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Information Dissemination and Use: Critical Components in Occupational Safety and Health

P.A. Schulte, PhD,[1]* A. Okun, DrPH,[1] C.M. Stephenson, PhD,[1] M. Colligan, PhD,[1] H. Ahlers, JD,[1] C. Gjessing, BA,[1] G. Loos, EdD,[2] R.W. Niemeier, PhD,[1] and M.H. Sweeney, PhD[1]

Background *Information dissemination is a mandated, but understudied, requirement of occupational and environmental health laws and voluntary initiatives. Research is needed on the factors that enhance and limit the development, transfer, and use of occupational safety and health information (OSH). Contemporary changes in the workforce, workplaces, and the nature of work will require new emphasis on the dissemination of information to foster prevention.*

Methods *Legislative and regulatory requirements and voluntary initiatives for dissemination of OSH information were identified and assessed. Literature on information dissemination was reviewed to identify important issues and useful approaches.*

Results *More than 20 sections of laws and regulations were identified that mandated dissemination of occupational and environmental safety and health information. A four-stage approach for tracking dissemination and considering the flow of information was delineated. Special areas of dissemination were identified: the information needs of the changing workforce, new and young workers; small businesses; and workers with difficulty in understanding or reading English.*

Conclusions *We offer a framework for dissemination of OSH information and underscore the need to focus on the extent to which decision-makers and others receive and use such information. More solid data are also needed on current investments in disseminating, diffusing and applying OSH information and on the utility of that information.*

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INTRODUCTION

Despite decades of progress, workplace injury, illness, and death still exact a large toll [NIOSH, 2000]. As the U.S. economy dramatically changes, implementing successful strategies to prevent occupational morbidity and mortality could become more difficult. These changes include new methods of organizing the workplace, extensive labor contracting, worker shortages in various sectors, expansion of service and knowledge sectors, economic pressures from globalization, and an increase in small businesses [Judy and D'Amico, 1997; Westerholm, 1999; Cornfield et al., 2001; Norris, 2000; Rudiger, 2003]. Providing useful information to decision-makers (including employers, government officials, insurers, practitioners, unions, and workers) will be essential in addressing occupational safety and health issues in the future [WHO, 1995; Abeytunga et al., 1998; Pantry et al., 1999; Institute of Medicine, 2000; Lagerlöf, 2000b; Knave and Ennals, 2002]. Moreover, with the structure and

[1]National Institute for Occupational Safety and Health (NIOSH), Education and Information Division, Columbia Parkway, Cincinnati, Ohio
[2]U.S. Agency for International Development, Bureau of Economic Growth, Agriculture, and Trade, Washington, D.C.
All work was performed at NIOSH.
*Correspondence to: P.A. Schulte, NIOSH, MS-C14, 4676 Columbia Pkwy, Cincinnati, OH 45226. E-mail: pas4@cdc.gov

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nature of labor markets changing, workers want and are more empowered and qualified to seek occupational information directly rather than through intermediaries [Rudiger, 2003].

Information is a precondition for action [Takala, 1998]. It may be used to galvanize individuals and organizations or enhance the existing stores, but an analysis of the dissemination and utilization of OSH information has not been prioritized. Few systematic attempts have been made to broadly outline the requirements and flow of information in the OSH field. Moreover, investigators have made minimal efforts to comprehensively track the process of OSH research leading to knowledge, recommendations, practice, regulations, and impact.

Information is created by research, practice, and experience. The ''push'' and ''pull'' on information can be described as dissemination and information seeking, respectively. Dissemination is the process of transferring and distributing information. It can be focused or targeted, or occur spontaneously. Information seeking and use is the complement to information dissemination and involves the process ranging from perception of information needs to decision-making involving that information [Vakkari et al., 1997].

In this discussion, we plan (1) to identify the laws that mandate OSH dissemination, (2) describe attributes of OSH dissemination practices and uses, (3) delineate a framework for tracking dissemination efforts, and (4) present some areas where dissemination efforts should be emphasized to meet the needs of specific audiences. These include young and new workers; the changing workforce; small business; and workers' and employers' literary and language limitations. We are responding to a challenge offered at an international workshop on research dissemination [Lagerlöf, 2000a] which was that: ''One of the greatest problems in the occupational safety and health community is the lack of appropriate emphasis on research involved in dissemination, adaptation, and utilization of information.''

In the last two decades, parallel developments have occurred in information science and occupational safety and health. They involved a shift from source-oriented paradigm to a user-oriented one [Dervin and Nilan, 1986; Rudiger, 2003]. Thus, in information science, more attention is focused on how the cognitive interaction of people and information occurs [Rich, 1991]. In the workplace, workers are increasingly advocating to be actively involved in decisions on health and well-being [Rudiger, 2003]. Active interest in occupational health requires that the workers and employers have the right information at the right time to make decisions affecting health and safety.

Underlying dissemination are questions of how research information gets transferred and converted into usable and accepted practices. The focus of OSH research has historically been more etiologic than prescriptive [Wegman, 1992]. OSH research more often focused on identifying hazards and linking exposures to outcomes rather than describing effective methods of addressing and applying etiologic information. As a result, minimal data have been gathered on transferring research information into practice [Lagerlöf, 2000a]. Rantanen [1999] noted that ''such 'research' on research is relatively scarce, and even the paradigm for such studies is not well developed.'' In addition to the lack of research, only a few mechanisms exist that enable and actuate individuals or companies to share effective prevention measures [Linn and Amendola, 1998].

Production–Dissemination–Utilization of Information Cycle

The production, dissemination, and use of OSH data, information, and knowledge involves three interlinked

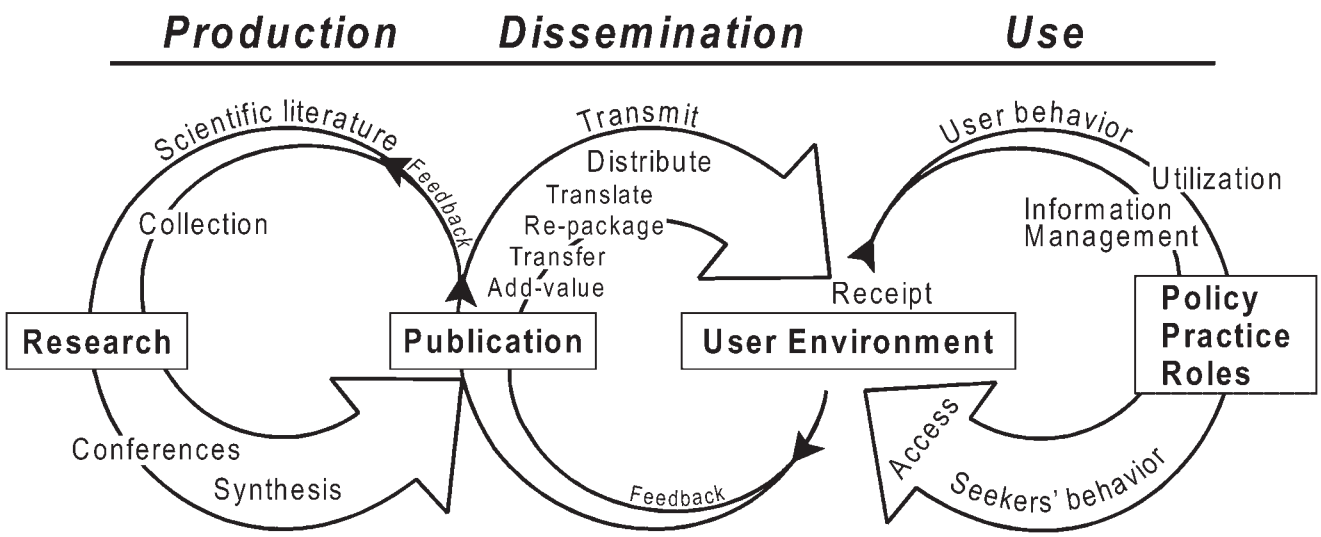

FIGURE 1. Production-dissemination-utilization of information cycle.

processes in a model depicted in Figure 1. This model is built on the work of Shannon and Weaver [1949], Robert [1983], Takala [1993], and Lagerlöf [2000b]. Information and knowledge are produced through research, collection, integration, synthesis, and publication. Value is added to information in the dissemination phase where it is transmitted and distributed, and given further context. Value is added by translating it from technical to general language, by repackaging it, by organizing it in databases and bibliographies, and by producing secondary and tertiary documents for specific audiences and users.

In some cases, the information is actively targeted to individuals, groups, and organizations. In other cases, it is part of the information or knowledge pool—the store of information that resides in databases, books, periodicals, collections, certification criteria, training materials, and general understanding [Cozzens, 1997]. This is then sought by people with information needs and seeking behaviors [Vakkari et al., 1997]. These behaviors are influenced by roles and contexts in which the seekers operate [Biddle and Thomas, 1966; Leckie et al., 1996]. Once information and knowledge is obtained, there is a process of utilization and impact on attitudes, practices, and policies [Weiss, 1981; Lagerlöf, 2000b; Rich and Oh, 2000]. In each of the stages, there is a feedback aspect. Every time information or knowledge is created or interacts with a person or situation its validity or appropriateness can be tested and the possibility of feedback arises, which can then result in new or modified information and knowledge. While this model has linear elements and builds on the source–message–channel–receiver model [Shannon and Weaver, 1949], it is more likely that all the stages are occurring simultaneously or at least, interacting with, or influencing each other [Lewenstein, 1999]. In practice, the boundaries of the science information process are permeable and information flows in all directions. For example, the user communities often have input in the OSH research by describing the needs for research. Disseminators interact with researchers to help translate research into tractable language and with users to segment (stratify into homogenous groups) audiences or tailor messages.

TAXONOMY OF INFORMATION DISSEMINATION

To understand the development, flow, and use of information in the occupational safety and health field, it is useful to have a taxonomy of different dissemination categories. Table I presents seven categories: they are not mutually exclusive but encompass approaches, channels, or interactions that have common features.

As preface to understanding the taxonomy of information dissemination, it is useful to consider the terms information, data, and knowledge. While these terms are often used synonymously or in overlapping fashion in the dissemination literature, they may be defined distinctly. The most common definition involves a hierarchy with 'data' defined as unorganized facts, 'information' as a composite of data and context, and 'knowledge' as information and judgment [Davenport and Prusak, 1997; Johnston and Blumentritt, 1998].

TABLE I. Taxonomy of Information Dissemination

- Information distribution
- Research and technology transfer
- Risk/health communication
- Training and education
- Campaigns/mass media/social marketing
- Networks/partnerships/communities of practice
- Diffusion of information

Information distribution is the dissemination of information by publication in journals, books, magazines, documents, brochures, CDs, posting on the web, in libraries, mailing and otherwise moving information from a source to various receivers, and audiences [Shannon and Weaver, 1949]. It is a process that can include tailoring information, segmenting audiences, and adding value to information. **Research transfer** is the process by which relevant research information is made available in a strategic manner for practice, planning, and policy making [Lagerlöf, 2000b; AWCBC, 2001; Lavis, 2003]. It is the process of transferring research to practice [Simpson, 2002]. **Technology transfer** in OSH is the application of new technologies or ideas to address workplace health and safety problems [Argabright, 1999].

Risk and health communication historically built on the transmission paradigm: the process or act of transmitting a message from a sender to a receiver through a channel that may have interference [Shannon and Weaver, 1949; Devito, 1986]. Other definitions focus on interaction between people through messages [Gerbner, 1967]. Risk communication is a process that characterizes hazards, risks, and risk-reducing actions. It is usually developed by technical experts and addressed to non-experts [NRC, 1989]. Health communication has been defined as the study and use of communication strategies to inform and influence individual and community decisions that enhance health [CDC, 2003]. **Training and education** are focused forms of dissemination. Training and education are generally conceived in the occupational field as worker (and employer) oriented or used in preparing OSH health professionals. Training workers involves instruction in recognizing known hazards and using available methods of protection. Worker education in contrast prepares one to deal with potential hazards or unforeseen problems; guidance is given in ways to become better informed and to seek actions eliminating the hazard [OTA, 1985; Cohen and Colligan,

1998]. The training and education of health professionals is generally a part of graduate degree programs to obtain competency and certification in a particular field [Institute of Medicine, 2000]. Applied to occupational or public health, **campaigns** can be defined as an integrated series of communication activities, using multiple operations and channels, aimed at populations or large target audiences usually of long duration with a clear purpose [Flay and Burton, 1990]. **Social marketing** is the application of commercial marketing technologies to the analysis, planning, execution, and evaluation of programs designed to influence the voluntary behavior of target audiences in order to improve their personal welfare and that of society [Andreasen, 1995]. **Networks/partnerships/communities of practice** involve interaction and relationship between senders and receivers [Wenger, 1998]. These interactive approaches can involve organizations and procedures for certification, conserving knowledge, mentoring, communicating, and transmitting cultural mores regarding OSH [Zohar, 1980; Wenger, 1998; Harris et al., 2000]. **Diffusion of information** is the process by which information or ideas spread from a point of origin to others [Rogers, 1983]. It can be both planned or spontaneous. A related term originally used by Rogers [1983] is ''diffusion of innovations.'' Diffusion is the process by which an innovation is communicated through certain channels over time among members of a social system [Rogers, 1983]. Information can be disseminated by all the methods described in this taxonomy; the method used will depend on the purpose of the sender or the needs of the receiver.

The implied purpose in most disseminations is that the information moves someone to action and, ultimately, this results in prevention or control of occupational disease. The action can be at the scientific level stimulating new research, it can be at organization level and form the basis of workplace safety and health policy, or it can be at the national level as a foundation for regulation or guidance.

Some dissemination methods are merely informational—others are meant to be persuasive or motivational. For information dissemination, evaluation may focus on the extent to which an information gap or need is filled. For a persuasive dissemination the evaluation may focus on change of attitude, skills, behaviors, or intentions [U.S. GAO, 2002].

LEGAL AND REGULATORY FRAMEWORK FOR DISSEMINATION

A broad range of legislation and regulations contain stipulations about disseminating and applying information concerning occupational and environmental health issues (Table II). This legislation includes the Occupational Safety and Health Act (OSH Act, Public Law 91-596) and various other laws and regulations focusing on the environment, workers, or hazards. From a legislative perspective, improved dissemination of information should encourage awareness, urge precaution, and lead to a reduction in occupational morbidity and mortality. However, dissemination practices have rarely been evaluated due to the complexity, difficulty, and expense of analyzing methods by which managers and workers receive and use information. In addition to laws and regulations, voluntary consensus standards (e.g., ANSI standards), corporate policies (e.g., Responsible Care®-American Chemistry Council), and labor and community organization health and safety practices historically stipulated large roles for information dissemination [Ashford and Caldart, 1985; Michaels et al., 1992; Tillett and Sullivan, 1993].

Numerous laws and regulations establish the requirements and authority of agencies to disseminate or require private sector dissemination of OSH information. Where government agencies are involved, the dissemination involves public information. The National Commission on Libraries and Information Science (NCLIS) recently reviewed the dissemination of public information and concluded that it should be formally recognized by the United States as a strategic national resource and reflected in appropriate statutory, policy, budgetary, oversight, and other contexts [NCLIS, 2001].

ATTRIBUTES OF OSH INFORMATION DISSEMINATION AND USE

Dissemination links information sources to individual workers, employers, unions, authorities, citizens, or other decision-makers [Takala, 1998; Lagerlöf, 2000b; Rich and Oh, 2000] and is only effective if information is received and used by target audiences [Lagerlöf, 2000b]. Information is a critical component of OSH decision-making, policy development, regulation, enforcement, compliance, coalition-building, training, education, and risk management in general.

Scientific literature has served as the main venue to disseminate OSH research findings and surveillance data. At least 155 journals publish OSH papers and approximately 35,000 OSH documents (papers, reports, pamphlets, fact sheets) are disseminated each year [Rantanen, 1999]. These data most likely serve as the basis for prevention and control recommendations by government agencies, unions, trade associations, insurers, coalitions, and employers. However, utilization of OSH information differs among users. Consequently, OSH data must be tailored to meet diverse needs ranging from workplace problem-solving to political efforts in securing resources [Papastavrou and Lehto, 1996; Abeytunga, 2000]. The ultimate goal of research and dissemination is to continuously improve and promote the safety, health, and well-being of workers [Atherly, 1998; Pantry et al., 1999; Kaukiainen, 2000]. However, research can have different functions for a particular user. Weiss [1981] has identified five functions of research: (1) instrumental,

TABLE II. Legislative and Regulatory Requirements for Disseminating OSH Information

Legislation	Information or training requirements
Occupational Safety and Health Act	
Public Law 91-596 http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=OSHACT&p_id=2743 U.S. Code Citation: 29 U.S.C. 651 *et seq.* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+29USC651 Section 20 (a)(7)(d) Research and related activities	Requires NIOSH to disseminate information obtained from this research and related activities to employers and employees.
Section 21 (a) Training and employee education	Requires the conduct or support of education programs to provide qualified personnel to carry out the purposes of the OSH Act, and information programs on the importance and proper use of safety and health equipment. Also provides for the establishment and supervision of programs for the education and training of employers and employees in the recognition, avoidance, and prevention of unsafe or unhealthful working conditions in employments covered by the OSH Act.
OSHA regulations 29 CFR 1910.1200 hazard communication (e) Written hazard communication program http://frwebgate.access.gpo.gov/cgi-bin/get-cfr.cgi?TITLE=29&PART=1910&SECTION=1200&TYPE=PDF	Requires employers to develop programs to make available information on hazardous substances and develop a written hazard communication program. Employers must also show how they will inform workers of hazardous chemicals and the hazards of nonroutine tasks.
Public Health Service Act	
http://www.fda.gov/opacom/laws/phsvcact/phsvcact.htm 60 STAT 421 as amended U.S. Code Citation: 42 U.S.C. 241 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+42USC241	Requires the Secretary of the Department of Health and Human Services to coordinate research and to collect and make available through publication and other appropriate measures the results of that research.
Presidential Memorandum (June 1, 1998)	
http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=1998_register&docid=fr10jn98-155.pdf	Requires the use of plain language in promulgating rules and regulations.
Federal Mine Safety and Health Act	
Public Law 91-173 as amended by Public Law 95-164 http://www.msha.gov/REGS/ACT/ACTTC.HTM	Requires mine operators to have a health and safety training program and requires the promulgation of regulations for health and safety training programs.
Section 115 (a) Mandatory health and safety training	Provides for mandatory training for miners, including the rights of miners, use of self-rescue equipment, hazard recognition, emergency procedures, and walk-around training on assigned jobs.
Section 502 (a) Training and education	Expands programs for educating and training operators and miners in the recognition and prevention of accidents and unsafe or unhealthful working conditions and in the use of detectors for methane and other explosive gases. Also provides for the establishment of a National Mine Health and Safety Academy.
Section 101 (e) Mandatory Safety and Health Standards U.S. Code Citation: 30 U.S.C. 813 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse_usc&docid=Cite:+30USC813	Every operator of a coal or other mine must establish and maintain records, make reports, and provide information to government agencies. These agencies are authorized to compile, analyze, and publish the reports and information obtained. Information and records obtained under this chapter may be published, may be released to any interested person, and shall be made available for public inspection.

(*Continued*)

TABLE II. (*Continued*)

Legislation	Information or training requirements
Toxic Substance Control Act	
Public Law 94-469 http://www.epa.gov/region5/defs/html/tsca.htm U.S. Code Citation: 15 U.S.C. 2601 *et seq.* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+15USC2601	Establishes and coordinates a structure for the exchange of research and development results on toxic chemicals among Federal, State, and local authorities.
U.S. Code Citation: 15 U.S.C. 2603 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+15USC2603	Includes ways to facilitate and promote the development of standard data formats, analysis, and consistent testing procedures as part of the research and development exchange structure.
Small Business Regulatory Enforcement Fairness Act	
Public Law 104-121 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=104.cong.publicLaws&docid=f:publ121.104.pdf U.S. Code Citation: 5 U.S.C. Sec 603 *et seq.* Section 203 Purposes http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+5USC603	Encourages the effective participation of small business in the Federal regulatory process, simplifies the language of Federal regulations affecting small businesses, and develops more accessible sources of information on regulatory and reporting requirements for small businesses. Also, each Federal agency shall endeavor to provide notice of each regulatory flexibility agenda to small entities or their representatives through direct notification or publication of the agenda in publications likely to be obtained by such small entities and shall invite comments upon each subject area on the agenda.
Solid Waste Act Disposal/Resource Conservation and Recovery Act II	
Public Law 89-272 as amended by Public Law 94-580 http://www.epa.gov/region5/defs/html/rcra.htm U.S. Code Citation: 42 U.S.C. 6977 http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+42USC6977	Training of instructors and supervisory personnel are required for persons in occupations involving the design, operation, and maintenance of solid waste management facilities and resource recover equipment.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)	
Public Law 96-510 http://www.epa.gov/superfund/action/law/cercla.htm U.S. Code Citation: 42 U.S.C. 9601 *et seq.* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+42USC9601	Training areas under this legislation include the safe packaging, loading, unloading, handlings, storing, and transporting of hazardous material and emergency preparedness for responding to an incident involving the transportation of hazardous materials.
Superfund Amendments and Reauthorization Act (SARA)	
Public Law 99-499 http://www.epa.gov/superfund/action/law/sara.htm U.S. Code Citations: 26 U.S.C. 9601 *et seq.* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+42USC9601 42 U.S.C. 9605 *et seq.* http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+42USC9605	Title III of SARA, as amended by CERCLA, provides a framework for emergency planning and preparedness and requires facilities to provide community groups with information on their inventories of hazardous chemicals and for manufacturers to report releases to the environment.
Health and Safety Standards in Building Trades and Construction Industry Act	
Public Law 91-54 http://www.dol.gov/esa/whd/contracts/cwhssa.htm U.S. Code Citation: 40 U.S.C. 333 (f) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi? dbname=browse.usc&docid=Cite:+40USC333	Establishes a program for the education and training of employers and employees in the recognition, avoidance, and prevention of unsafe working conditions.

TABLE II. (*Continued*)

Legislation	Information or training requirements
Longshore and Harbor Workers' Compensation Act Public Law 92-576 as amended by Public Law 98-426 http://www.dol.gov/dol/compliance/comp-lhwca.htm U.S. Code Citation: 33 U.S.C. 941 (b)(4) http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=browse.usc&docid=Cite:+40USC333	This section provides training and education of employers and employees in recognizing, avoiding, and preventing unsafe working conditions.

(2) political, (3) pedagogic, (4) interactive, and (5) tactical. Different dissemination strategies may be required for these types of functions.

Getting information to workers, employers, unions, trade and professional associations, coalitions, public health authorities, insurers, media, and the public are necessary to improve worker health. However, dissemination efforts face ''real world'' barriers [Michaels et al., 1992; Atherly, 1998; Vineis, 2000]. Critical to understanding the flow of OSH information is understanding the barriers to use of information. For example, information on practices that reduce risks of noise-induced hearing loss has been disseminated, but these practices have not been adopted by target industries at an appreciable level. The effectiveness of these practices does not appear to be an issue; however, economic, social, and political barriers to utilization are significant [Schneider et al., 1995]. Although the solutions are complex in many cases and may be outside the realm of communication efforts, a stronger emphasis is needed overall in terms of identifying the additional types of information required and determining how data are used by organizations and individuals in making decisions that impact occupational morbidity and mortality [Simard and Marchand, 1995; Sten, 1998].

Dissemination of etiologic information alone is not adequate to overcome barriers to action because the decision-making process for OSH is influenced by many factors. A company's decision to weigh scientific data for risk assessment and characterization against an allocation of resources for safety and health controls in the workplace presents a dilemma. Decisions can also be made at the levels of individual workers, employers, government agencies, unions, trades, or professional organizations. Information and guidance materials are needed at every level, but the type, content, and time often differ [Simard and Marchand, 1995; Hudspith and Hay, 1998; Vineis, 2000].

Disseminators and Receivers

Designated health professionals, workers, and other OSH personnel at the company, union, consultant, or health and safety group level have historically been the main recipients of OSH information. These target audiences disseminate and translate information to their respective constituents as well. In addition, product suppliers and trade associations play a large role in disseminating safety and health information, but the extent of these efforts have not been widely evaluated. Efforts to integrate relevant information and guidance into individual workplaces are affected by the following factors: (1) a growing body of evidence about new health disorders with varying degrees of relevance to work conditions and organization; (2) assessments of research and other materials for quality and relevance; and (3) integration of OSH management concerns into company decision-making processes [Westerholm, 1999].

The Internet is becoming a primary source of OSH information. The roles of OSH professionals and information specialists at the organizational level are expected to change from a central function to facilitator, trainer, coach, or mentor [Abeytunga, 2000]. In the future, reliance on the Internet by information customers will most likely be extensive. Future workers will undoubtedly consider the Internet as the first source for information. Dissemination on the Internet is generally considered to be passive, but list servers, video/net conferencing, and other interactive formats are available. Increasing adoption of broadband Internet access will augment the array of available resources. Easy availability of and accessibility to well-managed information can empower future workers and encourage life-long learning [Loos and Diether, 2001]. Despite the monumental potential of the Internet, however, a systematic assessment has not been made to date of how this technology is used in OSH and by whom [Abeytunga, 2000]. Employers will also use the Internet more for locating expert systems with specific workplace parameters. Web-based products may eventually serve as the main venue for OSH information. The nature and scope of OSH information on the Internet will be dictated by changing profiles, behavior patterns, and evolving needs of users [Abeytunga, 2000].

Increasingly, the Internet is the first step in information seeking. New partnerships and linkages such as the bilateral US-EU and Canada-EU efforts has created a network of

interlinked sites across the world—a global web portal for occupational safety and health. The Internet has caused primary users of OSH information to shift from professionals and subject specialists to include different populations with diverse backgrounds and experiences [Abeytunga et al., 1998; Abeytunga, 2000]. Workers and employers without formal training in OSH issues can now access this information. Information channels also are significantly changing as well. Most notably, the role of intermediaries in serving as a link between information providers and users is undergoing a radical transformation. Intermediaries traditionally disseminated information and knowledge, but this role has been expanded to an information and knowledge guide as well as an application designer [ISSA, 1996].

Failure to address the needs, capabilities, and receipt of information among target audiences will limit the progression from research to improved OSH. Comprehensive and multi-disciplinary approaches, including an understanding of the needs and behaviors of online information users, will be required to improve the health, safety, and competence of employees and managers [Rantanen, 1999; Westerholm, 1999].

Accessibility, Timeliness, and Utility

Highly technical research publications are often not accessible or understandable to those with a need for, or interest in, the information. Translating and synthesizing highly technical data into a more understandable and practical form is essential to providing timely, relevant, and usable information to decision-makers [NRC, 1989]. Accessibility will be enhanced by availability of the Internet to search and retrieve information [Agius and Bagnall, 1998; Herrick and Stewart, 1999; Stuart and Moore, 1999; Abeytunga, 2000]. Dissemination of information also requires an understanding of the preferred format by which information is delivered to and received by target audiences [Rothman and Kiviniemi, 1999].

Unfortunately, disseminators do not always provide necessary or appropriate information about particular hazards or controls. As a result, input and formative data from potential stakeholders are critical in developing and disseminating research and recommendations. Effective dissemination of information must be timely to allow decision-makers to take action. In this effort, data may need to be available in diverse formats, targeted to specific stakeholders and distributed under a multi-tiered strategy.

Well-designed campaigns to disseminate information may not lead to decisions, behaviors, or changes that will improve worker safety and health. These failures could be due to dissemination problems or barriers affecting the recipient's ability to implement, adopt, or act on warnings and recommendations [Shannon et al., 1997; Samuels, 1998]. To increase effective utilization of information, a strategy will be needed that combines enforcement, public awareness, technical assistance, and concerns by affected stakeholders of workplace hazards [Ashford, 1976; Linn and Amendola, 1998; Nytro et al., 1998].

Information Seeking Behaviors

Understanding information seeking behaviors of employers, workers, health professionals, and others is critical in developing information systems. A general model of information seeking behavior includes three elements [Wilson, 1981]:

(1) Information needs and drivers, that is, the factors that give rise to an individual's perception of need;
(2) The factors that affect the individual's response to the perception of need;
(3) The process or actions involved in the response [Wilson, 1997].

While there is a relatively large body of literature on information seeking, many of the studies remain unconnected by any larger framework or theoretical perspective [Leckie and Pettigrew, 1997]. Leckie and Pettigrew have developed a model of information seeking by professionals based on research on engineers, health care professionals, and lawyers. The model is underpinned by linkage to ''role theory'' which attempts to explain behaviors in different contexts such as professional roles in various specific organizational contexts [Biddle and Thomas, 1966]. Information seeking is also not linked to information dissemination in many models beyond what is implied by the ''receiver'' component in the transmission type models. While there is a growing literature on the information seeking behaviors of various professional groups, there is less available on information seeking by other types of workers. In a study by Yeatts and Hyten [1994] the importance of information gathering and communication skills has been demonstrated for high performing self-managed work teams. Subsequently, Barnes et al. [1997] building on the earlier research describe the information use environments of self-managed teams. High-performing teams were found to share characteristics of a very rich information use environment. They were effective consumers of information. They knew what information to gather and they knew where to get the information they needed [Barnes et al., 1997]. At a minimum, to account for information seeking behaviors in the OSH field, an approach comparable to a business marketing strategy could be useful to foster understanding of the needs of information users [Goodhue, 1995; Liverman et al., 1997]. This approach should include knowledge of the communication route, level of detail needed, types of information required, and barriers to retrieving data [Tsoukas, 1996; Liverman et al., 1997].

Barriers To Dissemination And Information Seeking

The process of dissemination can be viewed as consisting of three stages: transmitting or distributing information; the receipt of it; and the processing and ultimate use of it. There can be barriers at each stage. The information dissemination process also overlaps with the process of information seeking behaviors. The barriers to information dissemination include constraints and characteristics of the source. These can include limitations in the will to disseminate, inadequate resources, and the lack of knowledge of what to disseminate or how to do it. For example, OSH information from government agencies may not get to small business employers because they are not the focus of the information. The agency may not know how to reach the small business employers, and even if the employer is reached, the information may not be what is needed to make a decision.

In the terms of information seeking behaviors, the following categories of barriers have been defined: personal characteristics of the seeker; social and interpersonal characteristics; environmental or situational characteristics; and source credibility [Wilson, 1981]. The ultimate barriers are those that limit the information seekers from using the information in decision-making.

Dissemination and Adoption of Recommendations

A major purpose of dissemination is to transmit preventive recommendations to ensure guidelines are adopted and followed at individual, organizational, and societal levels [Simard and Marchand, 1995]. The ''stages of change'' model is useful in identifying an individual's tendency to adopt recommended behaviors [Prochaska and DiClemente, 1983]. For organizations, Beyer and Trice [1978], Maxfield et al. [1999], and others described a helpful stage of change model (Table III). The data show that dissemination and communication efforts at both individual and organizational levels can be targeted to the most receptive stage. Beyond the organizational level, changes that occur in OSH values are determined by a culture which produces risk, danger, and safety concepts [Lave and Wenger, 1991; Samuels, 1998]. To achieve a ''safety culture,'' information and knowledge must be circulated among individuals, communities, organizations, and institutions [Ashford and Caldart, 1985]. Consequently, understanding the dissemination pathways and utilization among individuals, organizations and society is critical.

Ultimately for recommendations to be adopted, there is a need for a clear path between the underlying research and the change of practice. Evidence-based decision-making in medicine has developed into a generally accepted method of linking the results of research to the practice of medicine. In the OSH field, there is a precedent for such activity in criteria documents that forms the basis for recommended standards and other systematic reviews relating to primary prevention [Zielhuis et al., 1991; Vineis, 2000]. However, evidence-based decision-making in OSH has not been the focus of much explicit attention until recently [Verbeek et al., 2002; Carter, 2000; Franćo, 2003]. In comparison with clinical research, the research for evidence in OSH differs in both the evidence-searching stage and evidence-appraisal stage [Franćo, 2003]. This is because, in clinical research, the paradigm has been the clinical trial, which is more difficult to find in the OSH field. Although, the area of ''intervention-effectiveness research'' is growing in that regard [Goldenhar and Schulte, 1994]. Evidence-based occupational health recommendations and practices will be influenced by the availability of databases and systematic reviews [Larsen and Jepsen, 2002; Verbeek et al., 2002]. Regarding evidence appraisal in OSH, evidence alone is not an adequate guide for action; factors such as applicability, economics, and other barriers are also involved [Franćo, 2003].

TABLE III. Stages of Organizational Change

Stage	Description
• Inaction	This stage is characterized by a lack of knowledge about the recommended policy or a perception that the policy or practice is irrelevant, overly costly or problematic to the organization.
• Advocacy	In this stage, individuals act as internal advocates for adopting the policy or practice in the organization. The effectiveness of advocacy efforts depends on several factors: specific risks; costs, influence, or power associated with adopting the policy or practice; or influence or power of the internal advocate.
• Consensus	Decision-makers in an organization achieve a level of consensus on an issue by moving to adopt a policy or practice. The consensus process can begin through a channel that is formal (e.g., employee health and safety committees in hospitals) or informal (e.g., prioritized by the CEO).
• Maintenance	The policy or practice must be maintained after being established. This stage is characterized by organizational systems for assigning personnel, continuing to allocate resources or enforcing policies.

Maxfield et al. [1999].

Sharing Best Practices

Practical solutions to reduce OSH hazards could be more effectively exchanged between companies and industries [Swuste et al., 1997]. Indeed, solutions to control occupational hazards have only recently received marginal attention in the professional and scientific literature. However, national and international efforts have been made to address the need to share knowledge about preventive measures [Swuste and Hale, 1994]. In the United States, several best practices conferences on ergonomics, noise, and other topics were recently convened. Internationally, there have been efforts to share potential solutions [Swuste and Hale, 1994] through development of databases, such as the Health and Safety Executive's and International Labour Organization's efforts on Control Banding [Jackson, 2002], and the EU-sponsored SolBase project [Tbnissen et al., 1998], to further develop a concept of participatory industrial hygiene [Zalk, 2002] and address information needs as well [OTA, 1995].

Dissemination through Education and Training

Education and training programs are another mechanism to disseminate OSH information. A culture that values OSH training is more likely to foster decisions which reduce morbidity and mortality. Effective training is believed to not only transfer information and skills to workers, but also to continually raise awareness about safety and health within organizations [Ford and Fisher, 1994; Nicolini and Mezna, 1995; Kennedy and Kirwin, 1998]. This theory requires a systems approach that promotes continuous learning to improve workplace safety and health. The focus for a continuous-learning climate extends beyond delivering data to forming, stimulating, and supporting communities with information, reinforcement, and resources. These communities are essential to the knowledge of an organization [Wenger, 1998; Gherardi, 2000]. Education and training efforts depend on communities for technical, professional, or organizational information.

Training also focuses on individual workers as stakeholders in safety and health performance throughout the enterprise [Abeytunga, 2000]. Notwithstanding the responsibility of employers to provide a safe and healthy workplace, a life-long learning approach to training and education is required. Of equal importance, as workers receive more information and responsibility, is the need to avoid blaming workers for OSH problems beyond their control.

The use of electronic technologies to disseminate information and a workforce oriented toward continuous learning has stimulated the growth of distance learning or distributed learning. This technology uses the Internet and CD-ROMs to train workers and employers in different geographical locations [Coldeway, 1989; Stuart and Moore, 1999]. These programs can also provide self-teaching courses and training modules. Distance learning is widely available and provides flexibility to students, but standards are lacking. Linking individual learning with organizational change may be difficult with this technology.

Like research on dissemination effectiveness in general, OSH training effectiveness research in particular is a significant data gap in the literature. Other research needs include an identification of linkages between training and practice as well as an examination of conditions that determine whether training sustains change at individual and organizational levels. OSH requirements and programs have rapidly increased, but data are limited in terms of effective models and complex factors that impact safety and health training effectiveness [Noe and Ford, 1992; Gotsch and Weidner, 1994; Johnston et al., 1994; Cohen and Colligan, 1998]. A recent effort to replicate research on training effectiveness emphasized a stepwise approach [NIOSH, 1999]. The training intervention effectiveness research (TIER) model describes a comprehensive approach from formative research to impact analysis.

FRAMEWORK FOR TRACKING DISSEMINATION EFFORTS

Laboratories and research organizations produce outputs in the form of scientific papers, recommendations, information, methods, tests, technologies, and devices. These products are considered to be immediate outputs [Geisler, 1996, 1998] that may advance along the innovative continuum to be applied and adopted by other researchers and organizations. Certain organizations will adopt, modify, and use immediate research outputs with the support of additional research and development of new organizational procedures, policies, regulations, and standards. Outputs that are transferred downstream are often modified by successive users. Until recently, however, no framework was established to identify and evaluate the downstream flow of information from producers of OSH research [Geisler, 1998].

Geisler [1995, 1998] has suggested a framework (Table IV) with four output categories to track the flow of OSH research that will lead to morbidity and mortality reduction. Each stage is conducted by a corporation, government, union, trade association, non-governmental organization, or another socioeconomic subsystem. The outputs in the framework are immediate, intermediate, penultimate, and ultimate.

Each stage in the framework creates a transformation activity that modifies the prior output to an input and eventual dissemination as its own output. Various mechanisms exist to monitor and encourage these dissemination and transformation efforts. One method is to first identify representative organizations and institutions at each stage

TABLE IV. Framework for Tracking Dissemination Efforts

Categories	Definitions/transformation	Examples
Immediate	Outputs from research include research papers, recommendations, and alerts as well as counts of papers, patents, ideas, methods, and prototypes of control devices. The recipients of these outputs could be anyone, but they particularly include other researchers, policy and decision-makers, workers, professional organizations, and government agencies.	An article is published in a peer-reviewed journal or is included in a bibliography.
Intermediate	Outputs of the organizations (governmental agencies, trade and professional associations, unions, etc.) that receive, adapt, and modify the immediate output of the research organization or primary researcher. These intermediate outputs could be recommendations, translations, lay documents, and guidelines.	OSHA issues a standard based on health effects research and using a NIOSH criteria document as a significant part of the rule-making process. A trade association or union newsletter article is published on new hazards. A National Safety Council or American Society of Safety Engineers employer/worker pamphlet is published. The American Conference of Governmental Industrial Hygienists establishes threshold limit values (TLVs).
Penultimate	Outputs from social and economic subsystems that incorporated the results from the organizations that developed the intermediate outputs. They could be employers, insurers, and municipalities that adopt the knowledge and recommendations in their policies, rules, regulations, and practices. Two broad factors may influence a company, business, or enterprise's incorporation of occupational safety and health practices: internal competence in occupational safety and health and external push and pull factors (customers, inspections, and business partners) [Nytro et al., 1998]	Corporate safety policies and manuals are published. Worker training activities are undertaken. Insurers require control technologies.
Ultimate	Outputs are the reductions in diseases and injuries, the improvement of worker health, the savings of compensation and insurance costs, and the increase in productivity [Geisler, 1995, 1999].	Positive results are reflected in reduced injuries, disease, and deaths in Bureau of Labor Statistics and in reduced workers' compensation costs.

Adapted from Geisler [1995, 1999].

and then to monitor transformation activities and the number of outputs and inputs at each stage [Geisler, 1995, 1998].

Problems with Measuring Outputs

Identification, access, and validity are problematic in terms of measuring sequential outputs [Geisler, 1998]. Identification is the process of determining outputs to be measured. Many organizations have developed unique methods to count and measure; therefore, universal comparisons may be difficult. Accessing organizations to collect output data may present a problem as well. Periodic surveys may provide some information, but these instruments may also be flawed in terms of accessibility and construct validity [Geisler, 1995, 1998]. There is a need for systematic approaches to measure information dissemination and impact. The OSH community should draw on expertise from areas and disciplines, such as information science, sociology of knowledge, diffusion of innovations, decision theory, communications theory, and others, to design research agendas on information dissemination and impact.

As outputs move downstream from immediate to ultimate and are absorbed and transformed by recipient organizations, a ''dilution effect'' may occur with respect to impact and the ability to measure contributions [Geisler, 1998]. A one-to-one relationship rarely exists between receipt of an input at one level and a corresponding output at another level. Measuring inputs and outputs of various recipient organizations is potentially useful for monitoring, but this approach does not necessarily indicate the full diffusion path or actual adoption of useful information

[Geisler, 1998]. A more comprehensive strategy to monitor dissemination can be developed from critical application of theories that attempt to explain methods by which individuals and organizations receive and accept new information or changes that occur in attitudes, behaviors, and practices. Examples of these theories include the transtheoretical model [Prochaska and DiClemente, 1983], organizational change theory [Beyer and Trice, 1978], theory of reasoned action [Hugentobler et al., 1992; Israel et al., 1992], diffusion of innovations theory [Rogers, 1983], elaboration likelihood model [Petty and Wegener, 1999], and PRECEDE-PROCEED theory [Green and Kreuter, 1991].

Tracking Expenditures for Dissemination, Diffusion, and Application

Translating information into communication and training products with demonstrated success is an expensive process; accessing data to track these costs is difficult. Moreover, tension may develop over the area to allocate resources and place emphasis, that is, research, dissemination, or surveillance [Lagerlöf, 2000b]. Improved monitoring of dissemination, diffusion, and application costs would help to inform these decisions. A better tracking system might also be useful for stakeholders to explore creative approaches for collaboration and funding of dissemination and application efforts.

SPECIAL EMPHASIS AREAS

Information Needs of a Changing Workforce

Rather than being static, the workplace and workforce are constantly changing. New OSH problems continue to be identified [Rantanen, 1999; Hernberg, 1999] and constantly affected by global economies. Diverse groups of workers with different information needs, literacy ranges, and skill levels are increasingly entering the workforce. By 2020, nearly one-third of the U.S. workforce is estimated to be foreign-born [Judy and D'Amico, 1997]. Many of these workers will be illiterate, semi-literate, or speak English as a second language. These demographics may require OSH information to be developed in a variety of languages, at different reading levels, and with a range of cultural sensitivities and disseminated by innovative means [Elkin et al., 2002]. The emergence of a world market has increasingly led to efforts to harmonize safety, health, and environmental practices and standards [Zielhuis et al., 1991]. Information dissemination and prevention programs will need to address the global scope and differences in information needs [Schulte, 2002].

Although a shift has occurred in the United States from industrial to service and knowledge products, this change is not uniform or representative of the entire economy. Current and future workers and workplaces reflect pre-industrial, industrial, technological, and knowledge activities; and there is a range of occupational hazards. While lead poisoning, accidental deaths, pneumoconiosis, occupational cancers, and injuries occur in some workforces, other areas experience cardiovascular, neurodegenerative, and psychosocial effects, such as stress, burnout, anomie, and decreased job satisfaction. Similar to most industrial countries, the United States is now faced with an ageing workforce, changing technologies, emerging environmental concerns, and rapid implementation of new information technologies. However, workers in coal mining, construction, health care, transportation, law enforcement and security, metals, electrical processing, farming, fishing, forestry, and other high-risk industries will continue to be at risk for occupational diseases, heavy physical work, and ergonomic stress [Watkins and Gutzwiller, 1999]. Hence, a broad range of information materials will be required to address this complex of OSH risks.

Training for Young and New Workers

Young and new workers are a critical audience for disseminating information through training. Most occupational injuries occur during the first year on the job, while the highest injury rates occur among workers 16–17 years of age [Castillo and Malit, 1997]. Stronger efforts are needed to integrate OSH information into vocational education programs, high school health curricula, and youth programs, such as 4-H and Scouts. This strategy could be effective in transferring information and increasing awareness of OSH. A systematic approach to OSH training for young workers is being driven by a new and voluntary effort to develop national standards of competence for occupations in all 16 economic sectors. OSH issues are being incorporated as core elements in national skill standards [Palassis et al., 2000]. Training programs to assist workers in meeting these standards will need to address safety and health. Efforts are also being made to develop new curricula for vocational and high schools that focus on occupational safety and health [ISSA, 2002].

Information Needs of Small Businesses

The majority of workers are employed in small businesses [Okun et al., 2001]. Providing OSH information to these companies continues to be a major challenge in the national effort to prevent occupational disease and injury [Zeimet and Ballard, 1998]. More than 30 years ago, the U.S.

Surgeon General emphasized the importance of city and county health departments providing health and safety information at the local level [DHEW, 1966]. *Healthy People 2000: National Health Promotion and Disease Prevention Objective* [DHHS, 1991] outlines the provision of programs in 50 states to provide consultation and assistance for small businesses to implement safety and health programs for employees. Implementation of OSHA consultation services [OSHA, 1997] assisted in achieving this goal.

The need to focus OSH expertise in small businesses is now established in many countries [Russell et al., 1998; Okun et al., 2001], but effective mechanisms to reach, assist, and impact these companies continue to be an area of uncertainty. To date, OSH research and interventions have been primarily based on lessons learned from large companies that maintain internal employee safety and health programs. Organizational interactions and communication channels that have been effective with large companies often do not exist in small businesses. Specific problems, limitations, and needs of small businesses have not been thoroughly examined; therefore, factors that increase the difficulty of small businesses recognizing and controlling workplace hazards should be characterized. Some recent characterizations generalized by Oldershaw [1997] have included: inadequate provision of hazard information; poor understanding of the hazard and exposure; and lack of expertise in risk assessment and risk control measures. Oldershaw [2002] has further expanded on these ideas with the following characterizations of small businesses: communications are oral and not written; there is a dependency on suppliers for information; literacy is generally poor; a belief exists that the chemicals being worked with are not dangerous; there is a poor knowledge of health effects but there is a better perception of acute rather than long-term effects; and controls are decided by custom and practice and not by risk assessment. Other data needs include research on methods to reach, influence, motivate, and assist small businesses and new strategies to foster communication.

Literacy and Language Limitations

Effective transfer, receipt, and utilization of OSH information will only be realized to the extent to which recipients actually can understand the information transmitted. Literacy is a limitation in this regard. Very few adult workers in the United States are truly illiterate. Rather, as the National Institute for Literacy concludes, there are many adults with low literacy skills who lack the foundation they need to find and keep decent jobs, support their children's education, and participate actively in civic life. The number of people who have these limitations is close to 90 million. For these workers, written material may be of little or no use [NIFL, 2003].

Increasingly, English may not be the primary language of many workers. A growing percentage of U.S. workers will have another language as their primary language and their facility with English will range from none to limited [NRC, 2003]. These workers will be predominantly Hispanic but the work force will also be characterized by workers whose first language is from countries such as Russia, Korea, Laos, Vietnam, and areas of Eastern Europe [NIFL, 2003]. In addition to linguistic literacy, some workers may have challenges to ''digital literacy.'' This is the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers [Gilster, 1997]. It has been estimated that about 22% of adults currently entering the labor marker possess the technology skills that are required for 60% of new jobs [Gupta and Ndahi, 2002].

CONCLUSIONS

Various laws and regulations require the dissemination of OSH information but little is known of the effectiveness of such efforts. Dissemination of OSH information and information seekers' behaviors has not been the focus of extensive scholarly assessment or research in OSH, but they should be. A multi-stage process based on data collected by Geisler [1995, 1998] is suggested as the framework for examining dissemination. The process traces OSH research and policymaking outputs from recipients who transform results for use or further dissemination effect to the ultimate goal of morbidity and mortality reduction.

Stronger data on current investments in dissemination, diffusion, and application of OSH information are needed to ensure allocations to these areas can be assessed. There is a need to invest resources in focusing information for young and new workers, workers with difficulty in reading or understanding English, and for employers and workers in small businesses. Ultimately, information development and dissemination should be considered as prevention tools and strategic plans should be developed to foster their development and use.

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