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Introduction: Who Counts?

GÉRARD JORLAND AND GEORGE WEISZ

This book has its origins in a difference of historical opinion. Several years ago, during a colloquium on therapeutics organized for the Fondation Mérieux by Olivier Faure and Annick Opinel,¹ Gérard Jorland presented a paper on the statistical medicine of the Parisian hospital physician, Dr. P.C.A. Louis. In conformity with the existing historiography, GJ viewed Louis's project as a failure and interpreted it as a rejection of quantification in medicine by French doctors of the early nineteenth century. This explanation fit in nicely with our knowledge of the French cultural landscape of the time, characterized by a shift back to the primacy of the literary from that of the scientific and reversing the order that had dominated under Napoleon: the Académie Française regained its place as the pre-eminent of the academies making up the Institut de France; Siméon-Denis Poisson's research on the probability of judgments was criticized at the Academy of Sciences and sank into oblivion, much as A.A. Cournot's research on the mathematical principles of the economy was barely noticed. In this context, the criticisms of Louis's numerical school appeared clearly as an episode in this larger cultural movement.²

None the less, another editor of this volume, George Weisz, directed GJ's attention to the fact that academic debates had never ceased to use statistical arguments, even after the controversy of 1837, and he referred to a relevant chapter in his book on the Academy of Medicine³ where he suggested that received historical opinion on the subject was incorrect. If the debate on quantification has been initiated by the reading of a long paper hostile to the numerical school, a review

of the interventions for and against this research program did not permit any judgments about winners and losers in this contest.

GJ and GW continued their discussions in Paris when the former invited the latter to present a number of talks, notably on the subject of medical quantification, at the École des Hautes Études en Sciences Sociales. If the failure of the numerical school could be explained by the methodological problems associated with simple counting and with the inability of the anatomo-pathological method to furnish sufficient numbers of cases for aggregation, it remained to be explained why it took until the Second World War for mathematics to become an effective tool, and not just a rhetorical one, in international medical research. GJ and GW thus decided to organize, under the aegis of the Fondation Mérieux and with the indispensable collaboration of Annick Opinel, a meeting devoted to medical quantification from its beginnings in the eighteenth century to our own day. This took place at the Musée Claude Bernard in Saint-Julien-en-Beaujolais. This volume presents the results of this colloquium.

Numbers of one sort or another now play a central role in all modern societies; they have transformed the way in which we think about and resolve a vast number of issues. While the origins and impact of statistics and quantification generally have been examined by a number of outstanding historians and philosophers of science,⁴ their role in medicine has until recently received far less attention. Quantification in eighteenth-century British medicine has been extensively analysed in two recent books.⁵ Several major figures who advanced quantification in British public health have received book-length studies, as has, most recently, the seminal figure in late-nineteenth-century statistics, Karl Pearson.⁶ There is some work on epidemiological thinking in the early twentieth century,⁷ while the rise of clinical trials has been significantly advanced by Harry Marks's major book on the American case, as well as by a number of doctoral theses.⁸ There exists one synthetic study of quantification in clinical medicine, which serves as a useful starting point but is seriously incomplete.⁹ A recent collection of essays on medical statistics in Britain makes an important distinction between the use of counting in medicine and reliance on sophisticated statistical techniques and points to the decisive role of Karl Pearson in this shift.¹⁰

The essays in this volume follow on this work (much of it written by contributors to this book) and extend it to new areas. In taking the perspective of the *longue durée*, the volume seeks to bring to the surface the changing nature of quantification in medicine as well as some of the enduring difficulties and tensions inherent in its application. Sociologists of science and of medicine have added considerably to our

understanding of the subject, and we have tried to include their perspectives in this volume. We have also taken some pains to invite contributions from authors who work on different countries in order to bring a much-needed comparative dimension to this subject. Finally we seek to move beyond the usual emphasis on either public health or clinical medicine (which have in recent years moved closer together because of their common reliance on the techniques of epidemiology) to include the central role of quantification in laboratory work and many kinds of medical instrumentation.

MEDICAL ARITHMETIC

In the first essay, Ulrich Tröhler shows how British doctors of the eighteenth and early nineteenth centuries created a medical arithmetic on the model of political arithmetic. This was not limited to therapeutics but extended as well to nosology. Therapeutic statistics carried with it the notion of probability of success rather than certainty, a notion that would durably shape therapeutic research. Scurvy was the subject of some of the most sophisticated studies of this sort. These led to rigorous reflection about clinical trials – how to compare things that are in fact comparable – questions which lacked a satisfactory response for a century and a half, as Iain Chalmers shows later in the volume. As for nosology, the two most important categories of the epoch – insanity and fevers – were the primary objects of statistical inquiry.

Tröhler demonstrates further how this medical arithmetic was made possible on one hand by the practice of inoculation, which required quantified follow-up as a means of responding to those who objected to the practice, and on the other hand by the development of hospital registers, which constituted a new source of reliable data. Harry Marks and Andrea Rusnock present case studies focusing on one of these conditions. Tröhler concludes with a question: if the British did so much clinical quantification, what is left of the pioneering role of the Paris school? His answer is: not much. One possible response would be that the key Parisian innovation was to apply arithmetic not just to symptomatology but also to pathological anatomy, understood as the correlation between symptoms and anatomic lesions, in order to create a new kind of statistical medicine.

Harry Marks examines inoculation. He revisits the famous controversy on this subject that pitted Daniel Bernouilli and Jean le Rond d'Alembert and concentrates on its political dimension, largely neglected by historians. While Bernouilli constructed a mathematical model on the basis of tables of mortality in order to quantify the number of lives of every age saved by this practice, and thus adding to the

power of the state, d'Alembert followed a completely different strategy. He took the position of the subject who must make a decision whether or not to inoculate his or her child. And he made use of the distinction introduced by Daniel Bernouilli himself between mathematical and moral expectations to differentiate between the point of view of the state and that of the individual subject; in the latter case, he took account of interpersonal differences of attitude when facing risk. This opposition between public and private perspectives would recur throughout the history of medical quantification.

Andrea Rusnock focuses on hospital registers. She shows that quantified representations of infant mortality appeared in eighteenth-century England and France as the first serious public health measure. She describes the move from use of parish registers, necessarily inexact because of the problem of baptisms, for this purpose, to use of hospital registers as a means of establishing mortality estimates that were more rigorous and more dramatic than had been previously imagined and that precipitated sanitary reforms, most notably inoculation. She thus sheds new light on another theme that recurs throughout the history of quantification – its role in the politics of any era. Numbers, in other words, are not just mathematical entities but part of the ordinary language that seeks to understand, convince, and get people to act.

Why did reasoning with numbers become convincing in the eighteenth century and, in the case of England, possibly earlier? New sources of data, we saw are one part of the answer. Another has to do with broad social changes and needs. Both Andrea Rusnock and Phillip Kreager,¹¹ for instance, have in recent essays discussed a new form of quantitative reasoning that emerged in England near the end of the seventeenth century. The former calls this “Merchant’s Logick,” and the latter, “mercantile bookkeeping.” A new kind of commercialized society was generating new business practices and new forms of reasoning and argumentation. The early and widespread development of commerce in England may well account both for the early emergence of medical quantification in that country and for its continued strength during virtually every period covered in this collection. Both Harry Marks and Ted Porter in this volume call attention to another kind of quantified reasoning, one growing out of the practices of state bureaucracies. This raises interesting questions about the kinds of quantification that each set of social practices produces. And if widespread commercial practices may be especially congruent with certain forms of quantification, one wonders whether administrative quantification may appear, as it did for d'Alembert, as a threat to individual choice and autonomy. Can the indisputable links between state administration and numbers in France explain the exceptional vehemence

of anti-quantitative rhetoric in that country in the early nineteenth century and the relatively slow acceptance of such practices as random clinical trials in more recent times?

QUANTIFICATION AND INSTRUMENTATION

Epidemiological modes of reasoning have become so pervasive that we tend to identify medical quantification almost exclusively with them. The essays in this section remind us that quantification is also embedded in a wide range of technologies and instruments and that these are related in subtle but important ways to the development of clinical and public health numbers.

Ann La Berge returns to the famous academic discussion of 1837 about medical quantification in general and to Louis's numerical school in particular. She reminds us that one aspect of this complex controversy pitted the advocates of a medical *science* favourable to quantification against supporters of a medical *art* hostile to numbers on the grounds that they homogenized individual differences. This disagreement was not dissimilar to the inoculation dispute between D'Alembert and Bernoulli, which split those for whom health was a state affair from those for whom it was the responsibility of individuals. But she reinvigorates the interpretation of this discussion by showing that the stakes surrounding quantification were much more profound, involving nothing less than the possibility of objectifying disease as a necessary condition for the introduction of medical technologies – in this case, the microscope.

The microscope, like other visualization technologies, represents one form of objectification that uses instruments to extend the power of the senses to new objects. Debates about their use have characteristically concerned the reliability of representations produced, whether or not they provided information not accessible directly to the senses, and whether they are in any way useful practically. But other instruments involve a more radical transmutation from sensory impressions to something entirely different – namely, numbers or time charts. Volker Hess, in his masterful essay, discusses one of the first instruments that embodied quantification – the thermometer. It was used to diagnose one of the essential, though declining, pathologies of the nineteenth century – fevers – which, in their innumerable forms, constituted a distinct nosological entity. He describes how the thermometer represented a new way to objectify disease. The problems posed by this technique were of the same order as the ones posed by statistics: how to standardize and calibrate categories and measurements so that results across time and space would be stable and comparable and how

to integrate into medical practice a technique that involved the adaptation not of the instrument to the individual but, on the contrary, of the individual to the instrument.

Despite this latter constraint, Hess finds that, surprisingly and contrary to the fears of opponents of quantification or emulators of Foucault, the thermometer served as a vector of democratization in medicine in two ways. First, objectivity of measurement freed diagnosis to some degree from the subjectivity of the physician's judgment; second and above all, by taking his or her own temperature, the sick person became the fully responsible subject of his or her malady, an active agent rather than a passive patient. This form of quantification, in other words, rather than imposing the power of the state on the body, in fact allowed subjects to reappropriate their malady. The illness of Jacques is not that of Peter or Pauline, not because the physician had a privileged relationship with each of them based on their idiosyncrasies but because Jacques, Peter, and Pauline were in a position to look after their own state of health.

In a similar manner, Christiane Sinding shows that standardized measures for diabetes preceded the arrival of insulin on the market after the First World War. This allowed for the new drug to be adapted to every individual case. In other words, quantification made possible a new kind of individuation of medicine rather than state dominance or standardized therapy for everyone. Reciprocally, each diabetic became the agent of his or her own therapy, examining urine, calculating food intake, planning meals, and doing physical exercise. In addition to all this, insulin was an extraordinarily effective medication.

Ilana Löwy presents us with a much less successful case of innovation, that of a Polish scientist, Jozefa Joteyko, who attempted to transform pedagogy into a rigorous science, pedology, based on an instrumental and quantitative physiology. This effort, like her earlier research in fatigue studies, represented an effort to use quantified scientific methods in order to promote social reform. Joteyko was largely unsuccessful, in part because of her marginal status in the scientific world and in part because of the contradictions inherent in her scientific program.

Finally, in their discussion of cancer research, Peter Keating and Alberto Cambrosio introduce a valuable distinction between quantification of pathology and quantification in pathology. The quantification of pathology does not reduce the pathological to the normal but rather "aligns" them and puts each on the same ontological plane while giving them the same epistemological status. Quantification in pathology is identified with instrumentation, which the authors study at three levels: morphology, immuno-phenotyping, and molecular

genetics. They then show that objectification reaches its culminating point in the automation of testing on cells, which eliminates all traces of subjectivity. Biological instrumentation thus represents the end or at least the transformation of classical clinical medicine. The authors highlight another aspect of this history: in becoming exact, medicine brings into being the fundamental science, which it uses to advance. Consequently, the quantification of medicine appears at the same time as the biologization of medicine.

STATISTICS AND THE UNDERDETERMINATION OF THEORIES

Medical statistics were thus part of a general movement of instrumentation in medicine. But they constituted a very particular sort of instrument. When confronted with unpleasant results, one might “shoot the messenger” (or, as the French say, break the thermometer in order to put an end to the fever), instead of dealing seriously with the problem. Both essays in this section analyse debates about disease causation – nearly a century apart – in order to understand some of the limits of statistical reasoning in medicine at different times.

Gérard Jorland examines the discussion of puerperal fever in the Paris Academy of Medicine in 1858. Even though Semmelweis’s argument and statistical data were well known, other statistical data produced before and after supported his conclusions, and special Parisian statistics were compiled for the purposes of the discussion, all these data proved incapable of producing belief in the infectious origins of this malady. Jorland argues that ontological realism (the belief that there must be an observable agent of disease), together with the underdetermination of theories by statistical observation (meaning that several interpretations of the evidence seemed equally plausible), blinded the leaders of Parisian medicine to the existing evidence.

This attitude was hardly unique. Medicine has had a strong penchant towards ontological realism – the belief that there must be a causal agent for any disease, whether an anatomical lesion or a physiological inflammation, a miasma propagated through the air or a microbe carried by water. A physician must see the cause in order to believe in the pathology. At the other end of the spectrum, statistics, being mathematics, is nominalistic. The only thing that it can say is that whenever you see a set of events, most of the time you also observe another set of events. Why? It cannot say. How? It cannot say. It cannot say even that it is always the case. Therefore the realism of medicine is at odds with the nominalism of statistics. And, correlatively, medical micro-determinism is at odds with statistical macro-determinism.

Mark Parascandola shows in a similar manner that a century later the statistical correlations between smoking and cancer were open to multiple interpretations, that they notably did not exclude the possibility that there existed a common cause for both variables; consequently, quantitative evidence did not convince many epidemiologists that a causal link existed. While Parascandola emphasizes the divisions inherent in a newly emerging discipline, it is possible here too to see epidemiologists' medical realism blocking their acceptance of quantitative data. To put it another way, epistemological underdeterminism was superimposed on opposition between ontological realism and nominalism. None the less, by the mid-twentieth century statistical thinking had advanced sufficiently so that uncertainty no longer led epidemiologists and doctors to reject statistical reasoning outright; they insisted instead that causal relations between tobacco and cancer be unambiguously established. Parascandola describes in detail how the techniques of statistical research were mobilized for this purpose

REDUCING UNCERTAINTY AND THE POLITICS OF HEALTH

The uncertainty associated with statistical reasoning has been lessened over time by the development of certain conceptual tools. Some of these have been mathematically based, like standard deviation and the chi-square test introduced by Karl Pearson; but others seem to have emerged from practical medicine and public health. (We shall see that the origins are sometimes contested.) The development of such tools has created a powerful set of techniques around which epidemiology has crystallized. In recent years, epidemiological techniques have become so central to the practices of health-care systems that they have become targets for pressure groups of various sorts that seek to shape the way in which they are conducted and used by experts and governments.

The first of the innovations to be discussed is that of William Farr, in many respects the most important medical hygienist of the nineteenth century. It was he who extended medical quantification as an instrument of fundamental research beyond therapy and aetiology to the domain of public health. His definition of zymotic maladies, though borrowed from the chemist Liebig, was designed to bring together all diseases susceptible to action by public authorities. Because he used this category to provide indices of public salubrity, replacing the more traditional reliance on life-span, he introduced the concept of "avoidable disease" and in effect founded contemporary epidemiology.

Lion Murard describes the appearance in the United States during the 1920s of a new indicator of public health, the Appraisal Form for Community Health Work, which local administrations could use. He also describes how these indicators were adopted by the League of Nations, under the rubric "Life, Environment and Health Indices," to measure the efficacy of public sanitary services. Conceived by Charles V. Chapin, superintendent of health of Rhode Island, and implemented by Charles Edward Winslow, head of the Department of Public Health at Yale University, these indicators were drawn from the tables of fire insurance companies. In fact, Winslow was also president of the the Committee on Administrative Practice financed by the Metropolitan Life Insurance Company. It was one of Winslow's protégés, Isidore Falk, who introduced these indices to the League of Nations, as a means of comparing the sanitary performance of its member states vis-à-vis one another and vis-à-vis the United States.

In his illuminating essay, Iain Chalmers describes how, 150 years after the appearance of medical statistics, one of the chief problems faced by early medical quantifiers – comparing the comparable – was resolved. The clinical testing of streptomycin for the treatment of pulmonary tuberculosis by the Medical Research Council in Britain after the Second World War, provided the occasion for serious reflection about ways to eliminate bias of all sorts. The techniques that were adopted were elaborated by Austin Bradford Hill. Chalmers shows how these techniques were designed to resolve two problems. The first was how to randomly distribute patients into one of two comparison groups; the choice was between alternation or some version of rolling the dice. The second involved ways of eliminating all possibility that doctors, patients, or anyone else involved in the study might gain knowledge of this patient distribution. These clinical trials have remained paradigmatic for the way in which Bradford Hill was able not only to resolve these problems but also to conceptualize his solutions. In telling his story, Chalmers takes issue with the current interpretation of the origins of clinical trials that argues that the work of statisticians such as R.A. Fisher, who theorized the role of randomization in purely statistical terms, was determinant in the acceptance of this practice. Chalmers in contrast uncovers a long-standing tradition within medicine of distributing subjects through alternation which shifted easily into randomization. This practice, he thus argues, was not based on purely statistical considerations but rather on the practical experience of physicians who had learned that knowing who was taking what medicine inevitably affected outcomes and biased results.

The development of new techniques has led to new disciplinary communities. In the case of quantification, the most visible has been

epidemiologists, who emerged from the public health domain to play a significant role in clinical testing as well. Mark Parascandola's essay discussed above introduces us to the fragmented community of American epidemiologists in the mid-twentieth century. Luc Berlivet examines the professionalization of French epidemiologists after the Second World War. He describes their integration into the various loci of medical knowledge: schools of public health, medical faculties, research institutes, and the public health administration. He shows that the major impetus for this integration in France was provided by statisticians – in this case, graduates of the elite engineering school, the Ecole Polytechnique, who exported their expertise to a medical domain that was rather doubtful about its value. One consequence was the separation between scientific research and health policy, reproducing the traditional opposition between the “fundamental” and the “applied.” It required doctors' entry into this domain, under the banner of Charles Mérieux and his foundation, for French epidemiology to become a multidisciplinary science and thus an effective instrument for aiding political decision-making. Berlivet shows as well that because the mathematization of medicine in France was due to forces external to medicine, quantification did not take hold of medicine in the way that it did of physics or economics. Epidemiology has thus remained to some degree at the margins of French medicine.

The gradual reduction of uncertainty and spread of epidemiological thinking to public policy did not eliminate all old problems and has in fact created quite a few new ones. Resolving an issue with statistics has turned out to be a lengthy and very expensive process. Frequently, decisions have to be made quickly on the basis of indeterminate data. Some can be put off until sufficient data accumulate, as happened with the tobacco–cancer link. But frequently either the immediacy of risk or promise of benefits leads to early decisions. The medical literature is full of issues that have yet to be resolved but that demand immediate action and of new data that call into question practices introduced on the basis of then-available evidence. In these numerous situations of uncertainty, whether one errs on the side of caution or not, whether one chooses to act or not, depends frequently on the balance of power among the groups involved. For one of the most striking things about the growing dominance of statistical thinking in the health-care sphere is the number of actors who are now involved in the process of statistical decision-making.

Nicolas Dodier illustrates this phenomenon vividly in his examination of AIDS in France. He shows how various people sought to shape clinical trials. These actors included doctors, of course, pharmaceutical laboratories, and – a relatively new phenomenon – the patients

themselves. Patients' associations acted in effect as pressure groups. Dodier describes in detail how AIDS patients, transformed into militants for a cause, came to negotiate the protocols of trials, including the number of patients enrolled, criteria of inclusion, and the length of trials. In other words, far from representing a means of controlling bodies, medical statistics in this case objectified the illness and thereby called into question medical authority; this allowed AIDS sufferers to move from the status of patient to that of agent, from objects of the medical gaze to the subjects of their own illnesses. Once again, the fears of Risueno d'Amador and others to the effect that numbers would subjugate the individual were, at least in this case, not realized.

AFTERTHOUGHTS

Two final papers take a longer and more synthetic view of the history of quantification in medicine. George Weisz compares some of the main themes of debate about medical statistics in the nineteenth century with those that have accompanied the explosive appearance during the past decade of "evidence-based medicine." To some degree, the latter reflects the same urge to objectify knowledge through numbers, protocols, and instrumentation that animated nineteenth-century reformers. Consequently many of the objections sound very similar, having to do with the ability of instruments such as random clinical trials to deliver the certainty that they promise and with the apparent contradiction involved in applying knowledge relating to populations to unique individuals. As in the nineteenth century, numbers provoke fear that skills and power are being displaced from practitioners to mechanical procedures and small groups of experts. But, unlike the statistical medicine of the nineteenth century, "evidence-based medicine" (EBM) exists in an extraordinarily complex institutional environment. It has been claimed by many different groups with wildly different agendas, so that it is coming to serve as a slogan for a wide variety of sometimes-opposing interests: defending the medical profession and limiting the power of the medical profession, spending more and better on health care and saving money by paying less. Whatever its strengths and defects as a scientific program, EBM is emerging as a powerful ideological weapon in the battle to shape health care in North America and Europe.

In the final essay, Theodore M. Porter pulls together many of the themes of this collective volume. Statistics, he suggests, were initially part of a public medicine that existed alongside private medicine. This distinction between public and private partially overlapped the oppositions between medicine as a science and medicine as an art, as the

processing of information versus the interpretation of signs. In addition to two institutions that made quantification both possible and necessary – the hospital and the laboratory – Porter emphasizes the role of a third institution going back to the inoculation debates, and no less efficacious, though not always as visible – the insurance company. In other words, quantification is implicated in bridging not just the opposition between public and private spheres but also the division between private enterprise and private life, with the former exercising increasing surveillance over the latter.

In fact there is little about modern life that has not in some way been deeply touched by the ever-growing influence of numbers. In medicine, this influence has become particularly striking. What medicines we take and our health status generally are frequently determined by numbers of one sort or another. The role of quantification is so ubiquitous that we have to remind ourselves that this has not always been the case. Medical statistics as a form of objectivity has had a relatively short history. The essays in this volume are meant to help us recover that history and better understand its current status.

NOTES

- 1 The proceedings appeared in Olivier Faure, ed., *Les thérapeutiques: savoirs et usages* (Lyon: Collections Fondation Mérieux, 1999).
- 2 Gérard Jorland, "La médecine statistique du docteur Louis," in *ibid.*, 123–34.
- 3 George Weisz, *The Medical Mandarins: The French Academy of Medicine in the 19th and Early 20th Centuries* (Oxford: Oxford University Press, 1995), 159–88.
- 4 Some of the many works on the history of statistics are *Journées d'étude sur l'histoire de la statistique* (France: Vaucresson, 1976); *Pour une histoire de la statistique* (Paris: INSEE, 1977); Stephen Stigler, *The History of Statistics. The Measurement of Uncertainty before 1900* (Cambridge, Mass.: Harvard University Press, 1986); Theodore M. Porter, *The Rise of Statistical Thinking 1820–1900* (Princeton, NJ: Princeton University Press, 1986); Ian Hacking, *The Taming of Chance* (Cambridge: Cambridge University Press, 1990); Alain Desrosières, *La politique des grands nombres: histoire de la raison statistique* (Paris: La Découverte, 1993).
- 5 U. Tröhler, *To Improve the Evidence of Medicine: The 18th Century British Origins of a Critical Approach* (Edinburgh: Royal College of Physicians, 2000); Andrea A. Rusnock, *Vital Accounts: Quantifying Health and Population in Eighteenth-Century England and France* (Cambridge: Cambridge University Press, 2002).

- 6 John M. Eyler, *Victorian Social Medicine: The Ideas and Methods of William Farr* (Baltimore, Md.: Johns Hopkins University Press, 1979; and *Sir Arthur Newsholme and State Medicine, 1885–1935* (Cambridge: Cambridge University Press, 1997); Theodore Porter, *Karl Pearson: The Scientific Life in a Statistical Age* (Princeton, NJ: Princeton University Press, 2004).
- 7 Steven. Kunitz, “Explanations and Ideologies of Mortality Patterns,” *Population and Development Review* 13 (1987), 379–408; J. Andrew Mendelsohn, “From Eradication to Equilibrium: How Epidemics Became Complex after World War I,” in Chris Lawrence and George Weisz, eds., *Greater than the Parts: Holism in Biomedicine 1920–1950* (Oxford: Oxford University Press, 1998); Mark Parascandola, “Uncertain Science and a Failure of Trust: The NIH Radioepidemiologic Tables and Compensation for Radiation-Induced Cancer,” *Isis* 93 (2002), 558–84; Harry M. Marks, “Epidemiologists Explain Pellagra: Gender, Race, and Political Economy in the Work of Edgar Sydenstricker,” *Journal of the History of Medicine and Allied Sciences* 58 (2003), 34–55.
- 8 Harry M. Marks, *The Progress of Experiment: Science and Therapeutic Reform in the United States, 1900–1990* (Cambridge: Cambridge University Press, 1997); Marcia Lynn Meldrum, “‘Departures from the Design’: The Randomized Clinical Trial in Historical Context, 1946–1970,” PhD thesis, State University of New York at Stony Brook, 1994; Desirée Cox-Maksimov, “The Making of the Clinical Trial in Britain, 1910–1945,” PhD thesis, Cambridge University, 1997; B. Toth, “Clinical Trials in British Medicine 1858–1948, with Special Reference to the Development of the Randomised Controlled Trial,” PhD thesis, University of Bristol, 1998.
- 9 J. Rosser Matthews, *Quantification and the Quest for Medical Certainty* (Princeton, NJ: Princeton University Press, 1995).
- 10 Eileen Magnello and Anne Hardy, eds., *The Road to Medical Statistics* (Amsterdam: Rodopi, 2002).
- 11 Philip Kreager, “Death and Method: The Rhetorical Space of Seventeenth-Century Vital Measurement,” in Eileen Magnello and Anne Hardy, eds., *The Road to Medical Statistics* (Amsterdam: Rodopi, 2002), 1–36; Andrea Rusnock, “The Merchant’s Logic’: Numerical Debates over Smallpox Inoculation in Eighteenth-Century England,” in *ibid.*, 37–54.