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Published by Oxford University Press on behalf of the International Epidemiological Association
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International Journal of Epidemiology 2007;**36**:719–723
doi:10.1093/ije/dym160

Commentary: Is epidemiology really dead, anyway?

A look back at Kenneth Rothman's 'The rise and fall of epidemiology, 1950–2000 AD'

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Accepted 3 July 2007

Rothman's inspired lament¹ about the demise of epidemiology at the end of the 20th century was published in 1981, when the century still had 20 years left to run. It was a premature obituary for a science in terminal decay, written by a scientist who was already one of its leading thinkers on principles,² on content^{3–5} and on methodology,^{6–9} and who would later publish several major textbooks. I was studying for a Master's degree in epidemiology at the time, so Rothman's article was the source of some dismay, but none of my fellow students jumped ship.

One of his gloomiest predictions turned out to be spookily accurate. But although I'm no follower of Pangloss—'all is for the best in this best of all possible worlds'—for me, the remainder of Rothman's pessimism seems like an unwitting panegyric to the success of epidemiology since its renaissance as a scientific discipline.

The pioneers

Rothman, a keen student of history,¹⁰ rightly dates that renaissance to the studies of William Farr and John Snow from around 1840, but he starts with the meteoric impact of John Graunt's 1662 epic,¹¹ *Natural and political observations...made upon the bills of mortality*. Graunt quantified, for the first time, the extraordinarily high childhood mortality (one in three died under the age of five), the slight excess of male

births (14:13) and the huge impact of plague, TB and rickets in 17th-century England, and produced the first life table. All that, 300 years before computers. Lionised and admitted to the new Royal Society (founded 1660) within weeks of his *magnum opus* being published, Graunt never published anything else on epidemiology. He died in poverty after his haberdashery business was destroyed in the Fire of London (1666).

Rothman sees the personal tragedy that befell John Graunt as a cautionary tale for the science he more or less single-handedly invented. Not me—Graunt's personal fame may have been brief, but he is still an incandescent torch for epidemiology today. Graunt was the first rock star of public health. If almost two centuries passed before anyone seriously picked up his abacus,¹² that simply confirms how far in advance of his time he really was.

During a 40-year career as Compiler of Abstracts to the General Register Office of England (which still exists today), William Farr (1807–83) brilliantly exploited the death certificates that became routinely available for all deaths in England for the first time, under the 1837 law on the registration of births, marriages and deaths. He identified high mortality in certain occupations and geographic areas, and gave Snow access to data that helped him unravel the origin of cholera even though, at the time, Farr himself believed foul odours were the cause.

But Farr did much more. The first International Classification of Causes of Death, forerunner of today's International Classification of Diseases, discussed at an international conference in Paris in 1900, was a direct result of his groundwork, and that

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of his French counterpart Jacques Bertillon (1851–1922).¹³ Within 50 years, the ICD had become so important as the basis of international comparisons of morbidity and mortality that Article 2 of the World Health Organisation's 1948 charter imposes a constitutional duty to maintain it¹⁴: 'to establish and revise as necessary international nomenclatures of diseases, of causes of death and of public health practices'.

The ICD, now in its tenth revision, has more than 12 000 rubrics into which diseases and causes of death can be classified, and a myriad specialist and national adaptations have arisen to refine its application in a wide range of settings. The nosological expertise required to code the causes of death written on death certificates into ICD-10 categories was embedded in computer algorithms in the 1990s. Most of us would not even consider analysing data on death or disease that were not coded to the ICD. An incomparable and vibrant legacy.

The limitations of observational studies

Rothman, at his most depressing, saw 19th century epidemiology as 'a formidable science to practise because it depended totally on the availability of large, accurate bodies of data on the mortality and morbidity of human beings', and—as if that was not enough to discourage a budding scientist—he went on: 'there was the further problem that the epidemiologic inferences built upon these collections of data suffered an extreme fragility inherent in their non-experimental origin'.

That argument seemed curious at the time, and it seems positively bizarre today. If you have large, accurate data sets on the health and death of human beings, what else do you need to improve the health of the public other than sound scientific method, cautious inference and a dialogue between science and policy? Rothman himself seems to have taken the same view later.^{15,16} Experimental methods were not exactly the zenith of human science in the 19th century anyway. Snow correctly identified the origin of cholera with observational epidemiology more than 20 years before Pasteur invented germ theory, and a century before randomized trials. What experiment could you reasonably have used to show that human cholera was a water-borne disease, either then or now?

Observational data on human disease and mortality are not intrinsically frail. On the contrary, they are our most crucial source of information on the patterns, causes and trends of disease and death in human beings in their natural habitat—human society. For that, experiments are next to useless.

Observational data can also underpin reliable inference. For most public health problems today, as with the cause of cholera in the 19th century, experimental methods remain limited in scope. We sometimes exploit what we are pleased to call 'natural experiments' to infer cause of disease—such as the 60% drop in hospital admissions for myocardial infarction, suddenly reversed when a law that banned smoking in public places in the city of Helena, Montana (USA) was revoked after only 6 months, whereas no such change occurred outside the city^{17,18}—but of course those are observational studies anyway. And we cannot randomly or deliberately assign human beings to potentially harmful exposures. Most of what we know about the causes of human disease—diet, tobacco, alcohol,

occupation, infection, sunlight, chemicals, sexual behaviour—comes from observational studies, not randomized trials. The International Agency for Research on Cancer, for example, after rigorous evaluation of all the published evidence from basic science to animal and human studies, has classified 87 of more than 870 chemicals or exposures as 'carcinogenic to humans' (<http://monographs.iarc.fr/>). For such a categorization, strong evidence from human studies is required, and that evidence is almost always observational.

Experiments are not always enough to solve the problems caused by disease, either. Yes, of course we need drug trials, but trials are usually done in the smallest number of subjects capable of providing a statistically significant answer to the limited question of whether drug A is more effective than drug B. Trials rarely include the elderly or patients with significant comorbidity, who also need treatment for disease, and in any case, it's not enough to know that a drug is effective. In order to detect significant adverse effects that are too rare or too delayed for detection in short-term efficacy trials, we need large-scale post-marketing surveillance—observational epidemiology. Again, the early experimental evidence from trials showing that platinum compounds greatly improved the survival of men with testicular cancer was crucial, but observational evidence that the survival of *all* men with testicular cancer rose rapidly during the 1970s and 1980s was also required to show how much the new treatment actually benefited public health.¹⁹ Both types of evidence are necessary, but experimental evidence alone is not sufficient.

Confidentiality and consent

One prediction that Rothman got dead right was on the problems that well-intentioned regulations designed to protect people's privacy would cause for the practice of epidemiological research. He saw this as a terminal illness: 'the seeds of decline were germinating'.

He correctly foresaw a maze of unnecessary regulations, a plethora of institutional or territorially based review boards with overlapping terms of reference and little or no comprehension of epidemiology,²⁰ widespread misinterpretation of the law or regulations and unreasonable delay in the execution of studies designed by *bona fide* scientists in the interests of public health.²¹ Professional bodies often seem unable to distinguish between the risk to personal autonomy from the use of identifiable data without consent to select a given individual for prurient interest or unauthorized disclosure²² (moving from population data to the individual) and the far smaller risk posed by aggregating individual data for research in order to draw general conclusions about society (from individual data to the population). I am not sure Rothman foresaw how *many* different national and international bodies would want to set up august panels of the great and the good to deliberate over these guidelines,^{23–25} or how many reports and sets of guidelines would be issued—it has become a snowstorm.

Compliance with the laws and regulations designed to protect the privacy of individuals has become a major cost for epidemiological research. Some studies are delayed, others not done at all.²⁶ Inappropriate fears of disclosure²⁷ are stoked by determined advocates,²⁸ and in the UK even the Information

Commissioner herself acknowledged the extent of confusion about the application of the law: ‘...it is clear that many practitioners are confused between the requirements of the Data Protection Act and those of the various regulatory and representative bodies...It is a common misconception, for instance, that the Act always requires consent of data subjects to the processing of their data’.²⁹ Careful exposition of the limits to informed consent³⁰ is echoed by sober warnings about the risks to the public interest from over-regulation of register-based research.^{31,32}

Striking the right balance between the confidentiality of identifiable health data and the need for medical research to improve public health is now an issue in many countries.³³ The societal pendulum has swung too far away from collective responsibility for medical research and public health surveillance, toward complete personal autonomy.³⁴ The resulting adverse regulatory climate prevents or delays confidential research that harms no-one and benefits everyone, yet, as Rothman himself noted in 1981,²⁰ this flies in the face of hard evidence that public opinion is in fact far more supportive of research using personal health records, without individual consent,^{35,36} than legislators appear ready to recognize: or at least, most legislators.³⁷

Vested interests

Rothman predicted that the fledgling American College of Epidemiology would have to provide an epidemiologist with lawyer-style credentials, because most epidemiologists would be hired by industry or government to argue their case ‘in the courtrooms and hearings where nearly all epidemiologic issues were decided’, in what he saw as the forthcoming ‘regulatory war’. That seems a peculiarly American perspective, in which the language of war is used to frame all disputes, and litigation (if not actual war) is seen as the only way to resolve them. It is not a perspective that seems to apply much elsewhere.

Some public health issues seem more likely to be played out in the court of public opinion than in a court of law—witness public pressure to reduce greenhouse gas emissions, or to curb the marketing of junk food. Even so, powerful vested interests in the industrial production of tobacco, of food, of energy, of weapons, of vehicles and of medicines will continue to pose public health problems for the rest of the 21st century. Yes, even medicines—so long as the protection of patents and drug company profits continues to restrict access to life-saving drugs for millions of AIDS sufferers in poorer countries.

Epidemiology is thus all the more necessary. Epidemiological expertise (among other human and physical sciences) will continue to be required for the foreseeable future in order to define, quantify and explain the impact of such challenges to the health of human populations, as well as to propose policy solutions,¹⁵ and to monitor their impact and effectiveness.

Even though phantom research institutes have arisen,³⁸ industry has learnt how to exploit ‘science’ for its own ends,³⁹ and fraud has become an unwelcome intruder,⁴⁰ we should not panic. Fraud is hardly exclusive to epidemiology. In the wider scheme of things, such deceptions are eventually unmasked, and recent history suggests not only that the most fervently protected secrets of government and industry do surface, but that with the internet, freedom of information laws

and brave individuals prepared to take risks to expose deceit or malpractice, they surface more rapidly now than ever before. Science is an evolving story.

The legacy

You leave a legacy when you die. Rothman predicted that the ‘legacy’ of epidemiology would include ‘the demise of the major 20th century epidemics attributable to tobacco, dietary fats and some carcinogens in the workplace and environment.’

Today, that prediction seems parochial and premature: it may be partly true for the USA and some developed countries, but tobacco-related morbidity and mortality are still rising in the three-quarters of the world’s population who live in developing countries.

Rothman also predicted a decline in the number of important epidemiologic studies published each year after 1990. Importance is a largely subjective judgement, but the number of papers has certainly not declined, and my impression is that epidemiology has continued to contribute important new knowledge to public health and the control of disease.

There is a direct historical lineage from Farr’s work in the 19th century to modern estimates of the global burden of disease and death, and their projections into the 21st century.⁴¹ The statistical methods were developed in the second-half of the 20th century, but the methods would have been virtually useless without the broadly reliable classification of disease and death provided by the ICD.

Modern projections of morbidity and mortality subtend nothing less than an attempt by mankind to set rational priorities for the control of disease. For that broad endeavour, epidemiological expertise is still required.

What more breathtaking challenge could a budding epidemiologist require?

Is epidemiology really dead, anyway?

Standing beside the deathbed of epidemiology in the USA in 1981, Rothman predicted the epitaph of epidemiology: ‘an unpleasant science, providing frequent reminders that...no action is without some risk’; a science that flourished for a few decades and ‘is now nearly gone’.

Four times as many students take courses in epidemiology in my institution today as 25 years ago. They come from all walks of life, not just medicine. Many more students take the courses over the web, from wherever they are in the world. Those who come for the face-to-face courses also come from all over the world, and they return home to practise when they have graduated, often in their country’s health ministry, or its health service. Many take doctorates and start a research career. In 1980–81, the Master’s course I took was the only one in the UK; today, many universities offer such courses. Some courses are specialized in infectious or non-communicable disease, or in epidemiology applied specifically to the problems of developing countries. New textbooks are written and old ones updated every year—I can no longer keep track of them all, still less read them. Some UK universities are closing first degree courses

in physics or chemistry for lack of demand. From where I sit, epidemiology is not even in decline, still less dead.

Epidemiologists are in increasing demand to provide answers to new problems of health and the causes of disease, of disease prevention and of health care, and to refine the methods used to monitor or predict trends in disease control. The public health applications of epidemiology continue to expand, from malaria control in Malawi to the eradication of onchocerciasis in sub-Saharan Africa; from reducing the toll of road traffic accidents to designing cancer control programmes; from health services research to defusing the obesity timebomb; and from racial or socio-economic inequalities in the outcome of health care to projections of the tobacco-related disease epidemic in China.

Rothman's terrible gloom in 1981 overlooked the inherent strength of epidemiology. It is a science that tells us what we want to know about the human condition and, often, how it might be improved, in a way which no other science can offer. It is the science that underpins public health.

Less than 10 years ago, tongue firmly in cheek, Rothman co-wrote: 'Should the mission of epidemiology include the eradication of poverty?'⁴² Mission impossible, even for a science that can contribute hugely, but Rothman the epidemiologist seems to have recovered his panache.

A science lives by the strength of its precepts, the intellectual vigour of those who practise it and the benefits it brings to mankind. By those standards, epidemiology is still very much alive, and looking good.

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