Cause of occupational disease

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Abstract
The concept of causality is reviewed with special emphasis on occupational diseases. Separate approaches from the philosophical, scientific, and legal points of view are identified. There is controversy over the methodology of logical causality; inductive and deductive methods are described and reference is made to the verification or refutation approach. Application of the methods to epidemiology are reviewed.

It is likely that many diseases have multiple causes and that only a component of occupational causality can be identified in each patient. Methods of assigning such a component are discussed. The difficulties of developing an equitable compensation policy in such circumstances are reviewed. The possible benefits of proportional compensation are noted.

(Keywords: causes; compensation; occupational diseases)

Identifying the cause of disease in a population or in an individual person may be difficult and the criteria for recognition of causality have been considered by several authors. Causality is particularly important in the case of occupational diseases because prevention is usually more important than therapeutic intervention and also because many countries have developed policies for the financial support of victims of occupational diseases that are more generous than those provided for other disabled people. The purpose of this article is to review the concept of causality as it was developed in classical philosophy, developments in epidemiological thought, and the impact of legal analysis. The emphasis is on causality of occupational diseases and related policy issues.

The nature of causality
The philosophers of early civilisations observed the natural world and proposed various explanations for what they saw. Francis Bacon in 1599 considered these to be superstitions that should be distinguished from the methodical approach of the true scientist. The true scientist in his view, collects empirical observations in an unbiased way and, with an open mind, infers the cause of events from the evidence. The terms inductive and deductive inference are exemplified as follows. Very extensive epidemiological surveys on the health of cigarette smokers have been carried out. The observations induce the inference that smoking is a major cause of lung cancer. This argument in inductive logic is from particular examples to a general rule. On the other hand, if it is once accepted as a general law or rule that cigarette smoking is a cause of lung cancer, then a physician may argue from the general to the particular and make the deductive (or hypotheticodeductive) inference that smoking was the most important cause of lung cancer in his particular patient. This example illustrates deductive logic from the general to the particular.

The Scottish philosopher Hume in 1739 questioned the validity of inductive logic from repeated observation to general laws of causality. In a formal logical analysis, he claimed that repeated and consistent observations of two associated events could not be used as evidence that one caused the other. This was the start of a major philosophical dispute. One school (the positivists or verificationists) claim that sufficient and increasing numbers of observations do provide a persuasive body of evidence of causality that works on a practical day to day basis. A certain framework must be used to avoid nonsensical associations. With that reservation, the positivists maintain that the inductive method offers sensible approaches to public health policy.

An opposite approach was favoured by Karl Popper who was directly opposed to all attempts to operate with the idea of inductive logic. In his view, simply collecting further observations that confirmed an association between two events could not contribute in any way to the debate as to whether one caused the other. He suggested that an explanatory theory connecting two events was first developed or invented in the mind of a creative scientist. Certain deductions or predictions could be made from the theory and these could be tested. If the conclusions turned out to be acceptable then the theory held for the time being, but this did not establish the truth of the theory or even its probable truth. If the conclusions were falsified, however, then the theory itself must be false. The application of Popper's ideas to human epidemiology was first proposed by Buck. This was followed by a vigorous debate in which other epidemiologists emphasised the value,
from a practical and policy point of view, of careful and repeated observations on defined populations with reasoned inductive inferences as to causality.

Criteria for causality in epidemiology were proposed by Hammond in 1955,4 Yerushalmy and Palmer in 1959,7 and in the landmark Report of the Surgeon General’s Advisory Committee on Smoking and Health in 1964.8 A framework for drawing inductive conclusions was formulated and was used to identify cigarette smoking as the major cause of lung cancer. The framework was developed more concisely by Bradford Hill whose name is firmly associated with inferences of causality.9 His suggestions for considering causality are widely taught and are as follows:

- the strength of association
- consistency specificity
- the relation in time
- the biological gradient
- biological plausibility
- coherence of the evidence
- the experimental evidence
- reasoning by analogy.

Hill wrote that none of these nine viewpoints could bring indisputable evidence for or against a cause and effect hypothesis and equally none could be required as essential (a sine qua non). What they could do, with greater or less strength, was to answer the fundamental question—is there any other way of explaining the set of facts? Was there any other answer that was more likely than cause and effect?

In a formal sense Hill’s proposals are subject to the same underlying weakness of inductive logic described by Hume so many years ago. Unease about the lack of distinction between association and causation in the case of smoking and lung cancer was expressed by such a formidable statistician as R A Fisher.10 In a series of essays, supporters of Bradford Hill’s inductive method or, conversely, of Popper’s deductive refutation, presented their arguments and counter arguments.11 For the general reader it is of interest to note that opinion is divided. Neither Bradford Hill’s nor Popper’s method receives universal support. The idea of using the Bradford Hill criteria in a Popperian sense was suggested by MacClure12 whereby a causal hypothesis based on inductive logic generates deductive predictions that could then be tested. If the Bradford Hill criteria failed to reject the hypothesis, then it could continue to be used for making day by day practical decisions, although fulfilment of the criteria did not, of itself, constitute formal proof.

The above analysis of causality refers essentially to single causes of disease. This is becoming uncommon in clinical medicine and the next section considers the consequences of multiple causality.

The nature of multiple causality

Occupational epidemiology examines the relation between disease in populations and concomitant toxic exposures. Clinical occupational medicine and the legal framework are more concerned with attribution of causality in the individual worker. It is increasingly clear, however, that many illnesses are the culmination of multiple causes. In a population of workers exposed to dust and to cigarette smoke, certain people will develop chronic obstructive airway disease. In some, the major cause of airway damage may be cigarette smoking and in others, it may be dust exposure. The relative importance of each will depend on the duration and concentration of exposure to dust or to cigarette smoke. It is not appropriate to treat either agent as if it were the single effective cause.

Attribution can be achieved by applying data from group epidemiological studies to the individual case. The increased risk of lung cancer in groups of workers who smoke 40 cigarettes a day is known. If a patient smokes that number, then it is not unreasonable to make the assumption that the same risk is born by that patient. When more than one cause is to be evaluated in the patient it is possible to assign the proportion of harm from each source by the use of epidemiological data including cohort or case control studies.13 This method has been used in deriving tables of proportional risk of malignant disease caused by exposure to radiation.14 The approach has been criticised on statistical grounds and the unmeasurable issue of individual susceptibility. No alternative method, however, seems to be available.

When two or more factors cause a disease the question may be raised as to whether one or other component made a significant contribution. A physician can reasonably hazard an informed guess whether some event such as an infection made any clinically significant difference to the inevitable train of events in a patient with untreated malignant disease. The same value judgement of significance cannot be used to evaluate the clinical importance of a proportional estimate of causality.

If cigarette smoking is estimated to account for 15% of the damage in a patient with obstructive airways disease, then this point estimate cannot be further evaluated in terms of clinical significance.

As physicians have struggled to analyse the cause of disease in their patients a parallel body of scholarship has been developed within the legal framework. To an extent the professions have remained separate and there has been relatively little common exchange. The following paragraphs summarise the idea of causality in law.

The legal framework

An extensive review of the development of legal concepts of causation, starting from the days of early Roman law was prepared by Honoré (1986).15 A distinction is drawn between scientific theories that attempt to give an account of the way in which events happen, and legal theories of causation and remoteness of damage that have the purpose
of defining how the limits of responsibility should be fixed. Some believe that rough common sense should suffice to define legal causation but this is generally thought to be too vague or imprecise. A difference in the professional approach is provided by the example of the physician who is concerned whether coal dust caused lung disease in a miner. A lawyer traces the sequence further back to see whether some wrongful act (failure to guard against dust exposure) can be regarded as the cause. The lawyer provides a further explanation of a different type. Honoré traces the development of the philosophy of causation through Marx and Hegel and Mill.\(^\text{16}\) Although there are many publications on the theory of legal causation Honoré proposes that the ideas around which the decisions revolve are limited to necessity, explanation, probability, and legal policy.

**Necessity**

This has given rise to the equivalence theory or essential condition (*conditio sine qua non*) theory. The crucial question is whether the event was necessary for the production of the harm. Each condition is necessary to the production of harm and is in that sense equivalent (equally necessary). In most cases it is impossible to apportion any particular part of the harm to any given condition. The rule, common in many countries, that independent tortfeasors, each of whom contributed to the harm, is wholly liable (*in solidum*) points to the equivalence theory. The theory was more popular in criminal cases and has fallen out of use in modern times.

**Explanation**

Causes of an event are those conditions that explain its occurrence. This extralegal idea is used in a negative way so that a tortfeasor is not liable for harm that is adequately explained by some other cause. This idea generates several theories. In the efficiency theory, various conditions can be thought of as making a quantifiable contribution to the harm. Those whose contributions come above a certain percentage are causes in the sense, and the quantification can be used as a basis for the apportionment of damage between tortfeasors.

**Probability**

The adequate theory—In its 19th century form, an essential condition (*conditio sine qua non*) is the adequate cause of harm if it is of the type that significantly increases the objective probability of harm, of the type actually suffered. Harm can have two or more adequate causes, and they need not be of equal probability of causing harm.

**Legal policy**

The theories are not strictly causal but refer to codes of law, responsibility, and a sense of equity between parties.

The very brief summary of legal theory shows clearly that the law is concerned with evaluating human conduct and not with inanimate objects. Whether asbestos causes cancer is an issue of scientific fact. Whether the industry that sells asbestos is involved in causing cancer is an issue of legal causality. A key question in decisions rests on the “but for” test. If harm would not have occurred “but for” the defendant’s actions, then those actions were a cause, not necessarily the only cause of the harm.

**The boundary between legal and scientific causation**

The distinction between scientific and legal causation or responsibility has been described, but there are many situations where the two are almost inextricably linked. The most important is the problem of multiple causation and the questions of what constitutes a significant cause. The difficulty of applying legal concepts to scientific analysis is illustrated by the case of the asbestos worker who smokes. Would he have developed lung cancer but for the exposure to asbestos? Obviously the answer can only be given in probabilistic terms. The risk of developing lung cancer may have been much less in the absence of asbestos, but was certainly not negligible if he was a heavy smoker.

Two much quoted judgements have influenced legal thought. In Bonnington Castings v Wardlaw (1956),\(^\text{17}\) a worker developed silicosis as a result of exposure to silica from a pneumatic hammer at which he worked and also silica from swing grinders at the same workplace. No dust extraction equipment was known or practicable for use with the hammer and the employers were not liable, in law, for the consequences, the health effects on the worker being covered by the regulations governing pneumoconiosis in the United Kingdom at that time. Although the swing grinders were fitted with dust extraction equipment this was not kept free from obstruction and, in this respect, the factory owners were in breach of their statutory duty. The evidence suggested that most of the dust came from the hammer but the legal argument then was that the dust from the grinders could have been the cause of the disease. In the House of Lords, judgement was given that the cause of the disease could have been from either source. No attempt was made to take account of contributions from two separate sources. It was held that the plaintiff did not have to show that the dust from the swing grinder was the sole or even the most substantial cause of his disease, if he could show, on balance of probabilities, that dust from that source had materially contributed to the disease. Anything that did not fall within the negligible (*de minimus*) principle would add a material contribution. The plaintiff won the case. It is evident that this is tantamount to treating the pulmonary disease as a single indivisible harm. Scientifically, however, the degree of lung damage in silicosis is closely related to the amount of dust exposure and, when two sources can be identified, then the corresponding degree of harm can be
apportioned. The worker might indeed have
developed a degree of silicosis from exposure
only to dust from the swing grinder but the
amount of disability is likely to have been
much less. A further issue is that terms such
as material or significant contributions have
no defined medical meaning. Courts seem to
be willing to infer that a given cause makes a
material contribution. This may respond to
questions of legal policy but there seems to be
no valid scientific support for the proposition.

A somewhat different situation occurred in
McGhee v the National Coal Board. A
worker developed dermatitis due to dust from
two sources. One was an unavoidable compo-
nent of his employment in a brick works and
was encompassed by appropriate legislation.
The other was due to dust remaining on his
clothing as he cycled home, and was held to
be the responsibility of the employer who
should have provided adequate shower facil-
ties. The physicians who gave expert testi-
mony did not seem to be able to quantify the
harm from the two sources of dust and the
damage could not be apportioned. In the
absence of any such evaluation it was evident
that the whole cause of the dermatitis could,
in principal, have been due to dust on the
workers clothing and the plaintiff won. This
case is better known because of the nature of
the legal tests of proof that were involved, but
this will not be discussed here.

Causation and public policy
The early literature contains many reports
that concluded that there was insufficient
proof that asbestos exposure caused cancer or
even that smoking caused cancer. Suggestive
evidence, but that more research is needed,
seemed to be the view of many writers.
Perhaps lack of evidence was not the real
issue. The ill effects of smoking are no longer
seriously disputed, but the overall world sales
of tobacco are rising. The certainty of causality
required in making public policy depends on
the potential for harm and the number of
people affected. Risks and benefits must be
weighed. Rothman and Poole point out that
practical policy making is really a political
process and, in their view scientists should not
allow themselves to be drawn into this during
working hours. Their estimates and interpre-
tations of causality should be as unbiased as is
possible. If a given agent is thought to be a
possible cause of human disease on weak evi-
dence, it may be reasonable to prevent it
being used in the first place. Removing an
agent, which has been present for many years,
might require much more evidence of causality
before huge costs are incurred.

Causation and toxic tort litigation
The cause of occupational or environmental
disease becomes an issue to be decided, not
by scientists, but by a non-medical jury in the
many cases that have come to be called toxic
tort litigation in the United States. In a
review, Foster et al note that the court must
assess the evidence and also the credibility of
expert witnesses who present the evidence.

The doubtful reliability of some of the expert
witnesses has created what one author has
called junk science. As far as the evidence
itself is concerned the plaintiff in these cases
must prove that the exposure, more likely
than not, caused the injury. Admissible evi-
dence, based originally on the Frye (1923) rule
on admissibility of evidence, does not allow
the judge and jury to make up their own
minds. One solution is the Judge's jury rule, of
which, among other criteria, evaluates evi-
dence of causation after taking account of the
testability of the theory, peer review, and
sources of potential error.

Significant references exist in the legal liter-
ature on the use of epidemiological evidence
for attribution of causality. Some think that
complex issues of risk assessment should not
be left to trial lawyers, judges, and juries.

Discussion
The central theme of this review is that identi-
fication of the cause of disease related to
occupation is difficult. Unambiguous proof is
rarely obtained and is not demanded by physi-
cians familiar with statistical and epidemi-
ological concepts. The nature of causality is
complex and the scientific and legal
approaches can be quite different. Many dis-
ases, both occupationally related and other-
wise, have multiple contributing causes. The
Pearson Commission thought that multiple
causality would be an increasing problem in
the future. Causality has a very special place
in occupationally related diseases because of
the issues of prevention and compensation. As
far as prevention is concerned it does not mat-
ter whether lung cancer in asbestos workers is
due both to smoking and to asbestos.
Reduction or removal of both is important.
Compensation is more difficult, however,
because of the practice of awarding full com-
penation even though only a part of the cause
in an individual person is due to occupational
factors. The percentage point at which an
occupational component is considered suffi-
cient to result in full compensation varies
remarkably with a range from 50% in some
jurisdictions to 5% in others. This has sub-
stantial economic effects on the individual
people and communities concerned. Whatev-
er the cut off point it leaves certain workers
without financial consideration even though a
portion of their illness or disability was occu-
pational in origin. Other workers may be over-
compensated in the sense that only a portion
of their illness or disability was due to occupa-
tion. The origin of the difficulty is the imposi-
tion of a binary decision process (full
compensation or no compensation) on a con-
tinuous distribution of causality. One solution
might be to compensate on a sliding scale in
proportion to the amount of occupational
causality. If disease in a worker, whether
obstructive airways disease, lung cancer, or
any other condition can be estimated to have
an occupational component of causality of
(say) 30% then that is the proportion of the
disability that is compensated. Whatever the
administrative difficulties of such an approach
it has the merit of consistency and logic.
A more radical criticism of occupational compensation is that financial support to a disabled patient depends on causation rather than on need.29 This generates a privileged class of disabled within the community30 that is the more illogical when occupational causality is only part of the origin of disability in an individual subject.

8 Surgeon General's Advisory Committee on Smoking and Health. Rockville, Maryland: Public Health Service; DHEW, 1964. (PHS No 1103.)

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*Occup Environ Med* 1995 52: 289-293
doi: 10.1136/oem.52.5.289

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