Teaching concepts in epidemiology

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In the United Kingdom most medical students are first introduced to epidemiology as a formal discipline during their clinical years—usually during a course in social or community medicine. The amount of time allocated to the subject varies greatly between schools, but everywhere epidemiology is a recent addition to an already overcrowded curriculum and, like all parvenus, has a need to justify its position in terms that everyone can understand. Such justification must of course be to clinicians who have often had to yield time and who are rightly suspicious of any new arrival; but, perhaps more importantly, it must also be to students who reasonably demand that any new burden must be not only intellectually satisfying but of obvious relevance to their immediate clinical interests. Moreover, having tasted at last the delights of clinical doing, students have a natural distaste for anything that seems to demand even a partial return to some form of systematised classroom learning.

The placing of epidemiology in the clinical years has, of course, great advantages for the teacher. He can build an understanding of the uses of epidemiology, as well as its methods, on the particular clinical interests and insights of individual students, so that they can feel it is they who have provided the starting points for teaching. This helps to bring a potentially dull subject alive and to allow epidemiology quite quickly to assume its essential role as a unifier of clinical, social, and preventive concepts of health and disease, instead of appearing as the mere servant of one.

There are, however, ways in which the teacher of epidemiology stands greatly disadvantaged next to his clinical colleagues. The clinician's justification of his activities, the immediacy of his time scales, the spiritual rewards of his action, need no conscious transmission to the student; they enhance (when they do not obscure) the scientific as well as the humanitarian basis of his thinking. But the epidemiologist has no such allies for his science—his activities seem remote, his time scales long, his rewards intellectual, and every step he takes, every conclusion he reaches, must be exposed to the cold logic and debate that he rightly insists are the very essence of his subject. Yet it is just this dependence on scientific reasoning that exposes epidemiology's weakest flank. For however deeply they have explored epidemiological methods and the statistical

techniques used to interpret them, teacher and student together may still emerge wondering whether the whole subject of epidemiology is sufficiently strongly enough developed conceptually to bear that very process of critical reasoning that it demands for its practice.

It seems to me that there are two components of this doubt. The first is that the analytical methods essential for the application of epidemiological techniques to the diseases of our age are generally more complex and of a later time than the simpler data-gathering processes of epidemiology's infancy. This makes it hard to join the two phases in a single coherent story, let alone to trace the development of the theoretical concepts that would bind them together; the apt student is right to be curious about the relatively silent years of epidemiology earlier this century.

The second component of the doubt is, however, more fundamental and extends beyond the teaching of the subject into the organisation of its concepts. It is simply this: the able student is too often asked to accept as a science a discipline justified only by its techniques. The teaching of epidemiology, certainly as illustrated in many of the good textbooks available to students, tends to depend too much on detailed description of methods and the uses to which they may be put without concentrating equally on the theoretical concepts that relate those methods and which alone can justify any claim epidemiology may have to be called a basic science (whatever that may be). Nor is there a chance that a mere collection of methods, however precise, can ever predict the pattern of its own future development, which is surely a legitimate demand on any science. If epidemiology were content to remain the mere interpreter of recorded observations then perhaps the elaboration and perfection of techniques would be enough, but it has higher aspirations than that and if they are to be realised it will only be by developing more fully the theoretical concepts that unite its methods. Only then can the bright student be expected to accept the subject as intellectually satisfying and to see its relevance to the many aspects of clinical and laboratory medicine which have a just and increasing claim on its interest.

To be useful, a unifying concept must start by being simple, and then be capable of increasingly complex and exciting development in any of the several

directions in which the science it explains is elaborated. These directions, in epidemiology, are as much dictated by new knowledge and understanding outside its formal territory as by new ideas and techniques within it. For it is surely as a mediator between the too tightly defined interests of specialty medicine and research that the modern science of epidemiology will find at least part of its future fulfilment and to which the elaboration of its concepts must pay due heed.

There are several basic ideas in epidemiology that offer themselves as concepts capable of development to the point where they become unifying principles. To me, the simple idea of a 'rate'—of a numerator related to a denominator within a defined period of time—seems the most attractive. It is certainly open to far greater conceptual elaboration than most textbooks, and indeed teachers, allow. It seems at present to be used as a starting point and then dropped when it has been sufficiently described in its simplest current usage; too little consideration is given to its potential development as an idea, not only in its separate parts but in the increasingly complex relationships which unite them. Such development can take us to the very boundaries of our clinical, pathological, behavioural, and social understanding, and so promise just those insights necessary for the intellectual delight of both teacher and student.

Consider how teacher and student can manipulate the idea of a 'rate'. If, perhaps, they incline to historical beginnings they can take the numerator—those diseased—and, separately, the denominator population from which they come, and trace how much the historical development of routine data-gathering has depended on contemporaneous understandings of biological and population sciences and, because of this and the inertias common to systems, how the gathering of data has sometimes forced us, and still does, to live with models of disease from which contemporary knowledge of biology, genetics, and behaviour would have had us free.

Still using the rate in a purely descriptive sense and still concentrating on its separate parts, they can then begin to see how poorly the 'binomial' definition suited to the numerators of the days of infectious disease suits the diseases of today. For an ageing population faced with diseases of personal and social behaviour, or genetically determined at birth, definitions must more often be sought in the tail of a Gaussian distribution, or in a concept of attributable risk, than in the yes/no judgments of the clinical laboratory. Such a need for new definitions may lift the student beyond the intellectual confines of his hospital experience towards a broader understanding of those aspects of social and behavioural sciences which have a direct bearing on disease, and send him

searching among the denominator populations for the characteristics he needs to build his new models. He need not be worried that his search will be confined to well-trodden demographic and social paths alone. Modern clinical and behavioural science provides such a kaleidoscope of ideas about the characteristics of populations that have a bearing on their diseases that his way will lead through just those details of genetics, immunology, pathology and psychology that he is used to thinking of in relation to his individual patients. In applying such thoughts to populations rather than individuals he will inevitably develop understandings which are not always compatible with what he has been taught at the bedside, but he will clearly be in a position to criticise some epidemiological studies for their lack of sensitivity to the things he knows are relevant to his patients. Why should he believe that a family history of disease is important to his patient if epidemiologists so often discount it?

The bearing that these multifaceted and interrelated features of a population have on disease is twofold, in aetiology and definition, though we have long been used to over-stressing the first at the expense of the second. But can we continue to be content with a definition of diabetes that depends on blood sugar alone and pays no heed to age or race, or lipoproteins, or HbA status? If we could draw distributions of these variables in defined populations we might find curves giving a different, perhaps a better, explanation of the prevalence and natural history, even the clinical behaviour, of the disease we understand so poorly. So, too, perhaps we might find ourselves redefining the stages of cervical dysplasia and invasion with reference to the age, immune status and even social behaviour of the affected population; and understand more of the natural history of urinary tract infection if we accorded the antigenic nature and pathological capabilities of the organisms the same dignity in definition as the slavish counting of mere numbers on a microscope slide.

Such explorations take the student far from a consideration of epidemiological methods but they lay for him a groundwork understanding of how close the interests of clinical, social and laboratory medicine must now be if much advance is to be made in any one of them. From there his move to an understanding of epidemiological methods is relatively easy.

It needs no elaboration of what has already been said to see how easily case-control studies, cohort, longitudinal and cross-sectional studies, surveys, repeatability, validity, screening, and all the multiple techniques of epidemiological investigation can take their starting points from a simple consideration of

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the rate, either as a whole or in its separate parts. Many of the seeming disparities of these methods, so often presented as isolated techniques, have a unity in the need for numerator and denominator definitions. The use and abuse of methods is much better appreciated if the single idea that unites them is so clearly stated that departures from it become self-evident.

But there is a further strength, too, in using the concept of a rate as a starting point—it can lead into an understanding of the principles of statistical analysis that does not depend on numeracy. It is surely the dream of a teacher of epidemiology to be able to convey essential statistical concepts without recourse to mathematical formulae and so to inspire, or at least not terrify, that half of any clinical class with an inborn (or acquired?) dread of numbers. For there are only two ideas that a student of epidemiology, at least at undergraduate level, must grasp in order to have an understanding of the statistical techniques needed to interpret epidemiological studies, and both these ideas are amply illustrated in the numerator and denominator of a rate, or comparative rates. The first is that 'like' must always be compared with 'like' and that the quality of 'likeness', for populations, is no more than a commonly held characteristic with a defined distribution in each. The characteristic of interest probably has some biological or behavioural relevance to the disease or condition studied, but apart from that limitation, most statistical tests do no more than attempt to refute the proposition that the distribution of the characteristic in one group is so similar to that in another, that, from the points of view of that characteristic, the two groups may be regarded as belonging to the same population. The groups, of course, are most often samples, and the diseased in the numerator of a rate can be presented as a sample from the denominator population from which they come, with the line drawn between them enlarged in concept to describe the process by which the sampling occurs. For statistical description, and to unite statistical techniques firmly to epidemiological method, it is easier to consider two rates—two different samples from the same population or different populations. The incidence and prevalence of a disease may provide examples.

In this context it may be a useful conceit to draw an analogy between the line that divides the numerator and denominator of a rate and a semi-permeable membrane. The line, the membrane, becomes the process of selection by which groups of patients present themselves, or are chosen, in any medical and social system. If the pores are wide enough, then what gets through to the numerator is a random sample of

the population from which it comes—if narrower, they are selective for some characteristic which may or may not be of importance to the aetiology or definition of the disease in the numerator sample. Or they may be permeable in a selective manner to some other characteristic of seeming importance that diverts and intrigues, perhaps for a whole generation, but ultimately disappoints as an explainer. In these terms, the principle of osmosis, of locality, perhaps, or wealth or social class, in the bias of samples is easily understood, and, thus, the different predictive values of a characteristic in, say, a numerator attending a clinic and a denominator in the streets outside.

The second statistical concept, and in my opinion the only other one of importance to the undergraduate medical student, is the idea of the association between two variable characteristics, and hence of correlation and regression. Clearly, different aspects of the various parts of the rate may be useful in illustrating these, but the ideas are essentially so attractive and have roots in so many remembered and half-remembered episodes of our clinical experience, historical and current, that it may be more useful to the student to illustrate the concepts with clinical rather than epidemiological material. It is easy for him to imagine an individual patient poised at any point along a regression line describing the relationship between two variables and so to use the particular to develop the general—the individual becomes a sample of matched individuals with variables grouped round a mean.

No claim is made that the 'rate' is the only concept in epidemiology capable of development to the point where it begins to unite techniques. A strong case could be made for the variability between and within observers, for example. But better developed concepts are badly needed if epidemiology is to appeal to the intellectual curiosity of the ablest students and open itself fully to other research and clinical disciplines with a just claim on its interest. Perhaps one of the strengths of the 'rate' is that it is so simple an idea that it can be dropped when it has strayed beyond its natural logic into the realms of the fanciful or taken up again when some process of thought has led teacher and student beyond rational understanding.

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