

Historical Research: The Origin of ‘Formula’: State of the Science, 1890s

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Abstract

In 1900, 13% of infants in the United States died before their first birthday, most of dehydration from diarrhea. As part of a nationwide effort to “save the babies,” pediatricians focused on several endeavors—experimenting with commercially made infant-food products; working with dairy farmers to clean up cows’ milk; lobbying to pass municipal and state legislation regulating the dairy industry; and devising mathematical “formulas” that represented instructions to chemists on how to “humanize” cows’ milk for the needs of a particular infant. Pediatricians dubbed the latter endeavor “percentage feeding” and, from the 1890s to the 1920s, they deemed percentage feeding a lifesaving scientific achievement. The complex, virtually infinite array of mathematical formulas that comprised this infant-feeding system is the origin of the word “formula” as used today to describe artificial baby milk.

Keywords

artificial food, artificial baby milk, breastfeeding, cows’ milk, infant mortality, public health, formula, pediatricians

Between 1900 and 1915, members of the American Pediatric Society presented 90 papers about infant feeding to attendees at annual meetings. No other topic commanded the attention of the first generation of American pediatricians more than what to feed infants who were not breastfed. These late 19th- and early 20th-century physicians focused on artificial food formulation to the exclusion of virtually everything else (Brennemann, 1938). For decades, they were so single-minded that, in the late 1930s, one physician predicted that “the pediatrician is a dying race” because artificial food had become significantly safer. The prognosticator contended that, with bottle-feeding no longer the principal cause of infant morbidity and mortality, future pediatricians would have nothing to do (Hess, 1954).

Pediatricians’ late 19th-century obsession was understandable. Thirteen percent of infants died before their first birthday in 1900 (Preston & Haines, 1991) and more than half the infants who died, died of diarrhea (Wolf, 2001). In 1910, the Chicago Department of Health estimated that bottle-fed babies, when compared to breastfed babies, were dying at a 15:1 ratio (Davis, 1910). With no pure food laws on the federal, state, and municipal levels, and, in an era before refrigeration and pasteurization, cows’ milk was a spoiled, adulterated product—a threat to the public’s health, but especially dangerous for infants.

For almost 40 years, urban newspapers joined public health officials and pediatricians in decrying babies “gone to a premature grave.... Could a proper death certificate be

made out many an entry of ‘cholera infantum’ [infant diarrhea] would be changed to starvation from being fed on watered milk (Chicago Milk, 1892).” Yet, water was the least offensive substance contributing to the contamination of milk. Assorted dyes tricked consumers into thinking that skim milk was still rich with cream. White powdered chalk was another customary additive—used to whiten milk exposed to dirt and dust (They Water and Color the Milk, 1894). And milk was commonly distributed to consumers from large vats with communal dippers for tasting, ensuring that diphtheria, typhoid, scarlet fever, and tuberculosis all became milk-borne diseases (Report of the Health Department Laboratories, 1906).

Cows’ milk had become a popular food for infants in the United States beginning in the late 1870s. Urbanization and industrialization brought broad cultural change that included the use of the mechanical clock, inspiring strict infant-feeding schedules that diminished mothers’ milk supplies. Complaining they did not have enough milk, mothers began

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to wean infants by their third or fourth month; a few did not breastfeed at all (Wolf, 2001). The move from human milk to cows' milk had begun, to the detriment of infants' health (Wolf, 2001).

In their quest for, if not the perfect artificial infant food when mothers could not breastfeed, at least a non-lethal food, pediatricians employed an array of ventures. They toyed with using commercially made products, they worked alongside dairy farmers and public health workers to clean up the urban milk supply, and they devised the first "formulas" based on a dubious "scientific" theory. The term "formula" to describe an infant's first food originated during this era, when chemists worked at so-called milk laboratories to fill the mathematical formulas written by pediatricians, much like pharmacists fill prescriptions today. Yet, none of these undertakings proved ideal.

Powdered, commercial infant foods were the poorest of the alternatives, proving to be just as dangerous as cows' milk because most of the foods had to be mixed with cows' milk. To their credit, however, the infant food companies that devised the ads that peddled their wares never touted their product as desirable. Rather, their primary claim was only that their product was better than similar, plainly life-threatening foods. An advertisement for Eskay's Food, for example, began, "From three weeks to four months about every artificial food but ESKAY'S was tried and utterly failed, and the child wasted away to a shadow." Accompanying the ad was an illustration of a chubby child, "Alfred Long, 1014 Halsey Street, Brooklyn, N. Y." Initially suffering terribly for want of mother's milk, Alfred weighed less than 6 pounds at 5 months of age. Fortunately, "We then tried ESKAY'S FOOD and the improvement was immediate and continual. Now 17 months old, Alfred weighed an improbable 43 pounds" (Eskay's Food, 1905). An advertisement for Nestlé's food likewise claimed product superiority over other, inferior human milk substitutes, but for a different reason. Nestlé's was to be mixed with water rather than deadly cows' milk. Mothers using Nestlé's food thus avoided many threats to their infants, including the "danger of carrying consumption [tuberculosis] and other dread diseases to babies in cows' milk!" (Nestlé's Food, 1914).

While pediatricians had no vested interest in infant food companies—simply employing the products in dire situations—they were at the forefront of activities designed to clean up cows' milk. Beginning with New Jersey pediatrician Henry L. Coit in 1892, physicians organized "medical milk commissions" to certify that a particular farmer produced milk under the commission's stringent conditions (Kerr, 1909). The physicians working with the commissions not only set the standards for cooperating dairies, they also served as the enforcers, monitoring every step of dairy production, from the washing of dairy workers' hands; to the cleanliness of their clothing; to the sterilization of utensils; to the health status, feeding, and hygiene of dairy cattle; to the ventilation and sanitation of barns; to the pasteurization,

chilling, bottling, and transporting of milk (Abt, 1908; Freeman, 1907; Howe, 1919). Consumers could then purchase milk labeled "certified" by a milk commission and thus be assured the milk was safe for human, particularly infants', consumption. Medical charities also purchased certified milk—in bulk to give away at milk stations in congested urban neighbors as part of the broad national effort to lower infant mortality (Melvin, 1983; Pearson, 1908; Wasserman, 1972; Wile, 1909). Yet, the safe infant food development effort that most visibly legitimized pediatricians, a group that long had been maligned as inconsequential "baby doctors," was accessible only to middle- and upper-class families (Abt, 1944; Wolf, 2006).

Beginning in the 1890s, Thomas Rotch, a Harvard pediatrician, theorized that "to copy nature closely" cows' milk had to be "humanized" to suit the needs of each baby, just as a mother's milk was uniquely formulated by "nature" according to the daily needs of her infant (Rotch, 1896). To test the science that he dubbed "percentage feeding," Rotch deployed an infinite array of mathematical formulas. These formulas are the origin of the word formula when used to refer to artificial baby milk. Rotch explained that the "exact precision" provided by formula-writing was as vital to maintaining infants' health as instituting and enforcing sanitary practices in the dairy industry (1896, p. 276). The mathematical formulas that were soon being written by pediatricians around the country were comprised of many variables including, but not limited to, an infant's age, weight, pallor, overall health, consistency of stools, and an assortment of pertinent medical diagnoses. "Weak sugar digestion" was one example of many diagnosis variables used in formula writing (Rotch, 1896, Rotch, 1904, Rotch, 1910).

One Chicago pediatrician offered the following example of a Rotch-inspired formula in which "E" equaled "energy quotient," defined as "a proper amount of energy for the baby;" "M" equaled milk; "P" equaled protein; "S" equaled sugar; "W" equaled weight; "R" equaled ratio; and "r" equaled the ratio of food to be used (Allen, 1907, pp. 242–243). The pediatrician offered the following sample equation:

$$E = PR$$

$$M = WP/4$$

$$S = WP(R - r)$$

$$\text{Water} = 2 \text{ to } 3 W - M$$

He filled in the blanks for colleagues:

$$W \text{ 12, } P \text{ 5, } R \text{ } 7\frac{1}{4}, \text{ whole milk } r = 4\frac{1}{4}$$

$$E = 5 \times 7\frac{1}{4} = 36\frac{1}{4}$$

$$\text{Milk} = 12 \times 5/4 = 15 \text{ oz.}$$

$$\text{Sugar} = 12 \times 5 \times 3 = 1.8 \text{ oz.}$$

$$\text{Water} = 12 \times 2.5 - 15 = 15 \text{ oz. (Allen, 1908, p. 501)}$$

Although early formulas appeared to be complex, they grew even more byzantine over time. While initially protein, sugar, fat, and minerals were the only components of cows' milk to be altered by a chemist according to a specific mathematical formula, the components of each

component eventually became variables, too (Holt et al., 1915).

To create the infant food from the formulas, Rotch suggested that milk laboratories staffed by chemists be established in urban areas. The laboratories were touted as taking infant feeding “out of the hands of ignorant, money-making manufacturers” and placing the welfare of babies squarely in the hands of pediatricians and scientists (Churchill, 1897, p. 410). According to Rotch’s percentage system, chemists did not merely transform cows’ milk into a generic substance akin to human milk. Rather, they created humanized cows’ milk engineered according to the formula written by a pediatrician to suit the unique medical and nutritional needs of a specific infant patient (Rotch, 1893).

Every sizable city in the United States in the late 19th and early 20th centuries housed at least one milk laboratory; the most widespread franchise was Walker-Gordon. The first Walker-Gordon Milk Laboratory appeared in Boston in 1891 (Rotch, 1907). In keeping with pediatricians’ insistence that clean cows’ milk was of the utmost importance in infant feeding, Walker-Gordon used only certified milk when filling a pediatrician’s formula (Rotch, 1893). The extraordinary cost of percentage feeding—45 to 50 cents daily in late 19th century currency—put any product of a milk laboratory well out of the reach of all but the most well-off urban families (Chicago Medical Society Proceedings, 1897).

Milk laboratories eventually fell out of favor after a curious Boston physician analyzed samples made according to the dictates of assorted formulas and found that the percentage feeding method, which relied on precision, was decidedly imprecise. The physician could not find any product of a milk laboratory that matched its formula. Instead, he found “appreciable” errors in every component—most often lower fat and higher protein than a formula dictated. Sugar erred in both directions. Since Rotch based percentage feeding on the claim that even minute changes in the percentage of a component in cows’ milk affected infants’ health, the Boston physician’s findings put the efficacy of the entire venture in doubt (Wentworth, 1902a, 1902b). Some prominent pediatricians likewise began to voice their qualms about the system, worrying that percentage feeding was so “peculiarly complicated” that errors were inevitable (Brennemann, 1908, pp. 104–105).

While the milk laboratories that filled prescription-like mathematical formulas had largely disappeared by the end of the 1910s, hospitals kept the theory of percentage feeding alive for decades. In 1936, physicians at Chicago’s Presbyterian Hospital, for example, celebrated the opening of a milk laboratory with “at least 25 different formulas, sometimes more, in order to serve the individual needs of each small patient” (The Presbyterian Hospital, 1936). Indeed, the notion that “science” supported the work of the chemists toiling in milk laboratories had been so appealing to the public that the medical charities funding certified milk stations distributed not only certified milk to the poor free of

charge but also a variety of generic formulas made with certified milk (Chicago School of Sanitary Instruction, 1912).

Despite the doubts, until percentage feeding was wholly abandoned, formula-writing remained pediatricians’ central skill and they were thus required to spend the bulk of their pediatric apprenticeships learning how to write formulas. Not until 1938, on the occasion of the 50th anniversary of the creation of the American Pediatric Society, did Chicago pediatrician Joseph Brennemann write the epitaph for percentage feeding: “It became increasingly more complicated and involved...[until] some of the articles seemed terrifyingly like treatises on mathematics or higher astronomy.” Writing formulas became “a headache,” Brennemann explained. “The whole edifice finally collapsed because the superstructure was top heavy and the foundation weak, and because really simpler ideas came into play” (Brennemann, 1938, p. 65). The one size fits all, cows milk-based infant formula eventually triumphed.

By the late 1920s, thanks to pediatricians and public health workers fighting for decades for the passage of municipal and state legislation that regulated the dairy industry, cows’ milk throughout the United States was gathered under sanitary conditions, pasteurized, placed in individual, sterile bottles, and kept cold during shipping. All dairy cattle were tested regularly for bovine tuberculosis to prevent spread of the disease to humans (Wolf, 2001).

There was one unforeseen side effect of this public health triumph, however. Due to the decades of publicity generated by urban newspapers, medical milk commissions, medical charities, milk laboratories, and public health departments, by the time cows’ milk was safe to feed to babies, consumers had come to believe breastfeeding was unimportant. As the breakfast cereal entrepreneur, Dr. John Kellogg explained, cows’ milk had become “the choicest product of nature’s laboratory” (Kellogg, 1921, pp. 332–333). Science had seemingly triumphed, at least in regard to infant feeding. Formula in baby bottles, with no mention or memory of the history behind formula, became the symbol signifying normal, healthy infancy.

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