The Intervention Research Process in Occupational Safety and Health: An Overview From the National Occupational Research Agenda Intervention Effectiveness Research Team

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The goal of occupational safety and health intervention effectiveness research is to determine whether specific interventions work to prevent work-related injury and illness. But that is not the whole story. It is also important that the development and implementation of the intervention be evaluated. All three phases (development, implementation, and effectiveness) are central to a model of intervention research proposed by the National Occupational Research Agenda Intervention Effectiveness Research team. Areas for future research are also presented. (J Occup Environ Med. *2001;43:616–622*)

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The National Institute for Occupational Safety and Health engaged 500 stakeholders from the occupational safety and health community to help define a national occupational research agenda (NORA) to improve worker safety and health.[1,2] Twenty-one priority research areas were identified, of which intervention effectiveness research was one. The overarching goal of intervention effectiveness research is to demonstrate the impact of interventions to prevent work injury and illness. Conducting scientifically rigorous intervention effectiveness research is challenging because of the varied scope and complexity of interventions and the complicated, changing, real-world conditions potentially affecting interventions and their outcomes. Public funds for such research have been relatively scarce. Widespread recognition of this situation, and the increasing pressure to justify and improve safety and health investments, helped influence the selection of intervention effectiveness research as one of the NORA priority areas. This article presents a framework for understanding the process of intervention research in occupational safety and health. It is based on work done by the NORA Intervention Effectiveness Research Implementation Team, which is composed of persons drawn from the broad occupational safety and health

community, including labor, industry, academia, and government. An Overview of the Intervention Research Process

The team believes that intervention effectiveness studies must be considered within the context of the broader intervention research field. Research studies that inform intervention development, and studies that evaluate whether the intervention was implemented as planned, complement effectiveness studies. The relationships between three broad intervention research phases (development, implementation, and evaluation) are presented in Fig. 1 as the core of the NORA Intervention Effectiveness Research team's intervention research framework.

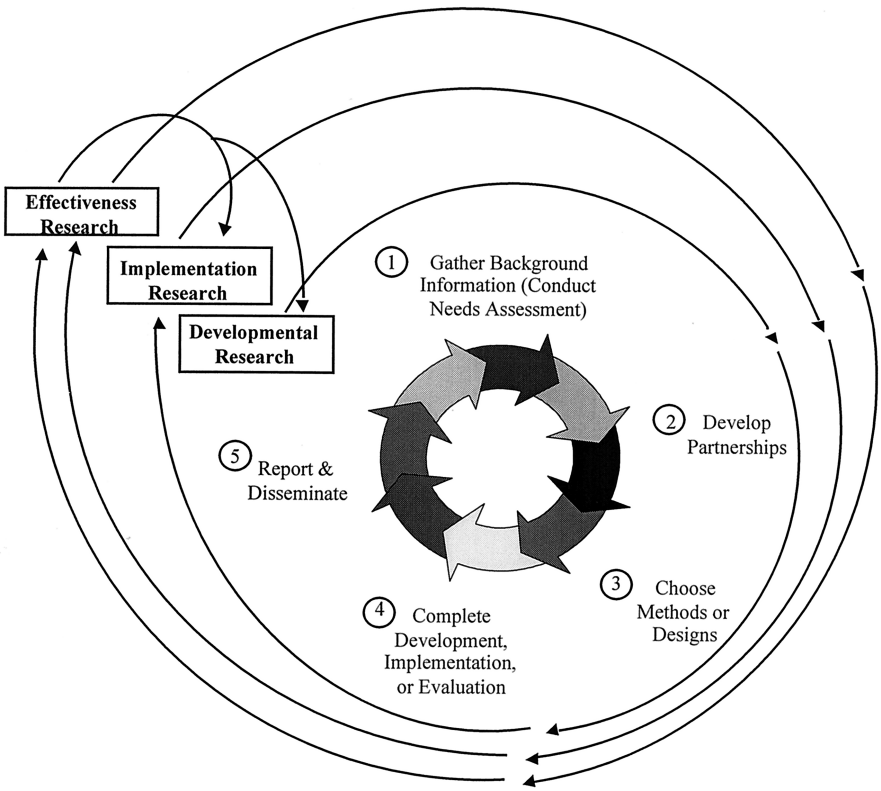

Fig. 1. The process: a conceptual model.

Intervention Research Process Phases

Intervention Development Research

Intervention development research studies provide answers to the following questions: (1) What changes are needed to enhance the health of the target population? (2) What are the best ways to bring about these changes? (3) What principles or theories in occupational safety and health and related fields might apply in a particular situation? (4) What barriers hinder the desired changes from happening? (5) To what extent does the target audience understand and buy into the need for the changes? Answers to these questions might lead to the development of new interventions or the selection, and possibly adaptation, of one developed previously.

To help answer these questions, one can look to surveillance and epidemiological data to ascertain and isolate the problem of interest and its cause(s), results of previous intervention research studies, information about the target population, theories, and other intervention frameworks.[3]

Analyze surveillance data. Surveillance is the systematic collection and analysis of information about disease, injury, risk factors, or exposures. This information can be used to guide the development of interventions. For example, Silverstein et al[4] examined how various health and hazard surveillance systems can guide the development of interventions to reduce work-related musculoskeletal disorders. Epidemiological studies, claims data, medical records and expert opinions provide additional information for intervention development.

What is the perspective of target population(s)? The knowledge, attitudes, and behaviors of the target population are critical for developing effective interventions. For example, Kidd et al[5] collected data from farmers using focus groups to explicate the link between psychosocial stress and injuries among farmers. This information was then used to develop specific intervention strategies that were consistent with occupational safety and health principles and the farmers' perspectives.

What is the context for the intervention? Intervention developers must understand the context in which the proposed intervention is to be tested. For example, Levenstein[6] states that standards-based regulatory approaches to occupational safety and health may be less successful when a government is committed to deregulation or an industry is faced with declining markets, because the support for occupational safety and health activities decreases. To obtain buy-in from stakeholders, the economic feasibility of implementing the intervention should also be addressed.

Translating theory into intervention. Rarely do authors provide a clear theoretical basis for selecting one intervention over another.[10,11] Too often, investigators do not even describe the intervention or address the issue of why or how it is expected to bring about the desired change. Well-designed, theory-driven, intervention development re-

search potentially increases the likelihood that an intervention will ultimately be effective because there is a greater level of understanding of how the intervention(s) might affect the target populations. Two vital issues must be addressed: (1) the best way to incorporate the theoretical principles/constructs into the intervention itself, and (2) the kinds of measurement tools that should be developed to assess any change in those constructs. Sinclair et al[7] describe how they incorporated theoretical constructs into a videotaped bloodborne pathogen training intervention and also how they developed ways to measure any change in those constructs. Other examples include how Leviton and Sheehy[8] applied behavioral theory to encourage small businesses to adopt effective technologies to prevent worker exposures to health hazards and how they used engineering theory and principles to develop and implement ventilation and equipment design changes to reduce asphalt fume emissions during road paving operations.[9]

Intervention Implementation Research Phase

Implementation research studies (also referred to as formative evaluation, process evaluation, program monitoring, and implementation assessment)[12–16] systematically document how an intervention is carried out. Weak, inconsistent, or nonexistent implementation is as common in occupational safety and health as it is in other contexts.[10,11,17] It is not recommended that a resource-intensive, time-consuming effectiveness study be conducted before determining whether the implementation procedures are sufficient. By documenting the experience of recipients/participants receiving the intervention, implementation research helps explain how and why changes were or were not achieved.[18] Implementation research helps answer such questions as (1) What are the components (eg, activities, materials, technology) of the intervention and how were they provided to the target audience? (2) What was the quality of the intervention components (eg, were trainers well qualified, was equipment properly calibrated)? (3) How many and who in the target audience experienced the intervention? (4) Did certain workers reject the intervention? (5) How did implementation of the intervention deviate from expectations, and why?

Implementation studies serve several purposes. First, they provide feedback for improving the intervention. The hazard communication standard of the Occupational Safety and Health Administration (OSHA) provides an excellent example of the value of a stand-alone implementation study.[19] A national survey of work establishments was conducted. Findings showed that roughly one fourth of responding employers were not providing hazard communication worker training and were therefore not complying with the standard. Overall, noncompliance with training, material safety data sheets, and labeling requirements was 53%, 46%, and 41%, respectively, suggesting that greater effort was needed to improve implementation of the standard before evaluating its effectiveness.

A second purpose of implementation research is to help interpret effectiveness study findings. For example, in an intervention study designed to reduce needlestick injuries among health care workers, injury outcome data showed a slight reduction in needlestick injuries. However, qualitative implementation data showed that for the intervention to be truly effective, managers needed a greater level of understanding of how to minimize employee risk and more training on how to share this knowledge with staff members.[20]

Finally, implementation research findings can be used to help replicate an intervention that has been shown to be effective in one context to another setting.[12] Implementation research findings can help others adapt an intervention to a new setting while avoiding pitfalls.

Intervention Effectiveness Research Phase

Occupational safety and health effectiveness research tells us the extent to which an intervention worked or did not work under *real-world conditions*. Effectiveness studies are also referred to as impact, outcome, or summative evaluation studies.[12,21] Determining whether an intervention is effective can be used to more effectively persuade decision-makers to invest in occupational safety and health interventions and intervention effectiveness research. Effectiveness studies answer such questions as (1) To what extent does the intervention reduce occupational injuries, illnesses, disability, or fatalities? (2) To what extent does the intervention reduce worker exposure to hazardous conditions? (3) What is the effect of the intervention on the social and economic consequences of work injury and illness (eg, worker compensation, medical and indemnity costs, quality of life)? (4) How have workers' knowledge, attitude, or behaviors changed because of the intervention?

Randomized, controlled trials are the accepted standard for determining cause and effect between interventions and outcomes. However, in the context of occupational safety and health, such studies are sometimes not feasible because of practical, ethical, legal, or other constraints.[22] Other design options (eg, quasi-experimental) and data collection methods (eg, qualitative case studies) can be used when randomized, controlled experiments are not possible. A sensible and economical approach to conducting occupational safety and health intervention effectiveness studies is to conduct qualitative and quasi-experimental studies first, followed, if feasible, by ran-

domized, controlled trials.[23] When experimental studies are not feasible, causal inference can be greatly enhanced by combining qualitative and quantitative approaches.[15,23–25] Some recent review articles provide overviews of effectiveness evaluation studies and strategies for occupational safety and health and other intervention contexts.[11,26–29]

Integrating the Research Phases

Ideally, developmental, implementation, and effectiveness studies would be conducted in sequence. The findings from studies in each phase would be used to revise the intervention development and implementation (Fig. 1), establishing a cycle of continuing improvement. This is analogous to (1) the Shewart Cycle for learning and improvement that is used widely in business,[30] (2) the public health surveillance feedback loop,[30] and (3) the reflection-action cycle of participatory learning.[31]

A recent study of an educational program to prevent low back injuries among postal workers provides a model of this integrated approach.[32,33] After reviewing the relevant epidemiological literature, the investigators conducted in-depth interviews with 4000 postal workers to identify the major behavioral risks for low back disorders. Potential barriers for performing safe lifting behaviors on the job were addressed, and suggestions were solicited from workers and their supervisors for overcoming these barriers. Using the PRECEDE model as the theoretical framework,[34] a randomized controlled study of a training intervention was designed and conducted. In addition, physical therapists followed up with, and provided feedback to, workers who had participated in the training by observing them as they performed lifting tasks. The effectiveness study led to the controversial conclusion that no long-term prevention of work-associated low back injury was associated with the training, as implemented. The combined developmental, implementation, and effectiveness studies provided the depth required to answer a number of criticisms of the study and its conclusions.[35–37]

A well-designed hazard communication intervention study provides another illustration of the value of integrating developmental, implementation, and effectiveness research.[38,39] An ecological model (accounting for the interplay of worker, organization, and environmental factors) was used to design a hazard communication program to reduce worker exposures and associated health effects (development phase) at a large multisite auto manufacturing company.[39] Worker training using adult educational methods was the primary intervention. Although all sites were supposed to get exactly the same program, the educational qualities of training varied considerably (eg, some sites provided more interactive, trainer-intensive sessions to smaller groups).[38] Luckily, the investigators also carefully tracked the intervention's implementation at each site. Changes in work practices and working conditions (proxies for decreased exposures and health impacts) were measured at follow-up to assess effectiveness. Interactive, small-group training methods were most strongly associated with the desired changes in work practices and working conditions.[38] Thus, in addition to demonstrating program effectiveness, the implementation evaluation of this intervention allowed the investigators to identify attributes of the intervention delivery that were most responsible for its success.

Intervention Research Tasks

The framework (Fig. 1) illustrates a set of five central tasks to be carried out in each research phase. All of the tasks are equally important for optimizing the quality and impact of intervention research.

Gather background information. Background information is gathered to help characterize the problem and its history, the range of intervention alternatives, and the sociopolitical work and evaluation settings (eg, labor-management relations, different evaluation agendas among stakeholders).[40,41] Questions include (1) What is the evaluation history of this intervention? (2) Have implementation or effectiveness studies been conducted on similar interventions in the past and, if so, what insights from previous studies can be applied? (3) What is known about intervention options, their application, their efficacy (effectiveness tested in a controlled environment), and their effectiveness (effectiveness tested under real-world conditions), including the economic, cultural, political, and other environmental conditions that might effect the interventions' implementation and effectiveness? (4) What is the quality of the data already gathered? (5) What specific aspects of implementation or effectiveness should be evaluated?

Develop partnerships. Stakeholder involvement in the research process maximizes the chances for upfront buy-in and, we hope, for some assurance that results will be sustained. Also, although not easily accomplished, multidisciplinary teams are better equipped to address the variety of scientific, technical, sociopolitical, and practical factors that come into play during the three intervention research phases. Depending on the nature of the project, these teams might include workers, employers, and scientists from various disciplines. If feasible, "participatory action research" and "empowerment" methods that integrate stakeholder perspectives by actively involving intervention subjects as participants in the research process, should be used.[18,42] An example of the potential value of such involvement is the recent collaboration of government agencies, the paving industry, manufacturers of paving equipment, and worker representatives to develop implement and evaluate the use of

new technology to reduce worker exposure to asphalt fumes.[43]

Choose methods and design. Developing an intervention may involve methods from a variety of research fields. For example, epidemiological, industrial hygiene, and behavioral research methods may be required to understand critical risk factors that the intervention should target. Engineering research may be needed to develop an intervention to reduce worker exposure to hazardous agents. Evaluations of intervention implementation often involve survey, case study, qualitative, and quantitative research methods. Effectiveness research should rely on experimental or, more typically, on quasi-experimental study designs. The principal goals in applying these designs are showing that the intervention made a difference (ie, internal validity) and that the results are generalizable (ie, external validity) while addressing the resource (time, funding, expertise) and feasibility (political and practical limitations, needs of partners, etc) limitations. Obviously, the range of methods and designs appropriate to the three phases of intervention research is beyond the scope of this article but is well described in treatises focusing on intervention research methods.[29,40,44,45]

Complete the research. It is no secret that interventions are difficult to implement[16]; it may take years before an intervention is completely implemented as planned. Some important implementation barriers include changes in the intervention during implementation; (2) changes in the cofactors that can confound the measurement of intervention effects (eg, procedures for reporting injuries or techniques for measuring exposures); (3) changes in participation by study subjects or collaborating parties; obtainment of responses to sensitive questions; and ethical issues (eg, discovering an imminent danger to participants in the course of the research). Some good resources describing such difficulties and potential solutions are LaMontagne and Needleman,[24] Robson et al,[29] and Centers for Disease Control and Prevention.[45]

Disseminate findings. This task is the essential closing of the intervention research loop. This crucial step, which applies equally to negative and positive findings, makes it possible for the intervention research cycle to continue. By disseminating research contributions from investigators working in diverse contexts, more emphasis can be focused on replicating successes rather than constantly reinventing the wheel by replicating failures. Results should be reported to intervention participants directly and expeditiously in a form that is readily understood. Carefully developed plans for communicating research findings to participants can improve future access to study populations and increase participation rates.[24] Findings should also be communicated to relevant nonparticipants (eg, employers, employer associations, safety and health professionals, producers of intervention products and services, unions, insurers, and government agencies) who are capable of taking action based on the results.

Future Directions

As intervention research becomes more widely accepted as an essential component of occupational safety and health research efforts, a few areas for future research efforts deserve particular attention.

Diffusion Research

Once an intervention has been through the three-phase evaluation cycle one or more times and has proved to be worth replicating, the next step is to diffuse it to all appropriate work contexts. Clearly, the potential impact of a useful intervention depends in large part on the extent to which the target population is exposed to it.[46]

Diffusion research studies would answer such questions as (1) What factors hinder and facilitate the diffusion of effective interventions to appropriate worksites? (2) How can the diffusion process be made faster and more effective? For example, it was shown that simply disseminating information to primary care physicians to increase their knowledge about clinical preventive medicine activities is insufficient for ensuring that those activities were adopted. Instead, organizational factors, such as inflexible office routines, lack of reminder systems, and unclear assignment of role responsibilities, influenced the adoption—or nonadoption—of prevention activities.[47,48] Similar research in the occupational safety and health arena will help facilitate the diffusion of effective interventions among worksites.

Policy Intervention Research

There has been a dearth of occupational safety and health studies evaluating "policy" interventions (eg, OSHA regulatory standards, the National Institute for Occupational Safety and Health recommendations for preventing work injury and illness, and International Standards Organization and American National Standards Institute voluntary standards).[22] Policy-level interventions are the most challenging to evaluate for many reasons, including the need for a large-scale study, the lack of control over the intervention, and design limitations imposed by ethical and other concerns.[22] Nevertheless, such evaluations will play an increasingly important role in political and economic environments that demand more accountability. An in-depth evaluation of the implementation and effectiveness of OSHA's 1984 ethylene oxide standard provides an example of an integrated series of policy-level implementation and effectiveness evaluation studies.[49,50]

Evaluability of Ongoing Interventions

How should interventions that have already been in place for some time be targeted for research? Al-

though it may be true that every intervention should be evaluated to some degree, it may be neither feasible nor a good use of resources to rigorously evaluate all occupational safety and health interventions. An evaluative assessment can help determine whether a more rigorous evaluation should be pursued.[14,51] Briefly, an intervention has to meet three criteria to be considered evaluative: (1) the intervention should be operating or have been implemented as intended, (2) the intervention should be relatively stable, and (3) the intervention should seem to be achieving positive results.[51]

Evaluating the Effect of Non–Occupational Safety and Health Interventions on Workers

There are a number of new work organization strategies that emphasize employee empowerment and introduce major changes in the way work is designed (eg, total quality management, reengineering, team concept, lean production, and patient-focused care). However, few studies have examined the impact of such systems on occupational injuries/illnesses or on occupational risk factors for illness and injury. For example, in a recent review article, Landsbergis[52] found little evidence that lean production "empowers" autoworkers, but findings did indicate that it may worsen job strain.

Conclusions

When an occupational safety and health problem is identified, the ideal goal is to develop a research agenda designed to carry an intervention through all three phases. First, a full (and, wherever possible, theory-based) rationale for developing or adapting a particular intervention would be proposed. Next, the implementation procedures would be outlined, and, finally, a rigorous effectiveness study would be designed. Along with the interdependence of the phases comes the recommendation of establishing an interdisciplinary research team to carry out the agenda.

Issues to consider when selecting an intervention for research should include the evaluative potential of the intervention; the extent of resources required to conduct the evaluation; controversy over an intervention's design, implementation, or effectiveness; and the intervention's timeliness (upcoming public and private program and policy decisions, more workers or employers expressing interest). In addition, standard criteria relating to public health importance should be considered, including the scope, frequency, and severity of injury, illness, or exposures that the intervention is designed to address.

So, although "Does it work?" is the ultimate question that must be answered, the broader view of the intervention research process includes research to evaluate the development (or adaptation) and implementation of interventions. This will create and maintain a cycle of intervention research whereby more and better effectiveness studies would be conducted because they would have ongoing links to development and implementation studies.

We hope that the proposed conceptual framework will help contribute to heightened awareness of the importance and value of intervention research in occupational safety and health. Further, we hope that it can be used to facilitate communication and collaboration among intervention researchers and other stakeholders and thus help to stimulate and nurture the growth of this new and promising occupational safety and health research area.

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