DETERMINANTS OF HEALTH AND THEIR INTERACTIONS

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Keywords: aggregation, environmental health, health care, health determinant, indicator, indicator family, interactions, knowledge-based indicator, life expectancy, model, multi-sectoral, nutrition, risk factor, "well-being".

Contents

Summary

Health as a concept is not rigorously definable, but it has different components such as: clinical, epidemiological, health care and social. While biological, genetic, physical environmental and nutritional factors clearly determine health in individuals and communities, other more indirect factors are also active. Education, economic pressures, employment, cultural constraints, housing, the social environment and social support, behavioural patterns of the individual and of the community can contribute to the burden of ill-health or, perhaps to positive well-being. Major determinants can be identified in each of these sources.

Determinants, from whatever sectors, influence different aspects of health. Their effects may be delayed or perhaps long-lasting; the "system" is therefore multi-input, multi-output and time dependent. Determinants inevitably interact. This creates difficulty in identifying causal determinants, their pathways and their effects; understanding needs "system models". Models need data and a methodology for identifying, from observations, the details of the system. Various statistical techniques are available when suitable data can be obtained. But the data cannot always be obtained, either by reason of impracticability or because the factor sought is conceptual rather than real. Indicators, rather than variables, are often a key element in studying the impact of health determinants.

Indicators have also been developed into "indicator families": for example, "life expectancy" has been generalised into "healthy life expectancy" and into various forms

of "impairment free-" expectancies; this approach allows separation of various determinant factors. Grouping indicators into a "system" linking determinants and health encompasses the structure of inter-connections linking causal factors. "Knowledge-based" indicators are needed in dealing with observations expressible only as "natural language" statements about causal relationships affecting health. Knowledge-based models use computational logic to explore the deductions and inferences arising from all available relevant "knowledge-based" statements, leading to testable hypotheses about health and its determinants.

1. Introduction

The health of individuals and communities has been commonly linked to a variety of determinants with biological, genetic, environmental and nutritional origins; more recently however, economic pressures, the social environment, cultural constraints, and behavioural patterns - both individual and community - have come to be regarded as important factors influencing health. Current views on these various determinants are described in the articles that follow. However, with the expansion of the perceived range of possible causalities, crucial new questions have emerged. For instance: how can potential determinants be recognised; do they interact in producing their effect; and how can the pathways by which determinants act, and/or interact, be understood? These issues are especially important in the difficult areas of socio-economic, cultural and behavioural domains where the available methodologies now need to be supplemented. So the matter of health determinants needs to be placed in the broader context of both insight (what factors may be relevant?) and methodology (what technical means exist or can be developed to validate hypotheses and utilise the findings?).

It is now commonly perceived that “health” involves many aspects beyond the simple presence or absence of overt or covert disease: well-being is relevant and has many dimensions; “health” is a complex concept. This perception complements the recognition that the health of the individual is influenced by factors of social, economic and environmental kind. Correspondingly, measurements intended to illuminate health status need to take account of this wider range of issues: potent non-health sector variables must enter consideration. There is little argument that income, education, economic pressures, unemployment, poor housing and poverty itself have appreciable consequences for health, although the interaction between health and non-health sector variables may occur in an unpredictable way. Furthermore, with this expanded view of health determinants, it should be recognised that some pathogenic agents may produce health impacts well into the future, rather than immediately (the effects of chemical pollution of soil or water, or of the pollution of fatty tissue in fish). This illustrates that the likely effect on health of non-health sector variables and indices involve both long latency and time-dependency. A search for and analysis of such influences must consider the "dynamics" of such other-sector variables: the time course of introduction, accumulation and dispersal of toxic materials; the time course of their transfer into the human body (perhaps through multiple pathways) and of the balance between accumulation in and removal from the body; and the development of health consequences.

The complexity of health needs to be regarded also in another perspective. The concept of "well-being" - positive health - does not stand alone: it co-exists with ideas of disease, which are changing. The meaning of disease is being re-thought, and the idea that health is merely equivalent to the absence of disease is no longer acceptable. Even the accepted World Health Organisation definition is far from adequate. Health also carries the implication of an element of "protection": against the effects of elements that might initiate pathological changes, or reduce resistance against morbidity, or reduce reserve to cope with stressor situations or otherwise cause illness. But even such factors are only one component of what is implied by "health".

The influence of recent scientific and socio-cultural developments on some of these issues has recently been examined. The current trend recognises a multi-dimensional conceptualisation of the phenomena of disease that includes the relatively independent dimensions: clinical syndrome(s); structural or functional deviation from the mean in a statistical sense; aetiology; co-morbidity; social functioning. At the same time, there has been "an increasing influence of economic judgements in decisions about which diseases should be treated, and how. Indirectly or directly, such judgements and decisions will affect the taxonomy of disease, e.g., by defining thresholds of 'severity' or 'treatability'." Naturally, certain aspects of the concepts of health and disease are appropriately studied with the methods of biomedical science, clinical science and epidemiology; but other aspects involve behavioural and social science and these must be taken into account. Economic and philosophical judgements cannot be avoided. In short, the concepts of disease and of health are social and cultural constructs. They are now firmly in the domain of social values and politics and, in consequence, public debate.

As an individual concept, distinct from the "health sector", "health" itself is not rigorously definable, although it might be possible to identify "bounds" to the "health" concept. In any useful sense, "health" - even on a simplified view - has a continuum of states from bad to good, simultaneously concerns many elements, and can be regarded in a variety of ways. It might be regarded as a "family" of concepts drawing upon such ideas as: clinical definitions: the presence or absence of "disease"; or as a epidemiological probabilistic model focussed on risk prevention; or in systemic terms looking at health support services, or again with a social focus, and so on. In short, our concepts of "health" must "integrate" ideas of well-being, functionality and resistance to disease, of disease, its origins and the risk factors associated with it: regarded in molecular, clinical or social (i.e., community or public health) terms: and take account of what is regarded as "health" and "ill-health" in the culture concerned, and other socio-economic and political viewpoints. It involves the pathways that link outcome back to risk factors and exposure to trauma or pathological agents. It has an element of description, of explanation, of ideas of well-being, of behaviour patterns, and of culture. It involves the structure of the health care services and the nature, accessibility and efficacy of the services they provide. And it involves national policies related to the provision of health care services. Consequently, the term "health" in this article includes generally the "health sector" or the "field of health".

Modern epidemiology tends to employ an exposure and risk factor approach to the task of recognising and assessing the importance of possible health determinants. Commonly

a static view is taken of the relation between determinants and their effects or associations; sometimes this is extended to accounting for time-dependency by using a series of "time windows" or "life-stages". However, it becomes clear as soon as socio-economic or ecological influences are considered that time-dependency operates continuously rather than in discrete, step-wise fashion. In consequence, health-determining pathways need to be considered in dynamic, continuous time terms, as illustrated above in the case of toxic chemicals entering the environment. As a further implication, understanding the way effects operate and describing the outcome of possible interventions requires the use of models of the overall system, rather than simple input-outcome linkages; these models will have a similarly dynamic character. Thinking further in general terms: due to the likelihood that determinants from different sectors are involved in effects on health, interventions in one sector must be expected to have consequences in other sectors.

The recognition that environmental factors can affect health (e.g., atmospheric pollution of industrial or agricultural origin) implies that there is a geographic or spatio-temporal aspect to be considered, which shows a further aspect of any model. Atmospheric pollution due to an industry in one country may affect the environment, and so health, both within its own borders and also in another country. These effects are, again, time-dependent because of variable time delays due to transit times of air-borne materials, not only due to variations by season but by changing economic conditions that influence the industry within the originating country. The spatial distribution of effects is controlled by meteorological factors which are also time dependent. Furthermore, the biological loading in individuals due to exposures to certain toxic elements is also time-dependent: it may be subject to a balance of inflow and elimination characteristics, or may be totally cumulative. So it follows that a model of the risk to individuals within affected regions needs to take account of the temporal pattern of production of the relevant chemical; the time-course and geographic distribution of its transmission within national borders and to other countries; the physico-chemical mechanisms of ingestion, accumulation and elimination in the body; and the mechanisms by which pathological consequences to the individual result.

Determinants can interact in their effect on health. Economic deterioration within a country leads to increasing unemployment and consequential health problems of those affected; it also influences behaviour patterns that have an impact on health, such as violence and drug-abuse. Changing socio-economic conditions may impact on a nation's Gross Domestic Product (GDP), employment, housing, income and such elements, and causally increase ill-health due to malnutrition, psychological stress, social violence; the effectiveness of the provision of health care services by public authorities is reduced due to consequential financial restrictions and an increase in demand-led loading. Reductions in GDP can influence the servicing of international debt through reduced ability to meet interest payments; this can result in the feedback of further consequences when international funding agencies impose economic adjustments that, in practice, react most severely on incomes of the poorest in the country and so, on the health of this group. So a global view of health determinants should include a recognition of several general concepts: multi-sectoral causalities; interactions between sectoral determinants; spatio-temporal factors: geographical, environmental, ecological; and dynamics and continuous time-dependency. It will be

evident from the above remarks, and the discussions in the following sub-sections, that many factors are thought to operate in determining health. Clarifying what factors operate, and their strength of effect, might be achieved through classical statistical methods, such as multi-variate analysis of causal or associative effects. However, this requires numerical data. But reducing complex social and behavioural factors to a set of numbers in order to conduct such analyses cannot be more than seriously incomplete. It cannot avoid generating a very circumscribed view of what are, in fact, rich phenomena, so a classical analysis may not be effective. It must be assumed that determinants do not individually act in isolation; they must interact in creating their impact. A major issue is: how to determine these interactions and indeed, how to describe the operative factors in a way that will permit interactions to be studied at all?

Determinants of ill-health are more readily identified than are determinants of, specifically, health itself. Thus it is usual to recognise the following categories of "ill-health" determinants:

communicable diseases (due to contagion or vector-borne);
non-communicable diseases and disabilities;
external mediated sources of ill-health;
(from the physical or social environment, including occupational diseases and trauma, accidents, social violence, malnutrition)
"internally" generated causes (including behavioural factors; mental disease);
inadequate or absence of treatment (due to failure of Primary Health Care for whatever reason).

There are various ways of looking at the broader scope of possible health determinants. One way is to categorise health into broad domains; this is particularly helpful in identifying the kinds of information needed to characterise determinants that affect health negatively and to some extent positively. It is useful in portraying relevant numerical data in a visual way that allows simple comparisons to be made between geographical regions, or between periods. It allows for progressive disaggregation of data as required, from the aggregated information applicable to, say, an entire population down to the sub-group of data pertaining to separate groups of the population or separate regions.

existing or potential diseases and health impairments
the health care system
food and nutrition
socio-cultural and economic conditions
environmental determinants

Another approach is to consider the desirable pre-requisites for health (including not only the absence of disease or impairment but also the presence of positive well-being: a satisfactory quality of life) together with identifiable influences by which health is or may be compromised.

pre-requisites for health in the sense of "well-being"
general environmental conditions including housing, access to safe water and

sanitation, a secure physical and social environment nutrition, employment provision of and access to medical and other health care services social support and security cultural environment demographic factors: ageing, urbanisation, changing patterns of behaviour (social and domestic violence; drug abuse); peer group pressures poverty spread of resistance to anti-biotics new and re-emerging communicable diseases stress and mental disorders influence of mass communication economic, financial and trade globalisation degradation of the environment

A different picture results from considering the global nature of the sectors that influence health. This leads to the idea of modelling the intersectoral interactions, and to the necessary technical procedures and their data requirements. This approach envisages a societal system comprising three components: a human reservoir (the individuals making up the community); a societal reservoir (containing institutions, infrastructure, products, beliefs); and the remaining environment. Examining the necessary interactions between these components, one recognises that, in order to describe the impact on health of different elements within these components, one is dealing with a multi-input multi-output system which is too complex to be utilised in any simple way to estimate causes and effects. A model is needed. Interventions and disturbances in large scale economic and societal systems generally produce consequences that take time to evolve. Successful interventions to reduce infant mortality, for instance, will create an increasing need for other services: education, health care, housing, food: as the infants grow; the consequences of the intervention are both delayed and evolve with the passage of time. This illustrates that the pathways by which these determinants act are, in this sense, dynamic.

Models need data, so in order to identify the causal pathways in the model, it is necessary to fall back on a variety of "indicators" which purport to provide an estimate of variables desired but not obtainable in practice. This highlights two of the major difficulties with the whole field of health determinants: the need to employ - and so, choose - suitable "indicators"; and the critical dependence on data quality and quantity. In consequence, very frequently, what is studied is what can be studied, not necessarily what is most directly required. But assume appropriate data, and discount dynamic aspects altogether. Then the analysis of the model commonly uses multiple regression to estimate, for instance, the relationship between health indicator variables (e.g., life expectancy, infant mortality, crude death rate and death rate from violence) as output and various socio-economic indicators (e.g., housing, education and communications) as input. However, this type of approach is, despite the fact that it discounts dynamic aspects, at least a starting point.

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Biographical Sketch

Bruce McA Sayers is Emeritus Professor of Computing Applied to Medicine and Senior Research Fellow (since 1993) at the Imperial College of Science, Technology and Medicine, University of London. He graduated in Physics and Electronic Engineering from the University of Melbourne and was then appointed Biophysicist to the Baker Medical Research Institute, Alfred Hospital, Melbourne. In 1954, he joined Imperial College in London to undertake research and teaching on Physiological Psychophysics, and subsequently on Electronics and in the Nuclear Power industry. He became Professor of Electrical Engineering Applied to Medicine at Imperial College in 1968; Head of the Department of Electrical Engineering, 1979-84; Professor of Computing Applied to Medicine and Head of the Department of Computing, 1984-89; Kobler Professor of Information Technology, 1989-93; Dean of the City & Guilds College between 1984 and 1993; Director of the Centre for Cognitive Systems, 1990-98. Honorary Consultant (1968-84) to the Royal National Throat Nose & Ear Hospital London, adviser to Venture Capital Funds in the UK and Europe; technical consultant to various industries; director of two information technology companies. Member of the Global Advisory Committee on Health Research, World Health Organization,1996-2000 Chaired Expert Committees for the UK Department of Health. Visiting Professor in Australia, Brazil, Canada and the USA. President of the Section of Measurement in Medicine of the Royal Society of Medicine in 1971. Elected Foreign Member of the Società Medica-Chirurgica (Bologna) - the oldest medical society, 1965; Fellow of the City & Guilds of London Institute, 1983; Fellow of the Royal Academy of Engineering, 1990; and Fellow of Imperial College, 1995. Major research specialty: analysis and interpretation of biomedical signals. Recent research interests: new ECG-based techniques for recognising fetal anoxia; physiological correlates of work-load fatigue in aircraft pilots; spatio-temporal signal analysis applied to the spread of communicable disease; application of computational logic to problems in public health.