Epidemiology, medicine and public health

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Epidemiology has played a critical role in the control of infectious diseases and the discovery of causes of cancer, cardiovascular and other chronic diseases. These accomplishments are not concentrated in the remote or the recent past. The density of genuine discoveries has, if anything, increased in recent years, although their scope has perhaps been more limited. Nevertheless, epidemiology is going through a soul-searching period as it confronts three main categories of criticism: it has lost its public health context and social perspective; it has become a field in which more and more sophisticated statistical procedures are employed for the study of factors of progressively lesser importance; and it has been dissociated from biology and relies increasingly on scientifically shaky grounds. Before addressing these criticisms, it is useful to examine what epidemiology is and how it has evolved over time.

What is Epidemiology?

Every epidemiology book and, perhaps, every epidemiologist has his/her own definition of the discipline they serve, but many, we among them, would agree that the principal objective of their endeavours is to study the causation of health-related events or conditions in humans. Moreover, epidemiology can investigate the causation of exposures that, in turn, cause disease, in the context of what has been termed behavioural or social epidemiology. There are important questions in this area of research, for instance, why is it that some people smoke and others don’t, and why is poverty linked to high-risk behaviours? Finally, epidemiology has a prominent role in the study of the causation and the prediction of disease outcomes in the realm of the rapidly expanding field of clinical epidemiology. Clinical epidemiology covers a wide range of activities, from the Bayesian principles of diagnosis and differential diagnosis, to randomized trials of therapeutic efficacy, to observational evaluation of the effectiveness and efficiency of health care macrosystems (health services epidemiology).

The methods of epidemiology have been considerably developed and refined over the last five decades. It is possible to study both qualitative and quantitative exposures and outcomes, whether these are common or rare. It is possible to control for complex confounding influences, to study effect modifications of variable nature, and correct for several forms of misclassification. There is no methodological obstacle if researchers or policy makers prefer to consider the population as a whole rather than focus on the variable, number of exposed individuals. If epidemiology has lost its population-based public health perspective, epidemiological methods are not to blame.

Evolution of Epidemiology

Historically, clinical medicine, aetiological considerations and public health concerns were interwoven. Hippocrates advised that ‘whoever wishes to study medicine properly should... consider the seasons of the year... the hot and the cold... the waters... and the way in which the inhabitants live... whether they are fond of drinking and eating to excess and given to indolence, or are fond of exercise and labour’. In more recent times, the great Virchow (1821–1902) was distinguished for his contributions to pathology and his public health activities. During the first half of this century, however, public health and clinical medicine have drifted apart, with epidemiology going along with public health. There were several reasons for this development which, in the USA and many other countries, has been reflected in the establishment of schools of public health distinct from schools of medicine, with epidemiology finding its home in the former. Perhaps the most important factor was that major discoveries, concerning mostly infectious (cholera and malaria, among others) but also some non-infectious (for example rickets and scurvy) diseases of major public health importance, were linked to macro-environmental exposures, the control of which depended on water sanitation, proper sewage draining and disposal, vector control, food hygiene and improved habitation. These were tasks for engineers, chemists, entomologists, architects, economists or policy makers, but hardly for clinicians.

After World War II, the emphasis of epidemiology shifted from the macro- to the micro-environment, with the focus on personal habits like tobacco smoking, alcohol drinking, diet, intravenous drug use and sexual preferences, or personal characteristics like occupations, education, marital status and parity. This shift brought epidemiology closer to the clinical profession. But, apart from the widely accepted randomized controlled trial, not close enough to make epidemiological theory an accepted, well-known and integrated part of clinical research methodology.

The situation is rapidly changing, however. Epidemiology is increasingly being used in the study of clinical outcomes, and epidemiological studies of disease aetiology increasingly examine genetic polymorphisms as interactive variables and molecular changes as exposure or early outcome indicators. Indeed, clinical and molecular epidemiology are two growth areas of the discipline and both tend to bring it closer to clinical medicine. In most clinical settings, however, this development is not yet prominent.

Addressing the Criticisms

Epidemiological results may appear to be contradictory more frequently than results from studies in experimental animals but this should not surprise anyone because humans are not
inbred as laboratory animals usually are, and they are not living in carefully monitored environments as experimental animals do. Certain epidemiological results have turned out to be clearly invalid, but this could only be documented through other, valid, epidemiological investigations. There is no evidence that epidemiology fares better or worse than other disciplines in the predictive power of the positive and null results that it generates. Epidemiological studies are simply more understandable and more interesting to lay people and they may receive more public scrutiny.

Most epidemiological studies are explicitly or implicitly guided by prevailing biomedical theories but some venture outside the limits of normal science and others are no more than blind shots. The ultimate testing ground of biomedical theories, as they apply to health and disease, is the empirical documentation of predictable causal associations. It is possible, however, that epidemiology firmly establishes associations that cannot be explained by existing theory and require new thinking. For example, the linking of homocysteine to coronary heart disease represents a striking paradigm shift that was driven by empirical evidence.20

The idea that epidemiology has somehow abandoned its public health vision and even mission is a strange one, because it postulates that epidemiologists are more responsible and competent than other professionals to bring about behavioural, social, and political changes. It is true that epidemiology has contributed to the documentation of poverty as a powerful predictor of ill health and has provided evidence that pollution of the environment may shorten life expectancy.13 However, corrective measures against poverty and environmental pollution are the responsibility of economists, social scientists, city planners and policy makers. Epidemiologists can only be advocates for the poor and the environment; their professional duty ends with the convincing demonstration that social ills seriously damage health—and this has been accomplished long ago (reviewed by Tomatis13).

**Future of Epidemiology**

A distinction should be made between the future of epidemiology as a discipline, and the future of epidemiologists as professionals. A discipline is best described in terms of its methods and research objectives, while the future of a category of professionals is a function of job opportunities.

Disease aetiology is likely to continue dominating epidemiological research, but with heavy input from genetics and more explicit molecular considerations. Some of the studies will focus on individuals or families at very high risk for diseases with strong genetic components, as a prelude to gene mapping, or as a prerequisite for the ascertainment of the mode of action and the environmental conditioning of genetic influences.21–23 While this approach may produce short-term benefits for a few, it is likely to have limited impact on the population at large and ‘fundamental threats to global health’11 may not be addressed at all.

More frequently, epidemiologists will try to identify and quantify interactions between genetic polymorphisms and environmental exposures in the causation of disease, with a view to prevention and possible public health impact. These studies are likely to become increasingly complex and difficult to interpret, because risk elevations are frequently modest, patterns of interaction uncertain, and study size limited by the need for biological samples. Nevertheless, the latter type of study may well become the dominant research activity of epidemiologists in the near future, and already some noteworthy findings have emerged from the field of molecular epidemiology.6,8 As a corollary, epidemiologists that do research on disease aetiology will have to devote more time and effort to learning molecular biology, collecting biological samples and interacting with clinical and laboratory scientists.

The future of nutritional epidemiology and occupational epidemiology depends on the identification and large-scale utilization of biomarkers of susceptibility, more often than not of genetic nature. Pharmacoepidemiology, however, will continue to represent an important area of epidemiological investigation of disease aetiology, because pharmaceuticals will continue to be introduced at high rates, and will require post-marketing surveillance.

Clinical epidemiology will flourish and could revolutionize the way clinical medicine is conceptualized, practised, and evaluated.24 Many, if not most, clinical inferences and decisions, including diagnosis, differential diagnosis, prognosis, and evaluation of treatment effectiveness and safety rely, explicitly or implicitly, on epidemiological principles. Health services evaluation also has an important epidemiological component, although many studies are likely to be of limited interest outside the institutions involved and the time period covered. To a certain extent this also applies to studies of social and behavioural epidemiology, because cultures vary by time and place in an indeterminate way.

Many epidemiological studies are likely to concentrate on the aetiology and prevention of diseases that are functions of continuous physiological variables like blood pressure (hypertension), intraocular pressure (glaucoma), body mass index (obesity), or bone mineral density (osteoporosis).25 This is justified by the public health importance of these diseases which, in turn, is due to the fact that those in the middle or even the low part of the distribution of the physiological variables, rather than the extreme high-risk individuals, may account for most future disease, disability and premature death. Hence, while aetiological researchers are preoccupied with high-risk individuals and use relative risk as a measure of association, public health action requires attention to absolute and population-attributable risk. In many instances, the population would benefit most by a shift in the entire distribution of, for example, blood pressure or body mass index.25

Much future epidemiological research, and certainly most of that focused on disease aetiology is going to remain ‘risk factor epidemiology’. This terminology has recently been used in an almost derogatory sense, but this reflects a misunderstanding. With the exception of associations concerning diseases that are defined on the basis of a specified exposure, e.g. measles or chronic beryllium disease, all other relations have to be considered as indicating risk deviations, unless and until causality has been firmly documented.

**A Paradigm for Modern Epidemiology**

Epidemiology must be recognized as a basic research discipline, with intimate links to clinical medicine and laboratory sciences. The principal objective remains to advance understanding of disease aetiology, regardless of its possible—always hoped for—
implications for public health. The distinction between aetiological and clinical research (clinical epidemiology) is intentionally blurred. Mutual benefit is within reach because epidemiology would be enriched biologically and clinical research methodologically. Researchers can work together to study a broad range of biological phenomena. For example, cancer epidemiologists can interact closely with tumour biologists, oncolgists and other clinical colleagues who diagnose and treat malignant diseases. And students of causes of dementia can create their scientific environment near the neuroscientists and geriatricians. Recruitment of patients into aetiological studies will be easier as a result of closer contact with clinical medicine. In many instances, randomized controlled trials of treatment or screening interventions offer an excellent framework for aetiological research.

To do their job well, epidemiologists studying disease aetiology must devote increasing time and effort to understanding the possibilities and limitations of molecular methods. The task is enormous, because knowledge grows so quickly. The closer access to expertise in biology and clinical medicine and to laboratory facilities should allow a more sensible—and soundly critical—integration of molecular methods into epidemiological research. In the paradigm we propose epidemiological investigators could meet the challenges of molecular epidemiology without the criticism that they do not take public health issues into account.

The idea that epidemiology and its practitioners can maintain responsibility in the 21st century for public health issues and modifications of people’s lifestyles, while simultaneously keeping tract of the exponentially increasing and complex knowledge about disease causation and molecular medicine, is unrealistic. Public health professionals need to have sound training in epidemiology and biostatistics, as well as substantial substantive biological knowledge, but their explicit focus should be the health of populations. Proper quantification as well as monitoring trends of the burden of disease belong naturally in the public health domain, as does social and behavioural epidemiology. The ‘defining’ expertise of public health professionals, however, should be in behavioural sciences, intervention strategies, media communication and policy making; all of them essential for health promotion. The enormous health consequences of poverty and inequality should receive the proper attention of public health professionals, as should social and cultural determinants of disease. In public health, these factors should be targets for intervention, while in aetiological research they are only surrogates of more specific exposures in the causal web that ultimately lead to disease. The increasing tension between aetiological research and concern for public health would be eliminated.

Conclusion

Epidemiology studies the causation of health events and conditions in humans. The study of clinical outcomes and their determinants is inherently clinical, and the study of disease aetiology increasingly depends on joint efforts of laboratory specialists, clinicians and epidemiologists. These developments distance epidemiology from public health and make it an integral part of medical research and clinical practice. In contrast, the study of social and behavioural determinants of exposure to disease-causing agents and conditions, frequently termed social or behavioural epidemiology, is an essential component for the effective practice of public health. These diverging trends make it unrealistic to consider ‘putting public health back into epidemiology’ a generic objective.

It is noteworthy that the leading medical journals, that primarily address the education and information needs of the clinicians, have long ago de facto recognized these developments by publishing a substantial number of epidemiological papers. Academic institutions have been adjusting slowly, as they always do. Strangely, the epidemiological community has been unnecessarily defensive in the realization that epidemiology has now become a basic discipline for clinical medicine as it has long been for public health.

References

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