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SUMMARY: The nineteenth century saw the incorporation of technology, such as the stethoscope, microscope, and thermometer, into clinical medicine. An instrument that has received less attention in the history of the role of technology in medicine is the weighing balance, or scale. Although not new to nineteenth-century medicine, it played an important part in the rise of the numerical method and its application to the development and shaping of pediatrics. This article explores the origin and development of the weighing of babies. During its clinical and scientific adoption, this simple procedure was refined and applied in a number of increasingly sophisticated and far-reaching ways: as a measure of the dimensions of the fetus and newborn, as an index of the viability of the newborn, as a means of estimating milk intake, as a way of distinguishing normality from abnormality, as a summary measure of infant health, and as an instrument of mass surveillance. In so doing it changed the way in which medical care was delivered to infants.

KEYWORDS: weighing balance, technology, infant, pediatrics, nutrition

Drawing on his experience as medical officer of health for Finsbury, George Newman wrote in 1906 in his influential book *Infant Mortality*:

> The importance of the weight of an infant as a criterion of its health and progress is well known. Indeed, the weight is often the only criterion as to whether the infant is improving in health or not. At birth the average weight is 7 lbs;

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> at three months it may be about 9 to 11 lbs; at six months about 13 to 15 lbs; at nine months about 16 to 17 lbs; and at twelve months 19 to 20 lbs. Dufour's standard has been used in the Finsbury Depot, as in French depots, and the charts appearing in the present volume are drawn to that scale.[1]

Newman was one of a group of British public health physicians whose relationships with colleagues in France helped form a bridge of sorts between the two countries across which continental ideas and initiatives concerning infant welfare passed. Newman's interest was in infant mortality, which he saw as a social problem, and belonging to an English public health tradition, he sought social and public health solutions to this long-standing and intractable issue.[2] However, this approach appeared to have failed, or at least run out of steam, by the end of the nineteenth century, and this prompted its leaders to look across the channel to France, where apparently miraculous reductions in infant mortality and improvements in child health were being reported. As Newman's colleague, George McCleary, medical officer of health of the neighboring borough of Battersea in west London, commented:

> It is becoming apparent that the ordinary methods of "sanitation" are inadequate to overcome the adverse influences, which menace the early months of life, and that the field of preventive medicine must be extended, if we are to deal effectively with the difficult, complex and supremely important problem of infantile mortality. . . . [In] the prevention of infant mortality, there is an increasing recognition of the value of the more special function of the physician, viz., the separate consideration of the individual human unit.[3]

Infant mortality rates had remained stubbornly high, at around 150 per one thousand live births in Great Britain throughout the century, since the collection of accurate records began in the 1830s.[4] It was the "individual human unit" that had become the focus of the French initiatives that seemed to be so effective. Pioneered in Paris in the 1870s by a group

1. George Newman, *Infant Mortality* (London: Methuen, 1906), on p. 303.

2. Published in 1906 and subtitled *A Social Problem*, *Infant Mortality* (n. 1) established Newman as a leading figure in the child public health movement. See also Eilidh Garrett, Chris Galley, Nicola Shelton, and Robert Woods, *Infant Mortality: A Continuing Social Problem* (Aldershot, U.K.: Ashgate, 2006).

3. G. F. McCleary, "The Municipal Feeding of Infants," *Practitioner*, 1905, *2*: 470–78, quotation on pp. 470 and 477.

4. The Registrar General's office for England and Wales was established in 1834, and for Scotland in 1854, to record, analyze, and report vital statistics. See David Armstrong, *Political Anatomy of the Body: Medical Knowledge in Britain in the Twentieth Century* (Cambridge: Cambridge University Press, 1983), chap. 1, "The Critical Gaze."

of obstetricians, pediatricians, and political activists who belonged to what became known as the *puériculture* movement, these initiatives concentrated attention on the health of the newborn baby, aiming to preserve its health during the critical months of early life by maintaining regular medically supervised contact with postparturient mothers and their babies.[5] By 1905 there were more than sixty *consultations de nourrissons* and *gouttes de lait* in France dedicated to this purpose, all based on the same three principles: support breast-feeding; weigh babies; and provide pure, clean, sterilized milk.

Pierre Budin, an originator of the *consultations,*[6] taught that careful follow up of infants, including advice on feeding, examination by a doctor, and weighing, were crucial. When women left the Maternité they were given a card on which their baby's date of birth, birth weight, and mode of feeding were recorded. If breast-feeding failed, pure clean cow's milk was supplied weekly, on the condition that mothers submitted their infants to regular weighing.[7] Weighing served not just as an index of progress but also as an entrée to the postnatal welfare clinics. It was an integral and universal component of an infant welfare service. "To create a consultation for infants, . . . three things suffice: a pair of scales, an apparatus for sterilising milk, and the devotion of a doctor,"[8] observed Leonard Robinson, physician to the Hertford British Hospital in Paris and a keen observer of the early *goutte de lait* movement.

In this article, I examine the part played by the weighing of babies in the development and implementation of child public health initiatives, particularly infant clinics, which were to become a hallmark of child

5. The *puériculture* movement developed out of growing concern for the welfare of mothers and babies arising from a recognition that infant mortality was closely associated with mode of feeding. Characteristic features of the movement were "scientific feeding," weighing (and other forms of quantitation), and medicalization of well-baby care. See Ann F. La Berge, "Medicalization and Moralization: The Crèches of Nineteenth-Century Paris," *J. Soc. Hist.*, 1991, *25*: 65–87; La Berge, "Mothers and Infants, Nurses and Nursing: Alfred Donné and the Medicalization of Child Care in Nineteenth-Century France," *J. Hist. Med. All. Sci.*, 1991, *46*: 20–43; Mary Lynn McDougall, "Protecting Infants: The French Campaign for Maternity Leaves, 1890s–1913," *Fr. Hist. Stud.*, 1983, *13*: 79–105; George D. Sussman, "The End of the Wet-Nursing Business in France, 1874–1914," *J. Fam. Hist.*, 1977, *2*: 237–58; and Rachel G. Fuchs, "Morality and Poverty: Public Health Welfare for Mothers in Paris, 1870–1900," *Fr. Hist.*, 1988, *2*: 288–311.

6. P. Budin, "Les Consultations de Nourrissons," *Annales de Medecine*, 1905, *1*: 618–45; G. F. McCleary, "The Infant's Milk Depot: Its History and Function," *J. Hyg.*, 1904, *4*: 329–68; and McCleary, *The Early History of the Infant Welfare Movement* (London: Lewis & Co., 1933).

7. Budin, "Consultations" (n. 6), on p. 619.

8. Leonard Robinson, "Consultations for Infants in France: Their Origins, Organisation and Results," *Practitioner*, 1905, *2*: 479–88, quotation on p. 481.

welfare in the twentieth century. A great deal has been written about the origins of this movement in France[9] and its radiation elsewhere,[10] but very little has been written about the nutritional science and pediatric thinking that underpinned it. The medicalization of infant care during the nineteenth century involved the application of scientific methods and technologies,[11] including the weighing of babies to measure their growth and, thereby, health. The weighing balance and the growth chart became diagnostic instruments with which to record the progress (or otherwise) of the individual child and of children as a whole. The use of these instruments (like the thermometer and temperature chart) represented a fusion of experiment and observation, which were central features of the "new" clinical medicine of the nineteenth century.[12]

I focus on France, Britain, Germany, and the United States for a number of reasons. It was in Paris that the weighing of babies was first used systematically to define the viability of the newborn. Out of this practice arose the process of estimating infant milk intake from infant weight gain and, thereby, the equation of weight with health. These uses of the balance laid the foundations for the *consultations* and *gouttes de lait*, which were exported to Britain, Germany, and the United States (and other countries),[13] where charting was developed and applied. The definition of growth standards followed,[14] and the practice of weighing babies extended

9. McCleary, "The Infant's Milk Depot" (n. 6) and *The Early History* (n. 6). See also Catherine Rollet, "The Fight Against Infant Mortality in the Past: An International Comparison," in *Infant and Child Mortality in the Past,* ed. Alain Bideau, Bertrand Desjardins, and Héctor Pérez-Brignoli (Oxford: Clarendon Press, 1997); Rima D. Apple, *Mothers and Medicine: A Social History of Infant Feeding 1890–1950* (Madison: University of Wisconsin Press, 1987); and Deborah Dwork, *War is Good for Babies & Other Young Children: A History of the Infant and Child Welfare Movement in England 1898–1918* (London: Tavistock, 1987).

10. See, for instance, Richard A. Meckel, *Save the Babies: American Public Health Reform and the Prevention of Infant Mortality, 1850–1929* (Baltimore: Johns Hopkins University Press, 1990); and Alisa Klaus, *Every Child a Lion: the Origins of Maternal and Infant Health Policy in the United States and France, 1890–1920* (Ithaca, N.Y.: Cornell University Press, 1993).

11. La Berge, "Medicalization and Moralization" (n. 5).

12. Stanley Joel Reiser, *Medicine and the Reign of Technology* (Cambridge: Cambridge University Press, 1978); and John Harley Warner, *The Therapeutic Perspective: Medical Practice, Knowledge, and Identity in America, 1820–1885* (Princeton, N.J.: Princeton University Press, 1997).

13. McCleary, *The Early History* (n. 6). See also Henry Koplik, "The History of the First Milk Depot or Gouttes de Lait with Consultations in America," *JAMA*, 1914, *63*: 1574–75; and Philip Van Ingen and Paul Emmons Taylor, *Infant Mortality and Milk Stations* (New York: N.Y. Milk Committee, 1912).

14. J. Rosser Matthews, *Quantification and the Quest for Medical Certainty* (Princeton, N.J.: Princeton University Press, 1995).

from the evaluation of the health of the "individual unit" to the surveillance of infants as a whole. In this article, I also illustrate how, through the application of the simple procedure of weighing babies, numerical and graphical methods became cornerstones of both "scientific" pediatrics and child welfare.

Infant Weight, Growth, and Welfare

The weighing balance or scale has a history extending back to ancient Babylon and Egypt, but it was not until the late seventeenth century that the weights of babies were first reported.[15] Anatomists from the Renaissance onward depicted the gravid uterus and its contents in manuscripts and models, but illustrations of the embryo and growing fetus alone marked a trend toward quantifying the dimensions of the newborn infant. By including the weight of a neonate alongside a picture of the proportions of the fetus at term in his textbook,[16] the great French obstetrician François Mauriceau added a measurement to his depiction of the newborn baby. The English physician Theophilus Lobb mentioned the weight of a single "child after delivery,"[17] and the Scottish obstetrician William Smellie[18] gave general figures for the weight of the fetus at nine months. The German obstetrician Johann Roederer[19] and his pupil Johann Dietz[20] expanded on these sporadic measurements. Albrecht von Haller mentions the weight of the newborn in his major work on human physiology,[21] and this was referred to by Joseph Clarke, master of the Rotunda in Dublin, who himself reported the birth weights of eighty newborn babies in 1786.[22] The practice of weighing the newborn appears to have become

15. Thomas E. Cone, "Pediatric History: De Pondere Infantum Recens Natorum," *Pediatrics*, 1961, *28*: 490–98.

16. François Mauriceau, *Traité des Maladies des Femmes Grosses*, trans. H. Chamberlen (London: John Darby, 1683).

17. Theophilus Lobb, *A Compendium of the Practice of Physic* (London, 1747), on p. 90.

18. William Smellie, *A Treatise on the Theory and Practice of Midwifery*, vol. 1 (London, 1766). See also Cone, "De Pondere" (n. 15); and J. M. Tanner, *History of the Study of Human Growth* (Cambridge: Cambridge University Press, 1981).

19. J. G. Roederer, "De Pondere et Longitudine Infantum Recens Natorum," *Commenetarii Societatis Regiae Scinetarum Göttingensis*, 1754, *3*: 410–24.

20. J. F. G. Dietz, *De Temporum in Gravidate et Partu Aestimatione* (Göttingen: Schultz, 1757).

21. Albrecht von Haller, *Elementa Physiolgiae Corpus Humani*, 8 vols. (Laussane: Pott, 1778).

22. Joseph Clarke, "Observations on Some Causes of the Excess of the Mortality of Males above that of Females," *Philos. Trans. R. Soc. Lond.*, 1786, *76*: 349–64.

established in some maternity hospitals and in the home,[23] and by the end of the eighteenth century there was a degree of agreement among European obstetricians about the weight of the newborn. This information had purposes and value other than for description alone.

Viability

In the early nineteenth century, systematic efforts were made to weigh large numbers of newborn babies to draw conclusions that might answer questions about the viability of the newborn. An impetus to address these questions arose out of the reforms of science and medicine that followed the French Revolution. The great Paris hospitals (Hôtel Dieu, Charité, Salpetrière, Maternité, Necker, Pitié), hitherto charitable refuges for the infirm, insane, and abandoned, began to be transformed, under the control of the state, into vast "laboratories" for clinical observation, medical education, and human experimentation.[24] The *méthode anatomo-clinique* that emerged was based on accurate and thorough clinical examination, with the careful noting of functional and physical data, and the correlation of direct observation of the living with postmortem examination of the dead. Weighing and measuring were integral to this observation and experimentation,[25] and in the maternity and foundling hospitals there were opportunities for both.

François Chaussier, one of the architects of these great postrevolutionary developments in Paris medicine, was the chair of anatomy and physiology as well as physician in charge of the newborn at the Maternité. Inspired by a search for an index of maturity and thereby viability, he invented a way of aging the fetus by weighing and measuring its proportions.[26] Chaussier had written his doctoral thesis on infanticide, and his interest in birth weight was forensic; the outcome of legal cases of disputed inheritance, legitimacy, and infanticide could turn on proof of viability. He measured the weights of small numbers of babies, but his pupil Michael Friedlander took advantage of the large numbers of newborns in the Maternité to weigh over seven thousand of them between 1802 and 1806.[27]

23. Cone, "De Pondere" (n. 15).

24. Erwin H. Ackerknecht, *Medicine at the Paris Hospital, 1794–1848* (Baltimore: Johns Hopkins University Press, 1967).

25. Matthews, *Quantification* (n. 14).

26. See Tanner, *History of the Study of Human Growth* (n. 18), p. 478, for details of the methods used by François Chaussier (1746–1825) to age the fetus and newborn.

27. Michael Friedlander, *De l'Education Physique de L'Homme* (Paris: Treuttel et Würtz, 1815).

Such attempts to define the "normal" weight of the newborn were examples of not just the descriptive anatomo-clinical method, but also the *méthode numérique,* the application of mathematics to medicine to measure and analyze clinical phenomena. The availability of large numbers of patients in Paris's public hospitals (estimated to be twenty thousand or more) invited opportunities for the study of medicine and the investigation of disease.[28] The collection by Pierre Louis of thousands of case histories and autopsy records in the wards of the Charité generated material with which to evaluate treatments and to define the boundaries between the normal and pathological.[29] Such systematic measurements coincided with the adoption of standardized metric units in France and debate about the use of numeric data in the physical, social, and biological sciences. Pierre-Simon Laplace equated enumeration with scientific reasoning, and appeal to his "calculus of probabilities"[30] was made by both supporters and opponents of Louis's work. Those who disagreed argued that the "art" of medicine had no need of "science" and that data obtained from the enumeration of large numbers of patients could shed no light on the predicament of the individual.[31] I will take up the significance of this debate later in this article.

The French clinico-anatomic method began to replace symptom-based descriptions of disease with a classification founded on pathology, but the newborn baby represented a special problem. Although some infants who died soon after birth clearly had gross congenital abnormalities obvious to the naked eye that could account for their demise—such as anencephaly or anogenital abnormalities—others seemed to die for no explicable reason. The viability of the newborn was insufficient, and their deaths were often ascribed to "debility" or "atrophy."[32] As the practice of autopsy was extended to infants, a search for internal abnormalities that would explain their deaths revealed lesions of the heart and lungs, for instance. However, in many cases nothing abnormal was found. In addition to the

28. Ackerknecht, *Medicine* (n. 24), p. 5.

29. P. C. A. Louis, "Recherche sur les effets de la saignée dans plusieurs maladies inflammatoires," *Arch. Gen. Med.*, 1828, *18*: 321–36; and Louis, *Researches on the Effects of Bloodletting* (Boston: Hilliard, Gray & Co., 1836).

30. Pierre-Simon Laplace (1749–1827) used calculus to explore probability in his *Essai Philosophique sur les Probabilitiés* (Paris, 1814). See also Matthews, *Quantification* (n. 14).

31. Matthews, *Quantification* (n. 14).

32. The words "atrophy" and "debility" were used in France and Great Britain, and by the 1880s, when infant mortality rate became a distinct category for the purposes of death certification, pathological causes of death, such as "atelectatis" and "asphyxia," started to replace them. See David Armstrong, "The Invention of Infant Mortality," *Sociol. Health Illn.*, 1986, *8*: 211–32.

scalpel, the weighing balance was used as a means of trying to define a cut-off point between the viable and the unviable.

In L'Hospice des Enfants Trouvés, Charles-Michel Billard used both balance and scalpel. As a foundling's hospital, the hospice received infants from birth to two years of age. Healthy babies and those weighing over six pounds were separated from the small, weak, and dying by a skilled nurse and the hospital physician.[33] Billard measured their weights, claiming that variations at birth were as great as at older ages. Acknowledging the "celebrated anatomist" Chaussier, he cited Friedlander's data from the Maternité, which reported a modal birth weight of between six and seven pounds with a range of one to ten, commenting that "it is impossible to assign any size in common to all young infants; they differ in this respect almost as much as adults. All the varieties of size, strength, shape and colour exhibited in the human species, are evident in the cradle."[34] In using figures to describe this variation in size, Billard's interest, like that of Chaussier, was in defining a cut-off point between viable and unviable babies that might be applied both pre- and postmortem and determining, in effect, when life began: "Viability is the capability of extrauterine life; it should consist not only in the normal state of the organs of the infant, but likewise in the absence of all physiological and pathological causes capable of opposing the establishment or prolongation of independent existence."[35] Detailed descriptions of the newborn, including its dimensions, based on observation and autopsy, drew Billard to conclude that "the newborn infant may be born healthy, diseased, convalescent or entirely recovered from a former condition."[36] As the translator of Billard's textbook stated, "In addition to pathology, another object of the author is to add something to the stock of legal medicine."[37] His book dealt with both, categorizing the diseases of infancy within the new pathological framework and proposing criteria with which to distinguish the viable from the unviable.

33. Murdina M. Desmond, *Newborn Medicine and Society: European Background and American Practice (1750–1975)* (Austin, Tx.: Eakin Press, 1998), chap. 1.

34. C.-M. Billard, *Traité des Maladies des Enfans Nouveau-nés et a la Mamelle*, trans. J. Stewart (London: J. Churchill, 1839), p. 36. See also J. B. Beckwith, "Charles-Michel Billard (1800–1832): Pioneer of Infant Pathology," *Pediatr. Dev. Pathol.*, 2002, *5*: 248–56.

35. Billard, *Traité* (n. 34), p. 515.

36. Ibid.

37. Ibid., translator's preface, p. 1.

Nutritional Sufficiency

Alongside this interest in the dimensions and proportions of the fetus and infant and investigation of the bounds of viability facilitated by the weighing balance arose the physiological application of the instrument. At the Charité Hopital, Alfred Donné, *chef de clinique* in the early 1830s and another colleague of Pierre Louis,[38] weighed babies to assess their growth and milk intake. Donné was an enthusiast for new technology, pioneering the clinical use of the thermometer and microscope as well as the weighing balance. His study of the microscopic appearance of milk paralleled developments in chemistry pioneered by Justus Liebig, who used simple gravimetric methods to analyze its constituents. By the 1840s, the basic composition of both cow's milk and human milk had been defined.[39]

Donné took a special interest in children's health, in particular the feeding of infants, rejecting "demand feeding," which had been fashionable since the preachings of Jean-Jacques Rousseau,[40] and recommending regularity. He urged physicians to focus on preserving health by monitoring infant development and growth. Donné advised weighing babies every two to four weeks, noting that they gained about a pound each month and doubled their birth weight by six months.[41] His popular book on infant care and feeding argued for "scientific" childcare in which the physician assumed medical responsibility for both mother and baby. The latter became a "patient" receiving attention equal to that paid the mother, and the growth of the baby demanded as much consideration as the quality of the mother's milk. Donné's book differed from Billard's in approach and layout[42] (Billard's chapters were dedicated to pathology rather than symptoms), taking the form of a manual for physicians who were caring for infants and advising their mothers, emphasizing hygiene and feeding. Dealing with common problems of infancy (teething, diarrhea, and constipation), its author aimed "to confine myself to the spheres of the physician and the physiologist."[43] Natalis Guillot, also a microscopist and

38. La Berge, "Mothers and Infants" (n. 5).

39. T. B. Mepham, "Humanizing Milk: The Formulation of Artificial Feeds for Infants (1850–1910)," *Med. Hist.*, 1993, *37*: 225–49. See also J. Liebig, *Supp für Sauglinge* (Brunswick: Fr, Wieweg und Sohn, 1866); and Louis Rosenfeld, "Justus Liebig and Animal Chemistry," *Clin. Chem.*, 2003, *49*: 1696–1707.

40. Jean-Jacques Rousseau, *Emile*, trans. Allan Bloom (New York: Basic Books, 1979). Book 1 deals with the care and rearing of infants. Rousseau (1712–78) emphasizes the perils of swaddling and the benefits of breast-feeding.

41. Alfred L. Donné, *Conseils aux Mères sur l'Allaitement et sur la Manière d'Eléver les Enfants Nouveau-nés* (Paris: Baillière, 1846), p. 175.

42. Billard, *Traité* (n. 34).

43. See La Berge, "Mothers and Infants" (n. 5), on p. 28.

professor in the Faculté de Médicine, went a step further than his colleague Donné, arguing that "Weighing the child every morning is not enough. In order to fully assess what is happening, the child has to be weighed before and after every feed; the weight gain shows the quantity of milk that has been absorbed."[44] The weighing of babies assumed a new purpose beyond the provision of a static measure of viability. It served as a useful tool with which to estimate milk intake and a ready way of linking dynamic information about what babies were given (milk) with whether the amount was adequate (weight gain). In Paris the balance was recommended as a useful instrument both in the clinic and outside to evaluate and promote infant hygiene. "Guillot," it was noted, "was an innovator in that he used the scales as a hygienist and as a doctor."[45]

Handbooks of infant feeding started to include chapters on the chemical composition of milk, with recommendations on how to transform cow's milk into something resembling breast milk.[46] Simple numeric data documenting the frequency and volumes of milk to be given and tables listing the nutrients in human and bovine milk were included. However, the routine of measuring infant weight and growth did not immediately catch on outside Paris, even if the link between feeding and growth was appreciated. "When we consider that a child has in the first year of life to acquire not far from one-third of its full growth and size, we must consider that it requires, at the same time as it has to supply waste and wear, a large quantity of food to meet the emergency. . . . The increase of weight, however, bears a direct ratio to the quantity and quality of food supplied," commented Charles Routh,[47] without explicit reference to regular weighing. In Britain, the medical care of infants was rudimentary, and public health services for mothers and their babies were virtually nonexistent. Neither the popular textbook of Michael Underwood[48] nor that of Charles West[49] (with whom Billard had studied in London in 1827)[50] cited the

44. Natalis Guillot, "Klinische Bemerkungen über Ammen und Säuglinge," *J. Kinderkrankheiten*, 1852, *19*: 113–25, quotation on p. 116.

45. G. Variot, *La Croissance Chez le Nourisson Accroissement Ponderal et Statural* (Paris: Doin, 1925), on p. 80.

46. See Mepham, "Humanizing Milk" (n. 39), pp. 241–45; and Rima D. Apple, "'To be Used Only under the Direction of a Physician': Commercial Infant Feeding and Medical Practice, 1870–1940," *Bull. Hist. Med.*, 1980, *54*: 402–17.

47. C. H. F. Routh, *Infant Feeding and its Influence on Life or the Causes and Prevention of Infant Mortality* (London: John Churchill, 1860) pp. 107–8.

48. Michael Underwood, *A Treatise on the Diseases of Children with Directions for the Management of Infants from Birth*, 8th ed., rev., with notes and observations by S. Merriman (London: J. Davy, 1827).

49. Charles West, *Lectures on the Diseases of Infancy and Childhood* (London: Longmans, 1852).

50. Beckwith, "Charles-Michel Billard" (n. 34), p. 253.

work of Billard, Guillot, or Donné.[51] The use of the weighing balance to assess nutritional sufficiency and growth was unknown, or at least not advocated, in Britain.[52]

In the German hospitals and schools of clinical medicine, on the other hand—where laboratory science was increasingly adopted—weighing, measuring, and statistic taking were widely applied and came to eclipse the anatomico-clinical method.[53] In the country where Liebig had established the basic principles of "nutritional balance" and coined the word "metabolism" to describe the body's inner workings,[54] weighing scales played a critical part in the investigation of the nutritional needs of the growing infant. The application of weighing to the assessment of the nutritional requirements (as opposed to milk intakes) of infants was first undertaken, also in Leipzig, by the obstetrician Freidrich Ahlfeld.[55] Coupled with the calorimeter, the balance became a key tool in the scientific measurement of energy metabolism, which in due course was to lead to estimates of milk requirements based on calories rather than volumes of milk.[56]

Normality and Abnormality

While the weighing of babies was promoted as a means of determining viability, of measuring milk intake, and as a guide to energy requirements, these purposes together suggested its value in the clinic as a general index of health. The weighing balance lent itself to the collection of data, which could be used to distinguish "normality" from "abnormality." Billard included measures of body weight in his pathological classification of the diseases of infancy, seeking to use them in part to distinguish, for instance, syphilis, tuberculosis, and rickets.[57] In the Brussels Foundling Hospital,

51. Billard, *Traité* (n. 34); Donné, *Conseils aux Mères* (n. 41); and Guillot, "Klinische Bemerkungen" (n. 44).

52. Billard's (*Traité*, n. 34) and Donné's books (*Conseils aux Mères*, n. 41) became known to English speakers through translations.

53. Matthews, *Quantification* (n. 14), see chap. 3, pp. 39–61; and see W. F. Bynum, *Science and the Practice of Medicine in the Nineteenth Century* (Cambridge: Cambridge University Press, 1994).

54. J. Liebig, *Animal Chemistry*, trans. W. Gregory (London: Taylor & Walton, 1843). See also Rosenfeld, "Justus Liebig" (n. 39).

55. Friedrich Ahlfeld (1843–1929), an obstetrician at Leipzig, is said by Garrison to have "introduced the use of the balance in weighing infants in connection with growth and metabolism." See Fielding Garrison, *History of Pediatrics* (Philadelphia: W. B. Saunders, 1923), p. 132; and Johann Freidrich Ahlfeld, *Ueber Ernährung des Säuglings an der Mutterbrust* (Leipzig, 1878).

56. M. Rubner and O. Heubner, "Die Naturliche Ernährung eines Säuglings," *Z. Biol.*, 1898, *36*: 1–55.

57. Billard, *Traité* (n. 34).

Adolphe Quetelet measured the lengths and weights of one hundred newborns, noting that boys were heavier than girls at birth and at one year.[58] These data contributed to his aim to define the *l'homme moyen*, on the basis of his belief that the average of all human attributes in a given country serves to define the "type" of the nation analogous to the center of gravity in physics: "The study of diseases and of the deformities, to which they give place, has shown the benefits derivable from corporeal measurements; but in order to recognise whatever is an anomaly, it is essentially necessary to have established the type constituting the normal or healthy condition."[59]

In defining averages (means or *moyens*) Quetelet recognized and sought to accommodate the variations surrounding them, observing, for instance, that the range of pulse rates of the newborn baby (130–140 beats per minute) represented a different range (and average) than that of adults. Quetelet was a lifelong friend of the epidemiologist Louis Villermé,[60] who himself was a colleague of Pierre Louis. Quetelet and Villermé applied the numerical method to hygiene and public health, measuring the physiques of adults and children in all sorts of circumstances, in relation to age, health, and mortality rates.[61] A "normal" weight was a measure of both viability and health. Quetelet's measurements remained the only source of data on infant growth, quoted by many authors, for several decades. However, the foundlings he measured were not representative of "normal," healthy infants.[62]

The collection, interpretation, and clinical utilization of numerical data posed two big questions: how to distinguish normality from abnormality and how to express or present large bodies of numerical data, especially those that had a time dimension, such as growth, changes in body temperature, or pulse rate. These topics were the subject of active debate throughout the second half of the century. Quetelet had recognized that the law of large numbers, proposed by Siméon-Denis Poisson, needed to be observed if meaningful clinical conclusions were to be drawn from the

58. A. Quetelet, "Sur la Taille Moyenne de l'Homme dans les Villes et dans les Campagnes, et sur l'Age ou la Croissance est Complètement Achevée," *Annales d'Hygiène Publique*, 1830, *3*: 24–26.

59. A. Quetelet, *Sur l'Homme et le Développment de ses Facultiés. Essai sur Physique Sociale*, 2 vols. (1835; New York: Burt Franklin, 1962), p. 4.

60. Erwin H. Ackerknecht, "Villermé and Quetelet," *Bull. Hist. Med.*, 1952, *26*: 317–29.

61. L. R. Villermé, "Mémoire sur la mortalité en France dans le Classe Aisé et dans le Classes Indigente," *Mémoires de l'Académie Royale de Médecine*, 1828, *1*: 51–98.

62. Quetelet, *Sur l'Homme* (n. 59).

analysis of many measurements. It was a complex debate that addressed many aspects of the use of quantitative, objective facts in medicine.[63]

In Leipzig, Carl Wunderlich, who had studied and worked in Paris, applied the numerical method to the measurement of body temperature. By defining normality and abnormality as oscillations on charts, he helped to establish the notion that objective, numeric, and graphic data could be applied to clinical practice. Wunderlich undertook tens of thousands of measurements of body temperature from patients with all manner of conditions, arguing that they generated "results that can be measured, signs that can be expressed in number and offer materials for diagnosis which are incontestable and indubitable, and are independent of the opinion or the amount of practice or the sagacity of the observer. . . ."[64] In attempting to define fixed laws of temperature in disease from the analysis of many observations, Wunderlich advocated the careful study of the form of the curves generated by them. From detailed comparisons, he envisaged the creation of "a sort of model curve, which may approximatively express the peculiarities of single cases."[65] The curve on the chart gave clinical meaning to sequentially obtained objective data, allowing the health (or otherwise) of the "individual unit" to be identified against a background representing the ranges of normality.[66]

The same could be said of gravimetric data. In the 1870s and '80s a number of studies of the growth of infants were published. Anton Russow in St. Petersburg confirmed the differences in weight growth of the two sexes[67] first documented by Quetelet forty years earlier.[68] Recognizing that artificial feeding was often associated with growth failure, he compared the lengths and weights of infants who were breast-fed with those fed by bottle. Between 1873 and 1878, he and one nurse carried out five thousand weighings on over nine hundred infants and reported measurements from one month to one year. Karl Schmidt-Monnard, a pediatrician from

63. Matthews, *Quantification* (n. 14), pp. 74–78.

64. C. A. Wunderlich, *On the Temperature in Diseases: A Manual of Medical Thermometry*, trans. W. Bathurst Woodman (London: New Sydenham Society, 1871), pp. 48–49. See P. A. Mackowiak and G. Worden, "Carl Reinhold August Wunderlich and the Evolution of Clinical Thermometry," *Clin. Infect. Dis.*, 1994, *18*: 458–67; and C. R. A. Wunderlich, "The Course of the Temperature in Diseases: A Guide to Clinical Thermometry," *Am. J. Med. Sci.*, 1869, *57*: 425–27.

65. Wunderlich, *On the Temperature* (n. 64), p. 289.

66. Tanner, *History of the Study of Human Growth* (n. 18), chap. 6, pp. 122–41.

67. A. Russow, "Vergleichende Beobachtungen über den Einfluss der Ernährung mit der Brust und der Künstlichen Ernährung auf das Gewicht und den Wuchs der Kinder," *Jahrbuch für Kinerheilkunde*, 1880, *16*: 86–131.

68. Quetelet, *Sur l'Homme* (n. 59).

Halle, measured the weights of three thousand healthy children.[69] Karl Vierordt, professor of physiology at Tübingen, collected the weekly weights of thirty-eight infants, which he published in Carl Gerhardt's *Handbuch der Kinderkrankheiten.*[70] Gerhardt, a pediatrician, quoted the rates of growth month by month, referring to Quetelet's data.[71] Eduard Henoch, another influential German pediatrician, stated simply that "at the end of the first month the weight has increased by about one third; in the fifth month it has doubled, in the twelfth month tripled."[72] As Henoch was succeeded by a new generation of pediatricians whose textbooks stressed the physiological basis of child medicine,[73] tables of infant growth rates designed to define normality began to appear in German textbooks.

These data reinforced the idea that growth could be used as a guide to well-being, and that normal standards were needed and could be defined. Graphical representation followed, and with it promotion of the growth chart to monitor weight gain (or loss) as an aid to diagnosis and treatment.[74] However, growth charts tended to display a single curve to depict the average growth of all babies (whatever their gender or mode of feeding). Vierordt[75] and Wilhelm Camerer,[76] a leading German pediatrician with an interest in child nutrition, had both pointed out the difference between the generalizing and individualizing methods (now called cross-sectional and longitudinal methods) of collecting and analyzing growth data and suggested ways of smoothing data and fitting mathematical curves, as had been proposed first by Quetelet.[77] Camerer's son (also Wilhelm) defined what was needed to describe normal growth: "It is desirable to obtain reliable average values from observations on a large number of children," but, he warned, the "normal curves for the growth in the first

69. K. Schmidt-Monnard, "Über den Einfluss des Militärdienstes der Väter auf die Körperliche Entwicklung ihrer Nachkommenschaft," *Jahrbuch Kinderheilkunde*, 1892, *33*: 327–50.

70. K. Vierordt, "Physiologie des Kindesalters," in *Handbuch der Kinderkrankheiten,* ed. C. Garhardt, 2nd ed., vol. 1 (Tübingen: Laupp, 1877), pp. 59–91.

71. Carl Gerhardt, *Lehrbuch der Kinderkrankheiten* (Tübingen: 1861–91, 4 editions).

72. E. Henoch, *Lectures on Children's Diseases: A Handbook for Practitioners and Students*, trans. John Thomson, 2 vols. (London: New Sydenham Society, 1889), 1: on p. 71.

73. Gerhardt, *Lehrbuch* (n. 71), preface. See Garrison, *History of Pediatrics* (n. 55), p. 91 and pp. 130–46. See also Meinhard von Pfaundler and Arthur Schlossmann, *The Diseases of Children: Pathology, symptomatology, prophylaxis*, trans. Henry L. K. Shaw and Linnæus La Fetra (Philadelphia: Lippincott, 1908).

74. P. Budin, *Le Nourrisson* (Paris: Doin, 1900), trans. William J. Maloney (London: Caxton, 1907); and Budin, *Manuel Pratique d'Allaitement* (Paris: Doin, 1907).

75. K. Vierordt, *Grundriss der Physiologie des Menschen* (Tübingen: Laupp, 1861).

76. Wilhelm Camerer (1842–1910) was a pupil and, later, colleague of Karl Vierordt.

77. Quetelet, *Sur l'Homme* (n. 59).

year of life have only a very limited value."[78] This was because, although the curves were derived from data obtained from many infants, there was no obvious way to express individual variation and the bounds of normality. The textbook in which he published these data, while emphasizing the physiological basis of pediatrics, was concerned with the care of sick children. Although "intended primarily for the needs of the practitioner, to limit pathological anatomy to the most important facts, and to put the physiological part in the foreground . . . ,"[79] it was not concerned with child welfare and health surveillance.

In Paris, the practice of weighing, popularized by Donné and Guillot in the 1850s, formed the foundations for a program of hospital-based investigations of pregnancy, fetal health, parturition, and infant welfare initiated by Stéphane Tarnier, *chef de clinique* at the Maternité in the 1880s. Many of Tarnier's pupils wrote doctoral theses based on research involving the weighing of mothers and babies in a variety of circumstances. Students of Adolphe Pinard, for instance, compared the weights of babies born to mothers who had worked to term with those who had rested during pregnancy,[80] showing that the latter were on average 10–12 ounces heavier. Another pupil measured the weights of 4,445 neonates according to birth order and whether their mothers had rested before delivery. Those whose mothers had rested weighed 4.5–12 ounces more than babies in the same birth order whose mothers had worked to term.[81]

Tarnier also took a special clinical interest in the care of "weaklings" (small, undernourished, premature, and sick babies),[82] and in 1893 his pupil Budin took over the direction of the Pavillon des Débiles, where these babies were cared for. The Pavillon took in babies born prematurely in the Maternité as well as infants from the Hôpital des Enfants Trouvés and infants brought in from the streets by their mothers. Fastened to the top of each incubator was a chart for recording the temperature of the

78. W. Camerer and S. Amberg, "Children's Growth in Weight and Height," in Pfaundler and Schlossmann, *The Diseases of Children* (n. 73), pp. 409–24, quotation on p. 412.

79. Ibid., preface, pp. v–vi.

80. A. Pinard, "Note pour Servir a l'Histoire de la Puériculture Intrauterine," *Bulletin de l'Academie de Médecine*, 1895: 593–97.

81. F. C. Bachimont, *Documents pour Servir a l'Histoire de la Puériculture Intra-utérine* (M.D. thesis, Facultie de Medecine, 1898), referred to by McDougall, "Protecting Infants" (n. 5), pp. 95–96.

82. P. L. Toubas and R. Nelson, "The Role of French Midwives in Establishing the First Special Care Units for Sick Newborns," *J. Perinatol.*, 2002, *22*: 75–77. See also Jeffrey P. Baker, *The Machine in the Nursery* (Baltimore: John Hopkins University Press, 1996) for a history of the incubator; and M. Henry, "Fondation du Pavillon des Enfants Débiles a la Maternité de Paris," *Revue des Malades de L'Enfance*, 1908: 142–54.

infant and his or her daily weight. The weighing balance was an essential piece of medical technology in the newborn nursery, just like the thermometer, providing an objective measure of health.

"When babies develop normally they put on weight regularly and of a quantity more or less according to their age—this is a general rule. When the curve of weight gain of an infant is good, one can conclude that it is in an excellent state of health, and is in no danger; if it is unwell one knows that the weight goes down."[83] The opening pages of Budin's manual of infant feeding are devoted to a discussion of the temperature and weight of the newborn,[84] and his lecture notes, published as *Le Nourrisson,*[85] were heavily illustrated with growth charts, including records of the volumes of milk given to babies beneath serial measurements of their weights. In using the balance to estimate how much milk infants needed, Budin acknowledged the work of his Parisian predecessor Guillot: "The observations I have made convince me that no means of assessing the state of health or illness of an infant, the quality of its nurse, or its loss or gain in weight, is as accurate as the one I am presenting to you."[86] In classifying the different types of newborns, particularly categories of weaklings, Budin adopted an approach reminiscent of that of Billard: "My method . . . is . . . based on clinical observation reinforced by the balance and thermometer. . . . It is often said that simple inspection enables a practiced eye to appreciate whether or not an infant is thriving. Do not believe it. . . . always have recourse to a balance. Recommend its usage at all times, knowing that nothing can replace it as a means to estimate its development."[87]

Weighing babies offered a means of distinguishing *les normalles* from *les débiles* (it provided an index of viability), while weighing them before and after a feed provided a measure of milk intake, and regular weighing was a way of monitoring their growth and nutritional status. "The balance is the best barometer of health."[88] The scientific interest in examining mother's milk microscopically and measuring its chemical composition as a guide to its adequacy and the nutritional needs of infants was giving way to weighing the baby. There was a shift of interest from the health of the mother and the quality of her milk to the health of the baby and its gain in weight.

83. Budin, *Manuel Pratique* (n. 74), p. 4.

84. Ibid., pp. 1–6.

85. Budin, *Le Nourrisson* (n. 74).

86. Budin, *Manuel Pratique* (n. 74), p. 30. See also Guillot, "Klinische Bemerkungen" (n. 44).

87. Budin, *Le Nourrisson* (n. 74), Lecture 5, p. 7.

88. Gaston Variot (1855–1930), pediatrician and colleague of Budin's, attributed this quotation of 1862 to Franz von Winckel (1837–1911) in Variot, *La Croissance* (n. 45), p. 80.

The weighing balance and growth chart were promoted as instruments for the quantitative assessment of infant feeding and health.

Growth Charting and Infant Health

By the 1890s, the weighing of babies was established in Paris hospitals as a simple way to assess and monitor their health, and it had been shown to be a ready means of extending the medical gaze from the individual baby at a single moment to surveying lots of babies over time. The association between infant mortality and improper feeding was well recognized, and the observation that many babies who died prematurely were marasmic, undernourished, and failing to grow[89] commended the balance as an instrument of health surveillance. Within the *consultations de nourrissons* and *gouttes de lait*, the balance became both the purpose for attendance and the entrée to these welfare clinics. In promoting the work of the *consultations*, Budin was well aware of the power of the numerical and graphical methods. The principal danger to babies from unwholesome raw cow's milk was diarrhea, and Budin commissioned two public health statisticians to review infant mortality rates in urban France. They calculated that diarrhea accounted for 25 percent of all infant deaths,[90] and that as a consequence of this and other preventable infant diseases, France lost the equivalent of one army corps per year. Such vividly suggestive statistics and histograms demonstrating graphically the tenfold higher mortality of artificially fed babies during an epidemic of summer diarrhea were published in his books[91] and reproduced as posters. The soaring columns of "dead babies" threw into question France's newfound confidence, which had just been regained following the disastrous Franco-Prussian conflict, celebrated and symbolized by the Eiffel Tower.

These figures and graphs were used to justify and publicize the *consultations de nourrissons*.[92] Budin, along with his colleague Léon Dufour in Normandy, showed how mortality rates were lower for babies who attended the *consultations* and *gouttes de lait* than for those who did not. Pediatrics and *puériculture* were blended together in the adoption and application of the weighing scale and the growth chart. Central to the clinical care

89. Rollet, "Fight Against Infant Mortality" (n. 9). See also George D. Sussman, *Selling Mothers' Milk: The Wet-Nursing Business in France, 1715–1914* (Chicago: University of Illinois Press, 1982). See La Berge, "Medicalization and Moralization" (n. 5).

90. A. Balestre and A. Gilletta, *Etude sur la Mortalité de la Première Enfance dans la Population Urbane de la France de 1892 a 1897* (Paris: Doin, 1901).

91. Budin, *Manuel Pratique* (n. 74) and *Le Nourrisson* (n. 74).

92. Budin, "Consultations" (n. 6); and *Le Nourrisson* (n. 74), Lecture 10.

of the newborn, they became indispensable tools for the support and surveillance of infants outside hospitals. Budin used the growth chart not simply as a guide to the milk requirements and a visual record of the clinical progress of individual babies but also as a teaching aid to instruct students and as a propaganda tool to promote the *consultations*. In publicizing the positive impact of weighing and charting on infant mortality rates, Budin and his colleagues changed the relationship between doctor and patient in France and with it, the systems of providing medical care—from reactive, hospital-based medical treatment to preventative community child welfare.

English-speaking physicians (both British and American) began to make use of the weight of an infant as a rough guide to its clinical progress. "The weight of the infant is the best means to measure its nutrition. It is as valuable a guide to the physician in infant feeding as is the temperature in a case of continued fever," taught Emmett Holt, a leading pediatrician in New York.[93] Textbooks and handbooks on infant care and feeding started to contain illustrations of suitable balances.[94] Nevertheless they were usually still accompanied by simple (albeit variable) rules of thumb concerning weight gain. Morgan Rotch repeated that "useful figures to remember are that initial weight is doubled at five months and tripled at 15 months"[95] alongside a graph of the weight gain of three babies, but with no indication of the normal rate. Rotch had a special interest in infant feeding and nutrition and was familiar with German and French medical literature, and his teachings influenced the writings of British disciples of his percentage feeding method.[96] Their textbooks on infant feeding were equally vague about normal infant growth,[97] simply reiterating the doubling and trebling weight milestones[98] or dismissing them with such

93. Luther Emmett Holt, *The Diseases of Infancy and Childhood* (London: Henry Kimpton, 1899), on p. 15.

94. See, for instance: Edmund Cautley, *The Natural and Artificial Methods of Feeding Infants and Young Children* (London: Churchill, 1896); W. B. Cheadle, *Artifical Feeding of Infants* (London: Smith Elder, 1889); L. Emmett Holt, *The Care and Feeding of Children* (New York: Appleton, 1901); A. Dingwall-Fordyce, *Diet in Infancy* (London: William Green, 1908); S. M. Sadler, *Infant Feeding by Artificial Means* (Aberdeen: Scientific Press, 1896); and R. Vincent, *The Nutrition of the Infant* (London: Ballierre, Tyndall & Cox, 1910).

95. Thomas Morgan Rotch, *Pediatrics* (Philadelphia: Lippincott, 1896), p. 103. See Thomas E. Cone, *History of American Pediatrics* (Boston: Little Brown, 1979).

96. Thomas Morgan Rotch, "An Historical Sketch of the Development of Percentage Feeding," *N.Y. Med. J.*, 1907, *85*: 532–40.

97. Eric Pritchard, *The Physiological Feeding of Infants* (London: Kimpton, 1904); and Vincent, *Nutrition of the Infant* (n. 94).

98. Cautley, *Natural and Artificial Methods* (n. 94).

comments as "curves and minute statistics of normal weights and heights at various ages are more often than not misleading."[99]

In spite of a long-standing and vociferous concern about the high mortality of infants,[100] systematic or institutional methods for their care or assessment hardly existed in Great Britain. Children's hospitals had appeared in many English cities following the first in London in 1852,[101] but infants were excluded as a rule from admission on account of the risk of introducing infection. The care of infants was the province of obstetricians, but in England they had not taken the initiative for their institutional care as had their Parisian counterparts. An exception was in Edinburgh at the end of the century, where John Ballantyne endeavored to establish perinatal care with a "plea for a pro-maternity hospital,"[102] pointing out that "the age of viability is not fixed, but a variable date." He constructed a schema for the transitional period between antenatal and postnatal life, when "fetal physiology endeavours to cope in neonatal surroundings."[103] Ballantyne was a lone British champion of both antenatal and neonatal care, remarking that "France stood alone amongst the countries of the world as the land in which great attention was paid to the maladies of early life, and the best textbooks upon diseases of children were all written by Frenchmen practising in Parisian hospitals." He used a portable balance as a clinician, hygienist, and physiologist, advising regular weighing to gauge adequacy of feeding and "when it is wished to form a diagnosis or prognosis in the care of the infant who is ill."[104] For Ballantyne, the balance was an adjunct to simple clinical methods, a means of assessing milk intake and an aid to the confirmation of "normality." Even though he referred to the work of Bouchaud and Tarnier, and although not alone among obstetricians and pediatricians in promoting the weight balance,[105] he made no mention of the growth chart. Moreover,

99. Alexander Dingwall-Fordyce, *Diseases of Children* (London: A&C Black, 1916), p. 4.

100. See, for instance, Editorial, "Town Milk," *Br. Med. J.*, 1903, *1*: 1039; Anonymous, "Physical Deterioration," *Br. Med. J.*, 1904, *1*: 319–20; and L. Emmett Holt, "Infant Mortality, Ancient and Modern, an Historical Sketch," *Arch. Pediatr.*, 1913, *30*: 885–915.

101. Elisabeth M. R. Lomax, "Small and Special: The Development of Hospitals for Children in Victorian Britain," Supplement 16 to *Medical History* (London: Wellcome Institute for the History of Medicine, 1996): 1–14.

102. J. W. Ballantyne, "A Plea for a Pro-Maternity Hospital," *Br. Med. J.*, 1901, *1*: 813–14.

103. J. W. Ballantyne, *A Manual of Antenatal Pathology and Hygiene of the Foetus* (Edinburgh: William Green & Sons, 1902). See also Ballantyne, "The Problem of the Premature Infant," *Br. Med. J.*, 1902, *1*: 1196–1200, quotation on p. 1197.

104. J. W. Ballantyne, *An Introduction to the Diseases of Infancy* (Edinburgh: Oliver Boyd, 1891), pp. 191–98, quotation on p. 193. Chap. 12 deals with infant growth and weighing.

105. Holt, *Diseases of Infancy* (n. 93), p. 15.

the concept and use of the growth chart to monitor infant health outside hospitals seems to have been unfamiliar to public health physicians in the English-speaking world, in spite of their concern for infant welfare.

Transfer across the Channel and Mass Surveillance

In Britain by the beginning of the twentieth century, it was reluctantly acknowledged that the social–public health preventative approach to dealing with infant mortality was not working. Looking back at fifty years of stubbornly high infant mortality rates (IMRs), the leaders of the British public health movement were short on new ideas. Reading an editorial about Léon Dufour and his Normandy clinic in 1898 (which reported a 50 percent reduction in IMR and a halving of deaths from enteritis), Drew Harris, medical officer of health of St. Helens, was inspired to visit Fécamp to see for himself the operation of the *gouttes de lait*. The editorial proclaimed that "The subject is of national interest, and an experiment of this kind should be tried in this country. If successful, as doubtless it would be, there is no doubt that similar societies would speedily be established throughout the country."[106] Impressed with what he saw, Harris quickly set up his own, and the first, infant milk depot in England a year later.[107] Contact between other British medical officers of health and their French counterparts followed.

Newman and McCleary visited France several times to meet Budin, Dufour, and Variot and to inspect their clinics, and in 1905 they were involved with the organization of the First International Congress of Gouttes de Lait at the Pasteur Institute in Paris.[108] This was followed a year later by the First National Conference on Infantile Mortality in London. It coincided with the publication of Newman's book, *Infant Mortality*, which opened with "The Present Position and Incidence of Infant Mortality" (chap. 1) and dealt in detail with "Infant Feeding and Management" (chap. 8). This closing section described the workings of the Finsbury infant milk depot, which Newman had established in 1905. Similar to those created by his colleagues in other parts of the country,[109] it contained two rooms, one a waiting and dressing room and the other the weighing room, equipped with a weighing balance. "It is obligatory that the child should be brought once a fortnight to be weighed . . . the milk is supplied

106. Editorial, *J. State Med.*, 1898, *6*: 612–14, quotation on p. 614.

107. F. D. Harris, "The Supply of Sterilised Humanised Milk for the Use of Infants in St Helens," *Br. Med. J.*, 1900, *2*: 427–30.

108. McCleary, *Early History* (n. 6), chaps. 7–9, pp. 99–120.

109. See McCleary, *Early History* (n. 6) for an account of the rise and fall of infant milk depots in Great Britain.

only on this condition."[110] As Newman stated in the quotation that opened this paper, the growth chart used in Finsbury was based on "Dufour's Standard." To illustrate the use of the chart, Newman reported details of the clinical progress of a selection of infants, their domestic circumstances, and the living conditions of their families. He chose this "thoroughly satisfactory" case to illustrate how the growth charts were used.

> K.A.W., f., born October 3, 1904; began depot milk November 25, 1904; aged seven weeks. Health of mother, fair, anaemic; first child; insured. Occupation of father, cabinet maker; 40s per week. Sanitary conditions of house good. Three rooms; 6s. 6d. per week. Infant—reported weight at birth, about 7½ lbs. Weight on admission, 8½ lbs. Reason for admission—mother had no milk. Condition of infant—fair, thrush at time of admission; slight eczema. Weight increased from 8 lbs 8 ozs to 25 lbs in 12 months. Child did excellently throughout. Touch of diarrhoea in August lessened the steady rise for a month.[111]

Newman used the growth chart as a pediatrician caring for a single baby. He adopted the "French methods," and his clinical notes concerning the progress of the baby show the attention given to each "individual unit," observing the importance that Budin laid on medical supervision.[112] Nevertheless, in Britain the emphasis became more on the dispensing of clean milk than on the support of breast-feeding, as indicated by the title and content of Drew Harris's report for the first infant milk depot in England.[113] This set the style of many of the infant milk depots that were subsequently established in Great Britain. An exception was the Marylebone Consultation Centre, which "unlike the milk depots which have been opened some years previously, at St Helens, near Liverpool, at Finsbury and at Battersea, was to keep the infants on the breast by the giving of advice as to how this natural method of feeding should be conducted, rather than to encourage artificial feeding by the supply of modified and other suitable forms of milk."[114] Pritchard adopted the French method of "controlling the quantity of breast-milk taken by the infant through the medium of the test feed. This method was borrowed from Professor Budin, and it consisted in weighing the baby on accurate scales before and after a breast-feeding—the difference represented the amount of milk taken by the infant."[115]

110. Newman, *Infant Mortality* (n. 1), pp. 1–19, 221–56; quotation on p. 296.
111. Ibid., p. 305.
112. Budin, "Consultations" (n. 6). See pp. 643–45.
113. Harris, "Supply of Sterilised Humanised Milk" (n. 107).
114. E. C. Pritchard, *Harley Street Calling*, unpublished autobiography (London: Wellcome Library archives GC/49), on p. 63.
115. Ibid., p. 64.

Whether babies were breast-fed or artificially fed, the balance and growth chart quickly became embedded within the routines of British infant welfare clinics as essential tools of health surveillance. The balance was changing the nature of the relationship between doctor and patient in Britain. The collection of objective numerical data became part of the consultation, contributing a measure of progress and a guide to treatment, of defining health (or otherwise) and of regulating attendance. Weighing was a precondition of admittance to the clinics. Thitherto children's dispensaries generally had had policies of open attendance. For instance, "Open every forenoon" proclaimed the dispensary for sick children in Glasgow in the 1890s: "No line is required—it is enough that the child is sick and poor."[116] In contrast, to gain admittance to the infant milk depot three streets away, the baby had to be weighed.[117] With the infant welfare clinics, the "medical gaze" widened and focused to embrace all babies, but on the condition that they submitted to the balance.

As the infant milk depots expanded in number, the question of their efficacy arose. Thitherto IMR had been the chief measurement used to gauge the effectiveness of the British infant milk depots, just as it had been in France. "The natural impulse of a medical officer of health who has started a milk depot is to get out and publish, as soon as possible, a death-rate, showing the improved health of children fed with depot milk."[118] But this was not easy, as Sidney Davies, medical officer of health of Woolwich, pointed out: small numbers of infants and difficulty in defining precisely for how long they were fed depot milk made it impossible to relate mortality directly with feeding. IMR was too crude a measure, and a better way of demonstrating progress was by serial weighing. In Glasgow, the medical officer of health compared the growth of babies attending its infant milk depot with others elsewhere who were breast-fed or given artificial feeds[119] using a growth chart derived from Pritchard's book on infant feeding.[120] The growth chart represented a simple record of progress, but as Newman had observed, it did not take into account local conditions and

116. Edna Robertson, *The Yorkhill Story: The History of the Royal Hospital for Sick Children Glasgow* (Glasgow: Yorkhill Management Board, 1972), on p. 57. See also D. A. Dow, *The Dispensary of the Royal Hospital for Sick Children* (Glasgow: Greater Glasgow Health Board, 1980).

117. Angus H. Ferguson, Lawrence T. Weaver, and Malcom Nicolson, "The Glasgow Corporation Milk Depot 1904–1910 and its Role in Infant Welfare: An End or a Means?" *Soc. Hist. Med.*, 2006, *19*: 443–460, on p. 447.

118. S. Davies, "Notes on Infants' Milk Depot Statistics," *Pub. Health*, 1908, *22*: 93–94, on p. 93.

119. Glasgow Corporation, *Report of the Medical Officer of Health of the City of Glasgow* (Glasgow: Robert Anderson, 1909), p. 21.

120. Pritchard, *Physiological Feeding* (n. 97), p. 171.

was not necessarily based on data collected from healthy thriving infants. Although described as a "standard," it was not universally appropriate, and as far as some were concerned, it was of dubious use.

While one English pediatrician dismissed the need for growth standards—"the normal for the individual is rarely the average normal, and, apart from the philosophical interest as to the individual divergence from the average normal, such comparisons are usually valueless"[121]—another was remembered as "the first pediatrician in this country [Great Britain] to appreciate the fact that infant feeding was more closely related to the weight than the age of an infant and the phrase 'expected weight' was one which he coined himself."[122] There was no unanimity about the use of growth charts, let alone agreement about the ranges of normality. Budin's infant growth charts (derived from figures obtained by Bouchaud, an intern at the Maternité in Paris in the 1860s[123]) also had a single growth curve applicable to both sexes. Budin clearly recognized that this represented an average, commenting, "At the end of the year, after 52 weeks, the infant who weighs at birth 3000g or 3250g attains 9kg or a figure close to this."[124] Alongside a chart showing the mean weights of infants used in the Babies' Hospital of New York, Holt suggested that there was a range of healthy normality extending one pound above and below the curve.[125] The Dufour Standard made no distinction between boys and girls, nor did it give any indication of the range of normality (as Newman had observed in this paper's opening quotation). Moreover, the growth chart he used in Finsbury was based on measurements of French babies in Fécamp, Normandy.

The mid-century debate about the appropriate use of group data in clinical medicine had found resolution in the acceptance of thermometry,[126] and the curves of body weight and their ranges could also be charted, like such measurements of temperature. Budin had shown that the regular measurement of the temperature and weight of babies could be life-saving[127] and extended the latter to his *consultations*. The *consulta-*

121. Dingwall-Fordyce, *Diseases of Children* (n. 99), p. 4.

122. Obituary of Eric Pritchard, *Lancet*, 6 Nov. 1943, pp. 589–90,

123. According to William Ballantyne, Bouchaud undertook detailed studies of infant growth, which he published in his doctoral thesis of 1864. See Ballantyne, *An Introduction* (n. 104), p. 194. Budin refers to Bouchaud's data in *Manuel Pratique* (n. 74), p. 31, and Variot, in *La Croissance* (n. 45), p. 81, says they were "the first tables of infant growth in France."

124. Budin, *Manuel Pratique* (n. 74), p. 29.

125. Holt, *Diseases of Infancy* (n. 93), p. 15.

126. Matthews (n. 14), see chap. 4, pp. 62–85.

127. The Pavillon des Débiles was the "clinical laboratory" in which neonatal care, based on temperature monitoring, feeding, and weighing, was demonstrated to reduce infant mortality rates. As well as Budin's publications (*Le Nourrisson* and *Manuel Pratique*, n. 74), see Toubas and Nelson, "French Midwives" (n. 82).

tions offered obvious opportunities to define growth standards, and these were exploited by Variot, who questioned the prevailing opinion that artificially fed babies were generally inferior to breast-fed babies in their growth and development. He published tables of the weights of around twenty-five to forty boys and girls measured each month. The artificially fed did almost as well as the breast-fed, particularly in the second half of the year, but the mixed-fed did the best. Variot aimed to show that the *gouttes de lait* and *consultations de nourrissons* could promote growth comparable to that of the breast-fed babies, using artificial feeds: "There is only a minimal difference between the weights and lengths of the babies raised on the breast or the bottle, if one applies to the latter modern, improved artificial feeds, as is done in the *Gouttes de Lait.*"[128]

By the First World War, in Great Britain, most of the infant milk depots had closed or were being changed into welfare clinics in which feeding was not their dominant or only function.[129] Infant mortality was declining, and it was recognized that the provision of free milk was benefiting only a small proportion of infants at risk. Moreover, with the introduction of the Notification of Birth Act, which alerted authorities to new births, home health visiting was proving a more economical and effective way of safeguarding infant health.[130] Other welfare initiatives that benefited mothers and children, such as instruction on domestic hygiene and nutrition, and maternity allowances, also inspired by the French *puériculture* movement, eclipsed the infant milk depots. Nevertheless, weighing babies remained a central feature of infant welfare clinics. Following the same thinking as Variot, and searching for British infant growth data, Brailsford Robertson selected a number of these infant welfare clinics in which to try to define the normal growth of babies. He too questioned the appropriateness of using French babies as a standard against which to measure English infants, and he noted that the Newman Standard did not distinguish boys from girls. In the Pimlico and Golden Square branches of the Westminster Health Society, the Chelsea Health Society, and the Leeds Babies Welcome, he collected the weights of healthy babies, with which he composed charts of the growth of boys and girls who were all appar-

128. G. Variot and M. Fliniaux, "Tables des Croissance Comparées des Nourissons Éléves au Sien et aun Bibéron durant la Première Année de la Vie," *Comptes Rendus de l'Academie des Sciences (Paris)*, 1914, *158*: 1361–64, quotation on p. 1363.

129. McCleary, *Early History* (n. 6).

130. The Notification of Births Act came into effect in 1908. Under its terms, all births had to be registered within forty-eight hours, thus alerting the authorities of the arrival of a new baby and thereby triggering the provision of postnatal surveillance and care.

ently healthy and well nourished.[131] Using these and other data Robertson brought together and reviewed all of the issues concerning normality and growth standards in infancy.[132]

Conclusions

The fortunes of babies in the nineteenth century were far from rosy, particularly those who were not nursed by their mothers. The lives of many hung in the balance, and a significant factor determining which way it tipped was how they were fed. The weighing of babies may not have been directly responsible for saving individual lives, but it served to focus the medical gaze on those who were at risk. Used initially to help to define the dimensions of the fetus, the weighing of babies contributed to the search for an index of viability of the newborn. With the development of a physiological interest in the growth of infants, weighing became a means of determining milk intake and, through the association between nutrition and health, a summary measure of normality. These uses of the balance were combined in the care of premature babies, and sequential weighing and charting became integrated into the clinical care of the newborn. They also offered a means to monitor the health and growth of infants outside hospitals and became a justification and purpose of infant welfare clinics. By providing a summary measure of health, the balance became an instrument of surveillance, a means of defining and ensuring normality. By the early twentieth century, it had become embedded within infant welfare clinics, though there was a continuing debate about the definition and construction of growth standards. Weight charts became tools for the screening of American schoolchildren for malnutrition, too, as pediatrics emerged as a primary care specialty in the United States.[133]

The incorporation of technological aids to diagnosis into medical practice, their geographical transfer, and temporal dispersion have been the subject of a number of studies. Stanley Reiser has argued that the entry of technology into the practice of medicine "altered the relations between physician and patient and influenced the systems of providing medical

131. T. B. Robertson, "Studies on the Growth of Man. III. The Growth of British Infants during the First Year Succeeding Birth," *Am. J. Physiol.*, 1916, *41*: 535–46.

132. T. B. Robertson, "Growth and Development," in *Pediatrics*, ed. I. A. Abt (Philadelphia: W. B. Saunders, 1923). See Tanner, *History of the Study of Human Growth* (n. 18), pp. 271–73.

133. Jeffrey P. Brosco, "Weight Charts and Well Child Care," in *Formative Years: Children's Health in the United States, 1880–2000*, ed. Alexandra Minna Stern and Howard Markel (Ann Arbor: University of Michigan Press, 2002).

care and treatment."[134] He traces how stethoscopy and thermometry not only changed the nature of the consultation but also strengthened the correlation between clinical signs and pathology. The use of technology to convert physiological signals such as temperature and pulse rate into numbers and graphs not only generated objective measures of disease but also made them available for group analysis and for generalization of their significance. Taking their places in the routines of clinical practice, the stethoscope and thermometer generated information that could be used to separate normality from abnormality and distinguish health from disease. The same can be said of the weighing balance. Almost a century after weighing babies had first been proposed as a means of monitoring their growth and health, and half a century after clinical thermometry had introduced complex sequential numerical data within medical practice, the balance and growth chart had become indispensable instruments of pediatrics and infant welfare.

New clinical methods, including the use of diagnostic instruments, that were pioneered in one center could radiate to others. By examining the lessons that young physicians who visited Paris in the early nineteenth century to learn medicine took home to the United States and how they used them in their medical practice, John Harley Warner has shown how the transfer of new technologies and ideas was selective and that they were adopted in different and novel ways in other settings.[135] He shows how Pierre Louis's numerical method, which was so influential in distinguishing effective from ineffective treatments in France, was seen as a threat to the traditional untested therapeutics practiced by American doctors who had stayed at home. The French *gouttes de lait* movement, which had apparently proved so empirically effective, was seized upon by British medical officers of health. Adoption of infant growth as a measure of child health was a welcome shift from an increasingly sterile and morbid preoccupation with IMR. The positive objective measure of growth focused attention on the "individual unit," on protecting it and safeguarding its health, and away from the numerous environmental threats that surrounded the vulnerable baby—and at the same time served to make it the subject of mass surveillance within infant welfare clinics.[136] In crossing the channel from France to England, the weighing of babies in the infant milk depots represented a new approach to combating infant mortality and generated the need for population standards to quantify and justify them.

134. Reiser, *Medicine and Reign of Technology* (n. 12), p. iv.

135. John Harley Warner, *Against the Spirit of System* (Princeton, N.J.: Princeton University Press, 1998).

136. Michel Foucault, *The Birth of the Clinic*, trans. A. M. Sheridan (London: Routledge, 1973).

The incorporation of numerical data into clinical medicine prompted debate about how they should be used throughout the century. Rosser Matthews has examined how quantitative information derived from the study of large numbers of patients came to inform the diagnosis, treatment, and prognosis of individuals.[137] Such debates attracted polarized views between the defenders of the "art" of medicine (who belittled science) and the champions of the "authority of numbers" (who promoted objective facts). Out of this debate arose agreement on statistical methods applicable to the variations inherent in medical and social phenomena, including the biology of growth. This debate coincided with, and informed the development of, clinical medicine and social hygiene, including infant welfare. Discussion of growth standards followed, taking into account not just the handling of numeric data but also clinical and biological variation, leading to the adoption of the growth chart in infant welfare clinics.

There was nothing unique or revolutionary about the fusion of weighing and charting: astronomy, cartography, navigation, and engineering, for instance, all employed instruments, math, and charts to obtain and translate complex numerical information into practical use. The growth chart gave meaning to numerical data and equipped the pediatrician with objective, quantifiable information beyond the medical history and physical examination that had hitherto been the foundations of clinical practice. It offered a simple way of charting the trajectory of infant growth, of mapping infant development, and of depicting its route to health. It became used in a number of ways: as a clinical record, a population standard, and a propaganda tool. A powerful visual statement based on no more than simple serial measures, the infant growth chart has now been adopted worldwide in infant welfare clinics as the "road to health,"[138] and a century after Budin's death, a set of universal growth charts, applicable to all babies globally, has been produced by the World Health Organization.[139] The measuring and charting of body weight became as routine a process as the recording and charting of body temperature. If anything is the symbol of twentieth-century child welfare, it is the weighing balance.

137. Matthews, *Quantification* (n. 14), chap. 2, pp. 14–38.

138. D. B. Jelliffe and E. F. P. Jelliffe, *Human Milk in the Modern World* (Oxford: Oxford University Press, 1978).

139. World Health Organization (2006), at **http://www.who.int/childgrowth/standards**.

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