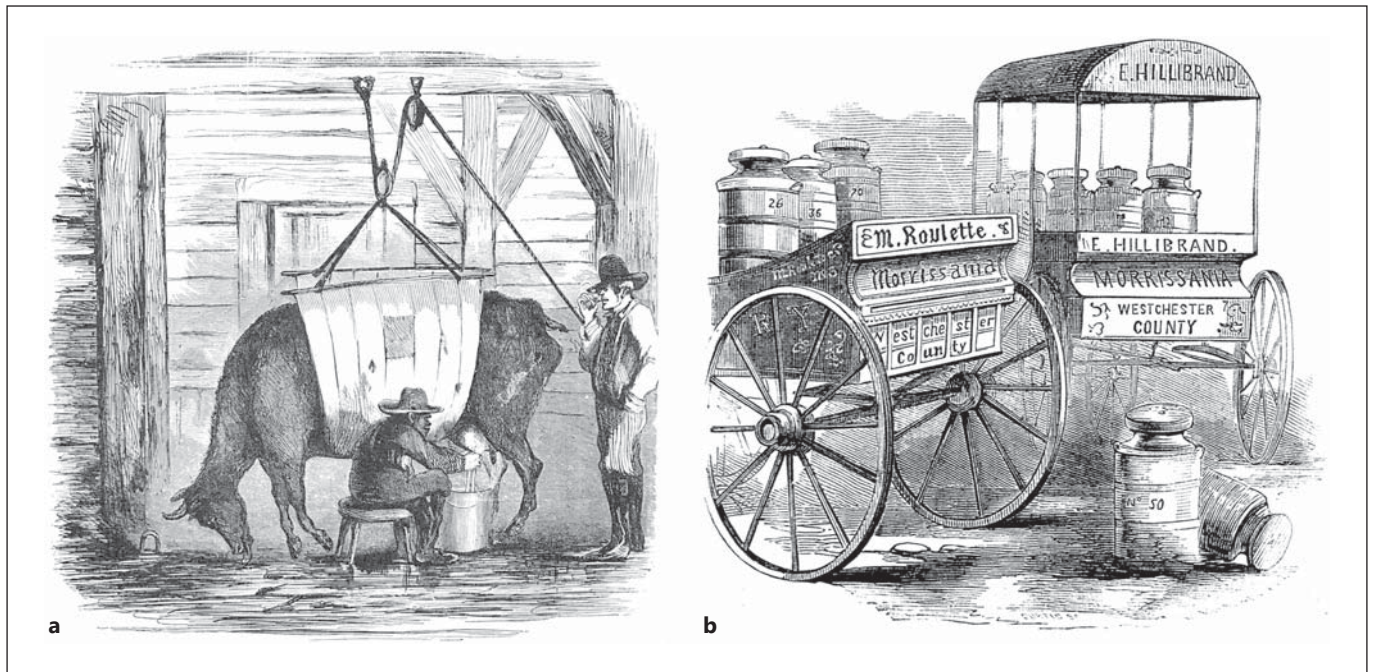


Fig. 2. a Sick cow being hoisted for milking. b Milk wagons for the transport of swill milk. Both figures from *Frank Leslie's Illustrated Newspaper*, 1858 [10].

nious controversy on *M. bovis* (the 'milk war') persisted for half a century and has been described by Barbara Orland [18]. Governments ordered tuberculin testing – or slaughtering – and certified 'tuberculosis-free herds'. Less belligerent but also long-standing was the debate on group B streptococci. Recognized as causing bovine mastitis (*gelber galt, garget*) by Nocard in 1887 [19], the germ was initially termed *Streptococcus agalactiae*. Rebecca Lancefield [20] identified type B serologically in 1933 and described sporadic infections in humans. But as late as 1966 it was recognized that B streptococci had become the most frequent single cause of neonatal sepsis in Boston [21]. As with *Mycobacterium tuberculosis*, there was extensive debate whether human and bovine strains are identical. Today B streptococci are frequent contaminants in the female genital tract, and there is no evidence that cattle are a significant resource for transmission.

Freshwater, Sewage and Drainage

An uninterrupted supply of freshwater is a precondition of urbanization. Early human cultures exerted great effort to construct and operate aqueducts, cisterns, wells and highly sophisticated distribution systems.

Breakdowns of their water supply probably contributed to the collapse of the Indus valley civilization, the Akkadian Empire in Mesopotamia and the Nabatean civilization in Petra, Jordan. In addition to freshwater distribution and public baths, the Romans built a sewer system connected to the *cloaca maxima*, described by Plinius in the first century CE [22]. Much of that ancient knowledge seems to have been lost during the Middle Ages. The large metropolises lacked sewage systems that separated the supply of freshwater and drainage of wastewater. Between 1831 and 1866, four pandemics of Asiatic cholera ravaged Europe, taking millions of lives in the ever growing cities, firstly and mainly infants. It was not until such catastrophes that the European capitals finally built efficient sewage systems and freshwater supplies.

François I ordered French houses to be equipped with cesspits in 1530. The cities were ill-smelling agglomerations of houses with sinks and cow stables nearby. Freshwater of doubtful quality was supplied to the houses by water carriers as Sebastien Mercier reported in 1802: 'The night-men, to spare themselves the trouble of conveying the filth to a sufficient distance from the town, empty their carts at break of the day into the common sewers and rivulets, these filthy drags are slowly floated

down the streets towards the river Seine, and infect those parts of the shore, where the men who carry water about, go on a morning to fill their buckets' [23]. The Paris Cemetery of the Innocents, adjoining the main market, was removed in 1780 because of its evil smell. Within Haussmann's newly constructed city, the engineer Eugène Belgrand began building a 600-km sewage system in 1853. The central freshwater reservoir Montsouris was finished in 1874. In 1906 the river Bièvre, filthy since 1577, was transferred underground to become the main collecting canal [24].

The situation was no better in Tudor England, as pointed out by David Forsyth: 'There were latrines, but no drains. At the back of every house stood a cesspool' [25]. Erasmus of Rotterdam, who lived in England between 1499 and 1506, described English houses in which 'the floors are commonly of clay, strewn with rushes, under which lies an ancient collection of spittle, vomit, urine of dogs and men, spilled beer, relics of fishes, and other unnamable filth' [26]. In such surroundings, artificial feeding of infants had little chance of success. In 1613, the 'New River' was finished, transporting freshwater to London over a distance of 67 km [27]. Its population, 250,000 at that time, quadrupled up to 1800, and additional water supplies had to be procured. Disposing of the wastewater of 3.2 million inhabitants and a quarter of a million tons of manure produced by London's cows each year in the early 1860s was a logistic challenge and environmentally hazardous [15]. Following the Metropolitan Water Act of 1852 and a final cholera epidemic, the London sewage system was built by Joseph Bazalgette, transforming the former Fleet River into a main sewer [28].

The freshwater supply of New York City was ensured by the Croton aqueduct. But the few existing drains were frequently clogged up by dead animals, garbage and refuse, and were cleansed by prisoners [29]. Construction of a modern sewage system began in 1871. In Berlin, most backyards hosted a latrine right next to the well pump. From 1872, after repeated urging by Rudolf Virchow, a radial sewerage and drainage system was constructed by James Hobrecht [30].

Certified Milk

The first milk depot in America was established by Henry Koplik in the Eastern Dispensary in New York in 1889 [31]. It distributed sterilized milk mixtures according to a physician's prescription for sick infants. Henry

Coit of New Jersey was another pioneer of clean and safe milk for infants. He was motivated by a sad experience with his own son in 1887: 'I was driven from one source of impoverished and contaminated milk to another, until, in desperation, I sought a small suburban dairyman... Honest and industrious, but without a knowledge of hygiene, he became a dangerous element in my family life' [32]. In 1893 Coit founded the Medical Milk Commission which gave a certificate to milk sealed in separate quart containers that fulfilled 3 criteria: 'uniform nutritive value; reliable keeping qualities, and freedom from pathogens' [33]. The Fairfield Dairy sold it for 12 cents a quart, 6 cents more than ordinary milk. Coit wrote 'the poorest baby in Coomes Alley will now fare equally well with Thomas Edison's baby in Lewellen Park' [32]. In 1896 the New York Medical Society likewise formed a milk commission, and by 1906 there were 36 commissions throughout the USA requiring the formation of an Association of Medical Milk Commissions to ensure bacteriological and chemical standards for certification, and Henry Coit was elected its president. Mostly maintained by private charity, the milk depots supplied 'best', 'proper', 'clean' or 'certified' milk to 'needy persons' or 'the worthy poor' and provided visits 'to educate mothers in the care of infants' [34].

Certified milk was not sterile, but it did contain under 10,000 bacteria/ml. In the worldwide raw-versus-pasteurized milk debate, Coit held the opinion that boiling destroys important properties and encourages the careless handling of milk. Over the long term, however, certified milk could not compete with the trend toward pasteurization. Atkins described how from 1922, British legislation ensured bacteriological quality grading of milk and its protection from contamination in transit [35].

Pasteurization Plants, Depots and Dispensaries

The impact of pasteurization has been described previously. French physicians (Budin, Auvard, Dufour) were in favor of boiling, whereas Germans (Heubner, Finkenstein) preferred raw milk. In the USA, Abraham Jacobi advised the boiling of all milk for children feeding as early as 1873, whereas Coit, Henry Arthur Meigs and Alfred Hess [36] opposed boiling. In 1891 Thomas Morgan Rotch together with Gustavus Gordon and George Walker established the Walker-Gordon Laboratory (from 1897 'farm') for the production of clean *guaranteed* milk [37].

The New York philanthropist Nathan Straus, co-owner of Macy's storehouse, became convinced that impure



Fig. 3. The *goutte de lait* at Belleville Dispensary, Paris, opened in 1892. Painting by Jean Geoffroy [50], 1901. Triptych: weighing (left); consultation (center); milk distribution (right).

milk was responsible for the deaths of many babies: 'Here in New York the lives of thousands of children are sacrificed every summer, simply and solely because they are fed impure milk' [38]. From 1893 he organized large pasteurization plants and used cooled cars to distribute 34,400 bottles per year: 'Only *certified milk* is used, containing not more than 10,000 bacteria per cubic centimeter. This purest milk obtainable is modified and pasteurized in the laboratory at 348 East 32d Street.' Pasteurization meant heating the milk to a temperature of from 140 to 157°F and holding it at this temperature for 20 min and then rapidly cooling it. Milk for the 1st to 3rd month followed the recipes of Drs. Green and Freeman (1.5 oz of 16% cream; 3 oz full milk; 13 oz water; 0.5 oz lime water; 1 oz milk sugar, fills 6 bottles of 3 oz), for the 3d to 7th month that of Dr. Jacobi (18 oz full milk; 18 oz barley water; 1 oz cane sugar; 20 grains table salt; fills 6 bottles of 6 oz). 'Coupons were placed without cost, and without restriction as to quantity, at the disposal of any physician giving his services freely to the poor...' In 1895, Straus wrote to the mayors of every city in the USA: 'I have long held that the day is not far distant when it will be regarded as a piece of criminal neglect to feed young children on milk that has not been sterilized' [38]. In 1908, Chicago, Ill., mandated milk pasteurization, followed by many cities throughout the USA. In 1911, 43 milk depots were in operation in 30 US cities [34].

In Britain, the pioneer Infant Milk Depot opened in St. Helen's in 1899, equipped with automated sterilizers and bottle washing machines. It was followed by Liverpool, Battersea, York and Glasgow up to 1904 [39, 40], predominantly supplying milk for the poor. The technical standard in the Glasgow depot was described by Bailie Anderson in 1905: 'Each trolley is capable of holding 540 bottles, or 60 baskets. The milk sterilizer has a capacity of 1,080 bottles, or one day's supply for 120 children... The cold chamber had a total capacity of 2,000 bottles... bottle washing machine had an output of 20 bottles per minute..., each bottle is washed three times' [41]. The National Clean Milk Society was founded by Wilfried Buckley in 1916 [15].

A debate on pasteurization ('killing the milk') continued even after an editorial of the *Boston Medical and Surgical Journal* stated in 1923: 'Boiled fresh milk is the only entirely safe milk that can be fed to infants' [42]. The terms pasteurization and sterilization were used somewhat interchangeably until being defined in 1927. Milk pasteurization became mandatory by law in the UK in 1985 [43] and in Australia in 1994. For the European Union, council directive 92/46 regulated the sale of raw and heated milk in 1992. Selling raw milk is illegal in 25 states of the USA [44]. In Germany at the beginning of the 20th century, the infant hospitals in Dresden and Berlin had model cow stables providing showers for the cows.

In the Maternité of Nancy, France, Adolphe Herrgott founded the consultation and follow-up service *oeuvre de la maternité* for neonates in 1890. The infants were brought by their mothers for medical examination 1 month after birth and when the child's progress was satisfactory, the mother received a gift of money. In 1892, Gaston Variot founded the consultation service in Belleville, Paris (fig. 3), and Pierre Budin that in the Paris Charité, named *goutte de lait*. They encouraged breastfeeding and distributed undiluted cow's milk sterilized in small bottles. The *goutte de lait* in Fécamp, France, founded by Léon Dufour in 1894, was associated with a dramatic fall in infant mortality and became a model for milk dispensaries throughout Europe [45]. As pointed out by Deborah Dwork [46], the clean milk movement did not directly lower infant mortality, but it did become the root of infant welfare. In 1912, 200 *gouttes de lait* took part in a national conference; their successor organization *école maternelle* is still found in every French town.

International Congresses

The International Congresses for the Study and Prevention of Infantile Mortality (Paris 1905, Brussels 1907, Berlin 1911) carried the subtitle *goutte de lait*. Their history and impact on infant welfare have been described by Catherine Rollet [47]. Nathan Straus lectured in Brussels: 'However, as the infantile death rate in New York went steadily down... coincident with the increased use of pasteurized milk, the significance of my work became apparent... 3.14 million bottles in 1906.' In Berlin in September 1911, Straus was the official delegate of the USA; he announced proudly 'to save 125,000 babies a year... infant death rate cut in half' and reported to President Taft the 'necessity for accurate and uniform vital statistics' [38]. With delegates from 28 countries, the trilingual proceedings of the Berlin *goutte de lait* has 1,256 pages. It appeared 2 years before World War I terminated the plans for a congress in London in 1915 – and global scientific efforts for infant welfare. Carlo Agostoni and Dominique Turck have shown how concerns that cow's milk may harm a child's health repeatedly became fashionable up to the present day [48].

Conclusions

Progress in bacteriology and hygiene lowered the risk of cow's milk as a human nutrient. This was especially helpful for artificially fed infants and even more so during

the summer months. From 1882, the clean milk movement paralleled the efforts pioneered by Philipp Biedert in Alsatia and Arthur Vincent Meigs in Philadelphia to modify the protein, fat and mineral concentration of cow's milk which in the future was to improve the outcome of infants with gastroenteritis [37]. For city dwellers it remained hazardous to consume raw milk until after World War I. The physician-initiated clean milk movement of Koplik and Coit in the USA and of Budin and Dufour in France improved the quality of cow's milk used for infant feeding, but, against their intention, did not promote breastfeeding. Pasteurization plants and infant milk depots provided clean milk at affordable prices. Borne of humanitarian motives, neither approach could withstand the power of global marketing. Moreover, they were internally inconsistent, and physicians were not unanimous. Decades of debate on milk-borne disease, pasteurization and the optimal composition of infant food delayed governmental legislation. Moreover, the debates paved the way for industrially produced formula for which neither physician nor parents had to worry about quality. Within the broader context of protecting nurslings, efforts to improve the quality of cow's milk were fundamental. Although a direct connection between the clean milk movement and declining infant mortality rate cannot be proven, the former doubtlessly encouraged international cooperation supporting infant welfare and public health.

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