Current Trends
in Science

PLATINUM JUBILEE SPECIAL

The ascent of public health science

V RAMAN KUTTY

Achutha Menon Centre for Health Science Studies, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Thiruvananthapuram 695 011, India.
e-mail: rkutty@sctimst.ac.in

In the last few centuries, 'Public Health' has emerged as a discipline and profession in its own right, distinguishable from medicine by its focus on health phenomena in populations rather than in individuals. Both public health and medicine are practical disciplines where implementing 'what works' may be given priority over answering the question 'how does it work?' Historically, public health concepts have emerged parallel to the evolution of ideas in science such as the germ theory of disease, the understanding of nutritional deficiency states, and infective agents and vectors. Later, with the emergence of non-communicable diseases, mainstream public health thinking has contributed some unique ideas such as 'risk factors' and 'causal complexes'. In the recent history of public health, we see that evolution of concepts has led to new investigative methods, and emergence of newer technology has thrown up new conceptual challenges. This ongoing dialectic shapes the development of public health as a science.

However, modern public health is as much a product of thinking in social science as in science. Especially in the twentieth century, strong ideas that have influenced public health include the rights of man, and equity in health. Whereas science tries to understand the world, social science has a vision of society as it ideally should be, which is shared by public health. However, without the methodological rigour of science, this vision cannot be validated. The strength of public health is that it tries to combine these two approaches to understanding the world and our society. Scientific ideas thus constitute the foundations of modern public health.

1. Introduction

Public health is defined as the art of applying science in the context of politics so as to reduce inequalities in health while ensuring best health for the greatest number (WHO, World Health Report 1998).

Public health, like medicine, is often recognized as a profession with strong scientific foundation. In the practice of medicine, though, we know that many common approaches are un-scientific: there are many systems of treatment which, under the methodological scrutiny of science, are found wanting. Moreover, even in the mainstream, 'scientific' medicine, some of the common practices have never been examined closely for supportive scientific evidence; if so examined, they would hardly stand up to such scrutiny. In fact, we recognize the presence of these forms by the use of the word 'quackery'. What is sometimes not recognized is that 'quackery' can exist right in the midst of what is often presented as scientific practice. This is often because claims of effectiveness often become incorporated into practice before they are verified through carefully planned and executed experiments. It is perhaps much more difficult in the discipline of public health to recognize what is 'public health quackery', because designing a public health experiment is complex and often not feasible: this does not mean that quackery does not exist in public health.

This strong dichotomy between the theoretical foundations, or the 'science' of a discipline and its practice is perhaps present in all those forms of

Keywords. Public health; epidemiology; social science; risk factors.

the pursuit of knowledge which are strongly oriented towards achieving practical, tangible ends. In medicine this goal would be defined as a cure of disease, in public health, as improvement of the population's health. In farming, this would be improvement in the quality and quantity of the produce. In all such areas of knowledge, experience (often cumulative experience of several years) *informs* practice much before scientific knowledge gets incorporated into it. In fact, many of the major, early triumphs of the public health approach were attained without a proper understanding of the science behind the intervention: James Linds' use of citrus fruit in sailors to cure scurvy, John Snow's linking of the cholera deaths in London to the source of water supply, and Semmelweiss' insistence on hand-washing to prevent the spread of puerperal sepsis spring to mind readily. All the above mentioned examples were demonstrated much before the science behind them became common knowledge. Because of this history and tradition of focusing on what works and not on how it works, we tend to think of public health as both 'science and art'. The artist often knows that the use of a particular hue in a certain way 'works', without being able to explain the visual principle behind it. Thus the key questions we may have to ask are: how much of public health is science, and does public health need to go beyond the science?

If we want to answer these questions, we should define what science is, or at the very least, what the scientific method is. An empirical approach is one identifiable characteristic of the scientific method, which means that everything tends to be measured and compared in objective terms. Experiments and observations should be reproducible, and the conclusions logical. This is generally true of public health also: it depends on measurable and reproducible observations and experiments as the mainstay of its method. As a practical discipline which strives to bring better health to more people, while the methods of public health may have all the attributes described above, there is considerable scope for disagreement on (i) prioritization of goals, and (ii) the appropriateness of methods to achieve these. As a rule, science may not insist on these: a scientist is free to study whatever question that engages his or her curiosity, within the constraints of funding support, and one has considerable freedom to set one's priorities.

One might argue that public health, as a pure science, should concentrate on identifying the causes of ill health in the population, as well as on evaluating intervention strategies for picking effective ones. This approach could perhaps be termed as the 'purely scientific' approach, and will avoid getting into controversies over the political consequences of public health policies. As an example, identifying an environment toxin as a potential carcinogen should lead to advocacy for its elimination from the atmosphere, and the public health scientist should not get into debates with the political establishment over what would be an acceptable level of risk, or the economic consequences of banning the production of a certain chemical. However, this level of 'detachment' would hardly be considered as mainstream public health viewpoint; in fact this is a serious criticism about current approaches in public health as well as epidemiology, its core science. According to Susser, '... present day epidemiology is an epidemiology of technique, at risk of existing for its own sake'. Epidemiological research as it is practiced lacks central purpose, and any central concern with subject matter. Pre-occupation with techniques rob epidemiology of its depth, and it operates on a 'single plane' [1].

Pre-modern epidemiology was largely done by amateurs, with the excitement of discovery. Modern epidemiology is technically competent, but lacks depth – which in turn comes from the biology, and breadth – which comes from social sciences. 'The science of epidemiology is utilitarian in its traditional values', says Susser [1]. Thus, many prominent thinkers in the field feel that the public health scientist cannot afford the luxury of abstract thinking. To understand this attitude, we should know something of the history of public health as a discipline.

2. When did science come into public health?

Public health is a population science. It studies disease and other health related phenomena in populations, as opposed to clinical medicine, which focuses on individuals. Many writers have attributed public health (or epidemiological) thinking to ancient thinkers such as Hippocrates. It is true that the eminent physician considered environmental influences as causes of illness and emphasized the importance of lifestyle in causing disease. His primary concern, however, was the individual patient and not the population. It is also true that medieval cities practiced quarantine – preventing ships coming from foreign lands, especially those known to come from cities with the plague, from entering the port for forty days – as a practical way of warding of the epidemic of plague. However, this was perhaps a reflection of practice based on experience rather than on knowledge of any underlying scientific principle. These approaches hardly merit the description 'scientific'.

It is often emphasized that science starts with measurement—when anything can be measured and expressed precisely, that is the beginning of the scientific approach. In this sense, perhaps the first person to attempt to measure any health related phenomenon in populations – the essential approach of public health – was the seventeenth century Briton, John Graunt. He studied the 'Bills of Mortality' – the predecessor of the death certificates – in London and came to many conclusions. He '. . . added more to human knowledge than most of us can aspire to in a lifetime', according to Rothman [2]. Among the more interesting of his conclusions, perhaps relevant even today, are the findings that more boys than girls are born, and that more men than women are sick, but more women tend to visit doctors. However, Graunt's observations were largely treated as curious facts and not considered as requiring any public action.

The nineteenth century witnessed major outbreaks of cholera in England and Europe. This was the new plague, imported from the far corners of the Empire. By this time, measurement was firmly entrenched in public health, and William Farr, a physician, made many observations about the spread of cholera based on the number of people killed by the disease. One thing he noticed was that 'Cholera destroys in a week more than phthisis consumes in a year. Phthisis is more dangerous than cholera: but cholera, probably, excites the greatest terror' [3]. Cholera was still attributed to environmental influences, such as pollution from fecal matter pervading the air, soil and water. John Snow, who examined death rates due to cholera in homes with water supply from two different companies, brought in irrefutable evidence on the waterborne nature of the disease. Thus by Snow's time, two very important scientific principles came to be well established in public health—measurement and comparison. Comparison of disease rates by income per head also helped Goldberger to identify the dietary deficiency as a probable cause of pellagra rather than an infectious agent.

Conceptual progress augmented methodological advance: the nineteenth century saw the emergence of the germ theory of disease and of cellular pathology. Advances in optics and the discovery of the microscope further facilitated the progress. Thus by the turn of the nineteenth century, the predominant paradigm in public health was that of micro-organisms, parasites and deficiencies causing disease. Public health, as a practical profession, focused on preventive measures against the spread of these parasites: sanitation, water supply, and vector control. The challenge was to extend these to the farthest corners of the world. Many of the training schools started in this era had names reflecting this line of thinking: these were schools of 'public health and hygiene'. The development of vaccines contributed vital tools in prevention. Though Jenner had invented the small pox vaccine much earlier, it was in the late nineteenth century, with identification of specific pathogens, that a focused effort at vaccine development took shape. Much of the conceptualization of vaccines as important elements in prevention can be attributed to such stalwarts as Louis Pasteur, who also contributed to methodology by an early experiment, or 'clinical trial' involving sheep, to test the efficacy of the anthrax vaccine.

Discovery of pathogenic organisms prompted the search for chemical agents to selectively destroy them. Though the accidental discovery of Penicillin by Sir Alexander Fleming gave birth to the first antibiotic to be used on a mass scale, its effect was so obvious as to not needing any scientific study for conviction. Streptomycin was the first effective antibiotic against the tubercle bacillus; Bradford Hill conducted an early clinical trial with patients of tuberculosis put on streptomycin, comparing them to those on routine treatment. Thus the elements of the randomized clinical trial methodology were born. Meanwhile, at around this time, people like McKeown had started questioning the very efficacy of specific medical interventions. He pointed that death rates from tuberculosis in Europe had started falling long before the discovery of streptomycin, and even before the discovery of the tubercle bacillus. From historical evidence, he pointed out other plausible causes such as improvement in nutritional status and the better housing conditions as possible explanations [4]. Thus by this time, public health started moving away from the single agent-single disease paradigm to that of multi-factor etiology. Disease and health, came to be seen not as the outcome of a single biological causative agent or deficiency, but rather as arising from a multiplicity of necessary and/or sufficient conditions, many of them social, economic and political, rather than biological. Investigations of the social causes of ill health are rooted in nineteenth century approaches, but was much stronger in Europe, especially UK. The origins of this line of thinking can be traced back to Rudolf Virchow in the nineteenth century, who, after studying the condition of miners in Upper Silesia, had reported that "Medicine is a social science, and politics is nothing but medicine on a grand scale" [5]. In the US, on the other hand, especially after the war, social epidemiology suffered a set-back, with epidemiologists focusing on individual risk factors [4]. The interest in 'social epidemiology' has been revived now, with great focus on the social determinants of health (social determinants of health report WHO) [6].

3. The multi-factorial etiology of disease: concept of the 'risk' factor

Control of infectious agents, vectors and deficiencies succeeded in avoiding death in an ever larger number of people at a young age; however, many non-communicable diseases such as heart disease and cancer could not be attributed to such single factors. Refinements in estimation of death and disease, such as certification, and documentation, helped in tracing the frequency of occurrence of these conditions and studying their associations. Classical studies linking smoking and lung cancer mortality were done on British doctors by Doll and Hill, contributing importantly to methodology (case control and cohort), and concept (smoking as a behavioural risk factor) [7]. Very soon, studies linking heart disease and cancer to a variety of factors such as diet, environmental toxins, behavioural attributes like lack of exercise, and genetic predisposition started appearing. No one factor could be isolated as wholly responsible for the disease, while contributing importantly to increase in probability of disease over time, or 'risk'. Thus the new concept of the 'risk factor' was born, an important idea in public health today, which was a contribution of epidemiological research. As Doll puts it, 'epidemiology has contributed more than any other method of investigation to identifying risk factors for cancer' [8]. An equally important contribution was Rothman's concept of 'causal complexes': that we can identify 'necessary', 'sufficient' and 'necessary and sufficient' causes for disease [9].

Studying diseases caused by multiple factors posed many methodological challenges. The chief among them was the impossibility of resorting to any experimental method in the human populations; also important was the need to control for the influence of various other potential risk factors when studying the effect of one. These challenges brought forth new insights in conceptual thinking and newer techniques of analysis. This was made possible in public health with the intense and intimate interaction with the discipline of biostatistics. Exposure to statistics introduced public health scientists to probabilistic thinking and prompted them to think of their discipline as an exercise in risk estimation. The latter half of the twentieth century saw the flowering of this marriage of method and concept, with many study designs such as cohort, case-control, and the randomized trial undergoing much methodological refinement.

4. Public health and technology

Public health as science has grown in two ways—one, by refinement of its concepts and analysis made possible by interaction with other scientific disciplines, and the other, by simultaneous development of technologies which made newer insights possible. Thus the development of the microscope, the discovery of micro-organisms, and the invention of antibiotics all contributed to the core knowledge in public health. The process of multivariate analysis of risk factors which largely developed in the latter half of the twentieth century would not have been possible without the great explosion in computing power that took place simultaneously. In recent years, with the explosion of new techniques in fields such as genetics, immunology and bio-informatics, public health could not but be affected. It opened the doors to a series of searches for genetic bases of chronic, degenerative diseases, cancers such as breast cancer, and non-communicable disease traits like obesity. However, despite the availability of superior technology, success in tracking and controlling gene-linked diseases has been evasive. Two problems have surfaced: first, in the case of many diseases like diabetes, there is no one-to-one link between gene and disease. Moreover, it is becoming increasingly apparent that knowing the genetic link is a far cry from controlling the disease, since many non-communicable diseases have a heavy behavioural overlay, which can facilitate or hinder the expression of the genetic basis of the disease. The second and more important reason why the technology to probe genetic links in disease has not led to early breakthroughs in prevention, is that it has opened up a plethora of questions on the extent of human control that is ethically and morally justifiable in natural biological processes. Similar considerations have plagued the development of stem cell and embryonic tissue research in health and medicine. This, however, re-emphasizes the importance of both concept and method in the progress of public health science, with improvements in method throwing up new conceptual issues, and developments in concepts leading to new methods of research. This has been the basic dialectics of the development of public health as a science; hopefully, the dilemma will be resolved with public health emerging stronger.

5. Science and social science

Science, however, is not the only influence that has shaped the development of public health as an independent branch of inquiry. Public health science, as we saw, is a way of understanding health states in human populations. Human populations, notoriously, have thoughts and opinions of their own, and their behavior is fashioned by these. Thus public health has to understand the organization of

human societies and the ways in which they function. "We are forbidden to be anti-human, or anti-social, or even asocial", according to Susser [1]. The recognition of this factor may prompt some of us into seeing the public health professional as a dual persona—the scientist who takes a dispassionate look at the causes of ill health and designs the most appropriate interventions, and the activist who tries to get public policy acceptance for these approaches. So much of the public health understanding of society owes to social science. At the methodological level, both medicine and public health acknowledge their debt to social science – we need only to look at the classical studies of disease and healing by medical anthropologists to understand the enormity of the debt medicine owes to social science. The concept of a just society, which has engaged the best minds of mankind over the centuries, gets reflected in the concerns of public health also. "The rationale for specific egalitarianism in the health space rests on the premise that health is a special good" according to Anand [10]. If an increase in the total (average) level of health is viewed as a positive value, and a more unequal distribution of it viewed as a negative value, then there is a trade off between these two states [10]. The experiments in pre- and post-war Europe, such as the state provision of medical care in the Soviet Union, and the introduction of the National Health Service in Britain, were milestones in the development of important public health concepts, such as the right to health care, and the role of the state in health care provision. The questions of equity, and related others such as the role of markets in health care, though still remaining somewhat unresolved, have raised the level of debate in public health from one involving merely technicalities to one firmly in the philosophical plane. Health equity, for instance, "... includes concerns about achievement of health and the capability to achieve good health, not just the distribution of health care", according to Sen [11].

After the second world war, many medical experiments of the Nazi establishment on the prisoners came to light. These shocked the conscience of mankind, and led to the Nuremberg trials and the Helsinki declaration of human rights. Ethics and human rights became inextricable parts of the public health ethos, and have contributed greatly to the development of the discipline since then. While an 'ethical' Physics or even an 'ethical' Biology may be a desirable but not an absolutely necessary entity, mankind has now come to realize that public health without ethics is in itself an evil. The emergence of HIV/AIDS in the closing years of the last century emphasized the fact that knowing the science – the virus and how it behaves – is hardly sufficient to contain the epidemic: we should attempt to find out what motivates people to behave in the ways in which they do behave, and what we can do to effectively to change such behavior. The AIDS epidemic also highlighted the concerns of human rights in the public health context. Research and practice in public health has come to be informed more and more by concerns of ethics and rights; equity has become an indispensable public health concern as well as efficiency. A great and important new field of public health ethics is evolving around the analysis of the ethics of public policy choices in health. Economic tools such as cost-benefit and cost-effectiveness analysis are extensively used, this being the result of a marriage of economic principles to analysis of health outcomes. The vision of a just and fair health outcome to all inhabitants of the globe was effectively articulated in 1978 in the Alma Ata declaration of the World Health Organization, calling for Primary Health Care as the strategy to achieve Health for All by the year 2000. This was another very important milestone in the evolution of ideas in public health. Thus in the last quarter of the twentieth century, concerns of social science took centre stage in debates among public health scientists.

The concerns of social science are different from those of science. While science asks questions such as how the universe, including living things, are put together, and how they work, social science tries to look at not only the structure and characteristics of human societies, but, perhaps more importantly, with how they ought to be. Thus rights, equity, justice, and fairness cannot but be legitimate concerns of social science. They are also constantly evolving, as human societies evolve: what is fair today is very different from what was considered fair even a hundred years ago. These concepts are uniquely human; the unfairness of the 'survival of the fittest' does not seem to bother Nature. When a scientist studies global warming, she may be concerned of the consequences to human society; however, this concern is external to the methodology of science and arises out of her role as a caring human being. There is no value judgment as to whether global warming is 'good' or 'bad' for the earth. It may threaten man's existence, which may be bad for man; this in itself does not constitute a value judgment. When a social scientist studies poverty, on the other hand, there is an implicit value judgment that this is 'bad' for the society as a whole; that is why it is worth studying. Thus the subject of study of a scientist is perhaps the world as it is, and as it functions; the social scientist, on the other hand, studies not only society as it is, but thinks about how it ought to be, and how societies can get

to that ideal state. Medicine, as applied science, can at best attempt to repair man to his original state as designed by nature; public health attempts to create a new society where individual men and women can attain their full health potential.

6. Is public health science?

There have been two main criticisms of the method of science in public health. One concerns its lack of clarity, and the lack of consensus on approaches. According to Miettinen, who is among those who contributed most to clarification of concepts in epidemiology, in most sciences, as they develop, concepts become clearer and there is a convergence to a homogenous and standardized set of definitions and concepts. In the last 50 years, in studies relating to causal thinking in public health, there is a tendency for more confusion and chaos [12]. To an extent this can be attributed to the comparative youth of public health as a science: compared to many other disciplines, it is still raw. The other and more serious criticism concerns the movement of public health away from its concerns for fairness, to what is seen perhaps as a more 'purely scientific' approach devoid of value loading. Many modern concepts and tools in public health have faced criticism of this sort [13]. Moreover, there is criticism also of the way society is organized, which throws up health issues, though this may be addressing an issue larger than public health. To be fair, many eminent men of science have also been intensely concerned over the ethical practice of research and the ethical use of technology. As the power of science to change the world has increased, its power of destruction has also kept pace. This has been a constant concern of all right thinking scientists. However, in their concerns, they are stepping out of the shoes of the scientist; it is another side of their personality, or another hat they are wearing. For a public health professional, these should be integral; i.e., without them, he is not a complete professional. Viewing things in this paradigm, public health is as much or more shaped by social science as by science.

However, the science in public health is indeed its very essence. Without science and the evidence it provides, public health approaches become mere opinions. The emergence of public health as a field of human knowledge in the last two hundred years has closely followed the major scientific developments in biology and medicine in this time. According to Piaget, experience is integral to 'knowing': we know by experience. Thus public health knowledge has grown in complexity as public health challenges and the experience of meeting them have grown in the modern world. In any branch of knowledge, we start with simple and perhaps self-evident ideas; from these, more abstract concepts are built up that may not be intuitively apparent to the uninitiated. Public health has reached such a stage where its core knowledge is accessible only to people willing to make the commitment to assimilate and understand these. This commitment involves a balance between science and social science. Thus the ascent of science in public health has been a necessary condition for the realization of its full potential; however, it is not a sufficient condition. It needs the integration into its conceptual frame, of ethics and equity to fulfill its promise.

References

[1] Susser M 1989 Epidemiology today – 'a thought tormented world'; *International J. of Epidemiology* **18** 481.

[2] Rothman K J 1996 Lessons from John Graunt; *Lancet* **347** 37.

[3] Farr W 2004 In: *A history of epidemiologic methods and concepts* (ed.) Morabia A (Switzerland: Birkauser Verlaug) 16.

[4] Susser M and Myer L 2007 Social epidemiology; In: *The development of modern epidemiology: Personal reports from those who were there*, (eds) Holland W W, Olsen J and Flurey C V (Oxford: Oxford University Press) 207–217.

[5] Anderson M R, Smith L and Sidel V W 2005 What is social medicine? *Monthly Rev.* **56**.

[6] WHO 2008 *Closing the gap in a generation: Health equity through action on the social determinants of health: Final report of the commission on social determinants of health.*

[7] A Morabia (ed.) 2004 *A history of epidemiologic methods and concepts* (Switzerland: Birkauser Verlaug) 59–65.

[8] Richard Doll 2007 Development of the epidemiology of cancer; In: *The development of modern epidemiology: Personal reports from those who were there*, (eds) Holland W W, Olsen J and Flurey C V (Oxford: Oxford University Press) 63–69.

[9] Rothman K J, Greenland S and Lash T L 2008 *Modern epidemiology* (Philadelphia: Lippincott Williams and Wilkins) 5–31.

[10] Anand S 2004 The concern for equity in health; In: *Public health, ethics and equity*, (eds) Anand S, Peter F and Sen A (New Delhi: Oxford University Press) 15–20.

[11] Sen A 2004 Why health equity? In: *Public health, ethics and equity.* (eds) Anand S, Peter F and Sen A (New Delhi: Oxford University Press) 21–33

[12] Miettinen O S 2007 Theoretical developments; In: *The development of modern epidemiology: Personal reports from those who were there*, (eds) Holland W W, Olsen J and Flurey C V (Oxford: Oxford University Press) 231–340.

[13] Mathers C 2007 Epidemiology and world health; In: *The development of modern epidemiology: Personal reports from those who were there*, (eds) Holland W W, Olsen J and Flurey C V (Oxford: Oxford University Press) 41–60.