ANALYSIS AND COMPARISON OF EPIDEMIOLOGIC STUDIES PUBLISHED IN OCCUPATIONAL HEALTH JOURNALS

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Submitted to the Graduate Faculty of

Graduate School of Public Health in partial fulfillment

of the requirements for the degree of

Master of Public Health

University of Pittsburgh

2008

UNIVERSITY OF PITTSBURGH

GRADUATE SCHOOL OF PUBLIC HEALTH

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Background: Occupational epidemiology plays an important role in public health by describing and analyzing environmental and occupational hazards affecting workers, and sometimes the general public. Since the results of occupational epidemiology serve as the background for public policy making as well as individual worker and employer decisions, the accuracy of these studies is quite important. No previous studies have attempted to describe the occupational epidemiology literature.

Methods: This study examines author affiliation, funding source, outcome, and topic in two major occupational health journals published in the United States in order to describe the literature over the past three decades and to find associations between the stated variables. **Results:** Associations between U.S. industry funded or U.S. industry authored studies and outcome were observed, with an increase in negative outcome (pro-industry) studies as compared to U.S. federally funded or U.S. university authored studies. An overall increase in international sponsoring and performance of occupational epidemiology has also been observed over the past three decades.

Conclusions: The published occupational epidemiology literature in two U.S. journals demonstrated associations between funding source and outcome as well as author affiliation and outcome. Further research is recommended to follow up on the findings of this study.

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1.0 INTRODUCTION

> To originate an idea is a matter of luck or inspired intuition, to test it requires skill and objectivity; if properly done, the result is a contribution to knowledge. Thus, epidemiology, together with the complementary disciplines of physiopathology and toxicology, provide the scientific basis for medicine, and occupational epidemiology for medical practice as related to the interface between health and work (McDonald, 2000).

1.1 KEY CONCEPTS IN EPIDEMIOLOGY

Epidemiology is the study of the distribution and determinants of diseases within human populations. Research in this field is based primarily upon observing people directly in their natural environments or in hospital settings. While epidemiology is for the most part concerned with the etiologies of disease, it is also concerned with disease prevention (McDonald, 2000). The uses of epidemiology and epidemiologic methods include:

- Descriptive purposes, such as surveillance of the occurrence (incidence) of a particular illness.
- Analytic purposes, such as studying risk factors for disease development.
- Assessment of the performance of diagnostic tests.
- Study of the progression or natural history of a disease.
- Study of prognostic factors, which are determinants of the progression of a disease.
- Evaluation of treatments for a disease (Greenberg, 2007).

Likewise, a number of applications of epidemiology exist and include:

- Disease surveillance
- Searching for causes

- Diagnostic testing (screening)
- Determining the natural history
- Searching for prognostic factors
- Testing new treatments (Greenberg, 2007)

A unique subgroup within both epidemiology and occupational medicine is that of occupational epidemiology. This field applies the concepts of epidemiology and occupational medicine to working populations. Major objectives of this discipline include determining the health consequences of workplace exposures and recommending remedial efforts. Occupational epidemiology also provides data for use in setting standards for worker protection and makes projections of risk to the general population where exposure is generally lower than workplace exposures. Occupational epidemiologists are also involved in elucidating mechanisms of toxicity and dose-response relationships (Marsh, 2007).

1.1.1 History of epidemiology

Since epidemiology relies on observation rather than controlled experiments, this discipline has not always been viewed as a science. In fact, “[some], even in quite high places, would say it never has, perhaps without sufficient thought for whether there is any better alternative” (McDonald, 2000). That said, significant improvements in the methodologies used to conduct epidemiologic studies have been made in the past 50 years or more, and these advances certainly have contributed to the wider acceptance of the importance of epidemiology in elucidating risk factors for disease and determining disease causation. While many individuals have played significant roles in shaping epidemiologic and occupational epidemiologic thought, several of those people deserve mention in the context of this paper.

1.1.1.1 John Graunt

The origin of modern epidemiologic thinking has been traced back to John Graunt. On and off for over 100 years beginning in 1532, the town council maintained a weekly count of deaths and causes in London. John Graunt became interested in the fact that these records were maintained, and he began to use the data to draw certain conclusions about causes of death among sub-populations in London. Furthermore, Graunt demonstrated the need for caution in interpreting epidemiologic data. When more male than female deaths were observed, Graunt questioned the ratio of male to female births and found that, indeed, more males were born each year. Rather than making specific judgments, Graunt offered explanations for discrepancies between physicians' records and data (Monson, 1990).

1.1.1.2 Bernardino Ramazzini

Bernardino Ramazzini (1633 – 1714) is considered a founder of occupational and industrial medicine. Throughout his career, Ramazzini worked to determine the cases of disease related to occupation and industrial hygiene. He investigated environmental causes of disease in groups of individuals, whether workers or community members, with a particular disease outbreak. His most famous book, *De Morbis Artificum Diatriba (Diseases of Workers*), published in 1700, is the first comprehensive publication addressing occupational diseases. In this book, Ramazzini describes the health effects of various chemicals, metals, and other toxic substances experienced by workers in 52 different occupations. Named in his honor, the Collegium Ramazzini is an international council of scientists and experts created to advance the scholarly study of environmental and occupational health ("Who Named It? Bernardino Ramazzini," 2008).

1.1.1.3 Sir Percival Pott

Sir Percival Pott (1713-1788) played a major role in the history of occupational epidemiology as one of the first physicians to find a correlation between a particular cancer and an occupational or environmental cause. In an early epidemiologic study, Pott observed that chimney sweeps in England had higher rates of scrotal cancer than the rest of the population. Chimney sweeps, often young men, frequently had to climb naked into chimneys and consequently suffered prolonged exposure to soot, which we now know contains carcinogens (Hill, 1965). Pott proposed that chimney sweeps reduce their exposure by bathing more frequently, and as a result of improved hygiene, the observed rate of scrotal cancers in this particular group of workers declined dramatically (Doll, 1975).

1.1.1.4 Alice Hamilton

In her autobiography, Alice Hamilton, M.D. described the opportunities granted her to study the "dangerous trades of Illinois (Hamilton, 1943)." Disinterested in injuries and fatalities, Hamilton chose to pursue industrial poisonings in her work. She states in her book,

> It was a voyage of exploration that we undertook, our little group of physicians and student assistants, for nobody in Illinois knew even where we should make our investigations, beyond a few notorious lead trades. American medical authorities had never taken industrial diseases seriously, the American Medical Associations had never held a meeting on the subject, and while European journals were full of articles on industrial poisoning, the number published in American medical journals up to 1910 could be counted on one's fingers (Hamilton, 1943)."

Hamilton's investigations are best described as "shoe-leather epidemiology," lacking the sophistication and degree of detail found in modern occupational epidemiology; however, she is considered the founder of occupational medicine in the United States, and her work proved extremely valuable. Her studies yielded important information used to formulate safer work policies and practices, thereby improving the lives of countless industry workers. In addition, Hamilton was the first female professor at Harvard Medical School and the first woman to receive the Lasker Award in public health (Bois, 1997).

1.2 OCCUPATIONAL EPIDEMIOLOGY

The workplace becomes a useful setting for epidemiologic studies when the investigator wants to study *exposed* persons rather than *diseased* persons. Industrial workers may have daily exposures to a variety of factors, including chemicals, noise, dust, heat, trauma, physical exertion, or radiation. Conducting cohort studies within industry is a useful way to assess exposure and health effects over time; however, these studies may take decades in order to fully reveal the long-term effects of certain exposures. Fortunately, with the maintenance of some records for 30 to 50 years or more, occupational epidemiologists can define cohorts in the past rather than prospectively. Defining cohorts in this way reduces the need for decades of follow-up (Monson, 1990) and is a widely used technique in occupational epidemiology.

Some occupational health professionals argue that occupational carcinogens and malignant diseases receive a disproportionate amount of attention in the occupational health literature. Perhaps this focus on cancer reflects the relative ease with which an epidemiologist can study mortality versus morbidity, or maybe it simply reflects the interests of an aging population. Regardless, while the study of occupational causes of cancer remains important and useful, a host of other causes of long-term disability, including asthma, hearing loss, skin disorders, musculoskeletal disorders, and neurobehavioral toxicity, deserve more attention than they have garnered in the recent past (McDonald, 2000).

1.2.1 Role of occupational epidemiology

The results of occupational and environmental epidemiologic studies may exert effects in several arenas. First, clinical decision making may be affected. This holds true for many general epidemiologic studies and not just occupational epidemiology. The distinctive nature of occupational epidemiology arises from its critical role in government decisions and public policymaking. Findings in occupational epidemiology studies may impact court decisions. Legislative decisions may also be affected, especially when drafting new legislation and when voting on current bills. Occupational epidemiologic studies may have a bearing on the promulgation of executive orders by the President. Public policies within federal and state agencies are certainly affected by the findings from relevant studies. Individual industries and companies then experience significant downstream effects from policies set using data from occupational epidemiology studies.

Healthy People 2010, a national health promotion and disease prevention initiative, lists occupational safety and health as a major target area for improvement. In addition, the issues surrounding occupational safety and health overlap with a number of other specified target areas, including cancer, disability, environmental health, injury and violence prevention, respiratory diseases, tobacco use, and vision and hearing (CDC, 2006). Data on occupational safety and health are compiled by and are available from the National Center for Health Statistics, a division of the Centers for Disease Control and Prevention (CDC) tasked with monitoring the nation's health. This data includes a host of surveillance activities involving work-related injuries and fatalities, pneumoconioses, needle sticks, and the like. Clearly, surveillance is a major task of epidemiology and plays an important role in the acquisition of information related to occupational health and safety.

Whether or not results of occupational epidemiology studies can be appropriately applied to the general population is a topic of much debate and controversy. Defining exposures, measuring them cumulatively over long periods of time, and correlating them with health effects are difficult enough in industrial settings but virtually impossible in the general population. Since many environmental exposures and their health effects were discovered in workplaces, occupational epidemiology is viewed by some as the cornerstone of environmental health. Unfortunately, as long as study results cannot legitimately be generalized to the wider population, occupational epidemiology will not receive this recognition (McDonald, 2000).

1.2.2 Occupational epidemiology and the media

As seen in the press recently with diacetyl flavorings in popcorn and neuropathy in pork processors, results of occupational epidemiology studies can serve as fodder for the media. While the intentions of the media may be good – educating the public is a good thing – oftentimes their methods are less scrupulous. Furthermore, journalists do not always understand the nuances of epidemiologic data and can easily misinterpret study results and consequently mislead the public. Unsurprisingly, industry has grown wary about conducting or funding epidemiologic evaluations of employees. “[If] the research finds evidence of a health problem, [industry] will be the first to suffer, and if it does not, it will be said that they paid for it (McDonald, 2000).”

A public outcry based on heavy media attention to a particular problem may lead to negative attitudes toward an industry or its products and can furthermore result in the promulgation of regulations with potential disadvantages for the industry in question. Maintaining scientific integrity and communicating the results of occupational epidemiology studies to the media in language that journalists can understand and translate effectively for the lay public can decrease the likelihood that this sort of scenario occurs inappropriately.

1.2.3 Sources of occupational epidemiology

Researchers who perform occupational epidemiology can be found in several settings including academia, industry or private sector, and government. While in general the amount of occupational epidemiology performed has decreased over the past 20 years relative to the full "epidemiological pie" (Siemiatycki 2007), the University of Pittsburgh has maintained a strong program in occupational epidemiology and biostatistics. In February 2008, the Center for Occupational Biostatistics and Epidemiology (COBE) opened at the Graduate School of Public Health (GSPH). The center's researchers employ a collaborative, multidisciplinary approach to studying the long-term health effects of employment in a variety of workplaces ranging from jet engine manufacture to pharmaceutical production. Researchers also examine particular industrial exposures, such as formaldehyde, tungsten carbide/cobalt, and man-made mineral fibers, as well as community exposures to industrial pollutants or hazardous waste site contaminants to determine associations with specific health outcomes. This new center builds upon GSPH's commitment to performing high quality biostatistical and epidemiological analyses of workplace exposures and health outcomes. According to its Web site, the specific goals of COBE are to:

- Stimulate the pursuit of collaborative research aimed at integrating biostatistics, epidemiology, industrial hygiene and occupational health.
- Enhance collaborative opportunities and expand programmatic funding opportunities.
- Create a multidisciplinary research environment that fosters the career development of junior faculty and the training of graduate level scientists with interests in occupational health and environmental epidemiology.
- Facilitate recruitment of faculty outside of the biostatistics department who have research interests in occupational health and environmental epidemiology, including epidemiologists and industrial hygienists, and the translation of basic research in this area to public health practice.
- Provide the University community with professional expertise, infrastructure, and training to perform studies involving occupational health and environmental epidemiology ("Center for Occupational Biostatistics and Epidemiology (COBE)," 2008).

Corporate entities may hire their own epidemiologists to perform occupational studies; however, this practice does not appear to be commonplace. Agreements exist between academia and the corporate world, such as the partnership between Alcoa and Yale University. Since 1997, Yale has provided occupational health expertise to Alcoa through a variety of services and research ("Yale University School of Medicine to Provide Medical and Occupational Health Services to Alcoa," 1997). This type of collaboration between university and industry has a number of obvious advantages, including but not limited to the expertise provided by academic faculty members and the availability of funding and data from industry. The government is responsible for a significant proportion of occupational health studies, either via the provision of funds to universities or other research organizations or through performing its own studies, usually at the National Institute of Occupational Safety and Health (NIOSH). With increasing demand from other sectors for a dwindling research budget, as well as shifting priorities of the federal government, the proportion of occupational health research funded by the federal government may change in the future.

1.2.3.1 National Institute for Occupational Safety and Health

The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the CDC in the U.S. Department of Health and Human Services (DHHS). The Occupational Safety and Health Act of 1970 (OSH Act) created both NIOSH and the Occupational Safety and Health Administration (OSHA). OSHA resides in the U.S. Department of Labor and holds the responsibility of developing and enforcing workplace safety and health regulations. NIOSH, as part of CDC and DHHS, is an agency established to help assure safe and healthful working conditions for working men and women by providing research, information, education, and training in the field of occupational safety and health.

Information pertaining to the responsibilities of NIOSH are found in Section 22 of the Occupational Safety and Health Act of 1970 (29 CFR § 671). NIOSH is authorized to:

- Develop recommendations for occupational safety and health standards;
- Perform all functions of the Secretary of Health and Human Services under Sections 20 and 21 of the Act
    - Conduct Research on Worker Safety and Health (Section 20)
    - Conduct Training and Employee Education (Section 21)
- Develop information on safe levels of exposure to toxic materials and harmful physical agents and substances;
- Conduct research on new safety and health problems;

- Conduct on-site investigations (Health Hazard Evaluations) to determine the toxicity of materials used in workplaces (42 CFR Parts 85 and 85a); and
- Fund research by other agencies or private organizations through grants, contracts, and other arrangements.

The Federal Mine Safety and Health Amendments Act of 1977 delegated additional authority to NIOSH for coal mine health research. The mine health and safety law authorized NIOSH to:

- Develop recommendations for mine health standards for the Mine Safety and Health Administration;
- Administer a medical surveillance program for miners, including chest X-rays to detect pneumoconiosis (black lung disease) in coal miners;
- Conduct on-site investigations in mines similar to those authorized for general industry under the OSH Act; and
- Test and certify personal protective equipment and hazard-measurement instruments.

NIOSH provides national and world leadership to prevent work-related illness, injury, disability, and death by gathering information, conducting scientific research, and translating the knowledge gained into products and services. NIOSH's mission is critical to the health and safety of every American worker (CDC, 2008).

NIOSH performs field studies (Health Hazard Evaluations), surveillance activities, and industry-wide studies, but its capabilities are limited by funding and manpower. According to Kay Kreiss, MD, Chief of the Field Studies Branch in the Division of Respiratory Disease Studies at NIOSH in Morgantown, WV, the services NIOSH provides are but a “finger in the dike” and can only serve to stem the tide of occupational safety and health issues in the U.S. that need investigation.

1.2.3.2 Sources of data

Where does the data used for occupational epidemiology studies come from? An obvious source is records kept by industries and health professionals performing occupational health services. Undoubtedly, most occupational epidemiologic studies depend on company held records for enumerating cohorts, describing job histories, and estimating exposures. No specific standard for occupational epidemiology exists; however, some OSHA standards allow for data to be recorded, maintained, and provided to OSHA as needed for epidemiologic studies (OSHA, 2007). Since these standards only mandate the maintenance of records and require the transmission of records to OSHA or NIOSH only upon request by these agencies, one can only surmise that most of these records are not serving any useful epidemiologic purpose.

Certainly, unrecognized sources of occupational health data exist that could be tapped to increase the fund of epidemiologic knowledge, if only appropriate access could be obtained. Through the provision of records and funding, industry has played a major role in increasing the knowledge base pertaining to workplace exposures and health. Industry involvement in providing access to their records is crucial to any effort to increase occupational health knowledge. The regulations theoretically provide for this access, but in practice, a minority of these records has actually been used. Many of these records are undoubtedly maintained as hard copies filed in storage areas or are maintained in a manner not conducive to epidemiologic evaluation; however, the advent and increased use of electronic medical records could revolutionize occupational epidemiology, if appropriate access to the records is granted to the necessary individuals.

NIOSH defines occupational health surveillance as the "tracking of occupational injuries, illnesses, hazards, and exposures." The data obtained through surveillance activities are used to focus efforts to improve worker safety and health, monitor trends in injuries and illnesses, and track the progress of various programs designed to decrease the outcomes in question. Surveillance includes both population-based activities, including mandatory reporting programs, and individual-based activities, such as worker screening and monitoring. Individual-based programs serve the purpose of early detection of disease in individuals where early intervention can prevent further exacerbation (NIOSH).

1.2.4 Funding of occupational epidemiology

The National Institutes of Health (NIH) budget for biomedical research, in constant 2007 dollars, fell from $31.7 billion in fiscal year 2004 to $29.1 billion in fiscal year 2007. Under the current administration, the budget is projected to decline to $27.5 billion by fiscal year 2009, representing a five year drop of 13.4 percent (FASEB, 2008). As the trend in funding for biomedical research has by default shifted away from federal funding as the national budget for health-related studies has declined in recent years, other interested parties including foundations and industry have sponsored a more significant proportion of total biomedical research. Because of the potential regulatory and financial implications of occupational epidemiology research, industry has perhaps always played a more significant role in occupational health research than in some other health services areas. That industry should be involved in research which impacts the way business is done is natural and unavoidable. Even when industry provides no funding, occupational epidemiology relies on industry for access to cohorts of workers, job descriptions, and exposure monitoring data in order to complete studies. Industry's role in funding and performing occupational epidemiology studies is investigated in this paper.

The federal research budget for occupational health has come under attack in the not so distant past. Recent legislation attempted to reduce NIOSH's budget and virtually eliminate NIOSH's National Occupational Research Agenda (NORA). Launched in 1996, NORA is a unique partnership program designed to stimulate research and improve workplace health and safety. Through NORA, a diverse group of partners work together to identify critical issues and then develop goals and objectives for addressing them (CDC, 2007). While the recent attempt to derail NORA failed, NIOSH will certainly face future attempts to reduce its budget or perhaps eliminate the program, and possibly even the agency, entirely. In the face of declining federal funding, other sources of funding will need to be found to maintain or expand existing research efforts.

Whenever an industry funds research relating to its products or services, one must question whether bias exists. Most of the investigations looking at funding and outcome have focused on the pharmaceutical and medical device industries. In the United States, approximately 70 percent of clinical drug trials are funded by industry (Bodenheimer, 2000), and pharmaceutical companies provided 30 percent of the almost $100 billion spent on biomedical research in the U.S. in 2004 (Moses, 2005). Furthermore, a meta-analysis of 37 studies looking at bias in pharmaceutical research found significant association between industry funding and pro-industry conclusions (odds ratio [OR] 3.6; 95% confidence interval [CI], 2.63 to 4.91) (Bekelman, 2003).

Clifford et al. found that 66 percent of clinical trials reported in five major medical journals received some industry funding but that trial outcome was not associated with funding source. They also found that published trials were more likely to report favorable statistical conclusions with 67 percent of published studies favoring a new treatment and only 6 percent favoring the conventional treatment (Clifford, 2002). Other investigators have reached a differing conclusion that industry funding has led to pro-industry outcomes (L. Bero, Oostvogel, F., Bacchetti, P., Lee, K.. ; Davidson, 1986; Friedberg, 1999; Rochon, 1994), but these studies used different classification systems where industry-funded studies included investigations receiving *any* industry funding as opposed to *wholly* industry-sponsored studies. Nonetheless, a significant body of literature exists on sources of bias in the pharmaceutical industry, and it appears that funding source has been and continues to be a source of bias in clinical trials.

The field of orthopedics has recently begun to look at sources of bias as well. In 2003, Leopold et al. looked at the orthopedic research and found that published studies with commercial funding were significantly more likely to publish positive results, defined as significant or pro-industry, and recommended more research (Leopold, 2003). In 2007, members of the same group looked at all studies on hip or knee arthroplasty submitted to The Journal of Bone and Joint Surgery over seventeen months and found that commercially funded studies submitted were not more likely to conclude with a positive (significant or pro-industry) outcome and were no more likely to be published than negative outcome studies; however, commercially funded studies were more likely to be published following peer review (Lynch, 2007).

In addition, recent research in nutrition has found that industry funding of nutrition-related investigations may lead to biased outcomes that favor the products of the funding source. Lesser et al. found that scientific articles about commonly consumed beverages, when funded entirely by industry, were about four to eight times more likely to favor the financial interests of the sponsor, as related to articles with no industry funding (Lesser, 2007).

Industries that fund occupational health research may have a different perspective from the above examples where potential bias exists. Oftentimes, industry may try to document that certain exposures, such as chemicals or physical hazards, do not increase workers' risk of experiencing work-related injury or illness. Thus, industry would seemingly prefer a negative outcome, one that does not show an association between exposure and event. This paper delves into the question of industry funding of occupational epidemiology and whether a bias toward negative outcomes exists.

A research culture that protects an investigator's independence from the sponsor is imperative in creating successful, bias-free, industry-sponsored research. Theoretically, no problem exists if the industry provides the funds and access to records and data and steps out of the way, allowing the researcher to do an unbiased evaluation, reporting all results accurately and honestly. Allowing industry sponsors to get overly involved in the design, conduct, interpretation, or presentation of studies leads to problems of outright or perceived bias. Ethical occupational epidemiologists with experience conducting industry-funded studies generally have policies to protect their work from industry bias and methods for ensuring the validity of findings.

1.2.5 Challenges facing the occupational epidemiologist

Many unique challenges face the occupational epidemiologist. Teasing out what non-occupational factors versus what occupational factors may contribute to a disease process or condition can be quite difficult. Multiple exposures occur in the workplace, and the effects are often delayed. High workplace exposures are frequently not constant, and exposure levels can vary across time and among different groups of workers. The health outcomes studied may not be obvious, demonstrable disease but rather subtle physiologic changes. Practical issues exist with access to worker populations and exposure data. The healthy worker effect must be taken into consideration. Various subgroups, such as women and children, may require special attention (Marsh, 2007). In short, occupational epidemiology is a complex practice involving multiple challenges and considerations.

In addition, the occupational epidemiologist "sits rather uncomfortably between two groups of people with understandably strong views (Seaton, 2000)" – the workers exposed to hazards and their employers. The profits of industries, and consequently the prosperity of the entire nation, rely on the continued work of employees. Each group has its own agenda, and when posed with the same problem will choose different endpoints as acceptable outcomes. The need for solid epidemiologic data is clear: the data can provide a starting point for discussions and deliberation about how best to protect workers but also keep industry profitable. The best occupational epidemiology goes beyond "demonstrating that water from certain companies causes cholera but also [facilitates] removal of the pump handle (Seaton, 2000)."

1.2.6 Legal and regulatory implications of occupational epidemiology

Almost 40 years have passed since the OSH Act was signed into law, and OSHA and NIOSH were established. Since then, complying with workplace safety and health regulations has become a well-established part of running a business in the United States (Howard, 2007). A variety of groups and individuals ranging from employers to workers, labor unions, lawyers, occupational health professionals, industrial hygienists, and safety engineers need to understand federal and state regulations in order to adequately perform their jobs.

A unique characteristic of occupational epidemiology involves the use of study outcomes. The results of occupational epidemiology studies are used as the basis for and rationale behind public policy including laws and regulations. There are legal implications related to employer liability, worker's compensation, and disability, and clear financial implications as well. Given that occupational health research is so politically charged, can we rely on the findings of this research? Can we assume its objectivity? Are there evident sources of bias? These questions are important to address in any type of research, but the regulatory and financial implications of occupational health research in particular could have enormous significance for workers, industries, and nations.

A general feeling that the occupational health literature lacks objectivity and contains bias toward industry has been expressed. Occupational epidemiologists may serve as consultants to industry or as expert witnesses hired by industry. In addition, the journals that publish occupational epidemiology studies may have perceived or actual biases. One author expressed the following in a recent special contribution to an international journal:

> The [American College of Occupational and Environmental Medicine] "takes industry positions on virtually all issues, and its official journal, the Journal of Occupational and Environmental Medicine (JOEM), is decidedly pro-industry in its editorial policy and publications (Ladou, 2006)."

Very little research has been performed that analyzes the literature relevant to occupational health. The few studies that have been performed focus on analysis of the impact factor and its usefulness in selecting publications (Gehanno, 2000) or methods of performing effective queries for relevant occupational health studies in medical literature databases

(Schaafsma, 2007). The impact factor, a quantitative tool used for evaluating and comparing journals, measures the frequency with which an "average article" in a journal has been cited in a particular time period, usually a year. In general, the annual impact factor is a ratio of citations to recent citable items published. Specifically, the impact factor for a particular journal is calculated by dividing the number of current year citations to source items published in that journal during the previous two years by the number of articles published in the journal during those two years. Uses of the impact factor include market research for publishers and other interested parties, management of library journal collections, and academic evaluation. Since many factors may influence impact factor, any journal evaluation should not rely solely on this measurement and should include informed peer review ("The Thomson Scientific Impact Factor," 1994)

Quality issues in the occupational health literature have also been reported. Questions of data quality and study design must be addressed when evaluating any type of epidemiologic or statistical analysis (Rushton, 2000). Difficulty arises in performing a comprehensive evaluation of the occupational health literature because of the wide variety of disciplines pertinent to occupational health practice. Occupational health entails components of toxicology, environmental health, general medicine, emergency medicine, respiratory and critical care medicine, preventive medicine, and more. The diversity of disciplines that publish literature relevant to occupational health can be seen in the wide variety of journals that publish occupational health articles. Table 1 provides groupings of journals in which occupational health literature appears including the impact factors of the various publications. A strong fund of knowledge in occupational health draws at least somewhat from many, if not all, of the disciplines represented in these journals; however, the wide spectrum of journals publishing occupational health research demonstrates the practitioner's difficulty in staying up-to-date with all the latest studies in this field. The two journals analyzed and compared in this paper, American Journal of Industrial Medicine (AJIM) and Journal of Occupational and Environmental Medicine (JOEM) were selected from this list, since they represent the two American journals publishing the greatest number of articles relevant to occupational health.

Table 1 Periodicals classified by number of published articles related to occupational health in 1998 (Gehanno, 2000)

>100 Articles in 1998	*Impact factor*	*50–99 Articles in 1998*	*Impact factor*	*10–49 Articles in 1998*	*Impact factor*
Am J Ind Med	1.280	*Contact Dermatitis*	1.130	*Med Lav*	—
Occup Environ Med	1.681	*Int Arch Occup Environ Health*	1.252	*Am Ind Hyg Assoc J*	0.766
		J Occup Environ Med	1.671	*Ann Occup Hyg*	0.818
		Scand J Work Environ Health	1.708	*Lik Sprava*	—
		Med Tr Prom Ekol	—	*Int J Occup Environ Health*	—
		Occup Med (Lond)	0.540	*Occup Health Saf*	—
				Ind Health	—
				Med Pr	—
				Mutat Res	1.754
				Arch Environ Health	1.226
				Am J Epidemiol	3.773
				Am J Respir Crit Care Med	4.705
				Int J Occup Med Environ Health	—
				Allergy	2.015
				Health Phys	0.827
				Eur Respir J	1.923
				Pneumologie	—
				*Environ Health Perspect Suppl**	2.119
				J Allergy Clin Immunol	3.769
				American Association of Occupational Health Nurses Journal	—
				G Ital Med Lav Ergon	—
				Ergonomics	0.749
				Clin Exp Allergy	2.559
				*Environ Health Perspect**	2.119
				Spine	1.568
				Ugeskr Laeger	—
				Cancer Epidemiol Biomarkers Prev	2.932
				Environ Res	1.552
				Gig Sanit	—
				S Afr Med J	0.726

**Environmental Health Perspectives* and *Environmental Health Perspectives Supplement* are two distinct journals, with different subscription procedures.

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Because of the highly regulatory nature of occupational health and safety, the occupational health literature tends to be grounded in politics and public policy. It is both affected by and has implications for public policy in the arena of occupational health and safety and environmental health. Historically, different journals have had ties with different groups, and this may have had some effect on the content selected for publication in the various journals.

1.3 GOALS AND OBJECTIVES

This paper details an analysis of the two major occupational health journals published in the United States, the Journal of Occupational Medicine (JOM) which later became the Journal of Occupational and Environmental Medicine (JOEM) and the American Journal of Industrial Medicine (AJIM). The goals of this project are to:

- Identify sources of epidemiologic knowledge within the occupational health literature;
- Identify differences and similarities between two major occupational health journals, including sources of funding, author affiliations, and general topics of studies published;
- Determine if an association exists between funding source and reported outcome;
- Determine if an association exists between author affiliation and reported outcome;
- Determine the number and percentage of studies that do not reveal funding sources and the implications of this omission;
- Evaluate the basic topical categories to determine if differences exist for each journal, over time, and to what extent;
- Make suggestions for future areas of research related to the quality and characteristics of the occupational health literature.

A primary goal mentioned above is the determination of funding sources for each journal and whether an association exists between funding source and reported outcome. Lee et al. reported that about one-third of research studies in the medical literature (83 of 243 articles examined for their study) do not disclose a funding source and that disclosure of funding source is associated with study quality (Lee, 2002). The existing research looking at possible associations between funding source and study outcome have targeted clinical trials with the pharmaceutical industry being significant funders of this research, as noted previously in this paper.

With federal research dollars on the decline, industry has become an important source of funding for scientific research. Industry support of research has yielded numerous medical and scientific discoveries that may not have been elucidated otherwise. However, the funding of scientific research by industry has come under fire for a couple of significant reasons. First, and most obviously, a conflict of interest may exist if a particular industry is funding research on its own products or services. The sponsor of the research project may have a vested financial interest in the outcome of the study. Even if the study results are reported accurately, such conflicts of interest may shape the public's perception of the accuracy and validity of such research (Clifford, 2002). The International Epidemiological Association (IEA) most recently updated its guidelines for the conduct of epidemiologic research in November 2007. The IEA supports full disclosure of conflicts of interest, including financial conflicts of interest, among epidemiologic investigators and describes the freedom under which researchers should ideally operate:

> Researchers should have no undisclosed conflict of interest with their collaborators, editors, sponsors or participants in research. Thus, researchers must disclose actual, apparent or potential conflicts of interest to the Ethical Review Committee. All sponsorship of research should be publicly acknowledged – it is difficult to justify secrecy. All results of a study, whether government or industry-sponsored, should be the intellectual property of the investigators, not the sponsor. Requests to withhold findings, to change or tone down the content of a report to produce a misleading or delayed publication should be categorically refused (IEA, 2007).

Secondly, deficiencies in the design of industry-funded studies have been reported, most prominently in the pharmaceutical industry (L. A. Bero, Rennie, D., 1996). In this industry, a preponderance of published trials received funding from industry and has conclusions favoring industry. Explanations for this phenomenon include publication bias perhaps in combination with methodological problems identified in industry-sponsored research (Clifford, 2002).

Two American journals were selected for comparison on the basis of the number of occupational health studies they publish annually and their impact factors. In 1998, AJIM published over 100 articles on occupational health, and JOEM published somewhere between 50 and 99 articles (Gehanno, 2000). AJIM and JOEM were selected for analysis since they publish predominantly studies on occupational health, including many epidemiologic studies. In fact, according to a source at JOEM, they are direct competitors with one another in terms of impact factor. They were also readily available for analysis by the author and are the two most prominent occupational health journals published in the United States. This study evaluates various characteristics of the epidemiologic studies published in the two journals across time.

1.3.1 American Journal of Industrial Medicine

Originally published in 1980, the American Journal of Industrial Medicine is based within the Mount Sinai School of Medicine of the City University of New York in New York, NY, where its editor-in-chief, Philip J. Landrigan, MD, is Professor and Chair of Community and Preventive Medicine and Professor of Pediatrics. Dr. Landrigan is a pediatrician, epidemiologist, and internationally known and respected expert on preventive medicine and environmental health (MSSM, 2007).

According to the instructions for contributors page in each issue of the journal, AJIM publishes the following types of articles:

- Original research
- Review articles
- Instructive case reports
- Analyses of policy in the fields of occupational and environmental health and safety
- Commentaries
- Book review
- Letters of comment and criticism

The stated goals of AJIM are “to advance and disseminate knowledge, promote research and foster the prevention of disease and injury.” Specific topics of interest range from occupational and environmental disease, occupational or environmental epidemiology, and disease surveillance to very specific topics such as ergonomics, pesticides, and endocrine disruptors ("American Journal of Industrial Medicine: Product Information," 2008). AJIM’s impact factor for 2006 was 1.433, and its rank was 60th of 98 journals in the category of public, environmental, and occupational health (Thomson, 2007).

1.3.2 Journal of Occupational and Environmental Medicine

JOEM, formerly known as the Journal of Occupational Medicine (JOM), was originally published in 1959. JOM was published monthly by the American Occupational Medical

Association. The editor in 1980 was Lloyd B. Tepper, M.D. Its title became JOEM in 1995. Lippincott Wilkins and Williams, the publisher of JOEM, provides the following current description of the journal:

> The Journal of Occupational and Environmental Medicine is an indispensable guide to good health in the workplace for physicians, nurses, and researchers alike. In-depth, clinically oriented research articles and technical reports keep occupational and environmental medicine specialists up-to-date on new medical developments in the prevention, diagnosis, and rehabilitation of environmentally induced conditions and work-related injuries and illnesses. The Journal of Occupational and Environmental Medicine is an excellent source for new ideas, concepts, techniques, and procedures that can be readily applied in the industrial or commercial employment setting (JOEM, 2007).

JOEM is the official journal of the American College of Occupational and Environmental Medicine. Its editor is Paul W. Brandt-Rauf, MD, ScD, DrPH, who is currently Department Chair and Professor of Environmental Health Sciences at the Mailman School of Public Health at Columbia University. Dr. Brandt-Rauf has recently been named Dean of the University of Illinois at Chicago School of Public Health, effective July 1, 2008. Dr. Brandt-Rauf's specific area of expertise is occupational and environmental carcinogenesis ("Dr. Paul Brandt-Rauf Named Dean of the UIC School of Public Health," 2008). JOEM's impact factor for 2006 was 1.472, and its rank was 38th out of 98 journals in the public, environmental and occupational health category (Thomson, 2007).

2.0 METHODS

Full volumes of each journal for the years 1994 and 2006 were obtained. Baseline data were obtained from 1980 for JOM and 1983 for AJIM, based on availability of journals in the author's university library. All studies of an epidemiologic nature were selected for analysis. Only articles presenting new data or re-analysis of old data were included, and any review articles were excluded. Case reports and case series were included as were all major types of epidemiologic studies, including cohort (prospective and retrospective, case-control, cross-sectional, and clinical or intervention trials. The following variables were recorded for each article included in the study:

- Author affiliation
- Funding source
- Outcome
- General topical category

Each of the variables except for topical information was assigned a numerical code to simplify the data collection and make sorting and counting the data more efficient. Totals and percentages were calculated for each of the categories and variables.

Outcomes were classified as positive, negative, equivocal, or not applicable. For the purpose of this study, positive outcomes were defined as those where an association between an exposure or risk factor and an illness or injury was found such that increased presence of exposures or risk factors led to increased incidence of illness or injury. Positive outcomes for intervention or treatment trials were defined to mean success of the intervention or treatment. Applying the studied intervention or treatment was associated with reduced risk factors, reduced exposures, or reduced disease incidence. Alternatively, negative studies failed to document an association between exposures and illnesses or injuries. Negative outcomes for intervention or treatment trials were found where the intervention or treatment did not yield decreased risk factors, exposures, or disease. Equivocal studies were inconclusive or, in a few instances, had both positive and negative outcomes. The studies classified as not applicable included case reports, case series, and descriptive studies that do not elicit associations.

Intervention and treatment trials were included among the counts for the various categories of information gathered in this study, but due to the different meaning of “positive” versus “negative” outcomes between intervention or treatment trials and the other types of epidemiologic studies evaluated, intervention and treatment trials were excluded from statistical analyses looking at funding source or author affiliation and outcome.

Information on general categories of occupational epidemiology studies found in the selected journals was gathered as well. Studies were assigned to the category or categories which best fit the stated intent of the article. Occupational health articles will nearly always identify an at-risk occupation, so care was exercised in using this particular category. Studies were categorized as “at-risk occupations” when the study served primarily to investigate various exposures or risks within a particular industry or set of jobs within an industry, whereas, the category “toxic exposure” was used if particular chemicals or other types of exposures were the primary focus of the investigation. Many articles were categorized under more than one topic in order to capture additional information such as organ system investigated.

All articles of an epidemiologic nature in the AJIM for 1994 and 2006 and JOM for 1994 and JOEM for 2006 were selected and analyzed to obtain the above described information. Baseline data was obtained from AJIM for 1983 and JOM for 1980. Information was stored in tabular format in Microsoft Excel. Counts were obtained for each variable selected and percentages calculated based on the number of epidemiologic studies published in each journal for the selected year.

Statistical analyses were performed using Minitab to test for correlation between funding source and outcome as well as author affiliation and outcome. The Chi-square test was used when appropriate. Fisher’s exact test was employed when sample sizes were insufficient to use Chi-square.

3.0 RESULTS

The number of occupational and environmental epidemiology studies varied across the years investigated. In 1980 JOM published 44 epidemiology studies, whereas AJIM published 17 epidemiology studies in 1983, the closest available year for comparison. In 1994, JOEM published 66 occupational epidemiology studies compared to AJIM which published 115 studies. In 2006 JOEM published 88 studies while AJIM published 78 studies.

3.1 AUTHOR AFFILIATION

Table 2 shows the various affiliations of the researchers publishing occupational epidemiology studies in the two journals investigated. Since research is a collaborative effort, most studies had more than one author, frequently having more than one author affiliation as well. In an attempt to document the broad array of affiliations involved in occupational epidemiology, each author affiliation was counted, not just the primary author affiliation. Across all three decades, the most prominent affiliations included U.S. universities, U.S. federal government, international universities, international government agencies, and U.S. industry. University affiliated researchers predominated in the 1980s; however, the 1994 data demonstrates a decrease in university-authored studies. In 2006, 62.5 percent of occupational epidemiology studies published in JOEM was done by U.S. university researchers compared to 41.03 percent in AJIM. In 1994 and 2006, 47.0 percent and 53.9 percent of AJIM studies, respectively, were performed by international university researchers. In the same years, JOEM published 19.7 percent and 43.2 percent, respectively. While the characterization of published studies for AJIM and JOM differed in some significant regards in the 1980s, with JOM publishing more industry-authored studies and AJIM publishing more university-authored investigations, by 2006 the two journals were more evenly matched in terms of the distribution of author affiliations.

Table 2 Number and percentage of studies by author affiliation, journal, and year*

Author affiliation	AJIM 1983 N (percent)	JOM 1980 N (percent)	AJIM 1994 N (percent)	JOM 1994 N (percent)	AJIM 2006 N (percent)	JOEM 2006 N (percent)
University	12 (70.6)	22 (50.0)	41 (35.7)	25 (37.88)	32 (41.0)	55 (62.5)
Industry, private	1 (5.9)	10 (22.7)	4 (3.5)	9 (13.64)	3 (3.9)	8 (9.1)
Federal U.S. government	5 (29.4)	9 (20.5)	14 (12.2)	29 (43.94)	14 (18.0)	14 (15.9)
State government agency	0 (0.0)	0 (0.0)	4 (3.5)	3 (6.06)	3 (3.9)	9 (10.2)
International university	1 (5.9)	7 (15.9)	54 (47.0)	13 (19.70)	42 (53.9)	38 (43.2)
International government agency	1 (5.9)	4 (9.1)	36 (31.3)	11 (16.67)	16 (20.5)	17 (19.3)
International industry	0 (0.0)	1 (2.3)	1 (0.9)	0 (0.00)	2 (2.6)	3 (3.4)
International research organization	0 (0.0)	0 (0.0)	3 (2.6)	0 (0.00)	4 (5.1)	3 (3.4)
International agency, other (IARC, WHO)	0 (0.0)	0 (0.0)	1 (0.9)	2 (3.03)	1 (1.3)	1 (1.1)
Local agency	0 (0.0)	0 (0.0)	2 (1.7)	0 (0.00)	1 (1.3)	4 (4.6)
Advocacy group	0 (0.0)	0 (0.0)	3 (2.6)	0 (0.00)	0 (0.0)	1 (1.1)
Union, trade organizations	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.00)	1 (1.3)	0 (0.0)
Research/consulting group	1 (5.9)	4 (9.1)	4 (3.5)	2 (3.03)	5 (6.1)	4 (4.6)
Private practice/hospital	0 (0.0)	0 (0.0)	2 (1.7)	1 (1.52)	1 (1.3)	0 (0.0)

*Percentages do not add up to 100 percent, since many articles had more than one article affiliation.

3.2 FUNDING SOURCE

Historically, authors of scientific studies have not always disclosed their funding sources. In fact, the 72.7 percent of studies published in JOM in 1994 revealed no funding source. The figure for AJIM for the same year was 58.3 percent. By 2006, funding disclosure had improved; however, 27.3 percent of JOEM occupational epidemiology studies and 30.8 percent of AJIM studies still failed to disclose funding sources. Table 3 shows the percentage of studies by funding source, journal, and year. These percentages should be interpreted as the percent of published studies by journal and year receiving at least some funding from that source. All sources of funding were counted, including studies having more than one source. When the funding source was disclosed, the U.S. federal government was the most common provider of funds with similar percentages of federally funded studies from the 1980s and 2006. A dip in federally funded studies is observed in 1994 in both AJIM and JOM with 12.2 percent and 9.1 percent of occupational epidemiology studies receiving some federal funding, respectively. Industry has not been a major supplier of funds for the occupational epidemiology literature published in AJIM or JOM/JOEM. Except for the data from 1980 and 1983, JOM/JOEM published more U.S. industry-funded studies than AJIM, with that fact most evident in 2006 when 13.6 percent of occupational epidemiology studies in JOEM had at least some U.S. industry funding, while AJIM did not publish any studies with U.S. industry funding. International government agencies have sponsored an increasing number of studies published in AJIM. This source of funding increased in JOM/JOEM over the same time frame but never reached the same extent as AJIM.

Table 3 Number and percentage of studies by funding source, journal, and year*

Funding source	AJIM 1983 N (percent)	JOM 1980 N (percent)	AJIM 1994 N (percent)	JOM 1994 N (percent)	AJIM 2006 N (percent)	JOEM 2006 N (percent)
Federal U.S. government	6 (35.3)	14 (31.8)	14 (12.2)	6 (9.1)	28 (35.9)	32 (36.4)
Industry	2 (11.8)	4 (9.1)	9 (7.8)	3 (4.6)	0 (0.0)	12 (13.6)
State government	0 (0.0)	1 (2.3)	3 (2.6)	1 (1.5)	2 (2.6)	7 (8.0)
University	0 (0.0)	0 (0.0)	4 (3.5)	3 (4.6)	3 (3.9)	3 (3.4)
Foundation	0 (0.0)	1 (2.3)	3 (2.6)	1 (1.5)	1 (1.3)	4 (4.6)
International university	0 (0.0)	0 (0.0)	1 (0.9)	0 (0.0)	2 (2.6)	0 (0.0)
International government agency	0 (0.0)	1 (2.3)	18 (15.7)	5 (7.6)	19 (24.4)	9 (10.2)
International industry	0 (0.0)	0 (0.0)	3 (2.6)	0 (0.0)	1 (1.3)	2 (2.3)
International foundation, nonprofit	0 (0.0)	0 (0.0)	4 (3.5)	4 (6.1)	9 (11.5)	8 (9.1)
International agency, other	1 (5.9)	0 (0.0)	1 (0.9)	1 (1.5)	0 (0.0)	2 (2.3)
Local agency	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)
State agency, non-governmental	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Union, trade organization	2 (11.8)	0 (0.0)	3 (2.6)	1 (1.5)	0 (0.0)	0 (0.0)
No funding received	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.3)	0 (0.0)
Not specified	9 (52.9)	27 (61.4)	67 (58.3)	48 (72.7)	24 (30.8)	24 (27.3)

*Percentages do not add up to 100 percent. Some studies received funding from more than one source.

Over the three decades examined, the number of different types of funders increased. In the 1980s in both AJIM and JOM, most studies either revealed no funding source or were funded by the U.S. federal government. By 2006, the percentage of studies with no disclosed funding source and the percentage of studies with U.S. federal funding both declined concomitant with an increase in funding from other sources, including foundations, international government agencies, state government, and industry.

3.3 STUDY OUTCOME

Table 4 clearly demonstrates that most published studies have positive outcomes. The percentage of positive outcome studies has varied from as low as 31.8 percent in JOM 1980 to as high as 65.4 percent in AJIM 2006. The low percentage of 31.8 percent from JOM 1980 appears to be an outlier with the other journals and years yielding positive outcomes in 58.8 to 65.4 percent of studies. In each of the three years investigated, JOM/JOEM published more negative studies with 29.6 percent in 1980, 22.7 percent in 1994, and 15.9 percent in 2006. In comparison, negative studies published in AJIM made up only 11.8 percent in 1983, 14.8 percent in 1994, and 5.1 percent in 2006.

Table 4 Number and percentage of study outcomes by journal and year.

Outcomes	AJIM 1983 N (percent)	JOM 1980 N (percent)	AJIM 1994 N (percent)	JOM 1994 N (percent)	AJIM 2006 N (percent)	JOEM 2006 N (percent)	Total
Positive	10 (58.8)	14 (31.8)	72 (62.6)	30 (45.5)	51 (65.4)	57 (64.8)	234
Negative	2 (11.8)	13 (29.6)	17 (14.8)	15 (22.7)	4 (5.1)	14 (15.9)	65
Equivocal	3 (17.7)	8 (18.2)	11 (9.6)	5 (7.6)	8 (10.3)	9 (10.2)	44
Not applicable	2 (11.8)	9 (20.5)	15 (13.0)	16 (24.2)	15 (19.2)	8 (9.1)	65
Total	17 (100.0)	44 (100.0)	115 (100.0)	66 (100.0)	78 (100.0)	88 (100.0)	408

Figure 1 graphically demonstrates the percentages of the various outcomes by journal and year for JOM/JOEM and AJIM, respectively. In general, there are more positive outcomes reported for both journals, although in 1980 and 1994 JOM had lower percentages of positive outcome studies with 31.8 percent and 45.5, respectively, as compared to 58.8 percent and 45.5 percent for AJIM. In addition, JOM/JOEM has published a greater percentage of negative outcome studies as compared to AJIM for each of the selected years. JOM/JOEM published an increasing percentage of positive outcome studies, while AJIM published a similar percentage of positive outcome studies over the three selected years. In all three years, JOM/JOEM published a greater percentage of negative outcome studies than AJIM, although the difference between percentage of positive and percentage of negative outcomes increased for JOM/JOEM.

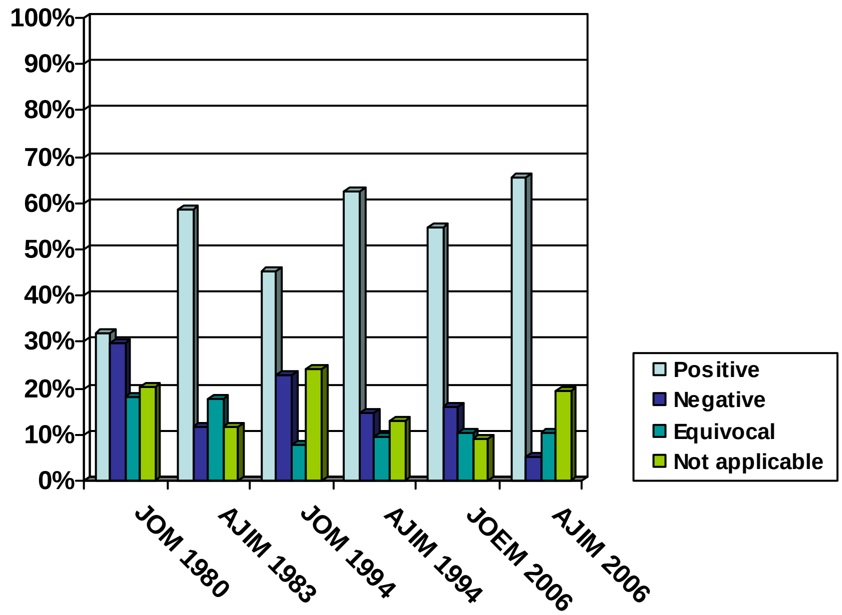

Figure 1 Outcomes by journal and year

3.3.1 Funding source and outcome

In addition to assessing study outcomes by journal, the major funding sources, including U.S. federal government, U.S. industry, and international government agency, were examined by journal and year. Figure 2 depicts federal funding and outcome for all U.S. federally funded studies reported in either JOM/JOEM or AJIM. Positive outcomes are most prominent with an increase in studies in the not applicable category in 1994.

Figures 3 and 4 look at U.S. federal funding and as it relates to outcome for each journal individually. While AJIM (Figure 4) consistently reported a majority of positive outcome federally-funded studies across all three years, JOM/JOEM (Figure 3) varied from year to year, publishing 50 percent in 1980, 16.7 percent in 1994, and 65.6 percent in 2006. In 1994, 66.7 percent of the U.S. federally funded studies fell into the not applicable category, meaning they were not analytic studies designed to determine associations.

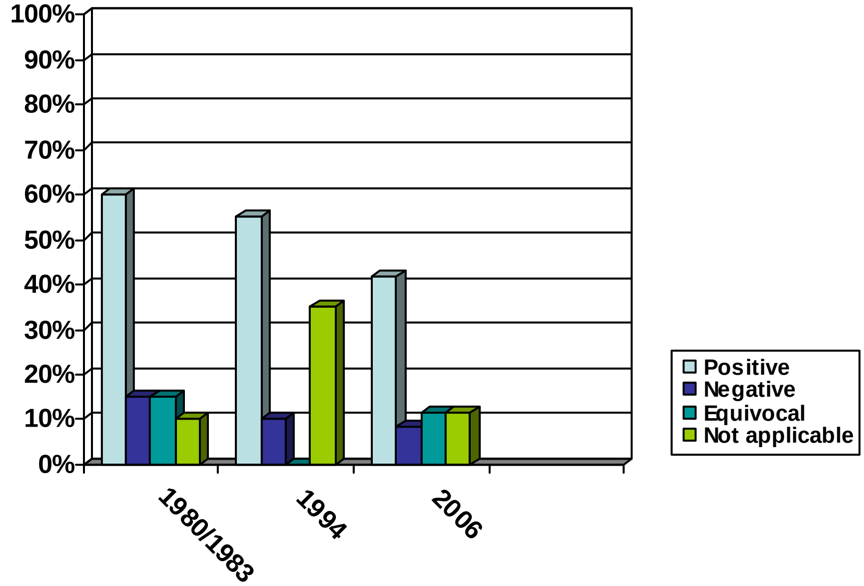

Figure 2 U.S. federal funding and outcome by year, both journals combined

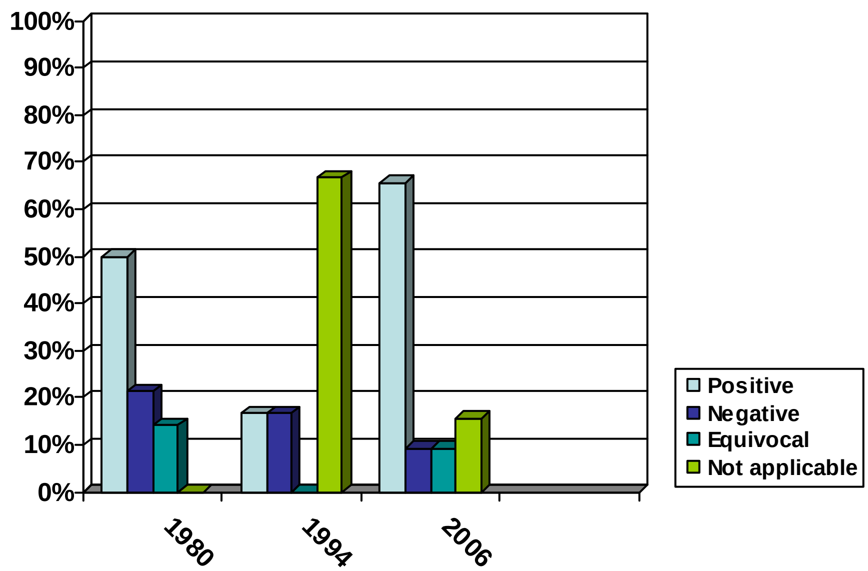

Figure 3 U.S. federal funding and outcome by year, JOM/JOEM

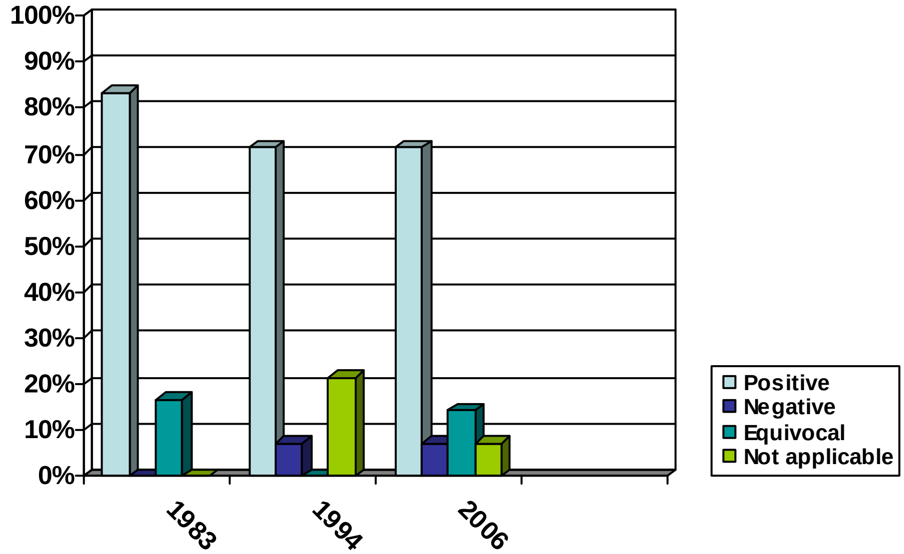

Figure 4 U.S. federal funding and outcome by year, AJIM

Figure 5 depicts U.S. industry funding and outcome reported in either journal. Except for the early years, 1980 and 1983, there are at least as many, if not more, industry-funded studies with negative outcomes as compared to positive outcomes. In 2006, 50 percent of the total number of industry-funded studies published negative outcomes, for both journals combined.

Figures 6 and 7 show the differences in U.S. industry sponsorship and outcome for JOM/JOEM and AJIM, respectively. Of its U.S. industry sponsored published studies, 50 percent in both 1980 and 2006 and 33.3 percent in 1994 had negative outcomes. For AJIM, only the 1994 data showed 33.3 percent of U.S. industry sponsored studies with negative outcomes. Otherwise, AJIM published no U.S. industry sponsored studies in 1983 or 2006.

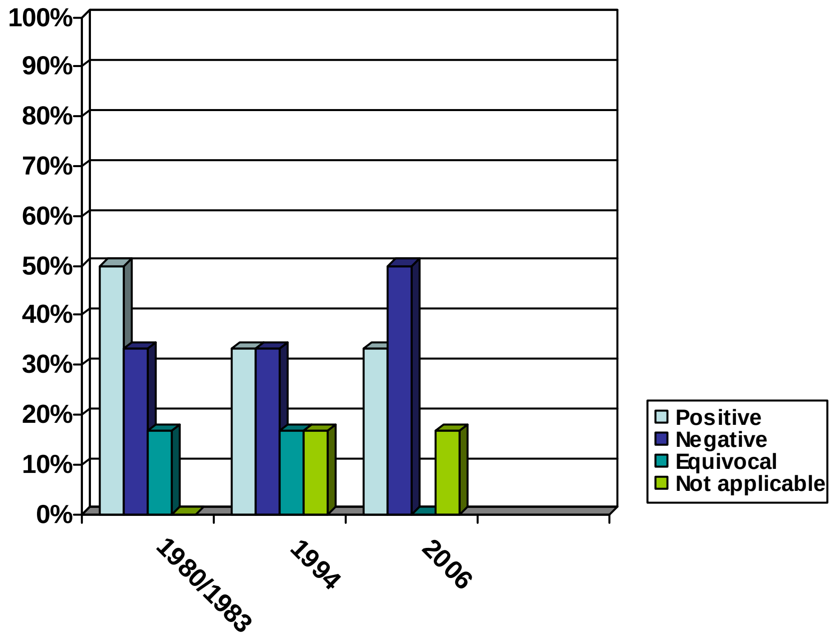

Figure 5 U.S. industry funding and outcome by year, combined, both journals

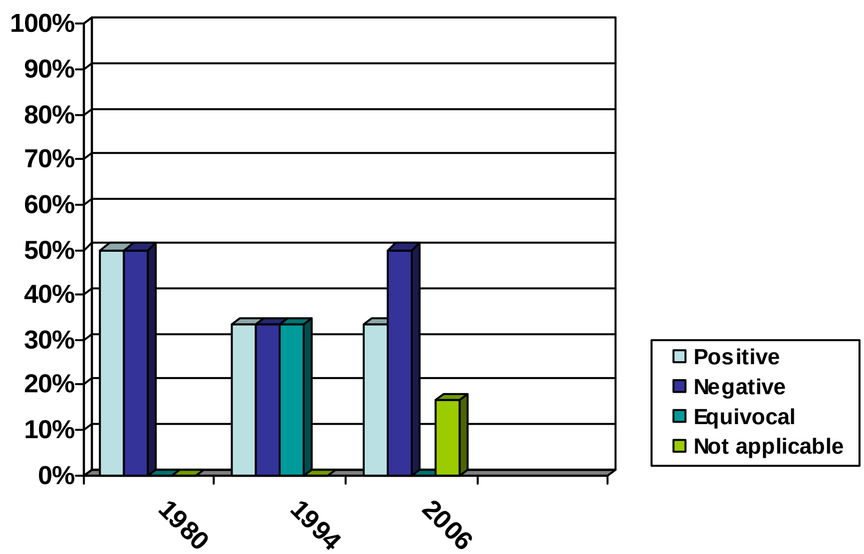

Figure 6 U.S. industry funding and outcome by year, JOM/JOEM

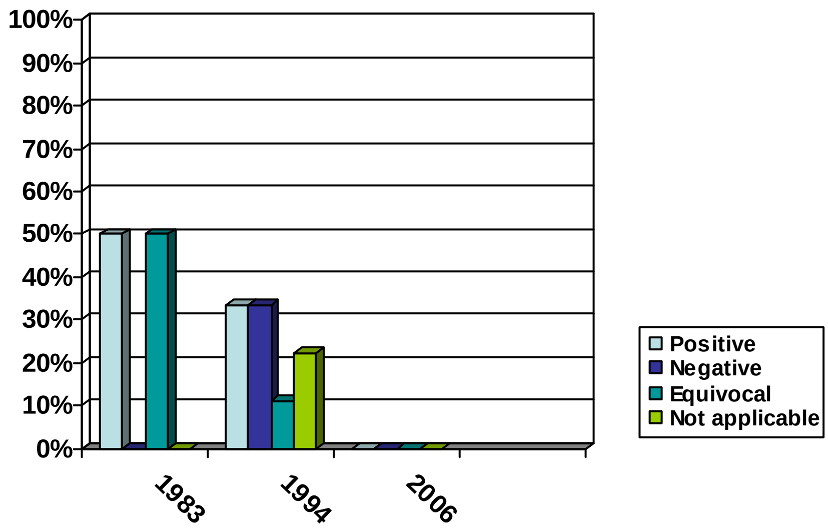

Figure 7 U.S. industry funding and outcome by year, AJIM

International government agency sponsorship of occupational epidemiology studies published in these two American journals has increased over the three decades studied. As shown in Figures 8 and 9, in 1980 (JOM) and 1983 (AJIM), no studies sponsored by international government agencies were published. Of the international government agency sponsored studies published in JOM in 1994, 40 percent had positive outcomes and 40 percent had negative outcomes. For AJIM in 1994, 56.3 percent had positive outcomes and 25 percent had negative outcomes. The picture in 2006 more closely resembles that of U.S. federal funding and outcome with a predominance of positive outcomes for both JOEM and AJIM.

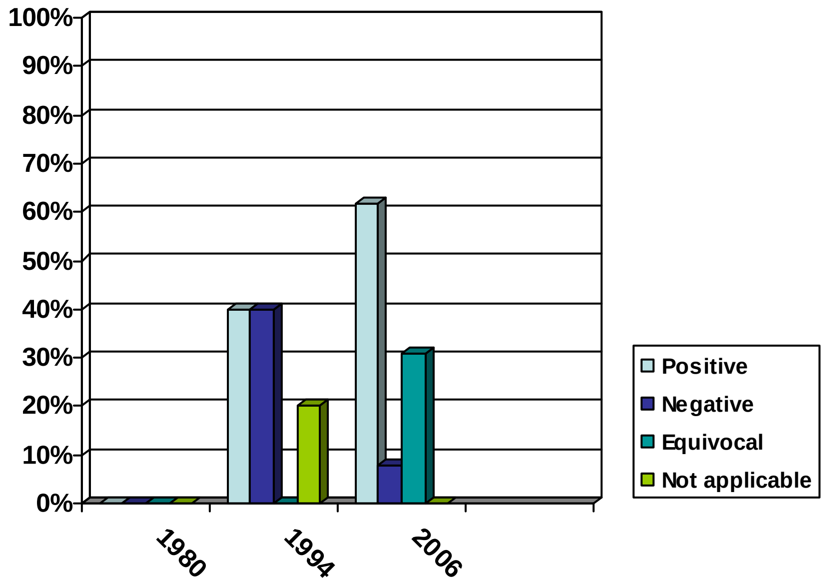

Figure 8 International government agency funding and outcome by year, JOM/JOEM

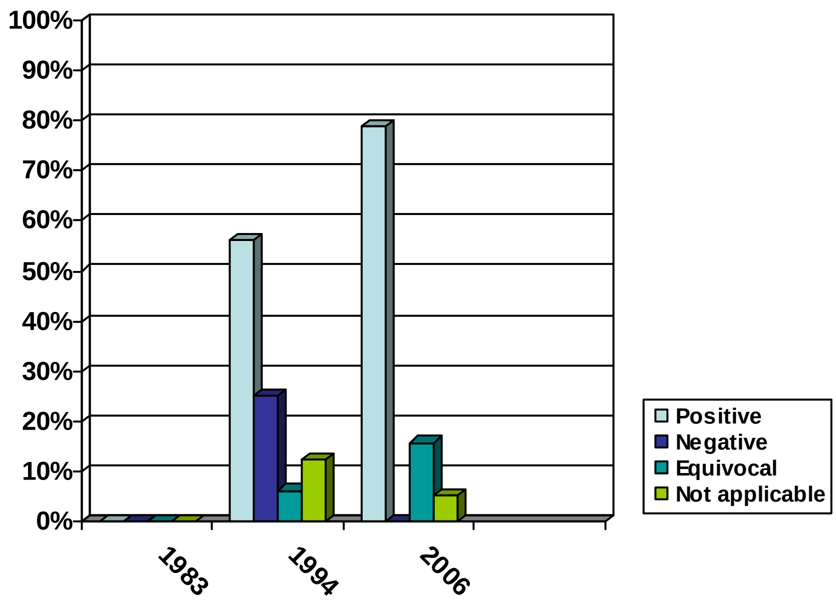

Figure 9 International government agency funding and outcome by year, AJIM

To determine whether an association between funding source and outcome exists, Chi-square analysis was performed. Since a positive or negative outcome for an intervention trial is defined differently than outcome for the other types of occupational epidemiology studies and the number of intervention trials in this study is relatively small, all treatment or intervention trials were eliminated. Also, all studies with more than one funding source (i.e., mixed funding) were eliminated. Studies that rejected the null hypothesis or, in other words, showed an effect between an exposure or risk factor and a health endpoint were categorized as positive. Studies that failed to reject the null hypothesis of no effect were categorized together as negative or equivocal in outcome.

Table 5 is the contingency table used to assess whether an association exists between the three major funding sources and outcome. Chi-square analysis reveals that funding source is not independent of outcome. In other words, an association exists between funding source and outcome (Chi-square = 16.86, d.f. = 2, p-value < 0.001).

Table 5 Major funding sources and outcome, all years combined.

Funding source	**Outcome**		**Total**
	Positive N Percent	**Negative/equivocal N Percent**	
U.S. federal	43 74.1	15 25.9	58
U.S. industry	3 20.0	12 80.0	15
International government agency	23 74.2	8 25.8	31

In order to determine which of the three major funding sources contributes to this association, two additional Chi-square analyses were performed using U.S. federal funding as the baseline and comparing it to U.S. industry and international government agency. When comparing U.S. federally funded studies and U.S. industry funded studies, there appears to be an association between funding source and outcome (Chi-square = 14.99, d.f. = 1, p-value < 0.001). In fact, U.S. federally funded studies are more likely to have positive outcomes than U.S. industry funded studies (odds ratio [OR] 11.5). U.S. industry funded studies are more likely to publish negative outcome studies (OR 11.5). Chi-square analysis of U.S. federal funding versus international government agency funding, however, fails to reveal an association between funding and outcome (Chi-square = 0.00, d.f. = 1, p-value = 0.995). U.S. federally funded studies are no more likely to have positive outcomes than international government agency funded studies (OR 1.0). In other words, both U.S. federally funded studies and international agency funded studies are more likely to have positive outcomes. Therefore, it appears that the relationship between funding source and outcome arises from industry funded studies, where more negative outcome studies are published relative to positive outcome studies.

The next step was to determine if a difference exists between the two journals in regard to outcome in industry funded studies. The sample sizes were too small to use a Chi-square test, so Fisher's exact test was employed. For all three years combined, no difference was found between JOM/JOEM and AJIM in regard to outcome for industry funded studies (p-value = 1.00).

Unfortunately, a significant percentage of the studies evaluated across all years did not reveal a funding source. Table 6 shows the number and percentage of different study outcomes by journal and year.

Table 6 Outcomes for studies with no specified funding source by journal and year.

Journal and year	Outcome			Total
	Positive N Percent	Negative/equivocal N Percent	Not applicable N Percent	
JOM 1980	7 25.9	14 51.9	6 22.2	27
JOM 1994	22 48.9	12 26.7	11 24.4	45
JOEM 2006	18 78.3	4 17.4	1 4.3	23
AJIM 1983	5 55.6	3 33.3	1 11.1	9
AJIM 1994	43 65.2	16 24.2	7 10.6	66
AJIM 2006	13 54.2	3 12.5	8 33.3	24

For most of the years analyzed, there are more positive outcomes than negative outcomes with the exception of JOM 1980 which has 51.9 percent negative outcomes versus 25.9 percent positive outcomes. The range of percentages of positive outcomes varies from 25.9 percent to 78.3 percent. The range of percentages of negative or equivocal outcomes varies from a low of 12.5 percent to a high of 51.9 percent. Study outcomes designated as not applicable make up 4.3 percent 33.3 percent of studies with no specified funding. The total number of studies with no specified funding is variable across time and journal as well with a high of 66 articles in AJIM 1994 and a low of nine studies in AJIM 1983.

3.3.2 Author affiliation and outcome

To determine whether author affiliation had any relationship to outcome, Chi-square analysis was performed using the data from Table 7. When looking at all years combined for both journals, there does appear to be an association between author affiliation and outcome (Chi-Sq = 13.34, d.f. = 4, p-value = 0.010). To further examine the relationship between author affiliation and outcome, a 2x2 contingency table was created comparing U.S. university and U.S. industry and outcome. Fisher's exact test revealed an association between funding source and outcome (p-value = 0.006). U.S university authored studies were more likely to have positive outcomes than U.S. industry authored studies (OR 8.6). U.S. industry authored studies were more likely to have negative outcomes (OR 8.6). U.S. university authored studies were somewhat less likely to report a positive outcome than international universities (OR 0.7) or international government agencies (OR 0.7).

After dividing the data by journal, however, there was no association between author affiliation and outcome for AJIM after excluding U.S. industry due to insufficient sample size (Chi-square = 0.397, d.f. = 3, p-value = 0.941, data not shown). There were only two studies performed by U.S. industry, each having a negative outcome, so these data were excluded. For JOM/JOEM, there does appear to be an association between author affiliation and outcome; however the statistical significance is borderline (Chi-square = 7.81, d.f. = 3, p-value = 0.050) the p-value only drops to 0.050 after combining international government agency and international university into one group to increase sample size. If U.S. industry is excluded;

however, no association between author affiliation and outcome is apparent (Chi-square = 2.32, d.f. = 2, p-value = 0.314). Furthermore, comparing U.S. university and U.S. industry for each journal using Fisher's exact test, there is no apparent association between author affiliation and outcome (p-value = 0.073 for AJIM, p-value = 0.133 for JOM/JOEM).

Table 7 Author affiliation and outcome, both journals, all years

Author affiliation	Outcome		Total
	Positive N Percent	Negative/equivocal N Percent	
U.S. university	40 65.6	21 34.4	61
U.S. industry	2 18.2	9 81.8	11
International university	39 72.2	15 27.8	54
International government agency	13 72.2	5 27.8	18

3.4 TOPICS OF STUDY

Table 8 shows general categories of topic of study and their percentages by journal and year. Some articles were categorized under more than one topic, so the percentages do not add up to 100 percent.

Table 8 General categories, number and percentage of studies by journal and year*

Topic of study	AJIM 1983 N (percent)	JOM 1980 N (percent)	AJIM 1994 N (percent)	JOM 1994 N (percent)	AJIM 2006 N (percent)	JOEM 2006 N (percent)
Toxic exposure	6 (35.3)	22 (50.0)	58 (50.4)	19 (28.8)	30 (38.5)	40 (45.5)
At risk occupations	10 (58.8)	16 (36.4)	21 (18.3)	7 (10.6)	25 (32.1)	12 (13.6)
Cancer, cancer mortality	6 (35.3)	9 (20.5)	21 (18.3)	23 (34.9)	9 (11.5)	18 (20.5)
Disability, Worker's Compensation, return to work	1 (5.9)	0 (0.0)	2 (1.7)	0 (0.0)	4 (5.1)	8 (9.1)
Psychiatry, neurobehavioral, neuropsychological	0 (0.0)	2 (4.6)	4 (3.5)	0 (0.0)	5 (6.4)	3 (3.4)
Productivity	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.5)	1 (1.3)	7 (8.0)
Obesity, BMI	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (3.9)	2 (2.3)
Air pollution	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (5.7)
Reproductive effects	0 (0.0)	4 (9.1)	3 (2.6)	2 (3.0)	2 (2.6)	2 (2.3)
Occupational injury, safety	0 (0.0)	0 (0.0)	3 (2.6)	4 (6.1)	10 (12.8)	2 (2.3)
Physical activity	0 (0.0)	2 (4.6)	0 (0.0)	1 (1.5)	0 (0.0)	2 (2.3)
Vibration	0 (0.0)	0 (0.0)	1 (0.9)	1 (1.5)	1 (1.3)	1 (1.1)
Hearing, hearing loss, noise	0 (0.0)	0 (0.0)	1 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)
Shift work, work hours	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.0)	3 (3.9)	1 (1.1)
Occupational health policy	0 (0.0)	1 (2.3)	2 (1.7)	0 (0.0)	1 (1.3)	2 (2.3)
Treatment, intervention trial, program evaluation	0 (0.0)	3 (6.8)	1 (0.9)	4 (6.1)	3 (3.9)	2 (2.3)
Renal, urinary	1 (5.9)	0 (0.0)	0 (0.0)	1 (1.5)	0 (0.0)	0 (0.0)
Respiratory	6 (35.3)	2 (4.6)	16 (13.9)	6 (9.1)	10 (12.8)	4 (4.6)
General mortality	4 (23.5)	0 (0.0)	15 (13.0)	4 (6.1)	3 (3.9)	0 (0.0)
Socioeconomic, psychosocial factors	0 (0.0)	2 (4.6)	0 (0.0)	0 (0.0)	2 (2.6)	1 (1.1)
Musculoskeletal disorders	2 (11.8)	1 (2.3)	4 (3.5)	6 (9.1)	7 (9.0)	3 (3.4)
Infectious disease	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.5)	2 (2.6)	0 (0.0)
Vision/ocular	0 (0.0)	0 (0.0)	1 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)
Study design	0 (0.0)	0 (0.0)	1 (0.9)	0 (0.0)	1 (1.3)	0 (0.0)

*Some studies had more than one topical category, so percentages do not add up to 100 percent.

Toxic exposure to various chemicals and substances is a prominent topic in the occupational epidemiology literature. At risk occupations is another topic consistently in the majority. Cancer and cancer mortality declined somewhat over the three decades but remained a significant percentage of published occupational epidemiologic studies in both journals.

Respiratory illnesses received more attention than musculoskeletal disorders, even though musculoskeletal disorders currently make up the larger share of occupational medicine clinical practice. General mortality studies were prominently used in 1980 in JOM but not so heavily relied upon in AJIM or in later years in JOM/JOEM. There are relatively few treatment or intervention trials published in either journal in any of the investigated years. Studies on disability, worker's compensation, and worker productivity have been more commonly published in recent years.

4.0 DISCUSSION

To the author's knowledge, this type of descriptive and analytic assessment of the occupational epidemiology literature has not been undertaken prior to this effort. In addition, no prior efforts to quantify the relationship between funding source and outcome in occupational health studies were found upon extensive searches of common literature databases, including Pub Med and Ovid.

A number of weaknesses exist in this study. First of all, descriptive data cannot be used to determine associations. A large part of this study is descriptive in nature. More questions were raised than answered from the descriptive data. Only one data collector was used, so potential bias exists based on the data collector's prior knowledge and opinions. A selection bias possibly exists in that the data collector may have included or excluded studies about which other researchers may have conflicting opinions. Along the same lines, data may have been incorrectly categorized. For example, a study may have been labeled as having an equivocal outcome when a different researcher may have categorized outcome as positive. Numerous possibilities for this type of error exist in this study.

The selection of years was done arbitrarily to have one year in each of three decades as equally spaced as possible, depending on journal availability, and may be a source of limitation for this study. The selected years may or may not actually be representative of journal trends. In particular, using only one year for baseline comparisons is problematic. An improved design might include using a probability sample of articles over three groups of years with three to five years in a group. This methodology would improve representativeness and account more effectively for time trends. Any future work in this area should incorporate improved methodologies, such as the one suggested, for more meaningful and accurate results.

Another area of weakness in this investigation is the lack of quality assessment. All studies were ranked equally with strong and weak studies receiving equal weight. Only published studies were examined, so a publishing bias most certainly exists. Certainly, some occupational epidemiology studies that are conducted never get reported, and this study does not capture this information.

This study suffers from the same problem that plagues many small studies. The sample sizes are small, and so achieving statistical significance is difficult. The sample sizes are particularly small among certain subsets of data, such as U.S. industry sponsored studies. Some years there were no or relatively few studies published. In addition, the question of potential industry bias proved difficult to assess with accuracy because the numbers of authors not reporting funding sources remained high, leaving a large gap in the knowledge of funding sources. Similarly, assessing changes over time in each journal proved difficult due to small sample sizes, particularly among industry funded studies. Expanding the data collection to include more years would help alleviate this problem.

The results of categorizing the collected studies by topic would have been more useful had the categories been subdivided by organ system or by broad areas of interest in occupational health research rather than combining everything together. Trends in subject matter for occupational epidemiology studies may have been obscured. Difficulty drawing conclusions about the data in its existing form limited the usefulness of this portion of the study.

The statistical methods used in this analysis, in particular the Fisher's exact test, have limitations. On the one hand, Fisher's exact test gives a conservative estimate of the p-value, but on the other hand, the sample sizes are small to begin with, and this leads to difficulty achieving statistical significance. A better statistical method to employ may have been logistic regression where multiple variables could be evaluated simultaneously.

This study demonstrates several key points about the occupational epidemiology studies published in the U.S. over the past three decades. The occupational epidemiology literature has changed over time. Who is doing the research has changed, as well as who is funding the research. The general topical categories have changed somewhat over time. These trends can be seen in the descriptive data collected; however, it proved difficult to assess time trends using analytic statistics due to small sample sizes in certain subsets of data.

In terms of author affiliation, U.S. universities and international universities perform the bulk of occupational epidemiology with the proportion done by international universities increasing, perhaps because of funding changes in the U.S. Both in terms of funding and performing published research, U.S. and international industry are actually minor contributors to the occupational epidemiology literature but have driven most of the discussion about sources of bias. Since a significant proportion of published studies do not disclose a funding source, questions remain about who is funding these remaining studies and whether the percentages of various funding sources found in this study are accurate.

Researchers commonly did not disclose funding sources in the studies examined from 1980, 1983, and 1994. By 2006, far more studies disclosed funding sources; however, roughly 30 percent of studies continued to not disclose funding sources. In general, the sources of funding have changed over time. The proportion of published studies receiving U.S. federal funds varied widely over the three decades examined with the nadir of U.S. funding occurring in 1994. As U.S. federal funding has declined, other sources of funding have played more prominent roles in sponsoring occupational epidemiology studies.

Most published studies have positive outcomes. U.S. federally funded studies and U.S. university authored studies were more likely to publish positive results, whereas U.S. industry funded and authored studies exhibited a greater tendency to report negative outcomes. JOM/JOEM published more industry-funded studies than AJIM, and this tendency was consistent across all three decades. Upon statistical analysis, in general, there appeared to be an association between funding source and outcome as well as author affiliation and outcome. This association was seen when all years were combined; however, when the data was subdivided into groups, whether by journal, funding source, or author affiliation, the association tended to disappear. When comparing U.S. federally funded studies and U.S. industry funded studies, a statistically significant association with outcome was apparent. For industry funded studies alone, no association was seen between journal and outcome. In other words, there was no difference between the two journals in regard to outcome of industry funded studies. Similarly, when comparing U.S. university authored studies with U.S. industry authored studies, a statistically significant association was seen between author affiliation and outcome. No association was seen between journal and outcome, however. Clearly, sample size is a problem with this study, and any future attempts to clarify the association between funding source and author affiliation should include a larger sample size.

Studies that did not report a source of funding also reported more positive than negative outcomes with the exception of JOM 1980 in which studies with negative outcomes predominated. Since industry-funded studies exhibited a tendency toward reporting negative outcomes, one may question whether the predominance of negative study outcomes among studies with no reported source of funding in JOM 1980 might imply that the studies with undeclared funding source might actually be funded by industry. On the contrary, most of the articles with unspecified funding had positive outcomes, and any inference about actual source of funding should be made with caution. Until journals imply stricter regulations about publishing articles only with adequate disclosure of funding and financial conflicts of interest will investigators actually be able to determine accurate relationships between funding source and outcome.

As can be expected, the topics of articles published over time change, as the major areas of interest within a health specialty change. Areas of previous interest that are now well elucidated command fewer pages of current journals. For example, vibration and hearing loss were major areas of occupational health and public health interest in the past but now represent a very small fraction, if any, of the current literature. Obesity and body mass index, as well as air pollution, were not represented in the journals during the years investigated until the current decade. Worker productivity is a major area of interest, both from a health standpoint (i.e. what causes productivity loss) and from an economic standpoint (i.e., how much do productivity losses cost), that became more prominent in the occupational health literature in the 1990s and 2000s.

Studies of toxic exposures show no consistent difference between AJIM and JOM/JOEM, but studies of at-risk occupations make up a larger share of the studies published in AJIM. These two categories of studies may be undertaken for different reasons. Investigations of specific toxic exposures may be conducted by industry in response to the threat of regulation or, conversely, by other groups trying to impose regulation in industry. These may be groups who are interested in documenting a threat to human health from a particular chemical. Studies documenting excess risk among workers in certain occupations or industries are undertaken for different reasons, often surveillance activities, and are less likely to be sponsored by industry. AJIM publishes a larger fraction of at-risk occupation studies than JOM/JOEM does, which is consistent with its smaller degree of industry funding overall.

4.1 RECOMMENDATIONS

This study provides baseline data and some preliminary findings which can serve to guide future investigations. Study quality is an active area of research and commentary in the fields of epidemiology and clinical research as well as occupational health. While a thorough evaluation of the quality of the literature published in these two journals is beyond the scope of this paper, an assessment of the quality of epidemiologic studies published will be a natural follow-up to the findings noted in this paper. Developing and validating or using an existing standardized method of assessing quality of epidemiologic studies will be necessary in order to complete this type of investigation.

This study had small sample sizes and could relatively easily be expanded by returning to the journals and evaluating more years, which would increase sample size. Evaluating other relevant journals and comparing them to the existing data would allow researchers to see what differences and similarities exist. Looking at international journals on occupational health would also add a different perspective to this study, which focused on journals published in the U.S.

From a public policy perspective, an interesting extension of this study would involve examining the context in which studies have been conducted and asking why particular studies were undertaken. For example, an investigator could look at occupational safety and health policies enacted and pending and how the published occupational epidemiology literature relates to the legislative and regulatory process. Are studies primarily done in reaction to various enacted policies or regulations, or are studies done in a proactive fashion intended to shape policy? How effective are studies in shaping public policy? These and other similar questions would make an interesting public policy investigation of past and current occupational health issues.

In an effort to encourage future work in this area, all data and information obtained from this study will be made available to investigators interested in expanding upon the existing database.

5.0 CONCLUSIONS

This study was undertaken in an attempt to describe the occupational epidemiology literature published in two prominent American occupational health journals, JOM/JOEM and AJIM. No prior analysis of this nature on this topic has been published to date. In addition to providing descriptive assessments, this paper attempts some basic statistical analyses in order to determine if associations between certain variables exist.

Important questions include whether an association exists between funding source and outcome and whether a relationship exists between author affiliation and outcome. When looking at combined data for all journals across all years, associations could be seen between funding source or author affiliation and outcome; however, analysis of subsets of the data often failed to reveal statistically significant associations. In all likelihood, insufficient sample sizes led to this problem, and increasing sample size in future studies will be a necessity. In general, it appears that U.S. industry, as a funding source and as an author affiliation, contributes to the association with outcome. The descriptive data reveals that U.S. industry studies, both funded and author-affiliated, have more negative outcomes when compared to U.S. federally funded studies or U.S. university authored studies.

The descriptive analysis also provides a broad picture of the changes in published occupational epidemiology over time. Changes in who funds these studies as well as what topics appear have occurred over the three decades analyzed. Improving the methodology involved in collecting topical data would make this part of the study more meaningful for future studies.

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