FINAL
REPORT OF THE CHAIR
OF THE
OCCUPATIONAL DISEASE ADVISORY PANEL

Brock Smith
February 2005

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I. INTRODUCTION

The Occupational Disease Advisory Panel (ODAP) was created by the WSIB in 2001 as part of the Occupational Disease Response Strategy. The panel was established to provide advice to the Workplace Safety and Insurance Board (WSIB) on the use of scientific evidence and legal principles in the compensation of occupational diseases. The terms of reference are in Section II of this report.

Up until the early part of 2003, ODAP met about a dozen times and considered a number of drafts of a possible report. However, it became apparent that further meetings of ODAP would not likely resolve the points of disagreement and that it was not possible to produce a consensus report. In light of this situation, the Chair of the WSIB asked me to work with WSIB staff and prepare a report dealing with all of the issues raised during ODAP's discussions and make recommendations.

That report was entitled "Draft Report of the Chair of the Occupational Disease Advisory Panel". It was the subject of a public consultation conducted by me during 2004. A review of the issues raised by stakeholders, during the consultation, and my response to them is contained in a companion document entitled "Chair's Response to the ODAP Public Consultation".

This is the "Final Report of the Chair of the Occupational Disease Advisory Panel". It incorporates a number of changes to the Draft document, which I have made in response to submissions, made during the public consultation. For ready reference, these are listed separately in the Chair's Response Document.

Despite the lack of consensus amongst panel members on some points, this final report represents the culmination of a great deal of effort by members of the ODAP and WSIB staff, some of whom were also members of the Panel. I wish to thank all of them and others who have assisted, for their many contributions.

I am recommending that the WSIB Board of Directors adopt this report as a whole and use it as a basis for the development of a statement of legal principles and levels of evidence guidelines for occupational disease adjudication and policy making. I also recommend that the Board adopt a process for future policy development and I have proposed one model that could be followed.

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II. TERMS OF REFERENCE

USE OF SCIENTIFIC EVIDENCE AND LEGAL PRINCIPLES IN COMPENSATION FOR OCCUPATIONAL DISEASES

OVERVIEW

As part of the Occupational Disease Response Strategy (ODRS), the Workplace Safety Insurance Board (WSIB) is embarking on a consultation process in order to assist it in developing guidelines for the use of scientific evidence and legal principles in:

- the scheduling of occupational diseases
- the development of operational policies for compensation of occupational diseases, and
- the adjudication of occupational disease claims.

OBJECTIVES

The WSIB has defined consultation for its purposes as:

The process through which the WSIB seeks information and advice from a cross-section of stakeholders[1] in order to make decisions on programs, services and policies.

[1] Groups of and/or individual workers, injured workers, employers and health care providers who may be affected by WSIB decisions.

The objectives of this consultation process are:

- To recommend guidelines for the use of scientific evidence and legal principles in amending Schedules 3 and 4 of the *Workplace Safety and Insurance Act*, developing operational policies and adjudicating claims;

- To develop a common understanding and application of scientific evidence and legal principles in occupational disease policy development and claims adjudication;

- To undertake a transparent process which gives the primary stakeholders a voice in the development of the guidelines; and

- To ensure that the guidelines are consistent with the highest scientific and legal standards.

CONSULTATION PROCESS

Process overview

The WSIB will establish an Occupational Disease Advisory Panel (ODAP) consisting of external stakeholders, medical and scientific experts, WSIB staff, and a chair.

The process will proceed in three parts:

1. The WSIB will draft a discussion document covering the main issues in the use of scientific evidence and legal principles in occupational disease adjudication.

2. The WSIB will arrange an educational component for the ODAP which will review the major scientific, statistical, legal and practical concepts underlying occupational disease claims adjudication. The WSIB will also distribute related reference material.

3. The ODAP will develop recommendations for the use of scientific evidence and legal principles in the development of policy that will guide the adjudication of occupational disease claims.

Composition/Representation of the Occupational Disease Advisory Panel

There will be representatives from each of the following stakeholder groups:[2]

1. Labour / Injured Workers (5)
2. Employers (5)
3. Medical and Scientific Community (3)
4. WSIB (2)

[2] The actual composition of the Panel was slightly different from this. See Appendix A.

Other experts from the scientific, legal and medical community will be made available to serve as advisors to the group.

Labour, injured worker and employer representatives will be nominated by their respective constituents. The WSIB will select its own representatives and will consult with the worker and employer members of the ODAP on the selection of the medical, scientific and legal experts.

III. LEGAL PRINCIPLES

The following section on legal principles begins with an overview of the statutory base and the historical context for occupational disease legislation. It also outlines key legal principles that apply to policy development and adjudication processes when evaluating entitlement. It is recommended that they be formally acknowledged and set down in writing by the WSIB as part of a statement of legal principles and levels of evidence guidelines, which will provide a guide for decision-makers, policy-makers and stakeholders.

A. Statutory Provisions

Under the *Workplace Safety and Insurance Act, 1997* (WSIA), like its predecessor the *Workers' Compensation Act* (WCA), (collectively, "the Act"), there are two routes to entitlement to benefits.

The general entitlement clause in s.13 (1) provides:

> A worker who sustains a personal injury by accident arising out of and in the course of course of his or her employment is entitled to benefits under the insurance plan.

"Accident" is defined in s.2(1) as:

> "accident" includes,
> (a) a wilful and intentional act, not being the act of the worker,
> (b) a chance event occasioned by a physical or natural cause, and
> (c) disablement arising out of and in the course of employment.

The specific entitlement provision for occupational disease is found in s.15, which provides, in relevant part:

> (1) This section applies if a worker suffers from and is impaired by an occupational disease that occurs due to the nature of one or more employments in which the worker was engaged.

(2) The worker is entitled to benefits under the insurance plan as if the disease were a personal injury by accident and as if the impairment were the happening of the accident.

"Occupational disease" is described in s.2(1) as including:

(a) a disease resulting from exposure to a substance relating to a particular process, trade or occupation in an industry,
(b) a disease peculiar to or characteristic of a particular industrial process, trade, or occupation,
(c) a medical condition that in the opinion of the Board requires a worker to be removed either temporarily or permanently from exposure to a substance because the condition may be a precursor to an occupational disease, or
(d) a disease mentioned in Schedule 3 or 4.

B. Historical Background and Definitions

The general and specific routes to benefit entitlement have been in the legislation since its inception in 1915. They follow the recommendations of Sir William Meredith, the father of workers' compensation in Ontario, that were provided in his *Final Report on Laws Relating to the Liability of Employers* (1913):

> By my draft bill ... industrial diseases are put on the same footing as to the right of compensation as accidents ... It would, in my opinion, be a blot on the Act if a workman who suffers from an industrial disease contracted in the course of his employment is not to be entitled to compensation. The risk of contracting disease is inherent in the occupation he follows and he is practically powerless to guard against it. A workman may to some extent guard against accidents, and it would seem not only illogical but unreasonable to compensate in the one case and to deny him the right to compensation in the other.

In 1915, the only route to entitlement to benefits for industrial diseases was Schedule 3 which then listed: anthrax, lead poisoning or its sequelae, mercury poisoning or its sequelae, phosphorous poisoning or its sequelae, arsenic poisoning or its sequelae and ankylostomiasis. These were the same diseases that were contained in the equivalent schedule in British legislation.

The definition of "industrial disease", now "occupational disease", has since expanded. In the late 1940's, the definition was amended to provide that the term "industrial disease" meant a disease in Schedule 3 or a disease "peculiar to or characteristic of a particular industrial process, trade or occupation".

The current definition was adopted in 1985. At that time, two more branches were added to the definition, both dealing with exposure to substances. As well, the definition changed from "industrial disease means ..." to "industrial disease includes ..." The term "industrial disease" was replaced by "occupational disease" in the Act effective January 1, 1995. With these changes, an "occupational disease" is no longer restricted to the four

enumerated branches but may include any condition that fits within the meaning of the words “occupational disease”.

The WSIB has never adopted policies that interpret what is meant by the terms “occupational/industrial disease” or any of the four enumerated branches of the definition. Rather the WSIB has traditionally focused on individual diseases for policy development.

The WSIB’s approach may, in part, be due to the difficulties associated with defining the difference between “occupational diseases” and “personal injuries by accident”. In Meredith’s time, the distinction between personal injuries and industrial diseases was clear. The same cannot be said today. This blurring of the distinction between injury by accident and occupational disease has been reflected in the legislation itself.

Prior to 1963, it was not clear whether injuries that developed gradually over time with no sudden onset fell within the definition of “accident”, although benefits were often paid in such cases. Therefore, for greater certainty, such injuries were sometimes included in Schedule 3 as “industrial diseases”. In 1963, the definition of “accident” was amended to include “disablement arising out of and in the course of employment”. This amendment formalised previous recognition by the WSIB and the courts that an “accident” includes injuries that develop gradually over time and also can include some diseases.

Bursitis is one example of a medical condition that could fall within either definition. Bursitis was added to Schedule 3 in 1932 and is consequently an “occupational disease” within the meaning of s.2(1) of the WSIA. It is also, however, a condition that develops gradually over time and could be considered a “disablement”.

From an adjudicative standpoint therefore, it is the nature of the condition, rather than how it is characterised (injury versus illness) under the Act that has the greater significance.

As a practical matter, the legal consequences flowing from the distinction between injury by accident and occupational disease under the Act are virtually non-existent. The only real legal significance now relates to Schedules 3 and 4 as these may only include “occupational diseases”.

C. Establishing Work-Relatedness

Four facets in assessing work-relatedness for occupational disease claims are reviewed below. The **causation test** supplies criteria for deciding whether a condition is work-related. The **burden of proof** clarifies who is responsible for proving that a worker’s condition is or is not linked to the workplace. The **standard of proof** speaks to the degree of certainty required (about the evidence) to be satisfied that a worker’s

condition is linked to the workplace. Finally, the **benefit of doubt** sets out the rule for reaching a decision when the evidence for and against is equal.

1. Causation Test

The "work-relatedness" requirements of the two routes to entitlement in the *Act* are worded quite differently. Under s.13(1) – dealing with injuries – a "worker who sustains a personal injury by accident arising out of and in the course of employment is entitled to benefits ...". This is the language employed in the original British legislation that Meredith adopted unchanged.

Section 15(1) – dealing with diseases – provides for benefit entitlement "if a worker suffers from and is impaired by an occupational disease that occurs due to the nature of one or more employments in which the worker was engaged". This again goes back to the original 1915 Act and was directly adopted from British legislation. It predates the addition of "disablements" to the general definition of accident. Pursuant to s.15(2) such cases are treated "as if the disease were a personal injury by accident and as if the impairment were the happening of the accident".

"Impairment" is defined in s.2(1) of the WSIA as "a physical abnormality or loss ... which results from an injury." The "impairment" need not be a permanent impairment that would give rise to a NEL (non-economic loss) benefit. It may be a temporary impairment, for instance a skin reaction that suddenly disappears as in the case of allergic contact dermatitis.

When determining entitlement under s.15(1), the essential and most problematic question is whether the "occupational disease" is work-related, that is, whether it is "due to the nature" of the worker's employment.

While the WSIB has no clearly articulated general policies on "arising out of employment" or "due to the nature of the worker's employment", it does have a policy establishing when an accident occurs in the course of employment, which is the other requirement for granting entitlement under s.13(1).

In determining work-relatedness, the Workplace Safety and Insurance Appeals Tribunal (the Appeals Tribunal) has adopted a test of "significant contribution" for both personal injuries by accident and occupational diseases. The WSIB has adopted a similar test *de facto*, although no formal policy has ever been adopted. It is recommended that the current test now be made explicit in the statement of legal principles.

The "significant contribution" test was developed by the WCAT/WSIAT (the Appeals Tribunal) with reference to the common law, based on the reasoning that the conversion from a common law to a no-fault statutory system was not intended to reduce the

breadth of protection for workers. The leading common law case is the decision by the Supreme Court of Canada in *Athey v. Leonati*[3]. The Court indicated:

- The general, but not conclusive, test for establishing causation is the "but for" test, which requires the plaintiff to show that the plaintiff's injury would not have occurred but for the negligence of the defendant.

- The "but for" test may not always be workable, in which case causation may be established where the defendant's negligence "materially contributed" to the occurrence of the injury.

- A contributing factor is "material" if it falls outside the *de minimis* range.

- It follows that the plaintiff does not need to prove that the defendant was the sole or even the primary or predominant cause of the injury. If the defendant was part of the cause of the injury, he or she is liable, even though his or her act, alone, was not enough to cause the injury. Liability is not reduced because of the existence of preconditions. Defendants are liable for all injuries caused or contributed to by their negligence.

In general, the "but for" test works well when there is only one causal agent. A simple example might be where a worker would not have broken her arm "but for" the fall from the ladder. In multi-causal situations, for instance lung cancer caused by asbestos and smoking, the "but for" test may not always work as well. In such cases, the "material contribution" test may be more helpful. The question to ask is whether the workplace exposure "materially contributed" to the development of the worker's lung cancer.

As stated above, the Appeals Tribunal has employed the "significant contribution" test, which though based on the test employed by the courts, has sometimes meant different things to different people. Some have argued in the past that the word "significant" is different from "material" and that it requires either more evidence or stronger evidence than the common-law test that is applied in negligence cases. However, the Appeals Tribunal itself has always identified the "significant contributing factor" test with the tests applied in the courts.

It is now generally, although by no means universally, accepted that the WSIB should follow similar rules for establishing causation to those used by the common law courts. And the advice I have received from WSIB legal staff, which I regard as authoritative, suggests that the process leading up to the general use of this principle is unlikely to be reversed. Accordingly, the statement of legal principles should expressly adopt the same test that the courts apply and at the same time acknowledge the link between the Appeals Tribunal's "significant contribution" test and the "material contribution" test in Athey.

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[3] (1996), 140 D.L.R. (4th) 235.

Explicitly stating the equivalence of the "significant" and "material" contribution tests will ground the workers' compensation causation requirement in a body of well-established jurisprudence as applied by the Appeals Tribunal. Moreover, the adoption of such a statement will help to put an end to speculation as to whether "significant" is more than "material".

2. Burden of Proof

Section 119 of the WSIA requires that the decision-maker consider the particular circumstances of each case. It states: "The Board shall make its decision based upon the merits and justice of a case and it is not bound by legal precedent." It should be noted that this is not an invitation to simply ignore general legal principles recognised by the courts or the specific provisions of the *Act*. It is, rather, an injunction to approach each case on its own terms, without allowing imported criteria to interfere with a just result.

A WSIB decision-maker hears, assesses and evaluates all the available evidence and makes decisions based on that evidence. The decision-maker may seek and receive opinions from medical and scientific experts, including WSIB internal experts and expert opinions provided through both the worker and employer. The opinions that experts provide significantly add to the body of evidence that the decision-maker must consider, but are not determinative of the issue. It is the decision-maker who must make the final decision based on all available evidence.

Unlike a judge in a negligence case, however, a WSIB decision-maker cannot decide that the claimant has not presented enough evidence to prove his or her case or that the available evidence is insufficient to reach a decision. In the workers' compensation system, there is no burden of proof on either the worker or the employer. The decision-maker must assess the evidence and determine which way the evidence points.

The statement of legal principles to be adopted by the WSIB should emphasise that the Ontario workers' compensation scheme is investigative or inquisitorial, rather than adversarial. There is no burden on either the worker or the employer to prove a case. It is the responsibility of the decision-maker to conduct the investigation and obtain the necessary evidence. The decision-maker cannot refuse to make a decision on the ground that there is not enough evidence. He or she must use whatever evidence is available or can be obtained and make a decision based on it.

3. Standard of Proof

The standard of proof describes the relative weight of the evidence required in order to establish one side or another in a case. The accepted standard of proof in the workers' compensation system is the "balance of probabilities" which is the same standard applied by the courts in civil law negligence cases. This is to be distinguished from the standard that is used in criminal law of "beyond a reasonable doubt".

In this regard, the following statement by Mr. Justice Gonthier in *Laferriere* v. *Lawson* (1991)[4] to be particularly relevant in the workers' compensation context:

> Cases in which the evidence is scarce or seemingly inconclusive present the greatest difficulty. It is perhaps worthwhile to repeat that a judge will be influenced by expert scientific opinions which are expressed in terms of statistical probabilities or test samplings, but he or she is not bound by such evidence. Scientific findings are not identical to legal findings … Recently, in *Snell v. Farrell*, [1990] 2 S.C.R. 311, this Court made clear (at p. 328) that "[c]ausation need not be determined by scientific precision" and that "[i]t is not ... essential that the medical experts provide a firm opinion supporting the plaintiff's theory of causation" (p. 301). Both this Court and the Quebec Court of Appeal have frequently stated that proof as to the causal link must be established on the balance of probabilities taking into account all the evidence which is before it, factual, statistical and that which the judge is entitled to presume ...

The statement of legal principles should indicate that in the application of the balance of probabilities to the proposed test for causation, the question for decision-makers is: "Is it more likely than not that this worker's employment was a significant contributing factor in the development of the occupational disease?".

4. Benefit of Doubt

Section 119(2) creates a statutory benefit of the doubt provision; it states:

> If, in connection with a claim for benefits under the insurance plan, it is not practicable to decide an issue because the evidence for or against it is approximately equal in weight, the issue should be resolved in favour of the person claiming benefits.

In addition to drawing attention to this provision, the statement of legal principles should include two points concerning the benefit of doubt provision.

First, this provision is related to decisions on "issues", not the final decision itself. Therefore, each time there is an issue for the decision-maker to decide, s.119(2) may apply. The statement of legal principles should include a brief discussion and/or a definition of the term "issue".

Second, this provision only applies where the evidence either way is approximately equal. This requires the decision-maker to evaluate the evidence carefully to make this determination. It does not preclude the need to make a decision and it is not open to the decision-maker to resort to s.119(2) because it is too hard to make a decision. For clarity, the statement of legal principles should recognize that the interpretation also applies to a similar clause in the *Workers' Compensation Act*.

[4] (1991), 78 D.L.R.(4th) 609 at pp. 656-657

IV. ROLE OF EVIDENCE

A. Legal Principles as Guide

Evidence regarding occupational disease claims may come in different forms including, for example, factual employment history, medical diagnosis of the disease, disease aetiology, exposure estimates, exposure-response information through studies on workplace populations, third party observations, and anecdotal reports. It is important that all relevant evidence be gathered prior to scheduling entries or developing policies, and prior to claim adjudication. Equally important, not all evidence is necessarily accorded equal weight. The decision-maker or policy analyst must evaluate each piece of evidence to establish where it fits in the continuum of relevance and validity.

The evidence considered and how it is weighed depends on circumstance. In drafting disease policies or entries to Schedule 3 or 4, the primary evidence that is considered is scientific findings. A review of the relevant scientific literature aims to discern general information about the connection between a specific disease and an exposure or a set of exposures. Occupational disease policies and Schedules 3 and 4 of the WSIA are intended to expedite the determination of work-relatedness.

In contrast, the adjudication of individual claims should require consideration of a number of other types of evidence where available, including employment history, hygiene exposure assessments, third party observations and anecdotal reports, as well as scientific evidence.

When adjudicating a claim, the decision-maker should apply the gathered and weighed evidence to answer the question: Is it more likely than not that the workplace and/or the nature of work performed by the worker was a significant contributing factor in the development of the worker's condition?

Most often, medical or scientific evidence is used to establish work-relatedness. At times however, this evidence may be weak or conflicting. There are, as well, other types of evidence that may be available. Sometimes there will be circumstantial evidence, such as

a cluster of cases. There may also be direct evidence from the worker, employer and / or other persons in the workplace.

It should also be pointed out that establishing causation for a disease does not have to be done with scientific certainty. Rather, the causal link between workplace and disease must be established using the legal standard, which is, based on the balance of probabilities, taking into account all the evidence. For example, treating doctors do not necessarily have to agree on a firm diagnosis and circumstantial evidence may be enough to establish causation in certain cases. Similarly, the inability to identify a specific causal agent in the workplace is not sufficient in itself to deny a claim.

That said, it must also be noted that mere speculation is not enough to establish entitlement under the WSIA.

The statement of legal principles should make it clear that the WSIA requires that a disease be work-related before benefits may be paid and the WSIB, in its role as investigator, must have some evidence of a connection between the disease and the employment. It would not be unreasonable to say that evidence must demonstrate some credible or plausible connection between the employment and the disease.

B. Scientific Evidence

1. Introduction

The terms of reference request that ODAP (1) recommend guidelines for the use of scientific evidence; (2) develop a common understanding of the application of scientific evidence to be used in scheduling, occupational disease policy development and claims adjudication; and (3) provide guidelines that are consistent with the highest scientific and legal principles.

Here, it is important to note that the WSIB is required, under s. 161(3)(a) of the Act to stay abreast of scientific developments as follows:

> (3) The Board shall monitor developments in the understanding of the relationship between work and the prevention of injury and occupational disease and the relationship between workplace insurance and injury and occupational disease,
>
> (a) so that generally-accepted advances in health sciences and related disciplines are reflected in benefits, services, programs and policies in a way that is consistent with the purposes of this Act;

The guidelines should draw attention to the fact that WSIB staff must continuously evaluate and re-evaluate scientific studies being reported and must merge older and new information into a consistent set of evidence for use in scheduling, developing policy and adjudicating individual claims.

Any review of the scientific evidence must begin with a consideration of the question one is attempting to answer using the evidence – whether the question arises in the course of adjudicating an individual claim, developing a policy or considering an addition to one of the schedules.

There are several types of scientific evidence; these include information derived from epidemiological, toxicological, case or animal studies or scientific experiments. Of these, epidemiological evidence, where it exists, is often considered to be the most persuasive in developing recommendations for policies or scheduling or adjudicating occupational disease claims.

I present below a brief review of the types of scientific evidence that can inform decision-making regarding occupational diseases, and the weight that they should be given.

2. Epidemiology

The guidelines should state that evidence arising from randomised controlled trials, which are very rare in this field, and evidence provided through well-conducted epidemiological studies offer the most persuasive evidence of the relationship between exposures and disease.

Epidemiology is the study of the distribution and determinants of diseases and injuries in human populations[5]. Occupational epidemiology then is the study of the distribution and determinants of diseases in occupational populations.

Occupational epidemiology is a non-experimental science and, as such, the ability of the scientist to alter variables in a systematic way is very limited or non-existent. As a result, judgements of causality in occupational epidemiology as in other sciences are not made with absolute certainty, but instead rest with probabilities. Judging the confidence one can place on the results of a particular epidemiological study must be based on careful examination of factors for both internal and external validity.

Internal validity is strengthened by: (1) subject selection where there is a high probability of independence between selection criteria and the issue being studied; (2) the accuracy of the information gathered for the study and the reference populations; and, (3) the similarity of the reference group to the study group except for the exposure of interest.

External validity is based on the ability of the study results to be generalised beyond the particular study population. Such inferences require generalisations based on scientific judgement, such as other findings and their connection with the study's findings, theoretical knowledge of the disease process and related factors, and biological considerations.

[5] Mausner, J.S. & Bahn A.K. Epidemiology: An Introductory Text. 1974

In this report, reference is made to the paper by Sir Austin Bradford Hill[6], which sets out attributes for inferring causality in epidemiological studies. As well, the World Health Organization has recently published a guideline entitled *Evaluation and use of epidemiological evidence for environmental health risk assessment* [7], which provides an overview of concepts useful in assessing the relative strengths of research studies, the range of their applicability and their usefulness in drawing causal inferences.

Appendices C, D, and E provide an overview of concepts useful in assessing the relative strength of research studies, the range of their applicability and their usefulness in drawing causal inferences as follows: Appendix C: Conducting Systematic Reviews of Occupational Epidemiology; Appendix D: Drawing Conclusions from Epidemiological Evidence; Appendix E: Types of Research Design.

It should be noted that even when studies are conducted under the rigorous criteria outlined in Appendices D and E, the very nature of research itself means that there will be gaps, methodological problems and other limitations. For example:

- *Diagnoses* can be misclassified or grouped along lines set out by classification schemes that are ill suited to the purposes of the research. For example, the most commonly used classification system (ICD-9) aggregates cancers into broad groups. Death certificates and medical records may contain errors; mortality studies may not adequately reflect the pattern of treatable diseases.

- *Experimental evidence*, such as duration and levels of exposure, latency and other relevant experience, is aggregated – thus combining the experiences of the least and most exposed as well as the least and most susceptible individuals.

- *Misclassification* for exposure categorisation can also cause difficulties in the interpretation of results.

- *Summary values*, while providing best estimates for a group, express nothing about the experience of a particular individual.

Evidence may be classified based on the strength of the outcomes in the context of the evidence.

- Positive Scientific Evidence: Where scientific studies consistently provide clear evidence of a relationship between exposure and outcome, exposures during the individual's working life, unusual exposures, and the time since the first exposure or latency period.

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[6] Bradford Hill A. *The Environment and Disease: Association or Causation*? Proceedings of the Royal Society of Medicine, 58: 295-300, 1965.

[7] E*valuation and use of epidemiological evidence for environmental health risk assessment: Guideline document*. World Health Organization- Regional Office for Europe, Copenhagen, Denmark; 2000.

- Negative Scientific Evidence: Where scientific studies clearly and consistently show there is no relationship between exposure and outcome.

- Weak Scientific Evidence: Where scientific studies do not provide clear evidence of a relationship between exposure and outcome either due to limitations associated with study design or lack of statistical power.

- Contradictory Scientific Evidence: Where some scientific studies show there is a relationship between exposure and outcome, while others show the reverse.

- No Scientific Evidence: Where there exists no study concerning the relationship between exposure and outcome. Absence of such a study does not mean that there is no relationship between the work exposure and disease outcome.

Epidemiology and published clinical reports may not provide sufficient support for the scheduling of a disease or the development of policy. However, they can still point out exposure risks that, when placed in the context of a claim, may shed light on the work-relatedness of that claim. Also, studies can provide insight into the circumstances, which create additional risk for individuals and make them vulnerable to the development of a certain condition.

3. Toxicology

Toxicology frequently provides useful scientific evidence for assessing the possible harmful effect of particular agents. It is the study of the way poisons (toxins) interact with biological organisms.

Some toxicological studies use live animals as test subjects (in-vivo tests) or cultures of specific cell lines (in-vitro tests) that are deliberately exposed to the agent under investigation. This allows knowledge to be gained about the pathogenic mechanisms and dose gradient for the agent.

However, due to the high doses normally used in living animals or cell culture tests, as well as differences in the sizes of organisms, agent absorption rates, metabolism and other factors, it is at times difficult to directly translate the results to humans. Evidence from a variety of animal species having similar responses, when the test agent is administered through a relevant route of exposure, have the highest validity for extrapolation to human exposures.

C. Other Relevant Evidence in the Adjudication of Claims

1. Employment and Exposure History

Where warranted, each worker's personal employment history should be assessed from the earliest, through to the most recent, employment. Each workplace experience should be explored to characterise the working conditions to which that worker was exposed.

The information needed about each workplace over time includes:
a) Activity of employer(s)
b) All different jobs with each employer and areas where work was performed
c) Any known chemical exposures, (Material Safety Data Sheets, if available)
d) Characteristics of exposure(s) over time in each job with each employer i.e., variability and intensity of exposure (daily, intermittently, peak periods, seasonally, low, medium, high levels …), shift work differences, overtime
e) Changes in production, work practices or ventilation which may have affected exposure levels over time
f) Any occupational hygiene or MOL investigation records
g) Ventilation of areas worked and personal protective equipment provided and/or used
h) Unusual (out of the ordinary) exposures

Where the information is not directly available from the worker or the employer, the information can be gathered through interviews with co-workers, managers or other knowledgeable individuals (eyewitnesses). In addition, other claim files from the same employer(s) can provide insight about exposures reported by the employer or other claimants. All this can form the basis of a retrospective exposure assessment. The WSIB develops employer profiles, and these can also be a useful source of information.

Where little or no exposure information is available for a particular workplace, additional information can be drawn from a number of sources. For example, additional information from the technical process literature can help in identifying and estimating exposure levels at the worksite. A comprehensive review of claim exposure evidence and additional supporting material can help to fill gaps in documented exposure evidence and provide comprehensive exposure assessment.

2. Individual Medical History

The medical history can hold much that is relevant to the disposition of a claim. Noting that medical records need only be held for 7 years, the history should be assembled as early as possible after a claim is filed. Relevant information that may be found in these records include diagnosis and related diagnoses (if appropriate), and diagnostic tests which would help to ascertain the diagnosis, treatment and prognosis. The medical records often also include family history of disease and any predisposing and lifestyle factors relevant to the condition(s) of interest.

V. GENERAL AND SPECIFIC CAUSATION

A. Overview

In the previous section, we examined types of scientific (and other) evidence. We now move to how such evidence is used to determine causation in individual claims. Scientific methods are intended to draw inferences about specific populations or groups, not specific individuals. Scientists do, however, acknowledge that within groups under investigation there is a wide range of individual differences. This highlights the fundamental difference in thinking required for developing occupational disease policy or schedule entries and adjudicating individual disease claims. Since Schedules 3 and 4 and occupational disease policies are intended to expedite adjudication, they are derived from scientific evidence that draws conclusions about the work-relatedness of an exposure in a specific population or group of workers. When not governed by an existing schedule or policy, claims adjudicators must go beyond the standard interpretation of scientific studies and base their decisions on not only science, but other evidence as well.

B. General Causal Inference

Drawing a causal inference is a question of judgement based on a number of medical, scientific and social dimensions. No specific rules have been established to make casual determinations. There are, however, guidelines that can provide a useful framework.

In 1964 the U.S. Surgeon proposed criteria for determining the causal relationship between cigarette smoking and lung cancer[8]. Sir Bradford Hill later expanded upon these criteria in 1965[9].

While Sir Bradford Hill was careful to point out that his considerations were only intended to assist the inferential process, they do provide a useful framework for drawing causal inferences from a body of work.

[8] U.S. Department of Health, Education and Welfare, *Smoking and Health: Report of the Advisory Committee to the Surgeon General*, 1964.
[9] Ibid 5.

These considerations should be incorporated into the guidelines along with a brief elaboration on each of them. It should also be noted that they continue to be reinterpreted and revised by scientists. The nine considerations are:

i. Strength of Association: This refers to the degree of increase in risk associated with an exposure. These are measured with statistics such as relative risk or attributable risk. The stronger the association, the less likely it is that the association is due to error. However, a weak association does not rule out a causal connection.

ii. Consistency: If all studies examining a given relationship produce similar results, a causal interpretation is enhanced. Sir Bradford Hill's discussion of this consideration also specified that the repeated observation of an association should be seen in different populations under different circumstances.

Lack of consistency does not rule out a causal association because some effects are produced by their causes only under unusual circumstances. Also, studies can be expected to differ in their results because they differ in their methodologies.

iii. Specificity: If the exposure is found to be associated with only one disease, or alternatively if the disease is found to be associated with only one exposure, a causal interpretation is suggested. This criterion only operates in one direction, however. When present, it strengthens the causal inference. Lack of specificity cannot be used to deny a causal relationship since many exposures have multiple effects and most diseases have multiple causes.

iv. Temporality: This refers to the necessity that the exposure precede the onset of the disease. Unlike the other eight Bradford Hill considerations, this standard is a necessary condition for determining causality.

v. Dose-response (biological gradient): The observation that frequency of disease increases with the dose or the level of exposure usually lends support to a causal interpretation. In other words, the greater the exposure, the greater the risk of developing the disease. However, in the absence of a dose-response effect, alternative explanations cannot be ruled out, such as a threshold effect, or a saturation effect. As well, an observed dose-response effect may be due entirely to a graduated distortion or bias.

vi. Biological Plausibility: If the suspected connection between the exposure and the disease is consistent with what is known about biological and chemical patterns, a causal interpretation is more likely to be warranted. However, biological plausibility is not required to establish causation since the current state of knowledge may be inadequate to explain scientific observations.

vii. Coherence: This implies that a cause and effect interpretation for an association should not conflict with what is known of the natural history and biology of the

disease. Sir Bradford Hill suggests that the absence of coherent information should not be taken as evidence against an association being considered causal.

viii. Experimental Evidence: Experimental evidence is highly relevant where it exists. While seldom available for human populations, occasionally "quasi-experimental" evidence may result from observations of the effects of the removal from exposure.

ix. Analogy: Support for a causal association may be strengthened by analogy with a similar exposure that causes the same or a related disease or analogy with animal and toxicological studies. (This criterion is frequently omitted from discussions of the Bradford Hill considerations since many analogies may be spurious.)

It must be emphasised that the Bradford Hill considerations are only guidelines. One or more of the factors outlined may be absent even when a causal relationship exists.

C. Specific Causation: Moving from Aggregate Data to an Individual's Claim

Scientific research generally uses group experience to draw conclusions. Policy-making in occupational disease relies heavily on this experience to provide the basis for the development of the policy for groups with common characteristics. However, using grouped data to draw conclusions about an individual claim can pose challenges.

Scientific research studies base conclusions on statistical methods which necessarily assign equal risk or probability of acquiring a disease to all individuals with known and identical exposures to putative causal factors in order to ensure that the analysis is unbiased.

For example, heavy cigarette smokers may have a 10% lifetime risk of developing lung cancer; this means, 10 out of every 100 heavy smokers are expected to develop lung cancer. However, it is impossible to know which 10. Therefore assigning equal risks for lung cancer to all heavy smokers reflects the lack of knowledge about the development of lung cancers in the population. In reality, a particular individual may smoke for decades without actually contracting lung cancer. Another may contract lung cancer after smoking for a short period. For such an individual, cigarette smoking merely added to the nearly sufficient constellation of causes that lead to the development of the cancer.

A single exposure rarely results in a disease outcome. However, exposure of a given individual to several causal agents may increase his/her risk of disease in a synergistic, additive or antagonistic manner. Equally, different individuals may respond differently to specific exposures depending on their individual susceptibilities, on the promotional effects of the exposures, or on other contributory factors.

Given the many combinations and permutations of occupational exposures, it is not uncommon for the WSIB decision-maker to be faced with adjudicating a claim for which there is no specific relevant scientific evidence. In other circumstances, the scientific evidence may be weak or contradictory.

Where there is consistent scientific evidence in support of or against work-relatedness, the decision-maker can interpret the information to help decide the claim in a relatively straightforward fashion. However, the full circumstances of the claim must always be considered.

Where there is no clear evidence of an overall relationship between exposure and outcome, either due to limitations associated with study design or lack of statistical power, the adjudicator can look to individual subgroups identified in the studies or special circumstances within the claim that may be similar to those identified in the studies. Where conflicting evidence exists between studies, the decision-maker must review in detail each study to decide if all studies should be accorded equal weight with regard to the validity of their designs, the appropriateness of their methodologies and the correctness of their data interpretations and/or uses of statistical information. If the conflicting evidence is found to be equally weighted for and against a relationship between exposure and outcome, then the decision-maker must seek out any other information to assist in the decision making. Would additional scientific, clinical or other input reduce ambiguity? If not, in the absence of any other information, the adjudicator must assume that there is no helpful scientific evidence and proceed to adjudicate the claim based on the internal logic of the claim, with the assistance of the Bradford Hill criteria described in the following section.

As an investigating body, the WSIB is responsible for assessing work-relatedness in a claim by gathering all possible evidence from the best available sources. A major portion of the scientific evidence that is reviewed will come from the research literature and medical and scientific textbooks. Other important sources that can provide the necessary and complete information to adjudicate the claim include information gathered from the worker, the worker's representative or survivors, the employer(s) or their representative(s) and health care professionals involved in the care of the worker. The decision maker must first gather as complete information as possible to be able to render the best possible decision; if in the course of considering that information, the decision-maker should request and consider any additional scientific, medical or other information which may assist in the process. For example, if a question arises around the relationship between a pre-existing condition and the occupational condition, the decision-maker should investigate the matter before rendering the decision.

Where there is no scientific evidence with a direct bearing on a claim, there may still be information from the research literature or scientific texts that can be usefully applied to the claim. (Where there is no research concerning the relationship between exposure and outcome, it must <u>not</u> be assumed that there is no relationship between the work exposure and disease outcome.) While not intended for this purpose, it is still possible to use some principles of the Bradford Hill criteria to help guide thinking around the types of evidence to be considered as follows:

i. **Temporality:** Exposure must precede the disease by sufficient time for the natural development of the disease to have taken place.

ii. **Strength of association and Dose-response (biological gradient):** How did the worker's exposure(s) vary from the exposures in published research? Are there other claims from that workplace from which exposure or disease information can be gathered? If there is more than one claim in a workplace, do workers have a history of longer / shorter duration or higher / lower level exposures than the published research? Did this worker experience a high accidental exposure or another short-term high intensity exposure?

iii. **Biological Plausibility and Coherence:** Is the disease pathology consistent with what is known about biological and chemical processes? Do the agents of interest behave in a particular way in toxicological evaluations? Does the clinical history seem consistent with exposure history? If the latency seems unusual, has there been any unusual exposure that may have delayed or accelerated the onset of the disease? Where there is no direct evidence, have studies examined exposures and diseases that might be similar? Have the agents of interest been examined in relation to other diseases or conditions in workplaces or in experimental studies?

iv. **Experimental Evidence**: "Quasi-experimental" evidence from observing the effects of removal of an exposure may be available. If so and the evidence indicates that eliminating an exposure reduces the incidence of a condition or disease, a work- relationship may be inferred. In acute conditions, does removing the worker from the workplace improve their condition?

v. **Analogy**: Does a similar exposure to a related substance cause the same or a related disease? Analogy can extend to animal studies, cell assays and toxicological studies; however, caution must be used in the absence of human evidence.

vi. **Consistency**: While there may be no direct evidence about the individual's disease, have studies shown that the exposure is associated with similar disease(s)? Do the studies characterise the exposures that gave rise to the similar condition(s)? Has the agent(s) of interest been examined in relation to diseases or conditions in the same system or similar tissue in experimental sciences?

There are other questions that would help to inform claims decision-making, but which do not fit neatly into any of the Bradford Hill categories, as follows:

vii. What information from the research or from medical or scientific texts can be applied to the claim? How did the exposures vary from those in published research? Do others in the workplace have the same condition with similar exposures? Are there claims for other conditions? Has the work process been evaluated for unusual exposure potential? Has any other relevant information emerged from similar claims? Has the WSIB received other similar claims for this

condition? Can anything be learned from these claims?

VI. ADJUDICATIVE CHANNELS

A. Introduction

The terms of reference include recommending guidelines for the use of legal principles and scientific evidence in amending Schedules 3 and 4. However, the Act does not set out any legal or evidentiary criteria for listing a disease in a schedule. Rather the schedules have evolved over time in response to particular situations. (See Appendix B).

The issues that present themselves are as follows. First, there is the broad issue of the role of the schedules. Is it the intention of the Act to make the schedules the preferred or "default" adjudicative channel because they offer the promise of clear and quick claims resolution? Or are they reserved only for diseases where occupational causation is obvious, as in the case of poisoning, or is grounded in strong scientific evidence.

The second issue, following from the first, relates to guidelines that may set out standards for assigning diseases to schedules or policy and, in the case of Schedule 3, the development of rebuttal guidelines.

The third issue relates to the use of qualifying criteria in the disease and process columns and whether diseases can appear in more that one schedule or more than once in a schedule.

Certainly, the purpose of the schedules is to expedite decision-making. In deciding when to schedule an occupational disease, it is important to recognise that a body of research does not produce a single measure of association but rather a range of results that need to be considered. Policy-makers must confront such issues as how to assess scientific information that may be contradictory or inconclusive and/or is based on results of exposures that are not comparable with Ontario workplaces. Also, the policy-maker may be confronted with very limited research, e.g., only one published study.

B. Standards for Adjudicative Channels (Scheduling, Policy and Case-by-Case Adjudication)

First, it is recommended that the Bradford Hill criteria (discussed in Section IV) should play a major role in assessing whether causation has been sufficiently established for scheduling and policy development. That is, prior to making any recommendation for scheduling or policy development, policy-makers should expressly apply the Bradford Hill criteria to the evidence. All references to causation below assume that the Bradford Hill criteria are being applied.

Future guidelines for scientific evidence may also incorporate additional criteria for the assessment of causation as they emerge from the scientific community.

Schedule 4:

Under s.15(4), the Act states,

> If, before the date of the impairment, the worker was employed in a process set out in Schedule 4 and if he or she contracts the disease specified in the Schedule, the disease shall be deemed to have occurred due to the nature of the worker's employment.

Schedule 4 therefore creates a non-rebuttable presumption that a disease is work-related if a worker was employed in the work process described beside the disease.

Recommended Standard for Schedule 4: Strong and consistent epidemiological evidence that in virtually every case the disease occurrence is linked to a single cause and that cause is associated with an occupation, workplace or work process.

Since the presumption of work-relatedness in Schedule 4 is irrebuttable, it must be unlikely that the association is confounded by non-occupational factors. Entries in Schedule 4 require both a definitive finding of a causal association, as well as a strong statistical association. The aim is to ensure that in virtually every case, workers who fit Schedule 4 requirements will have developed their diseases as a result of the scheduled occupational processes. Evidence of non-work exposure that would override the work exposure is not expected to exist in individual claims in practice.

Schedule 3:

Under s.15(3), the Act states

> If, before the date of the impairment, the worker was employed in a process set out in Schedule 3 and if he or she contracts the disease specified in the Schedule, the disease is presumed to have occurred due to the nature of the worker's employment unless the contrary is shown.

For conditions listed in Schedule 3, the Act presumes that a condition is work-related if the worker was employed in the work process described beside the condition; but allows this presumption to be rebutted with appropriate evidence.

Recommended Standard for Schedule 3: Strong and consistent epidemiological evidence supporting a multi-causal association with the disease, one cause being occupation.

Schedule 3 entries also require evidence of a definitive causal association, as well as findings of at least a high rate of disease in a defined group of workers. A number of issues affect the placement of causal associations into Schedule 3 rather than into a policy.

A primary consideration is that use of Schedule 3 should result in quick and clear claims resolution. This is best achieved by including in Schedule 3 only those diseases and processes for which the presumption of work-relatedness is not usually rebutted. Where the disease outcome is common in the general population and is often attributable to non-occupational factors and the work-relatedness of individual claims is often rebutted, it is preferable not to use Schedule 3.

Recommended Standard for Occupational Disease Policy: Strong and consistent epidemiological evidence supporting a single or multi-causal association with disease, one cause being occupation. This category can be used when Schedule 3 criteria are met but the process cannot be defined.

If the scientific evidence shows that the risk of disease is high only in certain processes, this can be accommodated as a schedule entry if the process can be readily described. However, when subgroups consist of workers with a certain minimum latency, or exposure duration, this information is not easily described in terms of a work "process". Therefore such subgroups cannot be entered into the Schedule. While the whole cohort could be included in the schedule, and the presumption rebutted in the case of those workers not included in the appropriate subgroup, this would result in a high rebuttal rate. In this circumstance, policy is preferable to Schedule 3.

Compared to scheduling, policy affords a more flexible approach for drawing broad guidelines for adjudication. Policies can focus on specific subgroups, levels of exposure and occupational categories to a degree that is not possible in the schedules.

Recommended Standard for Case-by-Case adjudication: Inconclusive evidence as to whether an occupation is a definitive or likely cause of a disease.

When the scientific evidence is inconclusive or there is no research as to whether an occupation is a definitive or likely cause of a disease, a causal relationship cannot be ruled out. The evidence may be too equivocal or inadequate to make a general policy. Alternatively, the scientific evidence may be conclusive but the worker may not fit the study group or occupational category sufficiently to meet the schedule or policy requirements. Nonetheless, as with all claims, a decision must still be made on the

balance of probabilities as to whether the work was a significant contributing factor in the development of the disease.

Where evidence for or against causation related to a particular exposure is currently unclear but may be clarified if subject to further systematic review, the WSIB should consider initiating such a review in parallel to a particular adjudication particularly if the adjudication may represent a "leading case".

C. Rebutting the Presumption

Schedule 3 confers a rebuttable presumption that a disease is work-related. That is, a condition is presumed to be work-related unless the contrary is shown. In relation to Schedule 3, the term "rebuttal matrix" has somehow slipped into the lexicon of occupational disease policy-making without there being any clear idea of what the term really means. In fact no one has actually produced or seen a "rebuttal matrix". It is recommended that use of the word "matrix" be discontinued and replaced with the terms "rebuttal evidence" or "rebuttal guidelines".

It must be emphasised that the wording of s.15(3) is "unless the contrary is shown" does *not* mean "in the absence of evidence to the contrary" or "unless the contrary is possible". Some have misinterpreted the wording of s.15(3) believing that the mere existence of another possible cause is sufficient to rebut the presumption even though that hypothesis has only slim support.

If the evidence supports the existence of another potential significant cause, this does not (on its own) rebut the presumption. Rather it is the prelude to the next stage of adjudication where non-work as well as other work factors are considered. The question becomes "Are the non-work factors of such importance that it is more likely than not the employment was not a significant contributing factor in the development of this worker's disease?" At this point, one must take account of all the factors for and against the proposition that the disease is, in the words of s.15(3), "due to the nature of the worker's employment.".

"Rebuttal guidelines" should be understood as a structured approach for analysing evidence to determine whether the presumption is rebutted. The guidelines should not be a set of rules but rather a framework for adjudication. The evidence regarding general causation, i.e., the evidence supporting the scheduling of the disease should be set out in a way that clarifies which other work-related and non-work-related causes are known to exist. This would include information about exposure and latency periods.

D. Qualifications and Double Entries to the Schedules

It is also recommended that the statement of legal principles should clarify what is legally permissible to include in the schedules. The following is recommended:

1. Qualifications may not be entered in the “disease” column. However, exposure limits, but not latency periods may be entered into the “process” column.

2. The same disease may appear in both schedules and more than once in the same schedule. Where a disease appears in both, it is essential that the information contained in the “process” column is sufficiently distinct so that it is clear where a worker’s case should be decided.

VII. FUTURE CONSULTATION

While not formally in the terms of reference the issue of future consultation with respect to occupational disease scheduling and policy arose repeatedly in ODAP's discussions. Accordingly, it is appropriate that this question be addressed in this report.

A. Background

The WSIB did not formally consult on occupational disease issues until the establishment in 1985 of the Industrial Disease Standards Panel (later the Occupational Disease Panel, ODP). The functions of the ODP were set out in legislation and included:

- investigating possible industrial diseases;
- making findings as to whether a probable connection exists between disease and an industrial process, trade or occupation in Ontario:
- creating, developing and revising criteria for the evaluation of claims respecting industrial diseases; and,
- advising on eligibility rules regarding compensation for claims.

The ODP was made up of "labour, management, scientific, medical and community interests". When the ODP made a finding, the WSIB was required to publish the ODP's report in the Ontario Gazette and solicit submissions from interested parties. The ODP had a staff that included researchers and analysts. It also consulted outside experts.

The ODP was dissolved in 1997. During its existence it produced twenty reports. The WSIB accepted all or most recommendations in nine of these. In two other cases the WSIB responded to certain report recommendations but not to others. In three cases the WSIB either rejected the recommendations or referred the report back to the ODP. The WSIB has not responded to six of the reports.

The existence of guidelines for legal and scientific principles such as are recommended in this report could help to expedite further development of occupational disease policy decisions by the WSIB.

B. Recommendation

I believe that there ought to be some kind of an ongoing process that plays an oversight and advisory role in the area of occupational disease policy.

The criteria for success of such a structure is (1) that it function on an integrated basis with WSIB staff; (2) that its members would be drawn primarily from the scientific community but also include legal and perhaps other policy experts; (3) it should have both public oversight responsibilities and direct access to the WSIB Board of Directors; (4) that it should involve minimal cost and no permanent staff and (5) it would have the ability to draw on other experts to create *ad hoc* advisory panels on specific issues.

I believe this could be accomplished by creating an occupational disease advisory committee to the WSIB Board of Directors. This body would:

* Meet regularly with the relevant staff within the WSIB to review, discuss and advise on occupational disease policy issues.

* Meet occasionally with the Board of Directors, particularly when the Board has occupational disease issues before it.

* Advise on future changes to the guidelines for legal and scientific principles flowing from this report.

* Approve an annual report by WSIB staff with respect to occupational disease policy developments.

* Oversee the work of *ad hoc* advisory panels.

I should add that this model was not discussed by the Panel.

VIII. APPENDICES

APPENDIX

A - Members of ODAP

Members of the Occupational Disease Advisory Panel (ODAP)

Chair

B. Smith, Chair

Members

B. Conard, Vice President, Environment & Health Sciences, INCO; nominated by the Ontario Mining Association

N. De Carlo, National Representative, Health & Safety, Union of Canadian Auto Workers; nominated by the Union of Canadian Auto Workers

C. M. Fortin, Director, Medical & Occupational Disease Policy, WSIB

L. Genesove, Provincial Physician, MOL; nominated by the WSIB

D. Gibson, Environmental, Health and Safety Specialist, Canadian Tire Corp. Ltd.; nominated by the Association of Manufacturers and Exporters

R. Huget, Health & Safety Representative, Communication Energy and Paperworkers; nominated by The Ontario Federation of Labour

N. Hutchison, Health & Safety Co-ordinator, United Steel Workers of America; nominated by the Ontario Federation of Labour

L. Jolley, Vice President, Policy & Research, WSIB

J. H. Murphy, Consultant, Resource Environmental Associates (until September 2002); Rosa Fiorentino, Workers' Compensation Specialist, Imperial Oil Ltd. (from September 2002) nominated by Canadian Petroleum Products Institute

J. Nielsen, Co-ord / Comp Specialties Building Trades Workers Services; nominated by Building Trades Worker Services

A. Peter, Director, Research Secretariat, WSIB

C. Rae, Manager, Occupational Disease & Survivor Benefits Program, WSIB

Members of ODAP (cont'd)

J. Raso, Legal Counsel, Ontario Sheet Metal Workers and Roofers Conference; nominated by the Ontario Federation of Labour

J. Richman, Vice President / Medical Director, Assessmed Inc.; nominated by the Employers' Advocacy Council

M. Smith, President, Dudley Enterprise; nominated by Employers' Council of Ontario and the Ontario Public School Boards Association

J. Sprenger, CHZM Hill Canada Limited; nominated by Association of Manufacturers and Exporters

T. Sullivan, Director Preventive Oncology, Cancer Care Ontario; nominated by the WSIB

D. Wilken, Staff Lawyer, Industrial Accident Victims Group of Ontario; nominated by the Ontario Network of Injured Workers Groups

APPENDIX

B - Changes to Schedule 3

Changes to Schedule 3 of WSIA
Summary by Year

1914 – 2001

This table contains a summary of changes to Schedule 3 of *the Workplace Safety and Insurance Act (WSIA)* from 1914 – 2001. The entries are organized by the year that the amendment took effect and "count" in this table is the number of conditions carried in the Schedule during the year. Until 1950, the Schedule formed part of the legislation and after 1950 it formed part of the regulations.

Date:	Details of change	Count
1914	**Added** (as part of original statute): 1) *Anthrax* 2) *Lead poisoning* 3) *Mercury poisoning* 4) *Phosphorus poisoning* 5) *Arsenic poisoning* 6) *Ankylostoniasis*	6
1917	**Added:** *Miners' phthisis* (+1)	7
1925	**Added:** 1) *Benzol poisoning* 2) *Stone workers' or grinders phthsis (+2)*	9
1926	**Added:** 1) *Silicosis* 2) *Pneumoconiosis* 3) *Compressed air illness/caisson disease* (+3)	12
1929	**Added:** Chrome poisoning (+1)	13
1931	**Removed:** *Miners' Phthsis* (-1)	12
1932	**Added:** 1) *Bursitis* 2) *Cancer* 3) *Dermatitis (venenata)* 4) *Infected blisters* (+4)	16
1937	**Added:** *1) Retinitis* 2) *Poisoning by carbon bisulphid*e 3) *Carbon dioxide poisoning* 4) *Carbon monoxide poisoning* 5) *Brass/Zinc/Nickel poisoning* 6) *Poisoning by nitrous fumes* 7) *Inflammation of synovial lining of wrist joint and tendon sheaths* (+7)	23

Changes to Schedule 3 of WSIA
Summary by Year

1914 – 2001

Date:	Details of change	Count
1940	**Added**: 1)*Poisoning by nitro- and amino-derivatives of benzene, phenol and their homologues* *2) Poisoning by chlorinated hydrocarbons* 3) Inflammation, ulceration or malignant disease of skin due to X-rays, radium *4) Cadmium poisoning (+4)*	27
1942	Cancer replaced by: 1) *Epitheliomatous cancer or ulceration of the skin due to tar, pitch, bitumen, mineral oil or paraffin* 2) *Ulceration of the corneal surface of the eye due to tar, pitch, bitumen, mineral oil or paraffin (+1)*	28
1944	**Added:** *1) Any disease due to exposure to x-rays/radium* 2) Any respiratory disorder due to inhalation of materials used in non-offset sprays Removed: *Inflammation, ulceration or malignant disease of skin due to Xrays, radium (+1)*	29
1950	Changeover from Statutes to Regulations - Reorganised diseases with sub-grouping of poisoning items and descriptions revised **Added:** *Tuberculosis contracted by a workman employed in a hospital, sanatorium or sanatorium to which Part I applies or a Province of Ontario laboratory* **Removed**: 1) Stone-workers' or grinders' phthsis 2) Ankylostomiasis	28
1955	***Revised:*** 1) Silicosis 2) Pneumoconiosis	28
1960	**Added:** *Poisoning by beryllium (+1)*	29
1961	***Revised***: Tuberculosis	29
1993	**Added:** *Primary cancer of the nasal cavities or of paranasal sinuses (+1)*	30
2001	Diseases reworded, ungrouped, organised by type: 1) Poisoning, Biological Agents, Physical Agents, Respiratory Disease, Eye and Skin Diseases, Cancer	30

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

This table contains a summary of changes to Schedule 3 the *Workplace Safety and Insurance Act* (WSIA) from 1914 – 2001. The conditions appear mostly in alphabetical order together with the associated processes and the year in which the condition was added, revised or removed.

#	Condition	Year	Process
1.	Ankylostomiasis	1914	Mining
		1950	(Disease removed)
2.	Anthrax	1914	Handling of wool, hair, bristles, hides and skins
		2001	Handling of animals and animal parts, or any other process that results in exposure to a source of anthrax infection
3.	Bursitis	1932	Any process involving continuous rubbing, pressure or vibration of the parts affected
		1950	(No process stated)
		2001	Any process involving constant or prolonged friction to or pressure on a bursae
4.	Cancer (Replaced by Epitheliomatous cancer or ulceration of the skin (#8) & Ulceration of the corneal surface (#33))	1932	Arising from the manufacture of pitch and tar
		1942	(Disease removed)
5.	Primary cancer of the nasal cavities or of paranasal sinuses	1993	Concentrating, smelting or refining in the nickel producing industry
6.	Compressed air illness or caisson disease	1926	Any process carried on in compressed air.
	Revised to: Dysbarism: decompression sickness including caisson disease	2001	Any process involving work in compressed or decompressed air

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

#	Condition	Year	Process
7.	Dermatitis (venenata)	1932	Any process involving the use or direct contact with acids and alkalies or acids and oils capable of causing dermatitis (venenata)
		1950	(No process stated)
	Allergic contact dermatitis	2001	Any process involving exposure to a skin allergen
8.	Epitheliomatous cancer or ulceration of the skin due to tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of any of these substances	1942	Handling or use of tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of any of these substances
	Revised to: Epitheliomatous (skin) cancer	2001	Any process involving use or handling of tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of these substances
9.	Infected blisters	1932	Any process involving continuous friction, rubbing or vibration causing blisters or abrasions
		1950	Any process involving continuous friction
		2001	Any process involving friction to the skin that creates opportunity for infection
10.	Miners' phthisis	1917	Mining
		1931	(Disease removed)
11.	Pneumoconiosis	1926	Quarrying, cutting, crushing, grinding or polishing of stone, or grinding or polishing of metal
	Revised to: The pneumoconiosis other than silicosis	1955	(No process stated)
	Revised to: Pneumoconiosis other than silicosis and asbestosis	2001	Any process involving exposure to relevant dust

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

#	Condition	Year	Process
Poisoning (Items 12 – 26)			
12.	Arsenic Poisoning or its sequelae	1914	Any process involving the use of arsenic or its preparations or compounds
		2001	Any process involving exposure to or the use of arsenic, arsenic preparations or arsenic compounds
13.	Benzol poisoning	1925	Any process involving the use of benzol
	Benzene	2001	Any process involving exposure to or the use of benzene
14.	Beryllium (poisoning)	1960	Any process involving the use of beryllium or its preparation or compounds
		2001	Any process involving exposure to or the use of beryllium, beryllium preparations or beryllium compounds
15.	Brass or zinc or nickel poisoning or its sequelae	1937	Any process involving the use of nickel or brass or melting or smelting of zinc
		2001	Any melting or smelting process involving exposure to brass, nickel or zinc
16.	Cadmium poisoning	1940	Any process involving the use of cadmium or its preparation or compounds
		2001	Any process involving exposure to or the use of cadmium, cadmium preparations or cadmium compounds

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

#	Condition	Year	Process
17.	Poisoning by carbon bisulphide or its sequelae	1937	Any process involving the use of carbon bisulphide or its preparations or compounds
	Carbon disulphide	2001	Any process involving exposure to carbon disulphide
18.	Carbon dioxide poisoning or its sequelae	1937	Any process involving the evolution of carbon dioxide
		2001	Any process involving the exposure to carbon dioxide
19.	Carbon monoxide poisoning or its sequelae	1937	Any process involving the evolution of carbon monoxide
		2001	Any process involving the exposure to carbon monoxide
20.	Poisoning by chlorinated hydrocarbons (carbon tetrachloride, trichlorethylene, tetrachlorethane, trichlornaphthalene, and others) or the sequelae	1940	Any process in the manufacture or involving the use of these substances
		2001	Any process in the manufacture of, or the use of, or involving exposure to chlorinated hydrocarbons
21.	Chrome poisoning	1929	Any process involving the use of chromium or its compounds
	Chromium	2001	Any process involving the exposure to or the use of chromium or chromium compounds
22.	Lead poisoning or its sequelae	1914	Any process involving the use of lead or its preparations or compounds
		2001	Any process involving exposure to or the use of lead or lead preparations or lead compounds
23.	Mercury poisoning or its sequelae	1914	Any process involving the use of mercury or its preparations or compounds
		2001	Any process involving the exposure to or the use of mercury or mercury preparations or mercury compounds

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

#	Condition	Year	Process
24.	Poisoning by nitro-and amino-derivatives of benzene, phenol and their homologues (trinitrotoluene, dinitrophenol, ainilin, and others) or the sequelae	1940	Handling any nitro- or amino-derivatives of benzene or phenol or any of their homologues, or any process in the manufacture or involving the use thereof
		2001	Any process involving manufacture, handling, use or exposure to nitro- or amino-derivatives of benzene, phenol or their homologues
25.	Poisoning by nitrous fumes or its sequelae	1937	Any process in which nitrous fumes are evolved
	Oxides of nitrogen	2001	Any process involving exposure to oxides of nitrogen
26.	Phosphorus poisoning or its sequelae	1914	Any process involving the use of phosphorus or its preparations or compounds
		2001	Any process involving exposure to or the use of phosphorus
27.	Any respiratory disorder due to the inhalation of materials used in non-offset sprays	1944	Any process or occupation involving the use of non-offset sprays in the printing industry
	Revised to: Asthma	2001	Any process involving exposure to allergenic non-offset sprays in the printing industry
28.	Retinitis due to electrowelding or acetylene welding	1937	(No process stated)
	Revised to: Photo keratoconjunctivitis and photo retinitis	2001	Any process involving prolonged or intense ultra-violet or infra-red exposure, including gas or arc welding or use of lasers

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

#	Condition	Year	Process
29.	Silicosis	1926	Mining
		1955	Mining, or quarrying, cutting, crushing, grinding or polishing of stone, or grinding or polishing of metal
		2001	Any process involving exposure to crystalline silica
30.	Stone workers' or grinders phthisis	1925	Quarrying, cutting, crushing, grinding or polishing of stone, or grinding or polishing of metal
		1950	(Disease removed)
31.	Inflammation of the synovial lining of the wrist joint and tendon sheaths	1937	(No process stated)
	Revised to: Tenosynovitis	1950	(No process stated)
		2001	Any process involving continual or repetitive injury to tendons of the limbs
32.	Tuberculosis contracted by a workman employed by and in a) a hospital, sanatorium or sanatorium to which Part I of the *Act* applies or b) a laboratory operated by the Province of Ontario	1950	(No process stated)
	Revised to: Tuberculosis contracted by a workman employed by and in, a) a hospital, jail, sanatorium, convalescent home, nursing home, home for the aged, health unit or visiting nursing association to which Part I of the *Act* applies or b) a laboratory, reform institution, health unit or treatment centre operated by the Province of Ontario	1961	(No process stated)

Changes to Schedule 3 of WSIA
Summary by Disease

1914 – 2001

#	Condition	Year	Process
33.	**Revised to:** Tuberculosis	2001	Any employment in a health care facility, a laboratory as defined in the *Laboratory and Specimen Collection Centre Licensing Act* or a reform institution, any employment in providing health care services or health care support services or any other employment in which there is a known risk of exposure to tuberculosis or to the tubercle bacillus
	Ulceration of the corneal surface of the eye, due to tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of any of these substances	1942	Handling or use of tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of any of these substances
34.	**Revised to:** Ulceration of the skin or cornea	2001	Any process involving use, handling or exposure to tar, pitch, bitumen, mineral oil or paraffin, or any compound, product or residue of these substances
	Inflammation , ulceration or malignant disease of the skin or other tissues due to exposure to X-rays, radium, or other radioactive substances	1940	Any process in the refining or handling of radium or involving the exposure to X-rays
	Revised to: Any disease due to exposure to X-rays, radium, or other radioactive substances	1944	(No process stated)

Prepared by Grant Lowe
February 8, 2002

APPENDIX

C - Conducting Systematic Scientific Reviews of Occupational Epidemiology

Conducting Systematic Scientific Reviews of Occupational Epidemiology

ODAP believes that, where possible the WSIB should build on work already provided by recognised international scientific authorities – adapting them as necessary for use in the Ontario workers' compensation system. Accordingly, the proposed guidelines have been adapted from the World Health Organization's publication *Evaluation and Use of Epidemiological Evidence for Environment Health Risk Assessment*.[10]

The following is recommended for evaluating and using occupational epidemiology and other research for assessing the work-relatedness of diseases.

1. Development of the Protocol for Review

The objectives of a systematic review are transparency, avoidance of bias, validity, replicability and comprehensiveness. A systematic approach provides an efficient way of updating the evidence base as new studies emerge and will facilitate research planning. A protocol for the systematic review ensures that there is a common understanding of the task.

The essential elements of a protocol are:

- the question(s) to be addressed;
- the criteria for selection of reviewer(s); and,
- specification of methods to be used for identification of relevant studies, assessment of evidence in the individual studies and interpretation of the entire body of available evidence.

2. Identification of Relevant Studies

A comprehensive bibliographic search would include:

- involvement of qualified searchers (e.g., librarians, trained investigators.);
- a clearly defined and explicit research strategy including identification of key words;
- an effort to include all available studies;
- searching of bibliographic data bases; and
- rationale for exclusion of studies, e.g., non-peer reviewed, non-English reports etc.

[10]While this document is oriented to "environmental" risks, we believe that it can be suitably adapted to occupational risks.

Optional methods can include hand searching of journals and inclusion of abstracts and unpublished data.

3. Systematic Overviews of Evidence from Relevant Studies

i. Qualitative Reviews

Each study included in the overview must be reviewed individually to establish any characteristics of the working population and the exposures that might assist in understanding the results.

The following issues must be addressed when designing and conducting qualitative reviews of epidemiological literature or assessing their findings:

Statistical Power of the Study: Does the study as designed and undertaken have the power necessary to validate the results anticipated or found? Did the study identify any particular subgroups at greater risk than the overall study groups?

Characteristics of Study Group(s): What were the characteristics of the groups in each study? How are they similar or different? How can those differences or similarities explain the outcomes? How has the healthy worker effect been considered in each study? Have confounders been addressed?

Characteristics of Exposure: Scientific reviews should describe as precisely as possible the exposure characteristics and the shape of the exposure-response function, distinguishing between acute and chronic effects of exposure, if appropriate. Since the potential for exposure misclassification in retrospective studies is great and its impact on the outcome variable of interest can be profound, the impact of possible misclassification should be explored.

Alternative Explanations: There may be other reasons for the observed associations. These fall into three categories: chance, bias (information, selection, analytic) and confounding associations. Has the study author addressed the issues related to alternative explanations?

Sensitivity Analysis: Were the outcome variable(s) examined with respect to (1) changes in expression of exposure variables, (2) addition of other plausible explanatory variables, and (3) introduction or removal of confounding variables? The demonstration of specific patterns of association can provide strong support for causal interpretations if consistent with biology. In such cases, more complex, and hence less implausible, patterns of confounding or bias are required as explanations.

Additional Issues: Is there any evidence that information and/or variables are missing? Has the review only considered positive studies? Have all the studies where no associations were found been published? Was additional information sought from the authors or the study(ies)? Was additional manipulation of the data conducted? How was that done and what were the results?

ii. Quantitative Reviews

Literature reviews are often more qualitative that quantitative. However, quantitative reviews are in some circumstances appropriate and informative. Quantitative reviews usually involve systematically combining the statistical results of a number of studies into a single summary statistic or "pooled" estimate.

Meta-analysis is one form of "pooling" results of a body of literature. While it provides a systematic method for combining study results, it is very often inappropriate for observational research, especially when the literature being reviewed combines different study designs (e.g. cohort, case-control) and there is wide heterogeneity in the study populations and the exposures. In these circumstances, policy makers may draw more appropriate conclusions from a qualitative review of the literature with particular attention focused on research, which reflects the characteristics of the provincial circumstances. For example, the effects of benzene exposure in Ontario workers may be better reflected by the investigations of North American petroleum employees than by cohorts of shoe manufacturing workers from Turkey. The application of meta-analysis is very complicated for a body of observational studies; nevertheless, it is very useful when used appropriately.

Occasionally, a review of literature for scheduling or policy development may focus on a single study. This would be the case when the investigation focuses on a single company and a specific disease, such as the incidence of nasal cancer at the Copper Cliff sinter plant of Inco Limited. Although the primary conclusions may be drawn from a specific piece of research, normally a review of the related literature should be undertaken to provide a contextual foundation.

The following questions should be considered when conducting meta-analysis.

- How will the differences (heterogeneity) among studies be assessed?

- Will summary effect estimates be calculated, and by which methods?

A number of issues must be addressed when designing and conducting meta-analyses of epidemiological literature or assessing their findings.

Protocol: Each meta-analysis must have its own protocol, perhaps "nested" within the overall qualitative protocol. The protocol should include a clear statement of the objectives of the review, and the methods to be employed. It is desirable for a meta-analysis to be inclusive rather than exclusive. Sensitivity to various inclusion criteria can then be examined. The criteria must be clear and explicit. The characteristics of the primary studies must be summarised and assessed individually. In meta-analysis, the results are usually weighted by the statistical precision of each primary study. Adjustment for statistical precision can be achieved through techniques such as inverse weighting or random effect models.

Publication Bias: Since the results of certain kinds of primary studies are more likely to be published than others, publication bias must be identified, minimised or corrected. Its impact should also be assessed by sensitivity analysis.

Heterogeneity: Systematic, quantitative assessment of study differences (heterogeneity) may contribute significantly to the identification of both methodological and "natural" source of variability or epidemiological effect estimates (which includes the identification of susceptible

subgroups and exposure conditions). This can be accomplished through stratified analysis or meta-regression.

Summary Estimates: The sensitivity of summary estimates to reasonable alternatives must be addressed with regard to the inclusion and exclusion of particular studies. One can also evaluate the sensitivity to alternative approaches to the extraction of results from published reports. Quantitative summary estimates are not essential but they can provide useful input to the overall assessment of work relatedness.

The core review of the scientific evidence must then be peer-reviewed to ensure an objective evaluation of the scientific evidence.

APPENDIX

D - Drawing Conclusions from Epidemiological Evidence

Drawing Conclusions from Epidemiological Evidence

Once the epidemiological evidence has been evaluated and appropriately summarised, the observed associations must be evaluated to determine whether a causal explanation exists. Ultimately, this is a matter of judgement and it should draw upon all available epidemiological evidence, as well as on evidence from toxicology, clinical medicine and other disciplines as appropriate. The guidelines cannot serve as a mechanical checklist for determining causation. Rather they are a description of best practices for the rigorous evaluation of scientific evidence.

1. Overview

The reasoning that leads to a judgement that epidemiological evidence tends to support work-relatedness (or not) must be explicit and include explanations of:

- the weighting of particular features of the epidemiological studies (e.g. assessments of bias, confounding, exposure response, healthy worker effect),
- how "causality frameworks" such as the Bradford Hill criteria were used: and
- non-epidemiological sources of evidence that may have influenced the interpretation of the epidemiological evidence and how that contributed to the overall judgement. These can include scientific reviews by other agencies, which are known to adhere to rigorous scientific standards, such as the National Institutes of Occupational Safety and Health or the International Association for Research on Cancer.

2. Measures of Association

Almost all research studies, which examine the association between workplace and disease, are observational. Except in animal studies, experimental evidence is rarely available and descriptive studies do not provide causal evidence.[11] The previous section recommended guidelines for the *conduct* of scientific reviews. Here we recommend that the guidelines also include a description of the measures, which are commonly accepted by the scientific community for evaluating research results. These are outlined below.

The magnitude of the association between an agent and a disease can be quantified through the following measures.

i. Relative Risk (RR)

The Relative Risk is defined as the ratio of the disease incidence rate in exposed individuals to the incidence (or mortality) rate among those who were unexposed. The

[11] See Appendix E for a description of the various kinds of observational studies.

incidence rate of a disease reflects the numbers of cases of disease that develop during a specific period of time divided by the number of persons in the population under study. A relative risk is interpreted as follows.

. A RR of 1.0 means that there is no difference in disease incidence between those who are exposed and those who are not. In this case there is no association between the exposure and the disease.

. A RR of less than 1.0 is interpreted to mean that the incidence in the exposed group is lower than in the unexposed.

. If the RR is greater than 1.0 the risk in the exposed group is greater. A RR of 1.2 would be interpreted as a 20 per cent increase in risk in the exposed group. A RR of 2.0 would be a 100% increase or double the risk of developing the disease.

ii. Odds Ratio (OR)

The odds ratio is the ratio of the odds that a case (person with the disease) was exposed, to the odds that a control (without the disease) was exposed. Both the OR and the RR express the association between exposure to an agent and the development of a disease. Odds ratios are used in case-control studies whereas cohort studies use relative risks. The interpretation of the OR is similar to the RR with an OR of 1.0 indicating no difference in exposure between cases and controls.

iii. Standardised Mortality/MorbidityRatio (SMR)
Standardised Incidence Ratio (SIR)

These ratios are commonly used in retrospective cohort studies to measure whether the number of cases of death or disease in the study population is greater or less than expected in relation to the general population.

iv. Attributable Risk

Attributable risk is the proportion of disease in exposed individuals that can be attributed to a particular agent, as distinguished from the proportion of disease attributed to all causes. It is important to reiterate that an association between an agent and a disease does not necessarily mean that there is a cause-effect relationship. Rather, in depth analysis, applying a framework such as the Bradford Hill criteria (see below) is required to determine what conclusions can be drawn from the research results. It is also important to consider any errors or bias in the conduct of the research and the corresponding implications. These are discussed below.

3. Errors in Research Results

The guidelines should also include a section on methods for dealing with errors that can arise in epidemiological research, as measures of association may not always reflect the true relationship between exposure and disease. Measurement errors can arise from chance, bias and confounding.

i. Chance or random errors

Random error is the part of the research that cannot be predicted. It has many components but the major contributor is the process of selecting study subjects or *sampling error*. This occurs because nearly all epidemiological studies are based on a small proportion (sample) of the relevant population. A key assumption in epidemiology is that research results are an estimate of the "true" exposure-disease association in the population under consideration.

The main techniques for assessing random error are statistical significance (generally expressed using a p-value) and confidence intervals. Confidence intervals are preferred since they provide both the relative risk found in the study and a range or interval within which the true relative risk resides (with some level of confidence). It is commonly accepted that an effect measure that has a lower 95% confidence interval greater than 1.0 can be interpreted as statistically significant excess and therefore, provided other sources of error have been accounted for, indicative of an association between the exposure and the disease.

Neither confidence intervals nor p-values should used as a mechanical rule to exclude research findings. Although a finding may not be statistically significant it should be considered in light of the other evidence available. Lack of statistical significance or broad confidence intervals can be a function of a small sample size. Small samples are often unavoidable in occupational epidemiology especially when investigating rare diseases or exposures. For this reason, techniques for pooling the results of several studies, such as meta analysis, are often used. These techniques are described in Appendix C.

ii. *Bias*

Bias can be defined as any systematic error in a scientific study that results in an incorrect estimate of the association between exposure and the risk of disease. Unlike chance and confounding which can be quantitatively evaluated, the effects of bias are more difficult to measure and account for. An important step in interpreting the findings of a research study is the consideration of the types of bias that may have occurred in the study as well as the most likely direction and magnitude of their impact.

. *Selection bias* refers to any error that arises in the process of identifying the study populations.

. *Observation or information bias* results from systematic differences in the way data on the exposure or outcome is collected from the study groups.

Ideally potential sources of bias should be eliminated or minimised through careful design and conduct of the study. In reality, however, complete elimination of bias is nearly impossible. Therefore, when reviewing research studies, it is always necessary to carefully consider what possible biases may have influenced the observed results; the direction of the likely effect, that is, whether the bias would have acted to mask a true association or to cause a spurious association where there truly is none; and, if possible, how great this distortion might be.

iii. Confounding

At times, a researcher may find an association between an agent(s) and a disease; but further analysis reveals that some other factor is responsible for both the disease and the presence of the implicated agent(s). This is confounding.

There are methods to control for confounding both in the design of research and in the analysis of results. If the causative agent was examined in the study, then confounding can be eliminated by separating the possible effects of each of the factors associated with the disease in the analysis. It is also possible that the confounding factor may not have been included in the study and or may remain unknown until uncovered by further research.[12] Nonetheless, the effects of confounding must be carefully considered when evaluating scientific research. Like bias, it is not sufficient to merely identify the presence or absence of confounding, but also to evaluate the direction and quantify the magnitude of its effect on the estimate of association between the exposure and the disease.

iv. Healthy Worker Effect

The healthy worker effect arises from the fact that any given population of workers will normally be healthier than the population as a whole. Thus epidemiological studies, which measure disease outcomes in a workplace(s) against outcomes in the general population, may underestimate mortality and disease incidence among workers.

The WSIB adopted a policy on the healthy worker effect in 1989, which should be incorporated into the guidelines.[13]

While the guidelines need not go beyond the adopted policy it is useful to note that the healthy worker effect is influenced by a number of variables.

. It is strongest in young age groups, decreases with age and disappears with retirement.

. It is stronger for men than for women since women are more likely to be absent from the labour force for reasons other than health.

. It is stronger for higher socio-economic groups.

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[12] The concept of confounding may best be understood through an example."... consider a study that showed a relationship between increased levels of physical activity and decreased risk of myocardial infarction (MI). One additional variable that might affect the observed magnitude of this association is age. People who exercise heavily tend to be younger ... Moreover, independent of exercise, younger individuals have a lower risk of MI than do older people. Thus, those who exercise could have a lower risk of MI quite apart from an effect of this habit simply as a consequence of the greater proportion of younger individuals in this group. In this circumstance, age would confound the observed association between exercise and MI ..." (C.H. Hennekens & J.E. Buring (1987) Epidemiology in Medicine, pp. 287-8.)

[13] WCB Minute #12, May, 1989. The policy requires that the Board assess historical cohort studies for evidence of the healthy worker effect. See Appendix F.

. It is stronger for respiratory and cardiovascular diseases and weaker for cancer.

The healthy worker effect applies only to those studies that have used the general population as a reference group. A study with a carefully selected and defined reference group generally corrects for the healthy worker effect.

4. General Causal Inference

Determining a causal inference is a question of judgement based on a number of medical, scientific and social dimensions. No specific rules have been established to make casual determinations. There are however guidelines that can provide a useful framework. One set that are frequently employed are the Bradford Hill considerations. These considerations should be incorporated into the guidelines along with a brief elaboration on each of them and a note to the effect that they continue to be reinterpreted and revised by scientists. The nine considerations are:

vi. *Temporality:* This refers to the necessity that the exposure precede the onset of the disease. Unlike the other eight Bradford Hill considerations, this standard is a necessary condition for determining causality.

vii. *Strength of Association:* This refers to the degree of increase in risk associated with an exposure. These are measured with statistics such as relative risk or attributable risk. The stronger the association, the less likely it is that the association is due to error. However, a weak association does not rule out a causal connection.

viii. *Dose-response (biological gradient):* The observation that frequency of disease increases with the dose or the level of exposure usually lends support to a causal interpretation. In other words, the greater the exposure, the greater the risk of developing the disease. However, in the absence of a does-response effect, alternative explanations cannot be ruled out, such as a threshold effect, or a saturation effect. As well, an observed dose-response effect may be due entirely to a graduated distortion or bias.

ix. *Specificity:* If the exposure is found to be associated with only one disease, or alternatively if the disease is found to be associated with only one exposure, a causal interpretation is suggested. This criterion only operates in one direction, however. When present, it strengthens the causal inference. Lack of specificity cannot be used to deny a causal relationship since many exposures have multiple effects and most diseases have multiple causes.

x. *Consistency*: If all studies examining a given relationship produce similar results, a causal interpretation is enhanced. Sir Bradford Hill's discussion of this consideration also specified that the repeated observation of an association should be seen in different populations under different circumstances.

Lack of consistency does to rule out a causal association because some effects are produced by their causes only under unusual circumstances. Also, studies can be expected to differ in their results because they differ in their methodologies.

x. *Biological Plausibility*: If the suspected connection between the exposure and the disease is consistent with what is known about biological and chemical patterns, a causal interpretation is more likely to be warranted. However, biological plausibility is not required to establish causation since the current state of knowledge may be inadequate to explain scientific observations.

xi. *Coherence*: This implies that a cause and effect interpretation for an association should not conflict with what is known of the natural history and biology of the disease. Sir Bradford Hill suggests that the absence of coherent information should not be taken as evidence against an association being considered causal.

xii. *Experimental Evidence*: Experimental evidence is highly relevant where it exists. While seldom available for human populations, occasionally "quasi-experimental" evidence may result from observations of the effects of the removal from exposure.

xiii. A*nalogy*: Support for a causal association may be strengthened by analogy with a similar exposure that causes the same or a related disease or analogy with animal and toxicological studies. (This criterion is frequently omitted from discussions of the Bradford Hill considerations since many analogies may be spurious.)

APPENDIX

E - Types of Research Design

Types of Research Designs used to Investigate the Causes of Occupational Diseases

The protocol should include a clear definition of the various kinds of studies that produce scientific evidence and an appreciation of the strengths and weaknesses of various research designs as discussed below.

1. Experimental and Quasi-experimental studies

An experimental study involves randomisation to allocate subjects to groups. This type of research includes laboratory experiments, clinical trials and community interventions. However, ethical constraints limit the use of experimental methodologies to assessing the value of agents that are thought to be beneficial to human beings. This type of design cannot be used to investigate the causes of occupational disease.

Quasi-experimental studies, however, are possible. These studies differ from experimental research in that the research participants are not randomly assigned and the investigator does not determine what study conditions will be manipulated. A quasi-experimental study in occupational disease may evaluate the health effects after the introduction or removal of an agent.

Experimental studies are considered to offer the most definitive scientific evidence. Since there is much less control using a quasi-experimental design, the results of this research are much more open to criticism, however, if properly conducted, this type of study can produce highly compelling findings.

2. Observational Studies

Most occupational health research is observational. Observational designs fall into two categories – analytic and descriptive.

Analytic observational research

Analytic observational research includes the two classic epidemiological research designs, cohort and case-control studies. An analytic study is conducted when enough is known about the disease before the investigation so that specific *a priori* hypotheses can be tested. The objectives are to identify risk factors for the disease, estimate their effects on the disease, and suggest possible interventions.

The goal of both cohort and case- control studies is to determine if there is an association between exposure to an agent and a disease, and the strength or magnitude of that association.

Cohort studies

Cohort studies are either retrospective or prospective. The key distinguishing feature of this study design is that the investigator measures and compares the incidence of disease in exposed and unexposed groups.

This design is thought to be most appropriate for fairly common diseases and rare exposures. It is the most common design used in occupational epidemiology.

Case-control studies

In a case-control study, the researcher begins with a group of individuals with the disease (the "cases") and then selects a group of individuals who do not have the disease (the "controls"). The researcher then compares the groups in terms of past exposures. If a certain exposure is associated with or caused the disease, a higher proportion of past exposure among the cases than among the controls would be expected.

Case-control studies are particularly appropriate for studying rare diseases, because if a cohort study were conducted, an extremely large group would have to be studied in order to observe the development of a sufficient number of cases for analysis. However, due to a number of weaknesses inherent in the design of case-control studies, the investigator must be vigilant in ensuring that the potential for bias and confounding are minimised. Due to the potential for bias in case-control studies, the results of these investigations are often considered to be inferior to those of cohort studies.

3. Descriptive Observational Studies

Descriptive studies are usually conducted when little is known about the occurrence, the natural history, or the determinants of a disease. The objectives are to estimate the disease frequency or time trend in a particular population and to generate more specific etiological hypotheses.

Cross-sectional

In a cross-sectional study, individuals are interviewed or examined, and the presence of both the exposure of interest and the disease of interest is determined in each individual at a single point in time. These studies determine the prevalence (presence) of both exposure and disease in individuals and do not determine the development of disease or risk of disease (incidence).

Since both exposure and disease are measured at the same time it is not possible to determine the temporal relationship between them.[14] Determining that the exposure occurred before the disease is a necessary precondition for establishing a causal relationship (see discussion of Bradford Hill criteria).

While cross-sectional studies cannot normally be used for drawing causal inferences, they are often very useful in generating hypotheses for future research projects.

Proportional Mortality Study

A proportional mortality study only includes dead subjects. The proportion of dead subjects who have been assigned one or more specific causes of death is compared with a corresponding

[14] Cross-sectional studies cannot determine temporal relationships except in circumstances where a personal characteristic does not change over time, such as blood type, and existence of a disease, such as aplastic anaemia.

proportion of dead unexposed subjects. The resulting proportional mortality ratio (PMR) is taken as a measure of the effect of exposure.

Ecological studies

Studies that collect data only about the population or group as a whole are called ecological studies. In these studies, information about individuals is generally not gathered, rather, overall rates of disease or death for different groups are obtained and compared. The objective is to identify differences between the groups.

Descriptive observational studies may be useful for identifying associations, but they are inappropriate for addressing causal hypotheses.

APPENDIX

F - Policy on the Healthy Worker Effect

To: Board of Directors

From: R.G. Elgie

Date: April 21, 1989

Subject: **WCB RESPONSE TO THE IDSP REPORT ON THE HEALTHY WORKER EFFECT**

Attached are materials on the Healthy Worker Effect (HWE) for your consideration at the Board of Directors meeting on May 4, 1989.

These materials consist of an Executive Summary of the Response of the WCB to the IDSP Report No. 3 on the HWE, a draft of the Board Response in a format written for The Ontario Gazette, and a further attachment which provides explanation of the Board response in more detail.

Generally, the response of the Board indicates agreement with the four recommendations of the IDSP on the HWE. The response also explains the Board's interpretation of the recommendations, and goes on to recommend additional methods for minimizing or accounting for the HWE. Finally, the Board response notes that, as suggested by five of the contributors to the IDSP report, if an epidemiological study of cancer does not take the HWE into account, the findings may still be valid.

The Board of Directors is asked to consider the following recommendations:

- That the Board of Directors approve the Board response to the IDSP report on the healthy worker effect.
- That the Board response and Attachment be printed in The Ontario Gazette.
- That a letter of thank you from the Chairman and a copy of the Board response and Attachment be sent to all those who made submissions to the WCB.

- That the Board response and Attachment be distributed to appropriate departments throughout the Board (e.g., Occupational Disease Department, Specialized Medical Services, Policy, etc.).

R.G. Elgie

Attachments

APPROVED BY THE BOARD OF DIRECTORS

this 5th day of MAY 19 89

Secretary

WORKERS' COMPENSATION BOARD OF ONTARIO

IN THE MATTER OF Section 86p of the Workers' Compensation Act, R.S.O., 1980, c. 539, as amended:

AND IN THE MATTER OF the findings of the Industrial Disease Standards Panel Report to the Workers' Compensation Board on the Healthy Worker Effect

In accordance with Section 86p(14) of the Workers' Compensation Act, the Board is publishing this notice of its acceptance or rejection of the findings of the Industrial Disease Standards Panel (IDSP), with reasons therefor (see Attachment for a detailed discussion).

Many occupational epidemiology studies compare the health of an occupational cohort to that of the general population. It has long been known, however, that the general population is less healthy than most actively working groups, and this circumstance creates a bias known as the healthy worker effect (HWE).

The HWE is defined as "the consistent tendency for actively employed people to have a more favourable mortality (or morbidity) experience than the population at large". It is an unintended bias which may produce an underestimation of the association of interest, usually the standardized mortality ratio (SMR) or standardized morbidity ratio (SMbR).

In a letter dated June 12, 1986, the Workers' Compensation Board (WCB) requested the Industrial Disease Standards Panel (IDSP) to review the issue of the HWE. The Board requested responses to the following questions:

1. Should the WCB take the HWE into account in evaluating the epidemiological data found in mortality and morbidity studies?

2. If the answer to question 1 is yes, then

   a) What type of correction factor should typically be employed to address this potential source of bias?

   b) Are there any sorts of mortality or morbidity outcomes (e.g., cancer) in respect of which this correction factor should not apply?

These questions were answered in a report by the IDSP, submitted to the WCB on June 21, 1988. In accordance with Section 86p(11) of the Workers' Compensation Act, the WCB published a notice in The Ontario Gazette on August 20, 1988 setting forth the nature of the findings of the IDSP and calling for comments, briefs, and submissions. The deadline for submissions was extended to December 15, 1988. Seven submissions were received by the Board.

After a thorough review of the IDSP's report and all submissions received by the Board, the Board has reached the following conclusions:

o **WITH RESPECT TO RECOMMENDATION 1**

The Workers' Compensation Board should take the healthy worker effect (HWE) into account in evaluating the epidemiological data found in mortality and morbidity studies.

The Board agrees with this recommendation. Each contributor to the IDSP report has recognized that the HWE is an important potential bias in occupational epidemiology studies. Consequently, those studies which have attempted to minimize or account for the HWE either by design or analysis will carry more weight by the WCB in the process of assessing a causal relationship between an occupational exposure and a disease.

o **WITH RESPECT TO RECOMMENDATION 2**

Each epidemiological study, especially of the historical cohort type, should be assessed to determine if there is any evidence of the HWE in the form of a reduced (i.e. < 100%) standardized mortality ratio (SMR) for all causes mortality or for all cardiovascular diseases mortality; or correspondingly reduced standardized morbidity ratios (SMbR).

The Board agrees with this recommendation. As indicated by contributors to the IDSP Report, analysis by all cause mortality and mortality for cardiovascular disease will help to uncover the HWE.

o **WITH RESPECT TO RECOMMENDATION 3**

A correction factor should not be employed to address this potential source of bias since each study requires individual interpretation concerning the extent to which the HWE may have biased the point estimate of the standardized mortality or morbidity ratios for each condition of interest.

The Board concurs with this recommendation and wishes to stress that there is no single correction factor or approach which is appropriate to all epidemiological studies. The contributors to the IDSP Report have all demonstrated that the extent of the HWE is dependent on a number of different factors (e.g., type of disease, time, place, nature of occupation). It is only when these factors are assessed in each study that an investigator can take steps for reducing or accounting for the bias of the HWE.

In the interpretation of epidemiological studies, it does not appear useful to correct for the HWE by dividing one SMR by another since this may only complicate any bias which already exists.

o **WITH RESPECT TO RECOMMENDATION 4**

Where there is evidence of the presence of the HWE, and there is the possibility of excess mortality (or morbidity) from non-cardiovascular disease causes, the epidemiological estimates of mortality or morbidity should in general be derived after removing from the analysis the initial group of years from the time of first employment. The number of years of follow up to be so removed should be approximately equal to the average estimated duration in time from the earliest clinical manifestations of the disease to final outcome (based, for example, on the use of survival curves). For lung cancer, for example, it is suggested that the initial 5 years following first employment should be removed from the analysis.

The Board recognizes that removal of an initial number of years of follow-up in an historical cohort study (as indicated in Recommendation 4) will serve to reduce the bias from selection as well as from other factors. It should be noted, however, that this is not the only way to account for or minimize the HWE.

Use of an internal comparison group or a more comparable external comparison group will also serve to reduce bias from the HWE. In addition, analysis by latency is another way to account for the HWE.

Each method, including the removal of an initial number of years (as in Recommendation 4), has advantages and disadvantages.

The Panel also noted that all of the above recommendations should apply to the Panel in its own work.

The Board agrees with this point.

May 9, 1989

ATTACHMENT

HEALTHY WORKER EFFECT
WCB RESPONSE TO IDSP REPORT No. 3

I. HISTORICAL BACKGROUND

Many occupational epidemiology studies compare the health of an occupational cohort to that of the general population. It has long been known, however, that the general population is less healthy than most actively working groups, and this circumstance creates a bias known as the healthy worker effect (HWE).

The HWE, as defined by McMichael (IDSP Report No. 3), is "the consistent tendency for actively employed people to have a more favourable mortality (or morbidity) experience than the population at large". It is an unintended bias which may produce an underestimation of the standardized mortality ratio (SMR) or other estimates of the association of interest.

In a letter dated June 12, 1986, the Workers' Compensation Board (WCB) requested the Industrial Disease Standards Panel (IDSP) to review the issue of the HWE. The Board requested responses to the following questions:

1. Should the WCB take the HWE into account in evaluating the epidemiological data found in mortality and morbidity studies?

2. If the answer to question 1 is yes, then

   a) What type of correction factor should typically be employed to address this potential source of bias?

   b) Are there any sorts of mortality or morbidity outcomes (e.g., cancer) in respect of which this correction factor should not apply?

These questions were addressed in a report by the IDSP, submitted to the WCB on June 21, 1988. In accordance with Section 86p(11) of the Workers' Compensation Act, the WCB published a notice in The Ontario Gazette on August 20, 1988 setting forth the nature of the findings of the IDSP and calling for comments, briefs, and submissions. The deadline for submissions was extended to December 15, 1988.

In addition to requesting submissions through The Ontario Gazette, the WCB distributed the IDSP Report on the HWE to a number of experts in the field of epidemiology. These experts were asked for their comments. The WCB also asked those individuals who had originally contributed to the IDSP report to comment on the Panel's final recommendations.

As of December 15, 1988, seven submissions were received by the WCB. Four submissions were received from contributors to the IDSP Report. One submission was from Ontario Hydro, one from the Ontario Mining Association, and one from Dr. Harvey Risch, Assistant Professor of Epidemiology in the Epidemiology Unit of the National Cancer Institute of Canada.

The purpose of this paper is to review the IDSP's report and the submissions received by the WCB so that recommendations can be made on a Board response.

Because it is integral to the understanding of the HWE, this report begins with an explanation of the standardized mortality ratio (SMR). It goes on to describe the IDSP report and presents a summary of the submissions to the WCB. Part V is the WCB Analysis of the IDSP Report.

II. EXPLANATION OF THE SMR

Most occupational epidemiology studies are historical cohort in design. That is, they identify a specific cohort of workers from the past and determine the cohort's morbidity or mortality patterns over time. The statistic most often presented in these studies is the standardized mortality ratio (SMR) or the standardized morbidity ratio (SMbR).

In order to understand the HWE and the implications of some of the suggestions for minimizing the HWE, it is important to have an appreciation of the calculation of the SMR or SMbR. Since calculation procedures for both statistics are the same, the SMR will be discussed below as an illustration.

The SMR is a ratio. The numerator of the ratio consists of the number of deaths attributed to a particular cause (e.g., lung cancer) which was observed in the cohort of interest over a period of time. The denominator of the ratio is the number of deaths that would have been expected in an equivalently aged group of individuals in the general population over the same period of time.

The calculation of expected number of deaths involves computing the person-years-at-risk of study subjects in each age and year interval (usually five year intervals) (see Table). The expected number of deaths (C) from each cause is computed by multiplying the person-years in the study group (A) by the cause-specific mortality rate for that age and year range (B) and then summing over all ages and years.

TABLE

ILLUSTRATION OF COMPUTATION OF STANDARDIZED MORTALITY RATIO (SMR)*

Person-years (A)

	Year		
Age	1950-54	1955-59	1960-64
20—24	1000	500	200
25—29	1000	1500	1000
30—34	500	500	1500

Observed deaths

20—24	2	1	0	
25—29	3	4	2	Σ Obs = 15 (D)
30—34	0	1	2	

Population rates (per 1000) (B)

20—24	1.8	1.8	1.6
25—29	1.7	1.5	1.5
30—34	1.9	1.8	1.7

Expected deaths = population rates × person-years

20—24	1.8	0.9	0.3	
25—29	1.7	2.3	1.5	Σ Exp = 12.9 (C)
30—34	0.9	0.9	2.6	

SMR = 100 × Σ observed/Σ expected = 100 (15)/12.9 = 116 (E)

*Monson, R.R., Occupational Epidemiology, CRC Press, Inc., Boca Raton, Florida, 1986, p. 85.

Normally, the provincial or national mortality rates are used for calculating expected numbers. Occasionally, local rates are used.

The total observed number of deaths (D) is then divided by the total expected number of deaths (C) to calculate a ratio of observed to expected. Normally, the ratio is multiplied by 100 to arrive at the SMR (E).

If the comparison group is less healthy than the occupational cohort under study (which is normally the case), the following will occur:

- The age-specific rate of disease in the general population will be higher than that in the occupational cohort.

- The expected number of deaths in the occupational cohort will also be high since these are derived from the age-specific rate of disease in the general population.

- The total expected number of deaths will be high.

- The ratio of observed to expected (the SMR) will be an underestimate of the association of interest because a high number of expected deaths in the denominator will reduce the SMR.

If the result of the HWE is an underestimate of the SMR, then it would be useful to know:

- the circumstances under which the HWE occurs

- how the HWE might be modified, reduced, or accounted for

- how a reported SMR should be interpreted

Each of these points is covered in the IDSP Report on the HWE.

III. SUMMARY OF IDSP REPORT

A. Methodology

After receiving a presentation on the HWE from Dr. Geoffrey Howe, Director of the Epidemiology Unit of the National Cancer Institute of Canada, the IDSP requested international experts in the field of epidemiology to provide short papers on the HWE. These experts were asked to include the following:

- examples of the presence of the HWE from their own studies
- methods they used to deal with the HWE
- knowledge they derived about the HWE
- conclusions which apply to the HWE, particularly with respect to cancer

The IDSP received ten papers on the HWE (one paper by Professor Robin Roberts of McMaster University was withdrawn). The nine papers (including the original presentation by Dr. Howe), make up the major portion of the IDSP Report on the HWE. Appendix 1 contains a list of the contributors to the IDSP Report and their affiliations.

The report also includes the Panel's findings, based on these reports, as well as four recommendations.

B. Discussion of the HWE

The following points were made by contributors to the IDSP Report:

- The HWE is a bias which produces an underestimation of the SMR.
- It occurs as a result of the incomparability of an occupational cohort to the general population (i.e., the general population, which contains employed and unemployed persons, is less healthy than the occupational cohort under study).
- The HWE is a result of a number of factors (e.g., selection by the employer to exclude those obviously at high risk of disease; selection to exclude those whose ill health makes the work unsatisfactory; self-selection by workers; beneficial effect of work; health benefits provided by employment).
- The greatest selection at time of employment is against those diseases which appear early in life (e.g., non-malignant diseases of the respiratory, digestive, endocrine and urinary systems). The least selection is against those diseases which do not manifest at time of employment (e.g., cancer).

- The HWE may also occur as a result of classification bias (differential ascertainment of mortality between the occupational cohort and the general population). This, however, would likely create an overestimation of the SMR.

- The HWE may also be due to confounding. The confounding factor is the health status of the group of workers.

- The HWE may vary according to a number of factors (e.g., type of disease, time, place, time since employment, sex, age, specific occupation, and socioeconomic status).

- There is more than one way to minimize or account for the HWE. Methods include improving the design of the study (e.g., by using an internal comparison group, by using a more comparable external comparison group, or by including in the study group all those who have left the workforce) or through the analysis (e.g., by excluding from the analysis some initial group of years or by subdividing the cohort according to latency).

- All but one contributor (Sterling) recommended against a uniform correction factor for the HWE.

- Although the HWE is operable when measuring relative risk, there is little evidence for the HWE in an absolute sense (i.e., when measuring attributable risk). Attributable risk can be determined by computing the observed minus the expected number of deaths and dividing by the number of person-years. Although the SMR (which is an estimate of the relative risk) is most often determined in occupational studies, it is becoming more widespread to calculate attributable risk in determining the magnitude of risk of cancer caused by exposure to radiation.

- Because cause-specific proportions are not independent, there is a tendency for proportionate mortality ratios (PMRs) for cancer to be greater than 100. This is a reflection of the HWE for circulatory and other nonmalignant diseases. Several contributors recommended against the use of the PMR.

C. IDSP Recommendations

The IDSP made the following recommendations on the HWE:

1. The Workers' Compensation Board should take the healthy worker effect (HWE) into account in evaluating the epidemiological data found in mortality and morbidity studies.

2. Each epidemiological study, especially of the historical cohort type, should be assessed to determine if there is any evidence of the HWE in the form of a reduced (i.e. < 100%) standardized mortality ratio (SMR) for all causes mortality or for all cardiovascular diseases mortality; or correspondingly reduced standardized morbidity ratios (SMbR).

3. A correction factor should not be employed to address this potential source of bias since each study requires individual interpretation concerning the extent to which the HWE may have biased the point estimate of the standardized mortality or morbidity ratios for each condition of interest.

4. Where there is evidence of the presence of the HWE, and there is the possibility of excess mortality (or morbidity) from non-cardiovascular disease causes, the epidemiological estimates of mortality or morbidity should in general be derived after removing from the analysis the initial group of years from the time of first employment. The number of years of follow up to be so removed should be approximately equal to the average estimated duration in time from the earliest clinical manifestations of the disease to final outcome (based, for example, on the use of survival curves). For lung cancer, for example, it is suggested that the initial 5 years following first employment should be removed from the analysis.

The Panel also noted that all of the above recommendations should apply to the Panel in its own work.

IV. SUMMARY OF SUBMISSIONS TO WCB

Unsolicited submissions were received from Dr. T.D. Sterling, one of the contributors to the IDSP Report, Ontario Hydro, and the Ontario Mining Association. The WCB contacted all other contributors to the IDSP to ask for comments and received a response from Professors R. Doll, R. Monson, and P. Enterline.

Also responding to the WCB was Dr. Harvey A. Risch, Assistant Professor of the Epidemiology Unit of the National Cancer Institute of Canada.

The major points from each submission are noted below:

- A suppressed SMR for all causes is sufficient evidence of the HWE (Sterling).
- Recommendation 4 is a form of a correction factor (Sterling).
- Following Recommendation 4 would have the effect of reducing the strength of the study (Sterling).
- Strong weight should be given to studies which use an internal comparison group (Ontario Hydro, Risch).
- A little loss of power from using an internal comparison group is less important than the increase in bias from non-comparability (Risch).
- It is not clear whether the consideration of latency will also take into account the HWE (Ontario Hydro).
- Recommendation 3 is strongly endorsed (Ontario Hydro).
- Although Recommendation 4 is appropriate, there is a question as to how published data will be judged if it is presented with initial years removed (Ontario Hydro).
- The rationale for Recommendation 4 is not clear (Enterline).
- It was mentioned by five contributors that the HWE is minimal for cancer SMRs. However, this was not addressed in the IDSP recommendations (Ontario Hydro, Ontario Mining Association, Enterline).

V. WCB ANALYSIS OF IDSP REPORT

A. General Comments

The HWE occurs because a group of workers are hired on the basis of apparent good health (and other factors), while those with notable health deficiencies do not apply for or would be rejected for work. After a certain period of time, diseases that were not notable at time of hire would begin to show up in the working population as well as in the general population. To add to the situation, working people probably have better health benefits and health care, as well as, perhaps, an outlook on lifestyle that promotes good health.

The term "healthy worker effect" may not be entirely accurate. Although selection factors may prove favourable to an occupational cohort (thereby reducing the SMR), there are also selection biases which might prove unfavourable (e.g., mesomorphs in the fire and police service; type A personalities in sales and business).

B. Recommendations for Minimizing the HWE

Contributors to the IDSP report have recommended a number of ways to minimize or account for the HWE. These recommendations are listed in Appendix 2 and are discussed below. Also presented are the recommendations of the IDSP and those who made submissions to the WCB on the HWE report.

The HWE can be minimized either through the design of the study or through the analysis. No one method is always feasible or perfect. In addition, Sterling recommends a correction factor which could be used by the reader once the study is completed.

1. Design

The HWE is a function of non-comparability between the study cohort and the comparison group. If a more appropriate comparison group could be found, then the HWE could be minimized, or perhaps eliminated.

A number of contributors have recommended the use of an internal comparison group. This would reduce the selection differences between the occupation (exposure) of interest and the comparison groups (unless there is selection bias for the occupation of interest). As noted by a number of contributors, a disadvantage to this option is that the power of the study would be reduced because the numbers in each group would be small.

It has also been suggested that the HWE would be reduced if those who leave the workforce before retirement are included in the cohort and if those with short working histories are also included. Individuals in each of these groups tend to have poorer health, and, therefore, their exclusion would inaccurately reduce the SMR.

Nicholson has also recommended that nested case-control studies be conducted within historical cohort studies to shed further light on the relationship between an occupational exposure and a disease.

2. Analysis

A number of contributors have recommended removing from the analysis an initial group of years from time of first employment. The IDSP recommends basing the number of years on survival of the disease in question in order to eliminate those diseases which have begun to develop but may not be manifest. Other contributors have chosen an arbitrary number of years (usually five) to ensure that the HWE which resulted from selection bias has worn off.

Whichever method is chosen to decide upon the number of years of removal from the analysis, the effect will be the same:

- The total number of person years at risk will be reduced.

- The total expected number of deaths (which is based on the total number of person years at risk) will be reduced.

- The observed number of deaths in the numerator will also be reduced.

- The magnitude of the SMR will not change substantially. However, with smaller numbers, the power to detect a statistically significant SMR would be reduced.

The HWE can be accounted for (i.e., identified, to some extent) by subdividing data according to latency (number of years between first exposure and identification of disease or death). An SMR within each latency group is calculated and reported. An example of this approach is shown in Appendix 3.

In Appendix 3, the investigator has analyzed data by both latency (years since entering follow-up) and cause of death. The latency has been subdivided into five-year groups. It can be seen that the ratio (observed to expected) increases as the number of years since entering follow-up increases. After ten years or more (depending upon the cause of death) the ratio begins to plateau.

The table in Appendix 3 is an excellent demonstration of the presentation of data to identify the HWE. In addition, it is clear that the extent of the HWE is different for different diseases.

This method of analysis demonstrates the HWE to the reader, accounts for latency, while at the same time, accounts for the concern that some cancers may have begun to develop prior to the beginning of entry into the study.

Mathematically, this method utilizes all person years in the calculation of expected number of deaths. However, the subdivision into several groups according to latency creates small numbers and ultimately reduces power within each latency group.

3. After-the-fact Correction Factor

According to Sterling, the HWE is a phenomenon of confounding rather than of selection bias. Consequently, it is possible to correct for the HWE by estimating the overall confounding effect in the industrial cohort with respect to the generalized population. He proposes that the SMR of interest (e.g., lung cancer) be divided by a comparable SMR that

is less affected by the occupational exposure in question.

Sterling's method is pleasing because it provides the WCB with a method for dealing with a study once it is complete. Since the WCB is often in the position of interpreting studies rather than suggesting changes to design and analytical methodology, the concept has pragmatic appeal.

However, this method may also be misleading. It provides a general approach to correcting for the HWE but does not focus on the individual characteristics of the study or the study population. In addition, it does not take into account the primary cause of the HWE bias (i.e., likelihood of hiring individuals who are healthier than those in the general population).

Finally, because the SMR depends on the age structure of the study population (Rothman, K. Modern Epidemiology, Little, Brown and Co., Toronto, 1986), dividing the lung cancer SMR (which is dependent on one age structure) by the cardiovascular SMR (which is dependent on another age structure) may further bias the final result.

C. Implications of IDSP Recommendations

In order to make decisions on occupational disease claims, it is necessary to determine whether there is a causal relationship between an occupational exposure and a disease outcome. The disease-specific SMR, which is calculated in historical cohort studies, is an integral part of the equation for assessing a causal relationship.

The questions for anyone who is trying to interpret the SMR are:

- Is the SMR correct?
- If not, is it an underestimate (or overestimate) of relative mortality?
- If so, by how much and in what direction?
- Is the HWE (or other bias) at play?
- What could be done to minimize, eliminate, or account for the HWE (or other biases)?

The WCB cannot usually influence a researcher's design or analysis of the data. However, whether or not the researcher attempts to account for the HWE and other biases will affect how much weight the Board puts on the conclusions of that study. In turn, how seriously the study is taken will affect conclusions about causal associations between occupational exposure and disease and will also affect decisions on claims.

D. Conclusions

The IDSP report on the HWE has been useful in providing an understanding of the HWE. The individual papers, taken together, provide an excellent discussion of the definition of the HWE, the components, modifiers, and effect of the HWE. Examples were provided on when the HWE might have less of an impact on the association of interest in an epidemiological study (e.g., in the case of cancer). In addition, useful suggestions were provided on how to minimize and/or account for the HWE in the analysis and design of historical cohort studies.

All of the methods for minimizing or accounting for the HWE have their limitations. It is not always feasible to use an internal comparison group in an historical cohort study, and this analytical method reduces power. Power is also reduced by eliminating the initial years of exposure, and through analysis by latency. However, loss of power may be more desirable than further increasing bias by using a single correction factor.

Finally, it should be emphasized that the HWE is not the only serious potential bias in historical cohort studies. It is just as important to be wary of other biases as it is to account for the HWE.

May 9, 1989

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ON THE HEALTHY WORKER EFFECT

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APPENDIX 2

RECOMMENDATIONS FOR
MINIMIZING THE HWE

CONTRIBUTOR	RECOMMENDATION
Axelson	Use a proper comparison group. Allow for an adequately long latency period. Analyze data comparing observed and expected cases in various periods of time since first exposure (latency) in cancer studies.
Doll	Exclude the first five years' observations after recruitment to the study.
Enterline	No adjustment necessary for cancer.
Howe	A single correction factor would be misleading. Use an appropriate internal comparison group. Present results compared to general population rates, especially when relative risks are high, if an internal comparison group is not available. The HWE is unlikely to have a substantial influence upon the assessment of the causality of an association.
McMichael	Use an ideal external reference population which comprises all other actively employed person. Restrict the analysis of the health experience of the working population to that occurring after some minimum specified time since commencement of employment (e.g., five years). Trace and include those individuals who leave the workforce before retirement.

RECOMMENDATIONS FOR
MINIMIZING THE HWE (cont'd)

CONTRIBUTOR	RECOMMENDATION
McMichael (cont'd)	Examine the variation in health outcome rate across a gradient of increasing exposure within the workforce. The HWE is unlikely in cancer studies. Use an internal comparison group. It is not appropriate to apply a standard correction factor.
Miettinen	Improve epidemiologic design of studies. Use a comparison group which consists of workers in other occupations.
Monson	Do not use proportionate mortality. In cases of cancer, in general the HWE can be ignored in analyses that use mortality rates (SMRs). A single parameter is not sufficient to control the HWE. The HWE is unlikely to have any substantial influence upon the assessment of the causality of an association. The use of an external population may increase the power relative to using an internal control group.
Nicholson	Use internal and external controls and general population rates. Exclude individuals employed for short periods of time. Develop dose-response relationships. Conduct nested case-control studies.

RECOMMENDATIONS FOR
MINIMIZING THE HWE (cont'd)

CONTRIBUTOR	RECOMMENDATION
Sterling	Divide the SMR of interest by a comparable SMR that is less affected by the occupational exposure in question. Test for dose-response relationships. Use the PMR, but with caution.
Ontario Mining Assoc. (submission)	Employers' hiring practices should be considered in studies.
Risch (submission)	Internal rate comparisons should be given more weight than external ones. Studies based on PMR should never be relied upon.
IDSP (Rec. 4)	Where there is evidence of the presence of the HWE, and there is the possibility of excess mortality (or morbidity) from non-cardio-vascular disease causes, the epidemiological estimates of mortality or morbidity should in general be derived after removing from the analysis the initial group of years from the time of first employment. The number of years of follow up to be so removed should be approximately equal to the average estimated duration in time from the earliest clinical manifestations of the disease to final outcome (based, for example, on the use of survival curves). For lung cancer, for example, it is suggested that the initial five years following first employment should be removed from the analysis.

APPENDIX 3

ANALYZING HISTORICAL COHORT STUDIES BY LATENCY TO ACCOUNT FOR THE HWE*

OBSERVED/EXPECTED DEATHS AMONG UNION WHITE MALE RUBBER WORKERS ACCORDING TO CAUSE OF DEATH AND YEARS SINCE ENTERING FOLLOW-UP

Cause of Death	Years Since Entering Follow-up						
	0-4	5-9	10-14	15-19	20-24	≥25	Total
All causes	0.6	0.7	0.8	0.9	0.9	0.9	0.9
All cancers	0.9	0.8	0.8	1.0	1.0	1.0	1.0
All circulatory	0.7	0.8	0.8	0.9	0.8	0.9	0.9
All causes other than cancer and circulatory	0.5	0.7	0.8	1.0	0.9	1.0	0.9
Lung cancer	0.7	0.8	0.7	1.0	1.0	0.9	0.9
Nonmalignant respiratory disease	0.4	0.4	0.6	0.7	0.6	0.9	0.7
Nonmalignant digestive diseases	0.4	0.7	0.8	0.8	1.1	0.9	0.8
All external causes	0.6	0.5	0.7	0.6	0.7	0.7	0.6

*Monson, R. Observations of the Healthy Worker Effect, Report to the Workers' Compensation Board on the Healthy Worker Effect, IDSP Report # 3, June, 1988.

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