Comparative Effectiveness Review
Number 175

Total Worker Health®

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Effective Health Care Program

Comparative Effectiveness Review

Number 175

Total Worker Health®

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Prepared by:
RTI International–University of North Carolina Evidence-based Practice Center
Research Triangle Park, NC

Investigators:
Cynthia Feltner, M.D., M.P.H.
Kristina Peterson, Ph.D.
Rachel Palmieri Weber, Ph.D.
Laurie Cluff, Ph.D.
Emmanuel Coker-Schwimmer, M.P.H.
Meera Viswanathan, Ph.D.
Kathleen N. Lohr, Ph.D.

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This report is based on research conducted by the RTI International–University of North Carolina Evidence-based Practice Center (EPC) under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD (Contract No. 290-2012-00008-I). The findings and conclusions in this document are those of the authors, who are responsible for its contents; the findings and conclusions do not necessarily represent the views of AHRQ. Therefore, no statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

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The information in this report is intended to help health care decisionmakers—patients and clinicians, health system leaders, and policymakers, among others—make well-informed decisions and thereby improve the quality of health care services. This report is not intended to be a substitute for the application of clinical judgment. Anyone who makes decisions concerning the provision of clinical care should consider this report in the same way as any medical reference and in conjunction with all other pertinent information, i.e., in the context of available resources and circumstances presented by individual patients.

This report may periodically be assessed for the currency of conclusions. If an assessment is done, the resulting surveillance report describing the methodology and findings will be found on the Effective Health Care Program Web site at www.effectivehealthcare.ahrq.gov. Search on the title of the report.

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Preface

The Agency for Healthcare Research and Quality (AHRQ), through its Evidence-based Practice Centers (EPCs), sponsors the development of systematic reviews to assist public- and private-sector organizations in their efforts to improve the quality of health care in the United States. The Office of Disease Prevention of the National Institutes of Health requested this report from the Evidence-based Practice Center (EPC) Program at the Agency for Healthcare Research and Quality (AHRQ). AHRQ assigned this report to the following EPC: RTI-UNC Evidence-based Practice Center (Contract Number: 290-2012-00008-I HHSA 29032009T). The report was presented at the NIH public meeting - Total Worker Health®: What's Work Got to Do with It?" The reports and assessments provide organizations with comprehensive, evidence-based information on common medical conditions and new health care technologies and strategies. They also identify research gaps in the selected scientific area, identify methodological and scientific weaknesses, suggest research needs, and move the field forward through an unbiased, evidence-based assessment of the available literature. The EPCs systematically review the relevant scientific literature on topics assigned to them by AHRQ and conduct additional analyses when appropriate prior to developing their reports and assessments.

To bring the broadest range of experts into the development of evidence reports and health technology assessments, AHRQ encourages the EPCs to form partnerships and enter into collaborations with other medical and research organizations. The EPCs work with these partner organizations to ensure that the evidence reports and technology assessments they produce will become building blocks for health care quality improvement projects throughout the Nation. The reports undergo peer review and public comment prior to their release as a final report.

AHRQ expects that the EPC evidence reports and technology assessments, when appropriate, will inform individual health plans, providers, and purchasers as well as the health care system as a whole by providing important information to help improve health care quality.

If you have comments on this evidence report, they may be sent by mail to the Task Order Officer named below at: Agency for Healthcare Research and Quality, 5600 Fishers Lane, Rockville, MD 20857, or by email to epc@ahrq.hhs.gov.

Richard G. Kronick, Ph.D.
Director
Agency for Healthcare Research and Quality

Arlene S. Bierman, M.D., M.S.
Director
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Stephanie Chang, M.D., M.P.H.
Director
Evidence-based Practice Center Program
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

Kim Wittenberg, M.A.
Task Order Officer
Center for Evidence and Practice Improvement
Agency for Healthcare Research and Quality

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Technical Expert Panel

In designing the study questions and methodology at the outset of this report, the EPC consulted several technical and content experts. Broad expertise and perspectives were sought. Divergent and conflicted opinions are common and perceived as healthy scientific discourse that results in a thoughtful, relevant systematic review. Therefore, in the end, study questions, design, methodologic approaches, and/or conclusions do not necessarily represent the views of individual technical and content experts.

Technical Experts must disclose any financial conflicts of interest greater than $10,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential conflicts of interest identified.

The list of Technical Experts who provided input to this report follows:

Brian Caveney, M.D., J.D., M.P.H.*
Blue Cross & Blue Shield of North Carolina
Durham, NC

Susan Curry, Ph.D.
University of Iowa (also NIH Pathways to Prevention Workshop Panel)
Iowa City, IA

LuAnn Heinen, M.P.P.*
Vice President, Workforce Well-being, Productivity and Human Capital
National Business Group on Health
Washington, DC

David Hopkins, M.D., M.P.H.*
Centers for Disease Control and Prevention
Atlanta, GA

Jim Johnson
DEKRA Insight
Boston, MALaura Punnett, Sc.D.*
University of Massachusetts Lowell
Lowell, MA

Jeannie Tomlinson, M.S.N., R.N., COHN-S, FAAOHN
American Association of Occupational Health Nurses
South Glastonbury, CT

Peer Reviewers

Prior to publication of the final evidence report, EPCs sought input from independent Peer Reviewers without financial conflicts of interest. However, the conclusions and synthesis of the scientific literature presented in this report do not necessarily represent the views of individual reviewers.

Peer Reviewers must disclose any financial conflicts of interest greater than $10,000 and any other relevant business or professional conflicts of interest. Because of their unique clinical or content expertise, individuals with potential nonfinancial conflicts may be retained. The TOO and the EPC work to balance, manage, or mitigate any potential nonfinancial conflicts of interest identified.

The list of Peer Reviewers follows:

Ebi Awosika, M.D., M.P.H.
Employee Health and Well-Being
Veterans Health Administration
Washington, DC

Guy Fragala, Ph.D., P.E., CSP, CSPHP
Patient Safety Center of Inquiry
Tampa, FL

Roberto Lucchini, M.D.
Icahn School of Medicine at Mount Sinai
New York, NY

Harold Paz, M.D., M.S.
Professor Adjunct of Internal Medicine
Yale University School of Medicine
New Haven, CT

Gregg Stave, M.D., J.D., M.P.H., FACP, FACOEM, FACPM
Assistant Consulting Professor
Department of Community and Family Medicine
Duke University Medical Center
Durham, NC

Total Worker Health®

Structured Abstract

Objectives. The purpose of this review is to provide an evidence report that the National Institutes of Health, Office of Disease Prevention, Pathways to Prevention Workshop Program can use to inform a workshop focused on Total Worker Health® (TWH). TWH is defined as policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being. This review describes the body of evidence evaluating TWH interventions, assesses the benefits and harms of interventions, and highlights research gaps and future research needs.

Data sources. We searched MEDLINE®, the Cochrane Library, the Cochrane Central Trials Registry, and PsycINFO® from January 1, 1990, to September 21, 2015. Eligible studies included randomized controlled trials (RCTs), nonrandomized trials, and prospective cohort studies with a concurrent control group; single-group pre-post studies were also eligible for Key Questions (KQs) describing interventions or identifying contextual factors, research gaps, and future research needs.

Review methods. Pairs of reviewers independently selected, extracted data from, and rated the risk of bias of relevant studies; they graded the strength of evidence (SOE) using established criteria. We synthesized all evidence qualitatively.

Results. We included 24 studies described in 33 publications. Fifteen studies had a concurrent control group (12 RCTs, 2 nonrandomized trials, and 1 cohort study) and were eligible for all KQs; 9 were pre-post studies. Studies were heterogeneous in terms of work settings and populations, interventions, and outcomes. For the 15 studies eligible for KQ 2, we rated 10 as high risk of bias primarily because of selection bias. Evidence of low SOE supported the effectiveness of TWH interventions for improving rates of smoking cessation (measured by self-reported 7-day abstinence) over 22 to 26 weeks and increasing the consumption of fruits and vegetables over 26 to 104 weeks; these results apply to populations of blue-collar manufacturing and construction workers. Evidence of low SOE supported the effectiveness of TWH interventions for reducing sedentary behavior at work over 16 to 52 weeks in office workers. Evidence was insufficient or completely lacking for other outcomes of interest (e.g., rates of work injuries, quality of life). Effective interventions were informed by worker participation and highlighted the potential synergistic risks of hazardous work exposures and health behavior. Work organization factors and union membership status were two commonly mentioned contextual factors that may have modified intervention effectiveness. Future studies should try to directly assess the effectiveness of integration itself by isolating the benefits (or harms) of integration from other components; future studies should also focus on outcomes related to occupational safety and health (OSH).

Conclusions. The body of evidence was small and diverse in terms of populations, interventions, and measured outcomes. TWH interventions were effective in improving intermediate outcomes traditionally measured in health promotion programs (smoking cessation and fruit and vegetable consumption) and reducing sedentary work behavior. Future research should be designed to

evaluate the effect of integration by itself (separately from new or improved OSH and health promotion components) and assess the effect of integration on outcomes related to OSH.

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Executive Summary

Background

The American worksite has been a venue for both health protection and health promotion programs. Health protection programs are interventions aimed specifically at preventing occupational injuries or illnesses. Work-related injuries and illnesses lead to morbidity, mortality, and considerable financial and social costs.[1-3] Health promotion (HP) programs, often called wellness programs, are interventions aimed at improving overall health and well-being. They often address modifiable behavior risk factors such as smoking, physical activity, and diet, which are leading causes of morbidity and mortality in the United States.[4]

Traditionally, occupational safety and health (OSH) programs and HP programs have functioned independently within the workplace.[5] Recently, interest in integrating these programs has grown appreciably;[5,6] this interest grows out of evidence supporting the idea that workplace factors contribute to adverse health outcomes traditionally considered to be unrelated to work (e.g., cardiovascular disease and depression).[7] The National Institute for Occupational Safety and Health (NIOSH) focused attention on integrated approaches in 2011 by creating the Total Worker Health® (TWH) program. NIOSH summarized the rationale for integrating OSH and HP programs in 2012 as follows:[8] (1) risk of adverse health outcomes is increased by exposures to both occupational hazards and behavioral risk factors; (2) occupational exposures and risk factors for chronic diseases are related and may have synergistic adverse health effects; (3) workers at highest risk for hazardous occupational exposures often have more risk factors for chronic disease; and (4) integrating OSH with HP efforts may increase worker participation in health-related programs and benefit the broader work environment.

TWH is currently defined as "policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being."[9] Earlier descriptions of TWH focused primarily on the integration of OSH and traditional worksite HP programs;[8] NIOSH now emphasizes recognition that work is a social determinant of health and that job-related factors (e.g., wages, hours of work, workload, and stress levels) are important factors in determining the well-being of workers.[9]

TWH is a trademarked term that was not commonly used in past studies of integrated interventions. For this review, we use the term "TWH interventions" to refer to integrated interventions that are consistent with NIOSH's TWH initiative. A range of interventions that differ in content, complexity, and approach to integration could be considered consistent with NIOSH's TWH initiative. For example, prior studies considered to fall under the TWH umbrella were developed through strategic intraorganizational coordination and employee participation that pair organizational change with individual-level content focused simultaneously on occupational hazard(s) and HP.[10,11] TWH interventions can also consist of a subset of these traits; for example, an intervention may combine components aimed at improving ergonomics and promoting physical activity with the aim of decreasing musculoskeletal injuries and improving overall health. Prior research has outlined indicators and metrics of "integration" important in TWH interventions that include factors such as organizational leadership; data integration; organizational coordination across departments responsible for health protection and HP; adequate resources; accountability; and training.[12] However, no research has evaluated these indicators separately in order to isolate whether (and to what extent) they contribute to intervention effectiveness beyond other factors such as intervention content.

Rationale for Evidence Review

The goal of this review is to identify gaps in the evidence about TWH effectiveness to help identify future research priorities. This executive summary is based on the methods, data, conclusions, and appendixes presented in the full report.

Previous reviews of the literature have differed in scope (i.e., used different search and inclusion criteria and addressed a narrower set of Key Questions [KQs]), thereby including studies of varied rigor and scope.[13,14] Moreover, the effectiveness of the interventions in individual studies and in the prior reviews has been judged based on various metrics (e.g., various improvements in health behaviors, physiologic outcomes, and economic outcomes, or a count of the number of significant outcomes). As a result, uncertainty remains about the benefit of TWH interventions for improving specific health and safety outcomes. These factors underscore the need for the current systematic review to synthesize the literature supporting TWH interventions, assess the strength of evidence (SOE) for important outcomes, and highlight research gaps and future research needs.

Scope and Key Questions

The purpose of this review is to provide an evidence report that the National Institutes of Health (NIH), Office of Disease Prevention, Pathways to Prevention (P2P) Workshop Program can use to inform a workshop focused on TWH.[15] This review will describe the body of evidence evaluating TWH interventions, assess the effectiveness of TWH interventions for improving health and safety outcomes, highlight the research gaps, and call out future research needs. The P2P Workshop Program Panel will use the evidence report as a resource to develop a summary of the current state of the science and future research needs related to TWH interventions. Specifically, we address the following six KQs.

Key Question 1. What populations, work settings, intervention types, and outcomes have been included in studies assessing integrated interventions?

Key Question 2. What is the effectiveness of integrated interventions for improving the following outcomes, and what are the potential harms?

a. Health and safety outcomes (e.g., cardiovascular events or incidence of work-related injuries)
b. Intermediate outcomes (e.g., change in blood pressure, tobacco use, or hazardous exposures)
c. Utilization outcomes and occupational injury and illness surveillance outcomes (e.g., hospitalizations or measures of workers' compensation claims)
d. Harms (e.g., discrimination or victim blaming)

Key Question 3. What are the characteristics of effective integrated interventions?

Key Question 4. What contextual factors have been identified as potential modifiers of effectiveness in studies of integrated interventions?

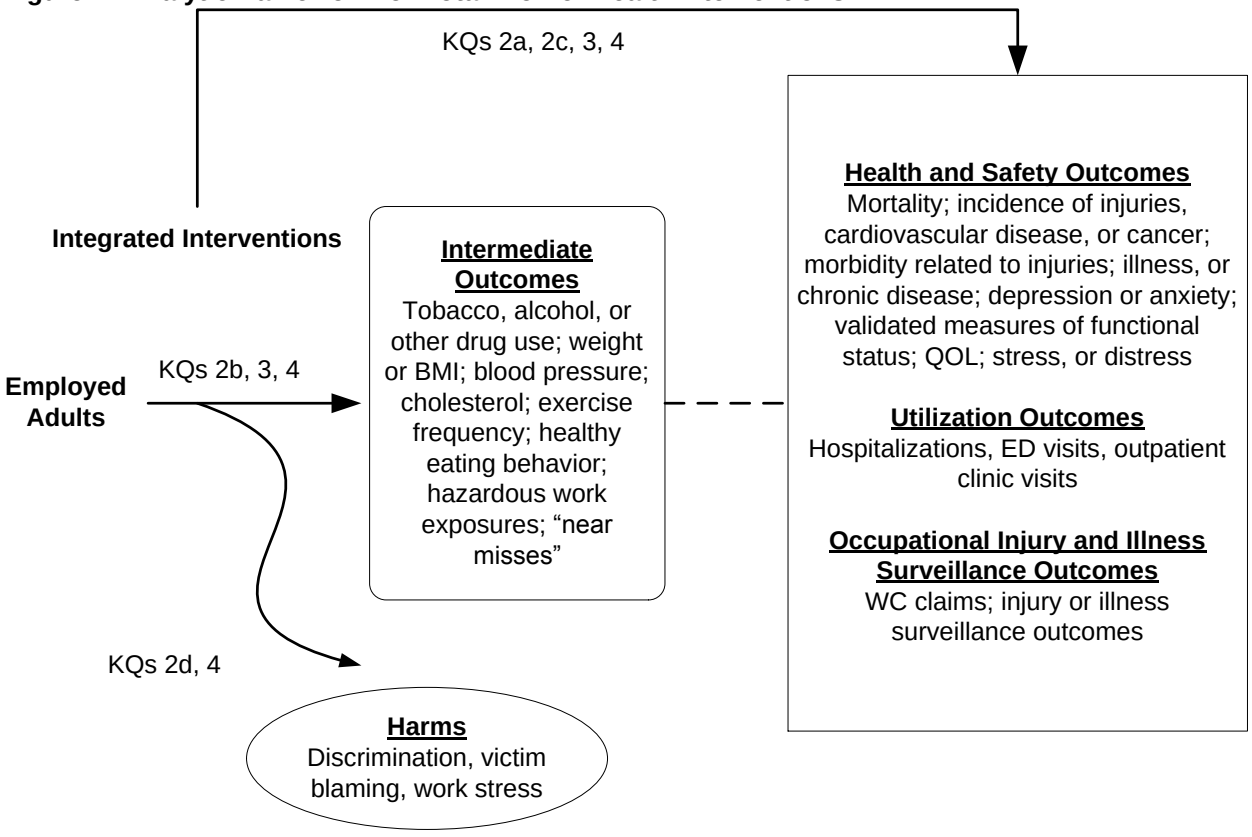
Key Question 5. What evidence gaps exist in the body of literature assessing the effectiveness of integrated interventions in terms of the following: populations, work settings, intervention types, outcomes, study designs, research methods, and contextual factors that may modify intervention effectiveness?

Key Question 6. What are the future research needs?

Analytic Framework

We developed an analytic framework to guide the systematic review process (Figure A). The analytic framework illustrates the population, interventions, outcomes, and adverse effects that guided the literature search and synthesis.

Figure A. Analytic framework for Total Worker Health interventions



BMI = body mass index; ED = emergency department; KQ = Key Question; QOL = quality of life; WC = workers' compensation.

Methods

Topic Refinement and Protocol Review

The NIH P2P Working Group provided the initial KQs. The RTI International–University of North Carolina Evidence-based Practice Center (EPC) further refined them and incorporated guidance from a Technical Expert Panel into the final research protocol. It was posted on the Agency for Healthcare Research and Quality (AHRQ) Web site on May 26, 2015, at www.effectivehealthcare.ahrq.gov/search-for-guides-reviews-and-reports/?pageaction=displayproduct&productid=2085.

Literature Search Strategy

Search Strategy

We searched MEDLINE®, the Cochrane Library, the Cochrane Central Trials Registry, and PsycINFO® from January 1, 1990, to September 21, 2015. An experienced research librarian used a predefined list of search terms and medical subject headings (MeSH).

We searched for unpublished studies relevant to this review using ClinicalTrials.gov and Academic Search™ Premier; on our behalf, the AHRQ Scientific Resource Center solicited scientific information packages via *Federal Register* notices or informational requests. We received a bibliography from NIOSH listing studies relevant to the TWH program. We used this bibliography to ensure that our database searches had not missed relevant citations. We searched reference lists of pertinent review articles for studies that we should consider for inclusion in this review.

Inclusion and Exclusion Criteria

We developed inclusion and exclusion criteria with the PICOTS framework (populations, interventions, comparators, outcomes, timeframes, and settings) in mind. We considered only trials or studies published in English.

The population of interest is employed adults. We excluded studies that enrolled only children or adolescents younger than 18 years of age.

Interventions of interest included any "integrated" intervention that met the definition of a TWH strategy (as defined earlier[12]). To meet inclusion criteria, an intervention had to have a component aimed specifically at improving workplace health and safety and a component aimed at improving overall health, health behaviors, or risk factors for chronic diseases. We did not create inclusion or exclusion based on the degree or type of integration.

Included studies for KQ 2 (effectiveness and harms of TWH interventions) had to have a concurrent control group. Acceptable comparisons included (1) a different integrated intervention that differed in content, complexity, or other factors; (2) an OSH intervention or HP intervention only (i.e., any active comparator that was not integrated); and (3) no intervention or usual work practice. For descriptive purposes relating to KQs 1, 4, 5, and 6, we included studies assessing an eligible intervention in only one group (i.e., pre-post studies).

We specified a broad range of outcomes—intermediate and final health benefit outcomes and treatment harms (Figure A). We did not exclude studies based on the outcomes reported. For KQ 2, we limited our evidence synthesis to commonly reported outcomes that are considered to be important measures of worker health and safety. We determined which outcomes are common

and considered important in this body of literature by reviewing prior studies of TWH interventions and asking for input from Technical Expert Panel members on our inclusion and exclusion criteria prior to finalizing the research protocol. Final health outcomes, for example, included quality of life, functional status, and occupational illnesses and injuries. Intermediate outcomes included rates of smoking cessation, healthy eating behavior, and outcomes related to hazardous workplace exposures or "near misses." We also included health care utilization outcomes, rates of workers' compensation claims, and short-term disability claims. Finally, we searched for harms associated with TWH interventions, such as increased barriers to reporting work-related injuries or illnesses, work stress, discrimination, and victim blaming.

We included studies conducted in any workplace setting in a developed country ("very high" Human Development Index according to the United Nations Development Programme).[16]

Study designs included randomized controlled trials (RCTs), nonrandomized controlled trials, prospective cohort studies, and pre-post studies. We did not include prior reviews but captured these in our database searches and used them to identify studies that our searches may have missed.

Study Selection

Trained members of the research team reviewed article abstracts and full-text articles. Two members independently reviewed each title and abstract using the predefined inclusion and exclusion criteria. Studies marked for possible inclusion by either reviewer underwent a full-text review. Two members of the team independently reviewed each full-text article. If both reviewers agreed that a study did not meet the eligibility criteria, we excluded it; each reviewer recorded the primary reason for exclusion. If reviewers disagreed, they resolved conflicts by discussion and consensus or by consulting a third member of the review team.

We screened unpublished studies and reviewed scientific information packages using the same title/abstract and full-text review processes. The project coordinator tracked abstract and full-text reviews in an EndNote database (EndNote® X4).

Data Abstraction

We developed a template for evidence tables using the PICOTS framework and abstracted relevant information into them using Microsoft® Excel. We recorded characteristics of study populations, interventions, comparators, settings, study designs, methods, and results. Six trained members of the team participated in the data abstraction. One reviewer initially abstracted the relevant data from each included article; a second member of the team reviewed each data abstraction against the original article for completeness and accuracy.

Risk-of-Bias Assessment

To assess the risk of bias (internal validity) of studies eligible for KQ 2, we used predefined criteria based on the AHRQ "Methods Guide for Effectiveness and Comparative Effectiveness Reviews" (Methods Guide). These criteria included questions to assess selection bias, confounding, performance bias, detection bias, and attrition bias (i.e., those about adequacy of randomization, allocation concealment, similarity of groups at baseline, masking, attrition, use of intention-to-treat analysis, method of handling dropouts and missing data, reliability and validity of outcome measures, and treatment fidelity).[17] Appendix C of the full report lists the specific questions used for evaluating the risk of bias of included studies eligible for KQ 2 (i.e., studies

with a concurrent control group). Both the questions and responses are shown in tables along with a rationale for all ratings that were either high or medium risk of bias.

In general terms, results from a study with low risk of bias are considered to be valid. A study with moderate risk of bias is susceptible to some risk of bias but probably not enough to invalidate its results. A study assessed as high risk of bias has significant risk of bias (e.g., stemming from serious errors in design, conduct, or analysis) that may invalidate its results. To assess publication bias, we looked for evidence of unpublished literature through searches of gray literature (ClinicalTrials.gov). We also reviewed, when available, the original protocols for included trials to assess for selective outcome reporting.

We determined the risk-of-bias ratings using the responses to all questions assessing the various types of bias listed here. To receive a low risk-of-bias rating, we required favorable responses to most questions, and any unfavorable responses had to be relatively minor. We gave high risk-of-bias ratings to studies that we determined to have a major methodological shortcoming in one or more categories based on our qualitative assessment. Common methodological shortcomings contributing to high ratings were high rates of attrition or differential attrition and inadequate methods used to handle missing data.

Two independent reviewers assessed the risk of bias for each study. Disagreements between reviewers were resolved by discussion and consensus or by consulting a third member of the team.

Data Synthesis

Quantitative synthesis (meta-analysis) was not appropriate to this topic, given the heterogeneity in the included populations, interventions, comparators, outcomes, work settings and geographic settings of included studies. We did all analyses qualitatively, based on our reasoned judgment of similarities in interventions, measurement of outcomes, and homogeneity of occupational groups.

Strength of the Body of Evidence

We graded the SOE based on the Methods Guide.[18] The EPC approach incorporates five key domains: study limitations, directness, consistency, precision of the evidence, and reporting bias.

Grades reflect the strength of the body of evidence to answer each KQ. A grade of high SOE indicates that we have high confidence that the evidence reflects the true effect. Moderate SOE indicates that we have moderate confidence that the evidence reflects the true effect. Low SOE suggests that we have low confidence that the evidence reflects the true effect. Insufficient evidence signifies that the evidence is not available, that we are unable to estimate an effect, or that we have no confidence in the estimate of the effect. We graded the SOE for an outcome only when it was reported in at least one study rated low or medium risk of bias; studies rated high risk of bias were used to assess the consistency of evidence when they reported the same outcomes in similar populations of workers.

Two reviewers assessed each domain independently and also assigned an overall grade for comparisons for each key outcome; they resolved any conflicts through consensus discussion. If they did not reach consensus, the team brought in a third party to settle the conflict.

Applicability

We assessed the applicability both of individual studies and of the body of evidence. For individual studies, we examined factors that may limit applicability (e.g., characteristics of populations, interventions, comparators, work settings, and geographic settings). Such factors may lessen our ability to generalize the effectiveness of an intervention to use in other occupational groups or work settings. We abstracted key characteristics of applicability into evidence tables. During data synthesis, we assessed the applicability of the body of evidence using the abstracted characteristics.

Peer Review and Public Commentary

Experts in workplace HP and OSH (clinicians and researchers) and experts in evidence-based assessments of workplace and community interventions were invited to provide external peer review of the draft report. AHRQ and an Associate Editor, who are leaders in their respective fields, also provided comments. The draft was posted on the AHRQ Web site for 4 weeks to elicit public comment. We responded to all reviewer comments and noted any resulting revisions to the text in the Disposition of Comments Report. This report will be made available 3 months after AHRQ posts the final review on its Web site.

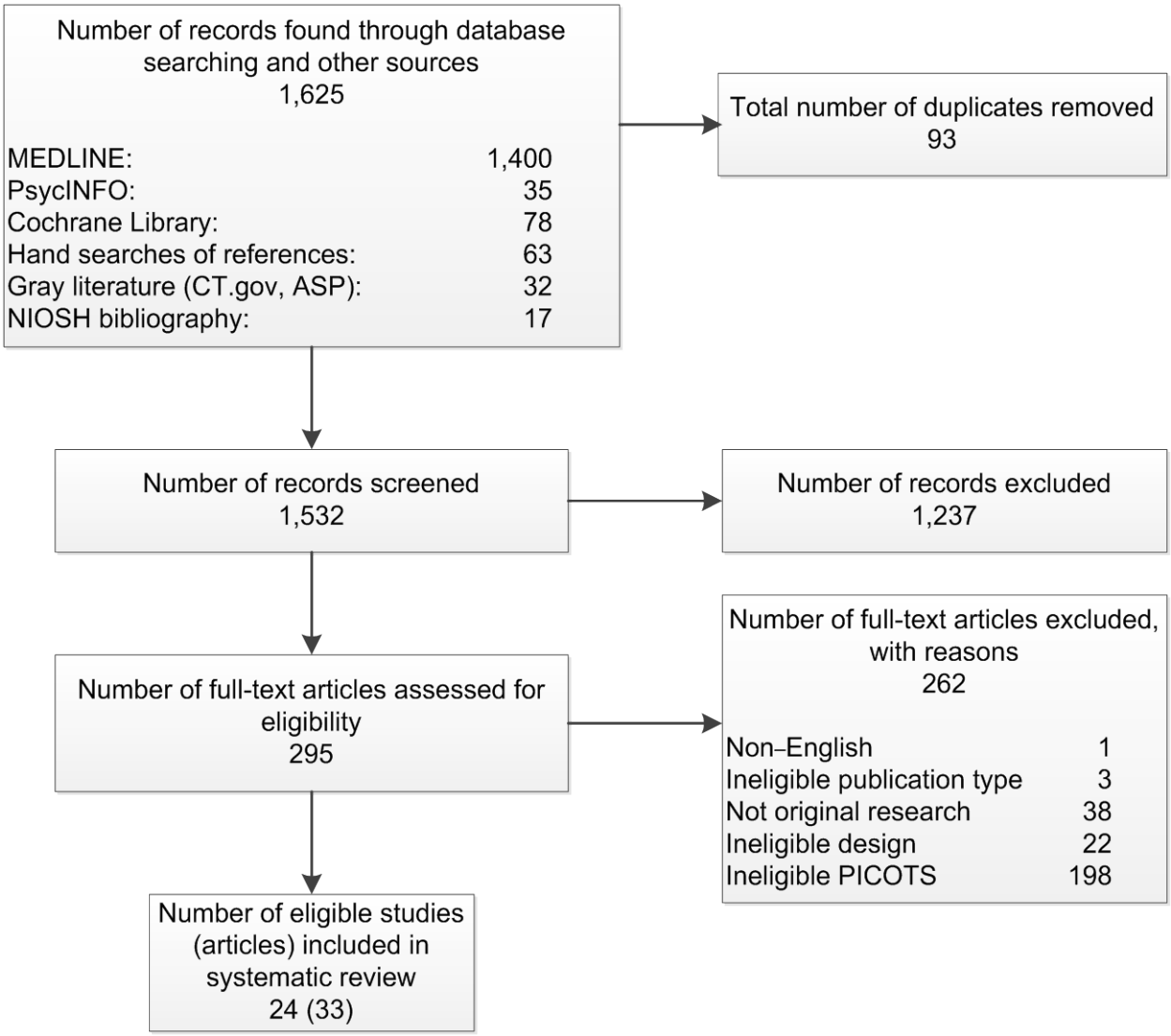
Results

We report results by KQ. For KQ 1 (characteristics of TWH interventions), we describe the characteristics of all included studies using a PICOTS framework. For KQ 2 (treatment effectiveness and harms), we grouped by outcome category. Table A summarizes key findings and SOE grades for KQ 2. The full report contains summary tables for results reported in KQs 1, 2, and 4. In the full report, Appendix C documents risk-of-bias assessments and Appendix D presents SOE grades. Evidence tables (showing all abstracted data by study) will be uploaded to AHRQ's Systematic Review Data Repository for reference and use in future research.[19]

Literature Searches

Figure B (disposition of articles diagram) depicts our literature search results. Searches of all sources identified a total of 1,532 potentially relevant citations. We included 24 studies described in 33 publications.[10,11,20-50] Of the 24 included studies, 15 studies had a concurrent control group and were also eligible for KQ 2. Appendix B provides a complete list of articles excluded at the full-text screening stage, with reasons for exclusion.

Figure B. Disposition of articles for Total Worker Health interventions



ASP = Academic Search Premier; CT.gov = ClinicalTrials.gov; NIOSH = National Institute of Occupational Safety and Health; PICOTS = populations, interventions, comparators, outcomes, timeframes, and settings.

Key Question 1. Characteristics of Studies Evaluating Total Worker Health Interventions

Work Setting and Populations

Across all 24 studies, we encountered substantial heterogeneity with respect to the work settings, populations, and interventions, and the outcomes evaluated. Studies enrolled populations employed primarily in manufacturing, construction, or health care work settings. Workers from the manufacturing industry were more commonly male; workers from the health care and social assistance industry were overwhelmingly female. Commonly targeted workers averaged between 30 and 50 years of age; only one study evaluated a younger workforce (mean <30 years of age) and only one study evaluated an older workforce (mean >50 years of age). Few studies described the baseline health status or medical comorbidity of included populations. Investigators generally did not describe either the OSH or HP services available at worksites in addition to the intervention under study.

Interventions and Comparators

All studies assessed an intervention focused on an integrated objective (in terms of addressing both occupational hazards and promoting overall health). Eight studies assessed an intervention that involved strategic integration across organizational departments responsible for OSH and HP, and 17 involved worker participation in the development, design, planning, or implementation of the intervention. Six studies assessed an intervention with both strategic integration and worker participation. Most studies were multicomponent interventions; only three evaluated a single-component intervention. Of the 24 included studies, 1 study assessed the effectiveness of integration alone (without added OSH or HP content); 6 studies included mostly HP content (tailored to the specific needs of workers); 5 studies focused primarily on reducing occupational injuries, illnesses, or exposures (including work–life stress and job stress) but also included educational or other content related to promoting healthy behavior; and the remaining 12 studies assessed interventions that included new comprehensive HP and OSH components not previously available to workers. Of the 24 studies, 15 included concurrent control groups, most of which received no intervention. Four studies included active control groups focused on HP or OSH alone.

Outcomes

Overall, these 24 studies assessed a diverse set of outcomes. Few studies measured the same outcomes in similar populations of workers. Approximately half of the studies measured a final health outcome (e.g., quality of life, functional status). Few studies evaluated work-related injuries or illness; work stress and changes in work safety behavior were commonly reported outcomes related to OSH. Commonly reported intermediate health outcomes were body mass index, biomarkers associated with risk of cardiovascular disease (e.g., cholesterol), and health behaviors (primarily physical activity, smoking, and dietary behaviors). Several studies assessed outcomes that we did not include for KQ 2 (i.e., on effectiveness and harms of TWH integrations); the two addressed most often were absenteeism and economic evaluations.

Key Question 2. Effectiveness and Harms of Interventions

Evidence for the effectiveness and harms of TWH interventions for improving outcomes consisted of 12 RCTs, 2 nonrandomized controlled trials, and 1 prospective cohort study.[10,11,20,23,24,26-28,33,36,37,45,46,49,50] Few studies of TWH interventions assessed the same outcomes among similar populations of workers. We rated 5 RCTs as medium risk of bias[27,28,46,49,50] and the other 10 studies as high risk of bias (mainly because of a high risk of selection bias). Most studies had high overall attrition (ranging from 14% to 45%); many studies had differential attrition across study arms. In general, studies rated high risk of bias did not use any statistical methods to address missing data. Other common areas of bias included baseline differences between groups that the investigators did not address in their analyses.

The 15 KQ 2 studies were quite different; few studies of TWH interventions assessed the same outcomes among similar populations of workers. We found no evidence from studies rated medium risk of bias for many important health and safety outcomes of interest. Table A summarizes our key findings by outcomes. We found low SOE to support the effectiveness of TWH interventions for improving rates of smoking and increasing fruit and vegetable intake compared with no intervention; we also found low SOE to support the effectiveness of TWH interventions for reducing sedentary activity at work compared with any comparator. Evidence was insufficient for assessing the effectiveness of integrated interventions for improving quality

of life, levels of stress, blood pressure, weight, consumption of red meat, overall physical activity, work-specific physical activity, safety compliance, and safety behaviors; SOE grades for these outcomes are shown in Appendix D.

Table A. Summary of key findings and strength of evidence for Total Worker Health interventions

Population; Intervention, Comparator; Time Point	N Studies; N Subjects Study Limitations	Outcome and Results	Strength of Evidence
Construction laborers[27] and manufacturing workers[20] Integrated intervention vs. no intervention 22–26 weeks	2; 737 Medium or high	**Self-reported 7-day smoking abstinence** One RCT (N = 188 smokers and recent quitters at baseline) rated medium ROB[27] found that more workers in the integrated intervention group than in the control group reported 7-day abstinence at 26 weeks: 19% vs. 8%; p = 0.03.[a] One RCT (N = 490 smokers at baseline) rated high ROB[20] found that more workers at intervention worksites than at control worksites reported 7-day abstinence at 22 weeks (26% vs.17%; p = 0.014).	Low for benefit
Manufacturing workers[10,28] and construction workers[27] Integrated intervention vs. no intervention 26–104 weeks	3; 6,056 Medium or high	**Self-reported fruit and vegetable consumption** Two RCTs rated medium ROB: One RCT (N = 578)[27] found that more workers in the intervention group than in the control group increased consumption of fruits and vegetables: mean increase in servings per day = +1.52 (SD = 3.39) vs. -0.09 (SD = 3.31); p = <0.0001. One RCT (N = 3,092)[28] found that more workers at intervention worksites than at control worksites reported consuming 5 or more servings of fruits and vegetables per day:[b] mean change from baseline = +7.5% vs. +1.1%; p = 0.048. One RCT (N = 2,386) rated high ROB[10] found that more workers at intervention worksites than at control worksites increased consumption of fruits and vegetables: mean change from baseline servings per day = 0.22 vs. 0.09; p = 0.04.	Low for benefit
Sedentary office workers[46,49] Integrated intervention vs. any comparator 16–52 weeks	2; 262 Medium	**Sedentary activity at work** One RCT (N = 412)[46] found decreased sedentary activity in a physical environment intervention group compared with controls: difference between groups in minutes per day spent sedentary = -57.9; 95% CI, -111.7 to 4.2; p = 0.03.[c] One RCT (N = 60)[49] found a decreased percentage of worktime spent sedentary among the integrated intervention group[d] compared with an OSH-only group: -2.0 (95% CI, -4.4 to 0.3) vs. -0.4 (95% CI, -1.1 to 0.2); p = 0.08.	Low for benefit

CI = confidence interval; OSH = occupational safety and health; RCT = randomized controlled trial; ROB = risk of bias; SD = standard deviation.

[a]This RCT also found benefit for rates of 7-day abstinence of any tobacco use favoring the integrated intervention (19% vs. 8%; p = 0.005).[27]

[b] In the overall sample of workers, there was no difference between intervention and control worksites (mean change from baseline percentage consuming 5 or more servings per day: +5.4% vs. 1.7%; p = 0.41); managers at intervention worksites reported decreased consumption of fruits and vegetables compared with managers at control worksites (mean change from baseline consuming 5 or more servings per day: -5.5% vs. 3.6%; p = 0.048).[28]

[c] There was no difference between the other 2 active comparators (social environment intervention and combined social and physical environment intervention) and the control group on any measure of work-specific physical activity or sedentary behavior outcome.[46]

[d] Workers were randomized to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a workstation that permitted seated activity.[49]

Key Question 3. Components of Effective Interventions

We evaluated common characteristics of interventions that were effective for improving any outcome eligible for KQ 2 for which the SOE for benefit was at least low. We focused on characteristics of interventions that relate to the approach to integration and specific content of the intervention. Overall, we were able to make very few SOE conclusions because of the limitations of the evidence base; effective interventions were heterogeneous, and separating individual components from the overall types (or "bundles") of interventions that showed efficacy for outcomes eligible for KQ 2 was not possible. Most effective interventions were informed by worker participation in the development, design, planning, or implementation of the intervention, or in more than one of these steps. Most effective interventions tailored intervention components or materials to cultural or social aspects of the worker population (e.g., to workers with low literacy skills or workers for whom English is not the first language). All effective interventions were multicomponent complex interventions that reinforced messages about health and safety through multiple levels of influence or multiple modes of delivery (or both) over time.

Key Question 4. Contextual Factors

We abstracted data from included studies that related to contextual factors that the original authors had identified as potential modifiers of intervention effectiveness. We included factors that had been noted in the results (e.g., whether the intervention was more or less effective at worksites that differed by a specific contextual factor) and also those mentioned in the discussion that could have potentially modified the effectiveness of interventions.

Eight studies identified a contextual factor that could have played a role in modifying the effectiveness of interventions. Work organization factors and union membership status were the two most commonly mentioned contextual factors. Other factors mentioned in at least one study included the following: presence of another (concurrent) OSH or HP policy implemented during the study period, health insurance status or access to primary care services, support from higher management, availability of resources, and employee stress or strain related to company downsizing during the intervention period.

Key Question 5. Research Gaps

We found numerous gaps in the literature base supporting TWH interventions in terms of work settings and populations, interventions, comparators, and deficiencies in methods.

Work Settings and Populations

No study enrolled workers from States in the Southwest; only one study each was conducted in a Southeastern or Western State (Arkansas and Oregon, respectively). Only one U.S. study enrolled a population across different U.S. regions.[27]

No studies enrolled workers from industries in these sectors: wholesale and retail trade; information (publishing, broadcasting, telecommunications); real estate; professional, scientific, and technical services; educational services; arts, entertainment, and recreation; or accommodation and food services. The service sector as a whole (e.g., retail, transportation, communications industries, health care) is underrepresented in included studies when considering the prevalence of work-related injuries among workers employed in this sector. In terms of specific occupational groups, few studies enrolled office and administrative support workers (the occupational group with the largest employment in the United States).[51] The following occupations were not represented in included studies: sales and related occupations (the second largest major occupational group in the United States)[51] and food preparation and serving workers (the third largest major occupational group in the United States).[51]

No study enrolled populations of workers who were very young or very old. No study addressed differences in outcomes among subgroups of workers defined by age, sex, race, ethnicity, comorbidity, or income. People who work part time (regardless of their occupation) were often excluded from studies.

Interventions

Studies evaluated quite diverse interventions; the type and level of integration involved in interventions varied substantially. We found no direct evidence on whether certain strategies of integration are more or less effective than others. A minority of included studies (8 studies) evaluated an intervention that included organizational integration (e.g., multiple departments within the work setting involved with planning, implementing, and managing the intervention).

We found no studies that directly assessed whether specific combinations or specific types of program content were more or less effective than other combinations. Studies differed in terms of the degree to which program content focused on OSH concerns versus HP concerns.

We could not assess whether strategies were more or less effective based on their complexity (single vs. multiple components) or level of influence (environmental or administrative controls, individual worker education, or both). Most studies assessed complex heterogeneous interventions that targeted both the worker and the worksite. Few studies assessed single-component interventions aimed at improving the work environment or work structure with the associated goals of improving OSH and promoting personal health.

Comparators

In general, studies were not designed to assess directly the effectiveness of integration alone (compared with no integration). Most studies compared an intervention that addressed both OSH and HP with no intervention. The effects of the new HP or OSH component (or both) offered to the intervention group could not be separated from the effects of integration. Studies that compared an intervention with no intervention or usual workplace programs generally did not describe the OSH or HP programs already in place and available to workers.

Outcomes

Although we considered a wide range of outcomes for this review, we were able to rate the evidence for only three: smoking cessation, changes in fruit and vegetable consumption, and changes in sedentary work activity. Very few studies measured outcomes important to OSH. Whether integrated interventions improve workplace safety (compared with OSH programs or policies that are not integrated with HP) is unclear.

No study eligible for KQ 2 reported on the following outcomes: incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; body mass index; or use of health care. A few studies (all high risk of bias) reported on the following: validated measures of quality of life or functional status, stress (job or general stress), rates of workers' compensation claims, short-term disability claims, alcohol use, and illicit drug use.

None of these studies prespecified harms as an outcome of interest. We found no information pertaining to increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, or victim blaming.

Deficiencies in Methods

As already noted, nine studies used a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. The 15 studies eligible for KQ 2 still had numerous methodological limitations. The RCTs often did not report on randomization and allocation concealment adequately. Most RCTs randomized worksites (not workers), but the numbers of worksites randomized were sometimes small. Investigators often did not adequately describe the flow of participants (especially for studies that randomized or assigned interventions at the worksite level).

Most studies mounted surveys before and after an intervention, but response rates to baseline surveys among eligible workers were sometimes low or not reported. This factor contributed to selection bias. Overall attrition was high in several studies; most studies performed a complete-case analysis; participants (or worksites) with missing data were excluded from the analysis. We encountered baseline differences between groups in several studies; statistical analyses often did not address these differences. Several studies had small sample sizes and thus lacked power for determining intended effects.

Investigators sometimes did not provide information on their statistical methods; also, authors sometimes did not provide measures of variance (e.g., confidence intervals) for outcomes. In several studies, contamination of the control arms compromised internal validity; for example, another worksite policy or program initiated during the intervention period could have influenced outcomes measured in the study.

Finally, in some cases, the length of followup may not have been adequate to assess the stability of findings over time. Only seven studies measured outcomes at or beyond 1 year.

Key Question 6. Future Research Needs

Work Settings and Populations

Future research could target specific worksites in diverse regions of the United States that differ in terms of State government policy on economic development and labor; these factors can influence where employers locate and the attention they give to worker safety.

The applicability of interventions that were effective for reducing smoking, improving fruit and vegetable consumption, and reducing sedentary work activity is limited. Future studies should consider similar interventions in other groups of workers (e.g., other blue-collar workers) to help clarify (1) the SOE for these interventions and (2) the applicability across various work settings and populations.

Consideration should be given to a broader set of populations of workers in the service sector—such as retail, transportation, and communications industries and health care—in future

TWH interventions. These populations have a high burden of occupational injuries. Occupational groups representing the largest number of U.S. workers should also be a focus of future research; these include (but might not be limited to) office and administrative support workers, sales and related occupations, and food preparation and serving workers. Future studies could enroll workers from diverse work settings (who receive a similar intervention, for example) to assess which factors related to the work setting modify the benefits (and potential harms) of TWH interventions. This approach might include recruiting worksites that differ by size, ownership of the enterprise (e.g., whether private or public sector), work organization (e.g., full- vs. part-time job patterns), and unionization.

Future studies could assess whether outcomes differ among subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate). Whether certain categories of workers would benefit more than others from TWH is not clear. Future studies could enroll populations who are likely to have specific concerns related to work–life balance (e.g., caregivers of young children or elderly parents, single parents) or workers with unique health and safety concerns (older workers or those with disabilities).

Interventions

Future studies should clearly describe the approach used to integrate OSH and HP programs, policies, or goals. Investigators should lay out a framework for how the integrated intervention addressed both OSH and overall health. Studies should focus on interventions targeted at work environment or work structure. Work schedules (e.g., shift work, work hours), for example, have been highlighted as an issue relevant to TWH. Few studies have assessed whether specific integrated strategies that modify the work environment improve worker health more than those focusing primarily on providing education or behavioral counseling to individual workers.

Comparators

An established body of literature supports the efficacy of worksite wellness interventions on smoking and other important outcomes.[52] Future studies should try to assess directly the effectiveness of integration itself; in other words, this aspect of TWH interventions should be isolated from the effects of a new or improved OSH or HP component. Studies should directly compare an integrated approach with a program that has similar OSH and HP elements available but does not deliberately coordinate them. In addition, investigators should clearly describe what programs related to health and safety are already in place and available to workers outside the intervention being evaluated.

Outcomes

Future studies should consider the feasibility of measuring OSH outcomes. To understand whether integration improves both OSH and HP, researchers need to examine indicators of improved safety.

Future studies should also consider direct measures of worker health if possible. For example, investigators should try to use validated measures of health status, functional status, and wellness. Researchers should measure the incidence or morbidity associated with chronic diseases when feasible, particularly in populations of workers at higher risk of chronic conditions (e.g., older workers).

Research teams should also choose intermediate outcomes carefully. These outcomes should be based on strong evidence for linkages to final health outcomes and for relevance to a particular population of workers.

Finally, future studies should consider assessing harms or potential unintended consequences of the interventions. Measures of harms and unanticipated effects should be made at both the individual worker and organizational levels.

Deficiencies in Methods

Worksite randomized trials should follow the recommendations for reporting outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement extension to cluster randomized trials[53] or the Ottawa Statement on the ethical design and conduct of cluster randomized trials.[54] In particular, authors should provide a clear diagram to show the flow of participants from group assignments through the final analysis. Of the 24 studies we included in this review, 9 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 15 studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations.

Randomized trials are not always feasible because of barriers associated with studying populations of workers. Well-designed prospective cohort studies (or nonrandomized trials) with a concurrent control group could inform the SOE related to TWH interventions. Studies without a control group are unlikely to contribute significantly to an understanding of the SOE supporting TWH interventions because of the inherent bias in the design; these designs should be avoided.

Investigators should plan for high attrition, and differential attrition between intervention and control groups. In addition, they should use methods to address missing data (e.g., imputation of missing data) when attrition is high; these methods should be informed by the potential reasons for missing data and whether the outcomes of participants are likely to change after they drop out.

Studies should address baseline differences between groups (when they are present) using appropriate statistical methods. Furthermore, investigators should report measures of variance (e.g., confidence intervals) for all outcomes they evaluate. Finally, in reporting their studies, authors should highlight whether other concurrent policies or programs related to health and safety had been in place or implemented during the intervention in question; this will enable them to assess bias associated with contamination.

Discussion

Key Findings and Strength of Evidence

We limit our discussion to key findings from the 24 included studies for all KQs. Other results can be found in the Results section and in more detail in the full report.

Key Question 1. Characteristics of Studies Evaluating Total Worker Health Interventions

Work settings, populations, interventions, and outcomes all differed considerably across this evidence base. Studies enrolled populations employed primarily in manufacturing, construction,

or health care settings. Overall, targeted workers were mainly 30 to 50 years of age. All studies assessed an intervention focused on an integrated objective to address both OSH and HP; 8 interventions included strategic organizational integration across departments; 17 included worker participation in the development, design, planning, or implementation of the intervention; and 6 included both strategic coordination and worker participation. Most studies were multicomponent and included HP and OSH components not previously available to workers. The outcomes assessed were highly varied and usually not measured in similar populations of workers.

Key Question 2. Effectiveness and Harms of Interventions

Evidence for the effectiveness and harms of TWH interventions for improving outcomes consisted of 12 RCTs, 2 nonrandomized controlled trials, and 1 prospective cohort study.[10,11,20,23,24,26-28,33,36,37,45,46,49,50] Of these, 5 RCTs were medium risk of bias[27,28,46,49,50] and the others high risk of bias. Studies rated medium risk of bias (rather than high) provided little or no evidence for many important health and safety outcomes of interest. Some evidence (low SOE) supported the effectiveness of TWH interventions for improving rates of smoking cessation, increasing fruit and vegetable intake, and decreasing sedentary work activity. Evidence was insufficient to permit us to assess the effectiveness of integrated interventions for improving quality of life; decreasing stress, blood pressure, weight, or consumption of red meat; or increasing safety compliance and safety behaviors.

Key Question 3. Components of Effective Interventions

We evaluated common characteristics of interventions that were effective for improving any outcome eligible for KQ 2 for which the SOE for benefit was at least low. Four studies, primarily enrolling blue-collar manufacturing and construction workers, contributed to our SOE grades for smoking cessation and healthy eating outcomes, and two studies enrolling office workers contributed to our SOE grade for sedentary work activity. Most effective interventions were informed by worker participation in the development, design, planning, or implementation of the intervention, or in more than one of these steps. All effective interventions included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. Most interventions tailored intervention components or materials to cultural or social aspects of the worker population.

Key Question 4. Contextual Factors

We abstracted data from included studies that related to contextual factors identified by authors as potential modifiers of intervention effectiveness. Of the 24 included studies, 8 identified a contextual factor that could have influenced the effectiveness of interventions, mainly work organization factors and union membership status. Other factors from at least one study included the following: presence of another concurrent OSH or HP policy implemented during the study period, health insurance status or access to primary care services, support from management, availability of resources, and employee stress or strain related to company downsizing during the intervention period.

Key Question 5. Research Gaps

As noted in the Results section, this knowledge base has numerous gaps. Of particular note is the lack of representation across regions of the United States and the appreciable

underrepresentation of the service sector (taking into account the prevalence of work-related injuries among workers employed in this sector). Few studies evaluated interventions in populations that varied by race, ethnicity, comorbidity, and other factors. Most studies compared an intervention with both OSH and HP components with no intervention; the effects of the new OSH or HP elements could not be separated from those presumably attributable to integration. Very few or no studies with a concurrent control group examined OSH outcomes, harms, unintended consequences, or any of the following: incidence of injuries or chronic diseases, morbidity associated with chronic diseases, and measures of health services utilization. Many studies had methodological limitations that included differences between intervention and comparison groups at baseline, small sample sizes and power, high overall or differential attrition, and choices of statistical analyses (e.g., no methods to address missing data).

Key Question 6. Future Research Needs

In the Results section, we enumerated numerous areas for future research to fill gaps and for improvements in study designs and methods. These include studying a broader range of workers and worksites in more regions and diverse States of the United States to account for different policies about economic development, labor issues, and worker safety. Moreover, examining similar interventions in other or different groups of workers or work settings might help clarify not only the SOE for interventions but also how generalizable they are across various work settings and populations. Funders should give more consideration to workers in the service sector industries and health care or other parts of the economy with high levels of occupational injuries. Finally, subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income, when appropriate, deserve more attention overall and in terms of whether certain categories would benefit more (or less) from TWH interventions.

We emphasized the need for later research to examine directly the effectiveness of integration (in isolation from the effects of any new or improved OSH or HP component) and to describe clearly what programs related to health and safety might already be in place. In terms of outcomes, future studies should do a better job of measuring safety-related outcomes to clarify whether integration improves both OSH and overall health. We noted the need for direct measures of final health outcomes and good selection of intermediate outcomes that link them solidly to final health outcomes, taking the worker population specifically into account. Finally, we advise that future research give more attention to possible negative side effects or unintended consequences of interventions for both organizations and individual workers.

Given that TWH trials may randomize at the worksite level, we call attention to the need to reflect CONSORT principles for reporting and those relating to cluster randomized trials for design and informed consent issues. More well-designed prospective cohort studies or nonrandomized trials with concurrent control groups could inform the SOE related to TWH intervention because studies without a control group are unlikely to yield meaningful information about the effectiveness (or lack of it) of TWH interventions. Finally, we urge investigators to plan ahead for how to handle differences between worker groups at baseline, as well as high attrition and differential attrition, and to use methods to address missing data when necessary, such as imputation of missing data. Studies should address baseline differences between groups when they are present using appropriate statistical methods and report measures of variance (e.g., confidence intervals) for outcome measures.

Findings in Relation to What Is Already Known

This emerging body of literature did not yield any previous systematic review that was similar in scope to ours or that assessed the SOE related to common outcomes of TWH interventions. One prior systematic review[14] and one expert (or narrative) review[13] gave broad overviews of TWH interventions. Our results are, in general, consistent with those in earlier reviews with respect to limitations of the evidence base. For example, although Anger and colleagues noted that integrated interventions improved risk factors for chronic diseases, they concluded that little or no evidence shows that integration itself confers a significant benefit and that this may be "perhaps the most glaring gap in the TWH literature."[14] Like previous reviews, we took a broad approach to defining "integration." Not surprisingly, our review and the two earlier reviews differ slightly in terms of included studies and whether we considered them integrated or not. For example, one study assessing a worksite wellness program designed for firefighters was in the review by Anger and colleagues; we excluded it, however, because it had no explicit coordination between OSH and HP programs and no obvious focus on health protection.[55] Our systematic review methods differ from those of earlier reviews. Prior reviews either did not address potential bias associated with TWH interventions or used study design labels as a proxy for risk of bias of included studies.[14] We used standard techniques for assessing risk of bias for individual trials or observational studies (documented in Appendix C of the full report) and grading the SOE for entire bodies of evidence (Appendix D).

Regarding overall conclusions about the effectiveness of TWH interventions, we assessed the SOE for specific outcomes, whereas prior reviews offered only general statements about the positive effects of TWH interventions or summarized benefits using primarily numbers of statistically significant outcomes across studies; they generally did not consider study limitations, directness, consistency, or precision in evaluating their findings.[13,14] In general, then, the two prior reviews drew stronger conclusions about the benefits of integrated integration than we reached.

Applicability

During our review process, we systematically abstracted key factors (identified a priori) that may affect the applicability of the evidence base (i.e., "the extent to which the effects observed in published studies are likely to reflect the expected results when a specific intervention is applied to the population of interest under real-world conditions"[56]). We focused on issues for populations of workers and worksites in the United States. Studies demonstrating the effectiveness of TWH interventions for improving rates of smoking cessation or increasing the consumption of fruits and vegetables involved U.S. blue-collar workers and used survey data collected before 2004 (and all from the same group of researchers[10,11,27,28]). Since the mid-2000s, workplace HP and OSH programs have very likely improved; whether the results of these trials would be applicable to worksites that already have active HP programs or policies that promote smoking cessation and healthy eating is not clear.

More recent changes in health policy or practice, such as community health interventions and health care, may limit the applicability of studies published 10 or more years ago. After implementation of the Affordable Care Act, national surveys show improvements in self-reported health care coverage and in access to primary care and medications, greater affordability, and better health among younger populations of men, at least in States that expanded Medicaid coverage.[57] Access to smoking cessation services may be more widely

available because of these changes; intervention components evaluated in older studies could now be considered "usual care" in some settings.

Limitations of the Review Process

As documented earlier, our inclusion criteria for interventions were broadly defined, and studies meeting those criteria used a range of strategies to address OSH and especially HP concerns. We based our work on NIOSH definitions for TWH programs and related guidance.[12] Nevertheless, relevant studies were often published before the terms "integrated intervention" or "total worker health" came into use. The definition of TWH itself has shifted in 2015 away from a more narrow focus on integrating OSH and HP to "an approach that advocates for a holistic understanding of the factors that contribute to worker well-being."[7] Our review scope did not include all studies that might fall under the larger umbrella of concerns relevant to TWH.

We did our searches to identify studies that would generally be considered to involve integrated TWH interventions; however, such studies are not indexed by standard or consistent terms. To address this deficiency, we solicited and received a database from NIOSH that listed studies deemed relevant to TWH. Our search strategies had identified the vast majority of these studies. Nevertheless, some studies that we excluded might still be considered related to TWH.

Publication bias and selective reporting of outcomes are potential limitations. Although we searched for unpublished trials and unpublished outcomes, we did not find direct evidence of either of these biases. Many of the included trials were published before trial registries (e.g., ClinicalTrials.gov) became available; had we been able to consult such registries, we would have had greater certainty about the potential for either type of bias.

Finally, for this review, we excluded non–English-language studies, based largely on limitations of time and resources. However, we identified non–English-language studies in our searches and did not see any references that were otherwise likely to meet our inclusion criteria. Searches of the NIOSH references also did not uncover any non–English-language studies. Given this, and the fact that TWH is a relatively new strategy, we believe that limiting our review to English-language studies had little effect on our overall conclusions.

Limitations of the Evidence Base

The limited scope and volume of this evidence base meant that it was inadequate to draw conclusions for some questions or subquestions of interest, even though we went beyond trial data to include observational studies.

For KQ 2, we limited our synthesis to studies with a concurrent control group, but limiting by study design is unlikely to have had a major effect on our SOE grade assessments for effectiveness or harms issues. For KQs 5 and 6, we included pre-post studies, but these questions did not entail making SOE judgments. Furthermore, among studies eligible for KQ 2, many had methodological drawbacks that introduced significant overall study limitations (especially nonresponse to surveys and high overall or differential attrition). It is of particular importance for future research to deal with the following problems: lack of reporting of randomization and allocation concealment, differences in intervention and control groups at baseline, small sample sizes (and thus lack of power for determining intended effects), lack of clarity in defining intervention components, and lack of adequate description or documentation of statistical tests and results.

Conclusions

Overall, we found the body of evidence to be small; heterogeneous in terms of populations, interventions, and measured outcomes; and, in some areas of interest, nonexistent. The small size of the body of evidence is not altogether surprising given that the concept of "integration" is relatively new. The body of evidence may reasonably be expected to grow over the next few years. Evidence of low SOE supported the effectiveness of TWH interventions for improving the following: rates of smoking cessation over 22 to 26 weeks, increasing fruit and vegetable intake over 26 to 104 weeks, and reducing sedentary work activity over 16 to 52 weeks. Evidence was insufficient to assess the effectiveness of integrated interventions for improving the following outcomes: quality of life, stress, blood pressure, weight, overall and work-specific levels of physical activity, consumption of red meat, safety behaviors, and safety compliance. Effective interventions were informed by worker participation and included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. The applicability of these findings is limited; most trials enrolled blue-collar workers (from manufacturing worksites in Massachusetts or unionized construction workers) before 2004.

Additional adequately powered multisite RCTs or other prospective studies with a concurrent control are needed to replicate encouraging findings, which have been observed to date in only a few trials. Investigators also need to design studies explicitly to assess the benefits of integration separately from new OSH or HP components. Including a broader range of workers in future studies could increase the applicability of TWH interventions and enable reviewers to assess the consistency of findings. It might also answer the question of whether integrated strategies are more effective or less effective in groups of workers who differ by demographic, social, or occupational characteristics that contribute to adverse health outcomes.

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Introduction

Background

The American worksite has been a venue for both health protection and health promotion (HP) programs. Health protection programs are interventions aimed specifically at preventing occupational injuries or illnesses. Work-related injuries and illnesses lead to morbidity, mortality, and considerable financial and social costs.[1-3] HP programs, often called wellness programs, are interventions aimed at improving overall health and well-being. They often address modifiable behavior risk factors such as smoking, physical activity, and diet, which are leading causes of morbidity and mortality in the United States.[4]

Traditionally, occupational safety and health (OSH) programs and HP programs have functioned independently within the workplace.[5] In the past decade, however, interest in integrating these programs has grown appreciably;[5,6] this interest grows out of evidence supporting the idea that workplace factors contribute to adverse health outcomes traditionally considered to be unrelated to work (e.g., cardiovascular disease, depression, and others).[7]

The National Institute for Occupational Safety and Health (NIOSH) focused attention on integrated approaches in 2011 by creating the Total Worker Health® (TWH) program. NIOSH summarized the rationale for integrating OSH and HP interventions in 2012 as follows:[8] (1) risk of adverse health outcomes is increased by exposures to both occupational hazards and behavioral risk factors; (2) occupational exposures and risk factors for chronic diseases are related and may have synergistic adverse health effects; (3) workers at highest risk for hazardous occupational exposures often have more risk factors for chronic disease; and (4) integrating OSH with HP efforts may increase worker participation in health-related programs and benefit the broader work environment. TWH is currently defined as "policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being."[7] Earlier descriptions of TWH focus primarily on integrating OSH and traditional worksite HP programs;[8] NIOSH now emphasizes recognition that work is a social determinant of health and that job-related factors (e.g., wages, hours of work, workload and stress levels, among others) are important factors in determining the well-being of workers.[7]

TWH is a registered trademark term that was not commonly used in past studies of integrated interventions. For this review, we use the term "TWH interventions" to refer to integrated interventions that are consistent with NIOSH's TWH initiative. A range of interventions that differ in content, complexity, and approach to integration could be considered consistent with NIOSH's TWH initiative. For example, prior studies considered to be integrated TWH interventions were developed through strategic intraorganizational coordination and employee participation that pair organizational change with individual-level content focused simultaneously on occupational hazard(s) and HP.[9,10] TWH interventions can also consist of a subset of these traits; for example, an intervention may combine components aimed at improving ergonomics and promoting physical activity with the aim of decreasing musculoskeletal injuries and improving overall health. Prior research has outlined indicators and metrics of "integration" important in TWH interventions that include factors such as organizational leadership; data integration; organizational coordination across departments responsible for health protection and HP; adequate resources, accountability, and training; and other factors.[11] However, no research has evaluated these indicators separately in order to isolate whether (and to what extent) they contribute to intervention effectiveness beyond other factors such as intervention content. Efforts

have been made to develop common validated metrics for these aspects of integrated intervention, but most existing studies were conducted prior to this work.[11,12]

Existing Guidelines

TWH is an emerging body of literature. However, NIOSH has created guidelines for employers interested in implementing TWH programs.[8,13-16] The guidelines highlight the importance of organizational leadership and commitment, employee participation, needs assessment, planning, integrated objectives, integrated implementation teams, data integration across systems responsible for OSH and HP, adequate resources, and solutions based on both organizational and individual factors. They also recommend using participation incentives and provisions to ensure accountability, evaluation, and continual improvement.

Rationale for Evidence Review

The goal of this review is to identify gaps in the evidence about the effectiveness and harms of TWH interventions to help identify future research priorities. Previous reviews of the literature have used different search and inclusion criteria, resulting in included studies of varied rigor and scope.[17,18] Moreover, the effectiveness of the interventions in individual studies and in the prior reviews has been judged based on various metrics (e.g., various improvements in health behaviors, physiologic outcomes, and economic outcomes or a count of the number of significant outcomes). As a result, uncertainty remains about the benefit and harms of TWH interventions on specific health and safety outcomes.

The authors of these studies and reviews also did not address all the Key Questions (KQs) broached in this systematic review. For example, intervention effectiveness has not been considered in relation to the occupational groups, industries, and settings in which the interventions take place. Uncertainty also remains about the role of many contextual factors that affect worker safety and health (e.g., health care coverage, company size, and unionization) as a modifier of intervention effectiveness. For example, small employers, which often do not offer health insurance, may struggle to provide comprehensive integrated interventions. In addition, more studies may have been conducted since the previous reviews and need to be added to the body of evidence. These factors underscore the need for the current systematic review to synthesize the literature supporting TWH interventions, assess the strength of evidence for important outcomes, and highlight research gaps and future research needs.

Scope and Key Questions

The purpose of this review is to provide an evidence report that the Pathways to Prevention Workshop Program of the Office of Disease Prevention at the National Institutes of Health can use to inform a workshop focused on TWH.[19] This review will describe the body of evidence evaluating TWH interventions, evaluate the effectiveness of TWH interventions for improving health and safety outcomes, highlight the research gaps, and inform future research needs. The Pathways to Prevention Workshop Program Panel will use the evidence report as a resource to develop a summary of the current state of the science and future research needs related to TWH interventions.

Specifically, we address the following six KQs:

Key Question 1

What populations, work settings, intervention types, and outcomes have been included in studies assessing integrated interventions?

Key Question 2

What is the effectiveness of integrated interventions for improving the following outcomes, and what are the potential harms?

a. Health and safety outcomes (e.g., cardiovascular events or incidence of work-related injuries)

b. Intermediate outcomes (e.g., change in blood pressure, tobacco use, or hazardous exposures)

c. Utilization outcomes and occupational injury and illness surveillance outcomes (e.g., hospitalizations or measures of workers' compensation claims)

d. Harms (e.g., discrimination or victim blaming).

Key Question 3

What are the characteristics of effective integrated interventions?

Key Question 4

What contextual factors have been identified as potential modifiers of effectiveness in studies of integrated interventions?

Key Question 5

What evidence gaps exist in the body of literature assessing the effectiveness of integrated interventions in terms of the following: populations, work settings, intervention types, outcomes, study designs, research methods, and contextual factors that may modify intervention effectiveness?

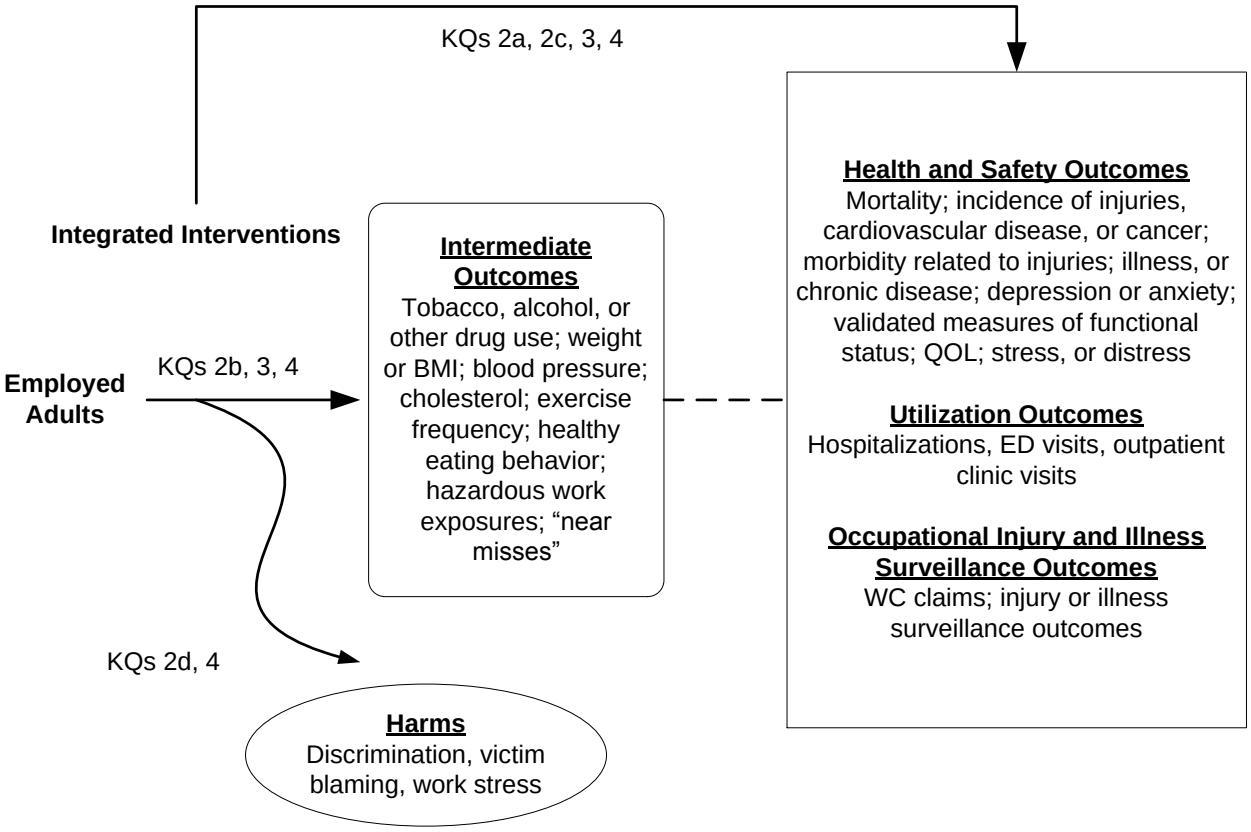
Key Question 6

What are the future research needs?

Analytic Framework

We developed an analytic framework to guide the systematic review process (Figure 1). The analytic framework illustrates the population, interventions, outcomes, and adverse effects that guided our literature search and synthesis.

Figure 1. Analytic framework for Total Worker Health interventions



BMI = body mass index; ED = emergency department; KQ = Key Question; QOL = quality of life; WC = workers' compensation.

Organization of This Report

The remainder of the review describes our methods in detail and presents the results of our synthesis of the literature with summary tables and the strength of evidence grades for outcomes eligible for KQ 2. The discussion section offers our conclusions, summarizes our findings, and provides other information relevant to interpreting this work for practice and future research. References and a list of acronyms and abbreviations follow the discussion section.

Appendix A contains the exact search strings we used in our literature searches. Studies excluded at the stage of reviewing full-text articles with reasons for exclusion are listed in Appendix B. Tables in Appendix C show the specific questions used for evaluating the risk of bias of all included studies eligible for KQ 2 (i.e., studies with a concurrent comparison group), document risk of bias ratings for each study, and explain the rationale for high or medium ratings. Appendix D presents information about our grading of the strength of the various bodies of evidence (tables for individual domain assessments and overall strength of evidence grades for

each outcome). Appendix E contains a reference list of studies in progress that are relevant to TWH interventions.

Methods

The methods for this review of Total Worker Health® (TWH) interventions follow those specified for the Agency for Healthcare Research and Quality (AHRQ) Evidence-based Practice Center (EPC) program. This guidance is codified in the "Methods Guide for Effectiveness and Comparative Effectiveness Reviews" (hereafter, Methods Guide, available at www.effectivehealthcare.ahrq.gov).

Topic Refinement and Review Protocol

The purpose of this review is to provide an evidence report that the Pathways to Prevention (P2P) Workshop Program of the Office of Disease Prevention at the National Institutes of Health (NIH) can use to inform a workshop focused on TWH.[19] The initial Key Questions (KQs) were provided by NIH's P2PWorking Group. The RTI International-University of North Carolina at Chapel Hill (RTI-UNC) EPC further refined the KQs. We incorporated guidance from a Technical Expert Panel (TEP) into the final research protocol, which was posted on the AHRQ Web site on May 26, 2015, at www.effectivehealthcare.ahrq.gov/search-for-guides-reviews-and-reports/?pageaction=displayproduct&productid=2085.

Literature Search Strategy

Search Strategy

We searched MEDLINE®, the Cochrane Library, the Cochrane Central Trials Registry, and PsycInfo from January 1, 1990, to September 21, 2015. Appendix A presents the full search strategy. Its start date (January 1, 1990) reflects the timing of increased attention and focus on "integrated" interventions. A review of TWH background documents from the National Institute of Occupational Safety and Health (NIOSH), previously published narrative reviews, and our literature scan indicates that the majority of programs began after 1990.

We used either Medical Subject Headings or major headings as search terms when available or key words when appropriate, focusing on terms to describe the relevant population and interventions of interest. We reviewed our search strategy with the TEP and incorporated their input into our search strategy. An experienced information scientist (an EPC librarian) conducted the searches. We conducted quality checks to ensure that our searches identified known studies (i.e., studies identified on NIOSH's TWH Web site and expert reviews focused on integrated interventions).

We searched for unpublished studies relevant to this review using ClinicalTrials.gov and Academic Search Premier; on our behalf, the AHRQ Scientific Resource Center solicited scientific information packages via *Federal Register* notices or informational requests. We received a bibliography from NIOSH listing studies relevant to the TWH program. We used this bibliography to ensure that our database searches had not missed relevant citations.

We also manually searched reference lists of pertinent reviews and included trials and background articles on this topic to look for any relevant citations that our searches might have missed. We imported all citations into an EndNote® X7 electronic database.

Inclusion and Exclusion Criteria

We developed eligibility (inclusion and exclusion) criteria with respect to PICOTS (populations, interventions, comparators, outcomes, time frames, settings), study designs, and study durations for each KQ (Table 1). The focus of this review is on providing an overall synthesis of TWH or "integrated" interventions. We cast a broad net and included any studies focused on interventions that could be considered integrated based on the intervention criteria outlined in Table 1. We included studies conducted in any workplace setting in a developed country ("very high" human development index per the United Nations Development Programme)[20] to increase the applicability of our conclusions to worksites within the United States.

We did not exclude any categories of workers or studies based on the type of outcomes reported. For KQ 2, we limited our evidence synthesis to commonly reported outcomes that are considered to be important measures of worker health and safety. We chose these outcomes by reviewing prior studies of TWH interventions and asking for input from the TEP on our inclusion and exclusion criteria before finalizing the research protocol.

Table 1. Inclusion/exclusion criteria for studies of Total Worker Heath interventions

PICOTS	Inclusion	Exclusion
Population	Employed adults (18 years of age or older)	Children and adolescents under age 18
Intervention	Any "integrated intervention" that meets the definition of a TWH strategy, defined as "a strategic and operational coordination of policies, programs, and practices designed to simultaneously prevent work-related injuries and illnesses, and enhance overall workforce health and well-being."[11] We will not judge inclusion and exclusion based on the degree or type of integration[a] To meet inclusion criteria, an intervention must include a component aimed specifically at improving workplace health and safety[b] and a component aimed at improving overall health, health behaviors, or risk factors for chronic diseases[c] Interventions may include a range of components that focus on changes in policy; organizational structure; work organization; environmental factors; or individual worker education, counseling, training, or social support (or combinations of these components).	All other interventions
Comparator	**All KQs:** Usual practice, usual care, standard care, or no intervention; head-to-head studies comparing an integrated intervention with another intervention that differs in content, intensity, or degree of integration **KQ 1 only:** Pre-post comparisons (in addition to the comparators listed above)	No comparison; nonconcordant historical controls

Table 1. Inclusion/exclusion criteria for studies of Total Worker Heath interventions (continued)

PICOTS	Inclusion	Exclusion
Outcomes	**KQ 1:** This is a descriptive summary of studies that meet inclusion criteria for all other domains (e.g., intervention and study design criteria); we will describe the range of outcomes reported across studies (in addition to the ones listed below for KQs 2, 3, and 4). **KQ 2a: Health and safety outcomes:** Mortality; incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; validated measures of functional status, quality of life, stress or distress **KQ 2b: Intermediate outcomes:** Tobacco, alcohol, or illicit drug use; weight or body mass index; blood pressure; cholesterol (total cholesterol, low-density lipoprotein cholesterol and high-density lipoprotein cholesterol); incidence of diabetes; frequency of physical activity; healthy eating behavior (e.g., increased consumption of fruit and vegetables); rates of hazardous exposures or "near misses" **KQ 2c: Utilization outcomes and occupational injury and illness surveillance outcomes:** Hospitalizations, emergency department visits, or outpatient clinic visits; measures of workers' compensation claims or injury or illness surveillance outcomes **KQ 2d: Harms:** Any potential harm reported in included studies, such as increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, victim-blaming, and others **KQ 3:** This is a descriptive summary of interventions that are effective for improving a health and safety outcome or an intermediate outcome (from our KQ 2 analysis). **KQ 4:** This is a descriptive summary of contextual factors identified as potential modifiers of intervention effectiveness across all included studies. Contextual factors may include (but are not limited to) the following: legal-regulatory environment (e.g., state laws with respect to union representation); employer characteristics, policies, or benefits (e.g., availability of health insurance coverage or paid sick leave); work organization (e.g., shift work); and social or economic factors (e.g., income or availability of community resources to support or promote health). **KQs 5, 6:** These entail a descriptive summary of, respectively, research gaps and future research needs related to TWH interventions.	**KQs 2, 3, 4**: All other outcomes, such as measures of aerobic capacity (e.g., VO_2 max) or exercise performance (e.g., number of sit-ups performed); intake of specific foods; measures of self-efficacy; participation in specific health promotion or safety programs (that are separate from the intervention); economic evaluation outcomes (e.g., cost or return on investment); work productivity measures (e.g., absenteeism)

Table 1. Inclusion/exclusion criteria for studies of Total Worker Heath® Interventions (continued)

PICOTS	Inclusion	Exclusion
Timing	Any duration of followup	None
Setting	Studies conducted in any workplace setting in a developed country ("very high" human development index per the United Nations Development Programme)[20]	Studies conducted in other countries
Study designs	**All KQs:** Original research, including randomized controlled trials, nonrandomized controlled trials, prospective cohort studies with a concurrent control group **KQ 1:** Pre-post cohort studies without a control group (in addition to the study designs listed above)	All other designs including case reports, case series, retrospective cohort studies, nonsystematic reviews, systematic reviews, studies with historical (rather than concurrent) control groups

KQ = Key Question; PICOTS = populations, interventions, comparators, outcomes, timing, and setting; TWH = Total Worker Health; VO_2 max = maximal rate of oxygen consumption as measured during incremental exercise.

[a] Variations in the degree to which interventions are "integrated" and how integration is accomplished, as well as the specific intervention components included, are considered characteristics of the integrated interventions and are the focus of KQ 1 (characteristics of interventions) and KQ 3 (characteristics of effective interventions).

[b] Occupational Safety and Health: Intervention (or program) components aimed at reducing hazardous exposures at work that can lead to work-related injury, illness, and disability. Interventions can be at the organizational or individual level (or both). Examples include (but are not limited to) the following: employer policies to improve (or remove) work hazards, engineering controls designed to eliminate or substitute hazards, adoption of improved personal protective equipment, and individual-level health and safety training to employees

[c] Worksite Health Promotion: Intervention (or program) components aimed at promoting worker health by decreasing risk factors for chronic diseases (e.g., smoking, sedentary behavior, obesity, blood pressure, and others), improving stress, and promoting overall well-being (e.g., via social support or physical activity). Intervention components may incorporate employee assistance programs, clinical prevention services, disease management programs, and other health benefits. Interventions may also include community-based services (e.g., referral for community-based health services) or environmental changes (e.g., increasing access to healthy foods at a worksite).

Study Selection

Two members of the research team independently reviewed all titles and abstracts (identified through searches) for eligibility against our inclusion/exclusion criteria (Table 1). We retrieved any publications marked for inclusion by either reviewer for evaluation of the full text. For titles and abstracts that lacked adequate information to determine inclusion or exclusion, we retrieved the full text for review. Then, two investigators independently reviewed the full texts to determine final inclusion or exclusion. The reviewers resolved any disagreements by discussion and consensus or by consulting a third member of the review team.

All results in both review stages were tracked in an EndNote database. We recorded the principal reason that each excluded full-text publication did not satisfy the eligibility criteria (Appendix B).

Data Extraction

For studies that met our inclusion criteria, we designed and used structured data extraction forms to gather pertinent information from each article, including characteristics of study populations, settings, interventions, comparators, study designs, methods, and results. One investigator extracted the relevant data from each included article; all data abstractions were reviewed for completeness and accuracy by a second member of the team. We recorded intention-to-treat results if available. All data abstraction was performed using Microsoft Excel® software. Once the final report is published online on the AHRQ Website, we will upload all

abstracted data to AHRQ's Systematic Review Data Repository (SRDR) for use in future research.[21]

Risk of Bias Assessment of Individual Studies

To assess the risk of bias (internal validity) of studies eligible for KQ 2, we used predefined criteria based on the AHRQ Methods Guide. These criteria included questions to assess selection bias, confounding, performance bias, detection bias, and attrition bias (i.e., those about adequacy of randomization, allocation concealment, similarity of groups at baseline, masking, attrition, use of intention-to-treat analysis, method of handling dropouts and missing data, reliability and validity of outcome measures, and treatment fidelity).[22] Appendix C lists the specific questions used for evaluating the risk of bias of all included studies. It also includes a table showing the responses to these questions and risk of bias ratings for each study and explains the rationale for all ratings that were either high or medium. As with our abstracted data, we will upload risk of bias ratings for the review's included studies to SRDR.[21]

In general terms, results from a low risk of bias study are considered to be valid. A study with medium risk of bias is susceptible to some risk of bias but probably not enough to invalidate its results. A study assessed as high risk of bias has significant risk of bias (e.g., stemming from serious errors in design, conduct, or analysis) that may invalidate its results. To assess publication bias, we looked for evidence of unpublished literature through searches of gray literature (clinicaltrials.gov). We also reviewed (when available) the original protocols for included trials to assess for selective outcome reporting.

We determined the risk of bias rating using the responses to all questions assessing the various types of bias listed above. To receive a low risk of bias rating, we required favorable responses to most questions, and any unfavorable responses had to be relatively minor (e.g., minor baseline differences between study groups unlikely to bias the results). We gave high risk of bias ratings to studies that we determined to have a major methodological shortcoming in one or more categories based on our qualitative assessment. Common methodological shortcomings contributing to high risk of bias ratings were high rates of attrition or differential attrition, inadequate methods used to handle missing data, and baseline differences between intervention and control groups that were not addressed in the analysis. We describe the results of all included studies for KQ 2 regarding of the risk of bias rating.

Two independent reviewers assessed the risk of bias for each study. Disagreements between reviewers were resolved by discussion and consensus or by consulting a third member of the team.

Data Synthesis

We did not perform any meta-analyses because of the heterogeneity across studies in terms of included populations, interventions, and outcomes. We summarized all included studies in narrative form and in summary tables that tabulate the important features of the study populations, design, intervention, outcomes, and results for KQ 1 and KQ 2.

KQ 3 asks primarily "What are the characteristics of effective interventions?" The aim of KQ 3 was to describe the characteristics of effective interventions; it is intended as a descriptive question to provide information about the interventions that work for employers or researchers who may want to implement or design TWH interventions. To address this question, we extracted detailed information on intervention components (described in KQ 1). We then focused on characteristics that relate to two main domains: (1) approach to integration (e.g.,

organizational integration across departments responsible for occupational safety and health and employee wellness, employee participation, and other factors) and (2) specific content of the intervention. We describe common components and combinations of components for all interventions that were effective for improving any outcome eligible for KQ 2 (at least low strength of evidence [SOE] for benefit).

For KQ 4, we compiled contextual factors identified in included studies as potential modifiers of effectiveness. Finally, KQ 5 and KQ 6 focus on evidence gaps in terms of PICOTS and future research needs, respectively.

Strength of the Body of Evidence

We graded the SOE of the accumulated evidence on a given issue to answer the specific KQs on the benefits and harms of the interventions in this review; we used the guidance established for the EPC program.[23] Developed to grade the overall strength of a body of evidence, this approach now incorporates five key domains: study limitations (including study design and aggregate risk of bias), consistency, directness, precision of the evidence, and reporting bias. It also considers other optional domains that may be relevant for some scenarios, such as plausible confounding that would decrease the observed effect and strength of association (i.e., magnitude of effect).

Table 2 describes the grades of evidence that can be assigned. Grades reflect the strength of the body of evidence to answer outcomes relevant to KQ 2 (comparative effectiveness, efficacy, and harms of the interventions in this review). Two reviewers assessed each domain for each key outcome, and differences were resolved by consensus. For each assessment, one of the two reviewers was always an experienced EPC investigator.

Table 2. Definitions of the grades of overall strength of evidence

Grade	Definition
High	**We are very confident that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has few or no deficiencies. We believe that the findings are stable (i.e., another study would not change the conclusions).
Moderate	**We are moderately confident that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has some deficiencies. We believe that the findings are likely to be stable, but some doubt remains.
Low	**We have limited confidence that the estimate of effect lies close to the true effect for this outcome.** The body of evidence has major or numerous deficiencies (or both). We believe that additional evidence is needed before concluding either that the findings are stable or that the estimate of effect is close to the true effect.
Insufficient	**We have no evidence, we are unable to estimate an effect, or we have no confidence in the estimate of effect for this outcome.** No evidence is available or the body of evidence has unacceptable deficiencies, precluding reaching a conclusion.

Source: Berkman et al.[23]

An unfavorable assessment for any one of the four key domains (e.g., inconsistency, indirectness, imprecision, or medium aggregate risk of bias) typically resulted in downgrading from high to moderate SOE. Two unfavorable assessments typically resulted in downgrading to low SOE. When only one study reported an outcome of interest (with unknown consistency and imprecision), we usually graded the SOE as insufficient; when similar interventions had consistent results in different populations of workers or at different outcome timings we graded the SOE as low. Appendix D presents tables showing our assessments for each domain and the resulting SOE grades for outcomes eligible for KQ 2, organized by outcome category.

Applicability

We assessed applicability of the evidence following guidance from the *Methods Guide.*[24] We used the PICOTS framework to explore factors that affect applicability. Some factors identified a priori that may limit the applicability of evidence include the following: geographic setting, work setting (industry and worksite), occupation (and associated occupational hazards) of enrolled populations, sex of enrolled populations (e.g., few women may be enrolled in the studies), and race or ethnicity of enrolled populations.

Peer Review and Public Commentary

This report was posted for public comment and peer reviewed. We addressed all comments in the final report, making revisions as needed; a disposition of comments report will be publicly posted 3 months after release of the final report.

Results

Introduction

This chapter presents the results of our systematic review. We first present the results of our literature searches and identify studies that met our inclusion criteria (referred to as "included studies"). We then discuss the findings from our analyses for each Key Question (KQ), starting with an overview of key points and then synthesizing the results. KQ 1 describes in detail all included studies by work settings and populations, intervention, and outcomes. A subset of included studies (i.e., studies with a concurrent control group) was eligible for KQ 2, which focuses on the effectiveness and harms of Total Worker Health® (TWH) interventions.

For KQ 2, we present the results of included studies organized by outcome category: health and safety outcomes, intermediate outcomes, utilization outcomes (including occupational injury and illness surveillance outcomes), and harms. For each outcome, we briefly describe the population, work setting, and intervention characteristics of the studies reporting a specific outcome. We describe the results of all studies eligible for KQ 2, regardless of the risk of bias rating. However, as described in the Methods chapter, we graded the strength of evidence (SOE) only for outcomes reported by at least one study that we had rated as either low or medium risk of bias.

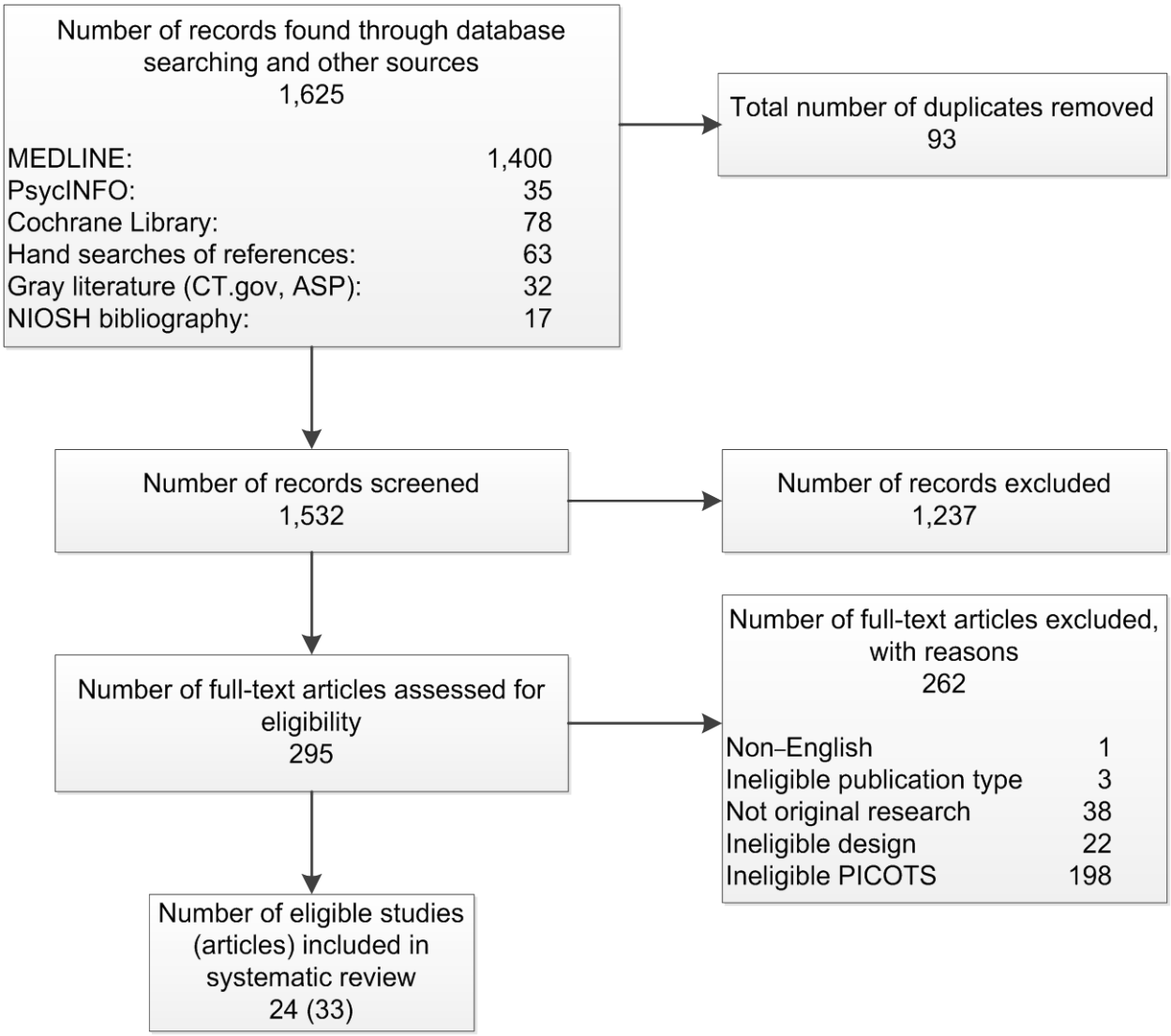
For KQ 3, we describe the components of effective interventions when we had least one study rated as low or medium risk of bias that showed benefit for an included outcome in KQ 2. We focus on components of interventions relating to the integration of occupational safety and health (OSH) and health promotion (HP).

The results of KQs 4 through 6 are based on all included studies. KQ 4 describes contextual factors that authors noted as potential modifiers of intervention effectiveness (e.g., work organization, social and economic factors, and others). Finally, KQ 5 and KQ 6 outline research gaps and future research needs (respectively) relevant to TWH interventions.

Results of Literature Search and Screening

Searches of all sources identified a total of 1,532 potentially relevant citations. We included 24 studies described in 33 publications.[9,10,25-55] Figure 2 describes the flow of literature through the screening process according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) categories.[56] Appendix B provides a complete list of articles excluded at the full-text screening stage, with reasons for exclusion. Of the 24 included studies, 15 studies had a concurrent control group and were also eligible for KQ 2.[9,10,25,28,29,31-33,38,41,42,50,51,54,55] Table 3 lists studies assessed for each KQ.

Figure 2. Disposition of articles for Total Worker Health interventions



ASP = Academic Search Premier; CT.gov = ClinicalTrials.gov; NIOSH = National Institute of Occupational Safety and Health; PICOTS = populations, interventions, comparators, outcomes, time frames, settings.

Table 3. Included studies, by KQ eligibility and KQ 2 outcomes

Author, Year, Study Design, Risk of Bias	KQ 1	Outcomes Eligible for KQ 2[a]	KQ 3	KQ 4	KQ 5	KQ 6
Allen et al., 2003[38] Nonrandomized controlled trial (NRCT), High	Y	Allergy severity Workers' compensation claims Short-term disability claims	N	Y	Y	Y
Barbeau et al., 2006[48] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Blackburn et al., 2009[30] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Boggild and Jeppesen, 2001[41] Cohort study, high	Y	Alcohol consumption Cholesterol levels Exercise frequency Smoking cessation Harms	N	Y	Y	Y

Table 3. Included studies, by KQ eligibility and KQ 2 outcome (continued)

Author, Year, Study Design, Risk of Bias	KQ 1	Outcomes Eligible for KQ 2[a]	KQ 3	KQ 4	KQ 5	KQ 6
Carr et al., 2015[54] Randomized controlled trial (RCT), medium	Y	Occupational sedentary behavior Occupational physical activity behavior Weight Blood pressure Musculoskeletal discomfort	N	N	Y	Y
Caspi et al., 2013[46] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Coffeng et al., 2014[51-53] RCT, medium	Y	Need for recovery after work Occupational stress and exhaustion Occupational physical activity behaviors Occupational sedentary behavior Overall physical activity level	N	Y	Y	Y
Eriksen et al, 2002[42] RCT, high	Y	Subjective health complaints Job stress Harms	N	Y	Y	Y
Hammer et al., 2015[55] RCT, medium	Y	Quality of life Blood pressure Safety participation and compliance scores	N	N	Y	Y
Hodges et al., 2004[37] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Maes et al., 1998[28] NRCT, high	Y	Cardiovascular disease (CVD) risk score General stress	N	Y	Y	Y
Maniscalco et al., 1999[47] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Nieuwenhuijsen et al., 2004[36] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Okechukwu et al., 2009[25] RCT, high	Y	Smoking cessation	Y	Y	Y	Y
Olson et al., 2015[43] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Olson et al., 2009[44,45] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Palumbo et al., 2012[29] RCT, high	Y	Quality of life General stress Job stress Functional status	N	Y	Y	Y
Porru et al., 1993[49] Single-group pre/post study, NA	Y	NA	N	Y	Y	Y
Sorensen et al, 1998[9,39,40] RCT, high	Y	Healthy eating behavior Self-reported workplace hazard exposure Smoking cessation	N	Y	Y	Y
Sorensen et al., 2003[10,26,27] RCT, high	Y	Healthy eating behavior Worksite hazardous substance exposure prevention ratings Smoking cessation	Y	Y	Y	Y
Sorensen et al., 2005[33-35] RCT, medium	Y	Healthy eating behavior Overall physical activity level	Y	Y	Y	Y
Sorensen et al., 2007[32] RCT, medium	Y	Healthy eating behavior Smoking cessation	Y	Y	Y	Y
Tveito and Eriksen, 2009[31] RCT, high	Y	Quality of life Subjective health complaints	N	Y	Y	Y

Table 3. Included studies, by KQ eligibility and KQ 2 outcome (continued)

Author, Year, Study Design, Risk of Bias	KQ 1	Outcomes Eligible for KQ 2[a]	KQ 3	KQ 4	KQ 5	KQ 6
von Thiele Schwarz et al., 2015[50] RCT, high	Y	Self-rated health[b]	N	Y	Y	Y

CVD = cardiovascular disease; KQ = Key Question; N = no; NA = not applicable; NRCT = nonrandomized controlled trial; RCT = randomized controlled trial; Y = yes.

[a] Other outcomes assessed in these studies are listed in Table 6 in KQ 1.

[b] Self-rated health was assessed using a single item where participants were asked to rate their current health status on a five-point scale that ranged from "very good" (1) to "very poor" (5).

Key Question 1. Characteristics of Studies Evaluating Total Worker Health Interventions

We included 24 studies described in 33 publications that assessed integrated interventions; 12 of the studies were randomized controlled trials (RCTs),[9,10,25-27,29,31-35,39,40,42,50-55] 2 were nonrandomized controlled trials (NRCTs),[28,38] 1 was a prospective cohort study,[41] and 9 were single group pre/post studies.[30,36,37,43-49]

Across the 24 included studies, heterogeneity was substantial with respect to the work settings and populations, the intervention types, and the outcomes evaluated. Detailed information extracted from all included studies is available from the Systematic Review Data Repository™ (SRDR), available on the Web at www.srdr.ahrq.gov.

Key Points: Work Settings and Populations

- The majority of studies enrolled workers from the manufacturing, construction, and health care and social assistance industries.
- Workers from the manufacturing and construction industry were predominantly male and included a mix of blue-collar production workers and white-collar workers. Workers from the health care and social assistance industry were overwhelmingly female nurses.
- The mean age of enrolled workers across most included studies was between 30 and 50 years of age; only one study evaluated a younger workforce (mean <30 years of age) and only one study evaluated an older workforce (mean >50 years of age).
- Few studies described the baseline health status or comorbidity of included populations.

Key Points: Interventions and Comparators

- All 24 studies assessed an intervention designed to simultaneously reduce work-related illness and injury and promote overall health and well-being. Eight included studies assessed an intervention that involved strategic coordination across organizational departments responsible for OSH and HP, and 16 included studies involved worker participation in the development, design, planning, or implementation of the intervention. Six studies involved both strategic integration and worker participation.
- Most studies assessed complex multicomponent interventions; three studies assessed a single-component intervention.
- Of the 24 included studies, one assessed the effectiveness of integration alone (without added OSH or HP content). Twelve studies assessed interventions that included new, comprehensive OSH and HP components not previously available to workers. Six studies

included mostly HP content that was tailored to the specific needs of workers (often by highlighting the potential synergistic toxicity of work hazards and health behavior), and five studies assessed interventions that focused mostly on reducing OSH hazards but also included content aimed at promoting overall health and well-being.
- Of the 24 studies, 15 included concurrent control groups, most of which received no intervention. Two studies compared an integrated intervention with an HP-only intervention.

Key Points: Outcomes

- Overall, included studies evaluated diverse outcomes. Few studies assessed the same outcomes in similar populations of workers.
- Approximately half of studies evaluated at least one final health outcome such as general physical or mental health (e.g., quality of life, functional status), subjective health complaints, and stress.
- Commonly reported intermediate health outcomes were cholesterol levels, blood pressure, and a range of health behaviors including measures of physical activity, smoking, and dietary behaviors. Job stress and changes in safe work behaviors were commonly reported OSH intermediate outcomes.
- Few studies evaluated work-related injuries or illnesses.
- Several studies assessed outcomes that we did not include in KQ 2 (effectiveness and harms of TWH integrations); the most common were measures of absenteeism, productivity, and economic evaluation outcomes.

Detailed Synthesis

Work Settings and Populations

Table 4 describes the characteristics of work settings and populations evaluated across included studies. The included studies primarily enrolled workers based on their occupation (e.g., farmers, truckers), affiliation with a specific training program or union, work setting (e.g., hospitals, factories), specific geographic location. (e.g., municipal workers in a specific city), or combinations of these factors.

Table 4. Characteristics of work settings and populations

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (states)	Occupational Group(s)	Mean Age[a] (SD), Years	% Female	% Non-white
Allen et al., 2003[38] International's Allergy Project	Manufacturing Worksites producing medium- and heavy-duty trucks and diesel engines (7; 519) United States (Illinois, Indiana)	Blue-collar production workers and while-collar workers (% across worksites not reported)	43–46 (NR)	31	NR
Barbeau et al., 2006[48] MassBUILT Pilot	Construction Building trade apprentice training program (1; 337) United States (Massachusetts)	Apprentice iron workers	30 (8)	3	21

Table 4. Characteristics of work settings and populations (continued)

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (states)	Occupational Group(s)	Mean Age[a] (SD), Years	% Female	% Non-white
Blackburn et al., 2009[30] Sustainable Farm Families Project	Agriculture Communities in Southeastern Australia (NA; 128) Australia	Farmers (cropping and grazing)	47 (8.8)	45	NR
Boggild and Jeppesen, 2001[41]	Health care and social assistance Inpatient wards (7) in one regional hospital (1; 172) Denmark	Nurses and nursing aides	35–42 (NR)	NR	NR
Carr et al., 2015[54]	Not reported Private company (1; 60) United States (Iowa)	Sedentary desk job workers at a private company[b]	45 (11)	70	4–15
Caspi et al., 2013[57]	Health care and social assistance Inpatient wards (7) in 2 teaching hospitals (2; 374) United States (Massachusetts)	Nursing staff (advanced practice nurses, nurse leaders, and patient care associates)	41 (12)	90	21
Coffeng et al., 2014[51-53]	Finance Departments of a financial service provider (NR: 412) The Netherlands	Office employees with mainly desk jobs	38–44 (9.2–10.5)	38–45	NR
Eriksen et al., 2002[42]	Transportation Post office or postal terminal (31; 860) Norway	Postal service employees (office clerks and blue-collar workers)	37–39 (NR)	59–64	NR
Hammer et al., 2015[55]	Multiple industries Workers employed by a municipal public works department (NR; 292) United States (NR)	Construction and utility workers including electricians, plumbers, carpenters, heavy equipment operators, sidewalk repair persons, and others	45 (9.6)	10	21
Hodges et al., 2004[37] City of North Little Rock Employee Health and Wellness Program	Multiple industries Various worksites employing municipal works in one city (NR; 900) United States (Arkansas)	Municipal employees (multiple)	NR	NR	NR
Maes et al., 1998[28] Brabantia Project	Manufacturing Producer of household goods (3; 264) The Netherlands	Blue-collar production workers	39–41 (10.4–10.5)	NR	NR

Table 4. Characteristics of work settings and populations (continued)

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (States)	Occupational Group(s)	Mean Age[a] (SD), Years	% Female	% Non-white
Maniscalco et al., 1999[58] Lafayette OBUWP	Oil and gas extraction Offshore crude oil exploration facility (1; 147) United States (Louisiana)	Production operators, platform repairmen (mechanical, electrical, and automation)	42 (NR)	10	NR
Nieuwenhuijse, 2004[36] Work Site Health Risk Project	Health care and social service Administrative office of a health maintenance organization (1; 40) United States (Michigan)	Administrative support and clerical workers, management, and data entry/computer programmers	36 (range: 19–65)	77	NR
Okechukwu et al., 2009[25] MassBUILT	Construction Building trade apprentice training program (10; 1,213) United States (Massachusetts)	Apprentice training participants (boilermakers; bricklayers; electricians; hoisting and portable engineers; ironworkers; painters; plumbers; pipefitters; and others)	28–29 (6.7–6.9)	4–6	15–18
Olson et al., 2009,[44] Wipfli et al., 2013[45] SHIFT Pilot Study	Transportation Carrier companies (4;29) United States (Pacific Northwest)	Truck drivers	48 (10)	21	3
Olson et al., 2015[43] COMPASS	Health care and service Home care workers residing near Portland, Oregon (NA; 16) United States (Oregon)	Home care workers	58 (8)	94	33
Palumbo et al., 2012[29]	Health care and service Hospital (academic medical center) (1; 14) United States (Vermont)	Registered nurses, licensed practical nurses on hospital wards requiring patient lifting	≥ 49[c]	100	NR
Porru et al., 1993[49]	Manufacturing Small factories (bronze and brass foundries, lead shot production facilities, and pylon painting factory) (7; 50) Italy	Production workers with exposure to lead	39 (range: 21–58)	NR	NR
Sorensen et al., 1998;[9] Sorensen et al., 1996;[39] Sorensen et al., 1995[40] WellWorks	Manufacturing Worksites producing industrial, chemical, and other products; textile dyeing; firefighting; and newspapers (24; 2,658) United States (Massachusetts)	Blue-collar production workers, firefighters, textile dying machine operators[d]	(%s) <35: 27 35-50: 51 >50: 23	24	<4

Table 4. Characteristics of work settings and populations (continued)

Author(s), Year Study Name	Industry Worksite(s) (N worksites; N workers) Country (States)	Occupational Group(s)	Mean Age[a] (SD), Years	% Female	% Non-white
Sorensen et al., 2003;[10] LaMontagne et al., 2005;[26] Hunt et al., 2005[27] WellWorks-2	Manufacturing Worksites associated with probable use of hazardous chemicals (15; 9,019) United States (Massachusetts)	Blue-collar (hourly) and white-collar (salaried) workers	(%s) Under 31: 12–16 31–40: 27–33 41–50: 28–32 51–60: 19–24 61–70: 4–5 71 or older: 0–1	34–43	15–22
Sorensen et al., 2005;[33] Hunt et al., 2007;[34] Barbeau et al., 2004[35] Healthy Directions-Small Business	Manufacturing Worksites producing medical equipment, dog food, specialty pumps, textiles, and electronics; and laundry and printing service providers (26; 1,740) United States (Massachusetts)	Blue-collar workers (83–84%) and managers (16–18%)	43–44 (NR)	25–44	18–25
Sorensen et al., 2007[32] Tools for Health	Construction Workers with membership in the Laborers' International Union of North America (NA; 674) United States (multiple states)	General laborers, concrete workers, heavy construction workers, demolition workers, jackhammer	40–41 (9.5–9.7)	5–6	30–37
Tveito and Eriksen, 2009[31]	Health care and social service One nursing home for older people (1; 40) Norway	Nursing auxiliaries, nurses, assistants, other helping staff	NR	100	NR
von Thiele Schwarz et al., 2015[50]	Health care and social service Inpatient units (12) in one county hospital (1; 312) Sweden	Registered nurses, assistant nurses, others with direct patient care	45–47 (9.2–12.1)	91–96	NR

COMPASS = Community of Practice and Safety Support; N = number (of participants or worksites); NA = not applicable: NR = not reported; OBUWP = Offshore Business Unit Wellness Program; SD = standard deviation.

[a] When only the mean age per study arm (e.g., intervention and control groups) is provided, we present that as a range across groups.

[b] Employees with the following were excluded: acute illness or injury, self-reported cognitive impairments, psychosis or other severe psychological illness; self-reported chronic conditions (e.g., heart disease or cancer); workers who had a height-adjustable workstation; workers with BMI less than 25 kg/m^2; and workers who reported sitting less than 75 percent of a typical work day.

[c] Mean age not reported; however, study enrolled nurses ages 49 years or older.

[d] More than half of the 24 worksites in the WellWorks study were described as comprising a majority of blue-collar workers, ranging from 52 percent of the workers at the high-volume battery manufacturing worksite to 98 percent of workers at the firefighting worksite; the investigators did not describe nonblue-collar workers in detail.

Geographic Setting

Sixteen of the 24 included studies were conducted in the United States.[9,10,25,29,32,33,36-38,43,44,46-48,51,54] Six of these studies were conducted in Massachusetts;[9,10,25,33,48,59] 7 were conducted in various other states, including Vermont,[29] Illinois/Indiana,[38] Iowa,[54]Arkansas,[37] Louisiana,[47] Michigan,[36] Pacific Northwest,[44] and Oregon.[43] One study enrolled construction and utility workers employed by a municipal public works department but did not describe the trial setting by state or city.[55] Finally, one study enrolled workers from multiple states based on their affiliation with a labor union.[32] Of the studies conducted outside the United States, 4 were set in Scandinavian countries (Norway, Denmark, Sweden),[31,41,42,50] 2 were set in The Netherlands,[28,51] and 1 study each was set in Italy[49] and Australia.[30]

Work Setting

The majority of studies included workers from the health care and social assistance, manufacturing, and construction industries. The degree to which studies described characteristics of worksites (e.g., types of workplace exposures or union representation) varied across included studies.

Seven studies enrolled workers from the health care and social assistance industry. Six of these focused on worksites providing direct patient care, including five set in worksites where workers are centralized (four in a hospital[29,41,46,50] and one in a nursing home for the elderly[31]), and one study enrolled home care workers who were dispersed within a specific geographic area (near Portland, Oregon).[43] Finally, one study enrolled administrative office workers employed at a health maintenance organization.[36]

Six studies enrolled workers from the manufacturing industry;[9,10,28,33,38,49] all included multiple worksites (ranging from 3 to 26). Three studies described the potential occupational exposures associated with included worksites such as adhesives and abrasives,[10] chemicals and textile dyes,[9] and lead.[49] Two studies described the extent of unionization across worksites; in one study, 5 of the 12 worksites randomized to the intervention were described as unionized,[9] and the other study included worksites that varied in terms of the extent of unionization (5 percent to 80 percent of workers were unionized across 5 sites).[38]

Four studies enrolled workers from the construction industry. Two recruited workers from apprentice training programs affiliated with a labor union,[25,48] and one recruited construction laborers employed at various worksites across the United States who are members of the Laborer's International Union of North America.[32] One study enrolled both construction and utility workers employed in a municipal public works department.[55]

Four studies enrolled workers from various other industries, including finance,[51] transportation and warehousing,[42,44] agriculture,[30] and oil and gas extraction;[47] and one enrolled workers from various industries employed as municipal workers.[37] One study enrolled sedentary office workers from a company employing >1,200 workers but did not describe any further details about the industry or work setting.[54]

Occupational Groups

Six studies enrolled health care workers who provide direct patient care.[29,31,41,43,46,50] Five primarily enrolled skilled nurses, four of which also enrolled a minority of other occupational groups such as nursing aides or other staff involved with patient care;[31,41,46,60] and one study enrolled home care workers.[43]

Three studies enrolled office workers from various industries. including administrative office workers employed at a health maintenance organization,[36] office workers with mainly desk jobs in a financial institution,[51] and sedentary office workers from a large private company in the Midwest (1,200 employees).[54]

Across the six studies set in manufacturing worksites, three enrolled a majority of blue-collar production workers,[9,28,33] two enrolled blue- and white-collar workers (but did not report specific details),[10,38] and one did not describe the specific occupational groups (but focused on workers who were exposed to lead).[49]

Four studies primarily enrolled construction workers; two recruited workers from apprentice training programs from various occupational groups, including iron workers[25,48] boilermakers, bricklayers, ironworkers, and electricians, among others;[25] one enrolled construction laborers,[32] (e.g., general laborers, concrete workers, demolition workers and others); and one enrolled both construction and utility workers employed in a municipal public works department.[55]

Other studies focused on a range of occupational groups, including truck drivers.[44] postal workers,[42] farmers,[30] blue-collar production workers employed at an offshore drilling site,[47] and municipal workers in a variety of occupations.[37]

Other Population Characteristics

Across the 22 studies that reported on age, the mean age of enrolled workers ranged from 30 and 50 years of age (Table 4). Only 1 study evaluated a younger workforce (mean <30 years of age),[25] and 2 studies evaluated an older workforce (mean >50 years of age);[29,43] 2 studies did not report on the age of enrolled workers.[31,37] Across the 20 studies that reported the sex, 12 enrolled a majority of male workers and 8 enrolled a majority of female workers (Table 4); 4 studies did not describe the sex of enrolled workers.[25,37,41,49]

Studies set in the health care and service industry enrolled populations that were overwhelmingly female,[29,31,36,43,46,50] with mean ages ranging from 35 to 47 years of age in four studies;[36,41,46,50] two studies enrolled older populations, one enrolled home care workers with a mean age of 58 years,[43] and the other recruited nurses ages 49 years or older.[29] In the six studies set in the manufacturing industry, the mean age of workers ranged from 30 to 50 years of age; in the four studies that reported the sex of workers, enrolled populations were predominantly male.[9,10,33,38] In the four studies focused on construction workers, populations were predominantly male, and the mean ages of enrolled workers ranged from 28 to 45 years of age.[25,32,48]

Eleven included studies described the race of enrolled workers, and all enrolled a majority of white participants; only two studies enrolled populations that were made up of more than 25 percent nonwhite workers.[32,43] Across the four studies that described the ethnicity of workers, all included a minority of Hispanic workers, ranging from 2 to 5 percent in three studies,[48,55,57] and 9 percent to 11 percent across arms in one study enrolling workers from manufacturing worksites that employ multiethnic populations.[33]

Five studies described the income of enrolled workers using various metrics; all five enrolled construction or manufacturing workers from worksites in the United States (four were published between 2003 and 2009,[25,32,33,48] and one was published in 2015[48]).

Four studies described the baseline health status or comorbidity of included populations beyond specific factors related to the primary outcomes of the study (e.g., baseline body mass index [BMI] or smoking status). One study enrolled a population of home care workers with a high rate of depression (50 percent), anxiety (31 percent), and musculoskeletal complaints at

baseline (>90 percent).[43] One study enrolling manufacturing workers reported on the average number of comorbidities (mean=2).[38] The third study enrolled administrative office workers; 15 percent of participants reported "great difficulty sitting" and 55 percent reported some kind of pain during the past 6 months.[36] Finally, one study enrolled sedentary office workers with a BMI ≤25 (mean 33.0 to 34.5 across study arms).[54]

Interventions

Table 5 describes the characteristics of interventions evaluated across included studies, including the approach to integration and a summary of the specific components or content of the intervention.

Table 5. Characteristics of Total Worker Health interventions

Author(s), Year Study Name Industry Study Design (N Worksites; N Workers)	Approach to Integration	Complexity: Summary of Integrated Intervention Content
Allen et al., 2003[38] International's Allergy Project Manufacturing NRCT (7; 519)	**Organizational integration:** Collaboration between OSH and HP staff to develop the intervention **Integrated objective:** Reducing unnecessary use of sedating allergy medications may improve overall worker health, reduce work injuries, and improve productivity	**Multicomponent**: Employee education about the appropriate medical treatment for allergies (via workplace newsletter, billboards, electronic alerts, and brochures); employees provided with an onsite consultation with an allergist
Barbeau et al., 2006[48] MassBUILT Pilot Construction Pre/post (1;337)	**Worker participation:** Intervention developed based on worker input and collaboration with union representatives **Integrated objective:** Smoking cessation intervention highlights the additive and synergistic effects of hazardous workplace exposures and smoking	**Multicomponent**: Worksite tobacco cessation educational module taught by industrial hygienist highlighting synergistic effects of toxic exposures among ironworkers who smoke; included group behavioral counseling sessions and access to nicotine replacement therapy; workplace posters and newsletter articles reinforced intervention messages
Blackburn et al., 2009[30] Sustainable Farm Families Project Agriculture Pre/post (NR; 128)	**Integrated objective only:** Intervention promoted safe farm work practices and healthy lifestyle behaviors	**Multicomponent**: Workshop series developed specifically for farmers focused on safe farming practices and promotion of overall health (e.g., education about safe work practices; health risk assessment and medical referrals if appropriate; supermarket tours, and other activities)
Boggild and Jeppesen, 2001[41] Health care cohort (1; 172)	**Worker participation:** Worker collaboration with study investigators to guide intervention implementation **Integrated objective**: Investigators hypothesized that improvements in shift-work scheduling would reduce risk factors for heart disease (by facilitating healthy behaviors, decreasing stress, and improving sleep)	**Single component**: Modification of shift-work scheduling (e.g., promote more regular and predictable schedules, provide days off after night shifts, minimize weekend work, and rotate day/evening and night shifts).

Table 5. Characteristics of Total Worker Health interventions (continued)

Author(s), Year Study Name Industry Study Design (N Worksites; N Workers)	Approach to Integration	Complexity: Summary of Integrated Intervention Content
Carr et al., 2015[54] Not reported RCT (1; 60)	**Integrated objective only:** Investigators hypothesized that an integrated OSH and HP intervention aimed at sedentary office workers would result in increased occupational physical activity, improved risk factors for CVD, and decreased musculoskeletal discomfort compared with an OSH-only intervention.	**Multicomponent:** 30-minute face-to-face consultation aimed at optimizing workstation ergonomics; access to a portable elliptical machine placed under their desk for 16 weeks; provision of an iPod Touch to track daily pedaling behaviors; email reminders and pedaling goal sheet to promote increased activity during the intervention
Caspi et al., 2013[46] Health care Pre/post (2; 374)	**Worker participation**: Workers collaborated with study investigators to guide intervention implementation. **Integrated objective:** Intervention aimed to reduce musculoskeletal disorders by simultaneously promoting safe patient handling and promoting physical activity.	**Multicomponent**: Workplace audit of hospital unit safety features; development of guidelines to improve coworker collaboration when moving patients; worksite posters and prompts to promote stretching and strength training breaks; monthly mentoring sessions provided to workers focused on safe patient handling, education, and information on worksite fitness resources
Coffeng et al., 2014[51-53] Finance RCT (NR; 412)	**Worker participation:** Program resulted from a needs assessment (questionnaire and focus groups) conducted in the target population; employees received training to be team leaders and conducted group motivational interviewing sessions. **Integrated objective:** Investigators hypothesized that a combined intervention focused on work environment and group motivational interviewing would reduce work hazards and increase physical activity.	**Multicomponent:** Social environment intervention focused on a series of group motivational interviewing delivered by team leaders (employees who received training) aimed at increasing physical activity and relaxation; physical work environment intervention included multiple modifications aimed at creating a more relaxing environment and promoting physical activity (e.g., posters, plants, open office area with exercise balls, lounge area, and other changes).
Eriksen et al., 2002[42] Transportation and warehousing RCT (31; 860)	**Worker participation:** Workers collaborated with study investigators to reduce occupational hazards. **Integrated objective:** Intervention focused on reducing occupational hazards and promoting healthy behaviors.	**Multicomponent**: Worksite evaluation (conducted by investigators) to identify potential work hazards (e.g., heavy lifts, repetitive motions); workers collaborated with investigators to reduce occupational hazards; to be educated about stress, coping, health, and nutrition; to engage in formal physical activity program (including exercise and strength training relevant to the work situation).
Hammer et al., 2015[55] Construction[a] RCT (NR; 292)	**Worker participation:** Worker participation in a facilitated team effectiveness session aimed at encouraging supportive behaviors related to safety, health, and work–life balance **Integrated objective:** Intervention focused on reducing risk factors for CVD (lowering blood pressure) by improving work–life stress and promoting safe work practices.	**Multicomponent:** Computer-based supervisor training focused on family and safety supportive behavior (e.g., emotional support, family-supportive role modeling, safety communications, and other topics); supervisor behavior tracking (self-monitored and tracked via software on an iPod Touch); 4-hour facilitated team effectiveness session (including supervisors and employees) to improve team planning and problem solving and to encourage supportive behaviors related to safety, health, and work–life balance

Table 5. Characteristics of Total Worker Health interventions (continued)

Author(s), Year Study Name Industry Study Design (N Worksites; N Workers)	Approach to Integration	Complexity: Summary of Integrated Intervention Content
Hodges et al., 2004[37] City of North Little Rock Employee Health and Wellness Program Multiple industries Pre/post (NR; 900)	**Organizational integration and worker participation:** Coordination across multiple organizational departments to implement intervention; an employee health and wellness steering committee gave feedback on programs and services **Integrated objective:** Intervention focused on providing comprehensive occupational medicine, primary care, and HP services.	**Multicomponent**: Provision of preplacement physicals for potential employees, free employee physicals, establishment of services to manage occupational injuries and workers' compensation cases, creation of comprehensive HP programing (e.g., health risk screening, educational classes), primary care services designed to reduce health care costs for workers and their families
Maes et al., 1998[28] Brabantia Project Manufacturing NRCT (3; 264)	**Organizational integration and worker participation:** Formation of a joint management–staff advisory committee that consulted with workers to design and implement the intervention **Integrated Objective:** Intervention aimed at improving work conditions and reducing risk factors for CVD.	**Multicomponent:** Intervention focused on multiple improvements in work conditions (e.g., reorganization of the production line to improve ergonomic conditions), provision of onsite exercise facilities and lunchtime exercise sessions, smoking policy in cafeteria, healthy food and nutrition information in cafeteria, health fairs, health risk screenings and referrals to medical providers for high-risk factors[b]
Maniscalco et al., 1999[47] Lafayette OBUWP Oil and gas extraction Pre/post (1; 147)	**Organizational integration and worker participation:** Intervention developed by managers, supervisors, and employees based on review of safety statistics; implementation guided by a committee that included employees and representatives from OSH and HP departments **Integrated Objective**: Intervention aimed at reducing occupational injury and improving levels of physical activity	**Multicomponent**: Establishment of an annual *Back Power* educational program during mandatory safety training (e.g., demonstrations of back exercises tor preventing injury), provision of onshore and offshore fitness facilities, group-based nutritional and smoking cessation program, annual subsidy for membership to local fitness facility, annual health risk appraisal
Nieuwenhuijse, 2004[36] Work Site Health Risk Project Health care Pre/post (1; 40)	**Worker participation:** Workers participated in a Wellness Ergonomics Team that addressed ergonomic concerns and promotion of healthy behavior. **Integrated objective:** Intervention focused on reducing repetitive strain injuries and promoting healthy eating.	**Multicomponent:** Workshops focused on "at-risk" (for injury/strain) body areas and included tips for improving ergonomics, workplace posters and booklets promoted proper posture and preventive activities, assessments of work stations to identify and implement low-cost ergonomic solutions (e.g., keyboard or chair height), organization of healthy potluck lunches, modification of workplace vending machines to provide healthier options
Okechukwu et al., 2009[25] MassBUILT Construction RCT (10;1,213)	**Worker participation:** Intervention developed based on worker input and union collaboration **Integrated objective:** Smoking cessation intervention highlights the additive and synergistic effects of hazardous work exposures and smoking.	**Multicomponent:** Tobacco cessation educational module highlighting synergistic effects of workplace exposures and cigarette smoking, posters displayed in worksites reinforced key concepts in the educational modules, group behavioral counseling sessions aimed at promoting healthy behavior, free nicotine replacement patches available to smokers

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name Industry Study Design (N Worksites; N Workers)	Approach to Integration	Complexity: Summary of Intervention Content
Olson et al., 2009;[44] Wipfli et al., 2013[45] SHIFT Pilot Study Transportation Pre/post (4; 29)	**Integrated objective only:** Intervention focused on losing weight and promoting safe driving behaviors.	**Multicomponent:** Self-paced computer training on trucking safety, group weight loss goals in a competition (with other teams of workers), biweekly individual feedback on personal weight loss goals, self-paced computer training on exercise and diet, motivational interviewing phone sessions with a health coach
Olson et al., 2015[43] Community of Practice and Safety Support Health care Pre/post (NR; 16)	**Worker participation:** Workers participated as team leaders during monthly meetings addressing OSH concerns and HP. **Integrated objective:** Intervention focused on injury prevention and promotion of healthy behaviors	**Multicomponent:** Monthly meetings focused on HP (e.g., healthy eating, functional fitness, mental health education, and body relaxation exercises) as well as OSH topics (e.g., back posture, back strain prevention, and use of tools and communication for hazard correction)
Palumbo et al., 2012[29] Health care RCT (1; 14)	**Integrated objective only:** Investigators hypothesized that the intervention would promote well-being and reduce work-related stress and absenteeism.	**Single component:** Tai chi classes aimed at reducing work-related musculoskeletal injuries and job stress and promoting physical activity and stress reduction in older nurses
Porru et al., 1993[49] Manufacturing Pre/post (7; 50)	**Integrated objective only:** Intervention aimed at reducing work exposure to lead and promoting healthy behaviors	**Multicomponent:** Worksite inspections (e.g., cleanliness, potential for harmful exposures, availability/use of exhaust ventilation, and personal protection equipment [PPE]); educational meetings with workers focused on lead toxicology, proper safety practices, and the effect of tobacco and alcohol use in increasing lead absorption
Sorensen et al., 1998[9]; Sorensen et al., 1996[39], Sorensen et al., 1995[40]; WellWorks Manufacturing RCT (24; 2,658)	**Organizational Integration and worker participation:** Joint worker–management participation in intervention planning and implementation (with study investigators) **Integrated objective:** Intervention aimed at reducing occupational exposures and promoting healthy behaviors.	**Multicomponent:** Worksite assessments by industrial hygienist with recommendations to employers, worksite environmental changes to increase availability of healthy foods (and decrease smoking), health education programs for employees related to nutrition and smoking cessation
Sorensen et al., 2003;[10] LaMontagne et al., 2005;[26] Hunt et al., 2005[27] WellWorks-2 Manufacturing RCT (15; 9,019)	**Organizational integration and worker participation:** Formation of employee–management advisory boards (including representatives from workers, management, other departments, and health and safety representatives) that participated in planning, promoting, and implementing the intervention **Integrated objective:** Intervention aimed at reducing occupational exposures and improving health behaviors.	**Multicomponent:** Worksite hazard assessment by industrial hygienist (with feedback to employers); group educational sessions; educational materials; demonstrations and displays; consultations with management on tobacco control policies, food catering, and cafeteria policies; messages concerning smoking or nutrition and the interplay with occupational exposures; demonstration and displays; health risk self-assessment with feedback

Table 5. Characteristics of Total Worker Health™ interventions (continued)

Author(s), Year Study Name Industry Study Design (N Worksites; N Workers)	Approach to Integration	Complexity: Summary of Intervention Content
Sorensen et al., 2005;[33] Hunt et al., 2007;[34] Barbeau et al., 2004[35] Healthy Directions-Small Business Manufacturing RCT (26; 1,740)	**Organizational integration and worker participation:** Formation of employee advisory boards (composed of workers, management, and OSH representatives) to participate with investigators in the intervention planning and implementation **Integrated objective:** Intervention aimed at reducing occupational exposures and improving health behaviors.	**Multicomponent:** Worksite hazard assessment by industrial hygienist (with feedback to employers), promotion of worksite policies aimed at tobacco control and promoting healthy eating, group educational sessions (on physical activity, healthy eating, and smoking cessation), health fairs and other activities/written materials available to employees aimed at promoting healthy behaviors
Sorensen et al., 2007[32] Tools for Health Construction RCT (NR; 674)	**Worker participation:** Intervention was developed based on worker input and union collaboration. **Integrated objective:** Intervention content focused on the synergies of hazardous work exposures (or conditions) and health behaviors.	**Multicomponent:** Baseline health survey with tailored feedback, one-on-one motivational interviewing focused on tobacco use and diet, provision of nicotine replacement therapy and counseling to participants interested in quitting tobacco, investigators creased and mailed tip sheets that reinforced messages and addressed synergy between work hazards and health behavior
Tveito and Eriksen, 2009[31] Health care RCT (1; 40)	**Worker participation:** Workers gave input on ways to minimize work hazards identified during a workplace examination (by study investigators). **Integrated objective:** Intervention aimed at reducing work hazards (injuries and stress) and improving overall physical and mental health.	**Multicomponent:** Workplace examination (by study investigators) to identify potential work hazards; workers provided input on ways to manage work stress; onsite aerobic dance classes; educational sessions on stress, coping, and healthy lifestyle behaviors
von Thiele Schwarz et al., 2015[50] Health care RCT (1; 312)	**Organizational integration only:** Integration of OSH and HP program management into staff quality improvement meetings	**Single component:** Integration of OSH and HP programs (and administrative functions) into an ongoing employee participatory continuous improvement system; OSH and HP issues were addressed and recorded in meeting minutes along with other quality improvement issues

BMI = body mass index; CVD = cardiovascular disease; HP = health promotion; mg/L = milligrams per liter; mm Hg = millimeters of mercury; N = number (of participants or worksites); NR = not reported; NRCT = nonrandomized controlled trial; OBUWP = Offshore Business Unit Wellness Program; OSH = occupational safety and health; PPE = personal protection equipment; RCT = randomized controlled trial.

[a] Also included utility workers.[55]

[b] High-risk criteria for referral to a general practitioner included the following: serum cholesterol level of 250 mg/L or higher; diastolic blood pressure 105 mm Hg or higher; systolic blood pressure 160 mm Hg or higher; BMI 30 or higher; or smoking 1 or more cigarettes per day.[28]

Approach to Integration

We developed inclusion and exclusion criteria for study interventions (as discussed in the Methods section); during data abstraction, we identified factors that have been highlighted as "indicators of integrated approaches."[11] All included studies assessed an integrated approach to reducing work-related injuries or illness and promoting overall health among workers. Included

studies also used the following approaches to integration: (1) organizational integration (e.g., strategic coordination across organizational departments responsible for OSH, HP, and others) and (2) worker participation in the development, design, planning, or implementation of the intervention. Most included studies evaluated interventions that used more than one approach to integration.

Organizational Integration

Eight included studies evaluated an intervention that involved strategic coordination across organizational departments (or staff) responsible for decision making related to health protection and HP.[9,10,28,33,37,38,47,50] Most focused on developing a comprehensive program to promote worker health and safety informed by staff from various departments (e.g., human resources, managers, OSH representatives, HP representatives, and others). One study assessed the effectiveness of integration alone (with no additional OSH or HP content or components); in this study, OSH and HP functions were integrated into ongoing staff meetings (focused on quality improvement).[50]

Worker Participation

Seventeen studies evaluated an intervention that involved worker participation in the development, design, planning, or implementation of the intervention.[9,10,25,28,31-33,36,37,41,42,46-48,51,55] The type and degree of participation varied across included studies.

Six studies included worker participation on a committee with other organizational representatives (e.g., managers, human resource representatives, OSH and HP representatives) responsible for the design and implementation of the intervention[9,10,33,37,47] or in consultation with such committees.[28] Four studies evaluated an intervention that was designed based on input (or prior research) from members of a specific occupational group (e.g., related to culture, potential occupational hazards, or work experience) and implemented in collaboration with support from employees,[51] union members,[32] or apprenticeship program leaders.[25,48]

Finally, seven studies assessed an intervention that involved worker participation or collaboration with study investigators (but not other organizational representatives) related to a key feature of the intervention.[31,36,41-43,46] In two of these studies, workers gave input or guidance on intervention implementation only,[41,46] and in five studies workers participated with study investigators to develop strategies to reduce occupational hazards (e.g., work stress, work–life stress, or injuries)[31,42,55] or develop ongoing meetings or workshops among groups of workers that addressed both OSH concerns and HP (e.g., through education and social support).[36,43]

Organizational Integration and Worker Participation

Six studies evaluated an intervention that featured both organizational integration and worker participation in the development, design, planning, or implementation of the intervention.[9,10,28,33,37,47]

Integrated Objective Only

Five included studies assessed an intervention that simultaneously addressed the prevention of work-related illness and injury and the promotion of overall health; these interventions were designed by investigators based on the potential work hazards and risk factors for chronic disease in a specific occupational group.[29,30,44,49,54] None of these studies explicitly describes whether the intervention was designed (or implemented) based on input from employees or representatives across organizational departments responsible for OSH or HP decisionmaking.

Intervention Complexity and Content

Most studies evaluated complex multicomponent intervention "bundles" that included multiple components aimed at improving work safety and promoting health (generally involving changes at the worksite as well as content targeted at individual workers) (Table 5).[9,10,26-28,30-40,42-47,51,54,55] Three interventions involved a single-component integrated intervention.[29,41,50]

The specific intervention content across included studies varied significantly. Only 1 study assessed the effectiveness of organizational integration alone (with no new added OSH or HP components).[50] Six studies focused primarily on providing a new HP initiative that was tailored to the potential work hazards of an occupational group (or highlighted the potential synergistic effects of workplace exposures and health behavior),[25,29,32,38,41,48] and 5 studies focused primarily on reducing occupational injuries, illnesses, or exposures (including work–life stress and job stress) and also included other components aimed at promoting healthy behavior.[36,46,49,51,55] The remaining 12 studies assessed interventions that introduced new comprehensive OSH and HP programs not previously available to workers prior to the intervention.[9,10,28,30,31,33,37,42-44,47,54]

Interventions varied in terms of whether they were directed at the individual worker or worksite (or both). The majority of interventions included an educational or training component aimed at individual workers (e.g., workshops, educational materials, individual counseling, behavioral training). Nine studies assessed an intervention that included a worksite inspection (or audit of safety practices) to identify potential work hazards;[9,10,28,31,33,36,42,46,61] in most cases, inspections were conducted by study investigators who used the inspection either to provide recommendations to employers (related to adopting proactive policies to reduce hazardous exposures)[9,10] or to determine the specific work hazards (or ergonomic concerns) to address with workers.[31,42] Four studies assessed an intervention that primarily focused on improving work organization, ergonomics, or the physical work environment; one was aimed at improving manufacturing ergonomic conditions,[28] one assessed an ergonomic workstation intervention,[54] one assessed modifications to shift-work schedules,[41] and one included multiple changes to the physical work environment to create a more relaxing space and promote physical activity.[51]

Incentives

Several studies included incentives to promote participation in the intervention. Some of the incentives for participating included health-related items or services such as water bottles, stress relievers,[28,37] or chair massages;[51] raffles for cash,[25,44,45,48] or other prizes;[28,44,45,51] contests;[10,26,27,33-35] and cash payments for participation in[43] or completion of a program or survey.[47,54,55]

Comparators

Fifteen included studies had a concurrent control group; four [10,35,51,55] (all RCTs) compared an integrated intervention with an active comparator, and all others compared an integrated intervention with no intervention (or usual work practice). In one RCT, the integrated intervention was compared with an HP-only intervention,[10] and in another RCT the integrated intervention was compared with an OSH-only intervention.[54] Two RCTs compared four arms, including a comprehensive integrated intervention (aimed at reducing occupational hazards and promoting physical activity), two active-comparator arms that included one or more components of the comprehensive intervention, and a no-intervention control group.[35,51]

Outcomes

Table 6 summarizes the types of outcomes evaluated across included studies. Overall, studies included heterogeneous outcomes; few studies measured the same outcomes in similar populations of workers.

Table 6. Outcomes evaluated in Total Worker Health interventions

Author(s), Year Study Name Industry	Final Health and Safety Outcomes	Intermediate Health Outcomes	Utilization and Other Outcomes
Allen et al., 2003[38] International's Allergy Project Manufacturing	Allergy symptom severity	Use of allergy medications, knowledge related to coping with severe allergy symptoms	Productivity, absenteeism, WC claims, short-term disability claims
Barbeau et al., 2006[48] MassBUILT Pilot Construction	NR	Smoking cessation, other measures of cigarette use	NR
Blackburn et al., 2009[30] Sustainable Farm Families Project Agriculture	NR	BMI, cholesterol levels, blood glucose, blood pressure	Participation in intervention
Boggild and Jeppesen, 2001[41] Health care	NR	Physical activity, prevalence of smoking, weekly alcohol consumption, cholesterol levels	Changes in shift schedules according to ergonomic criteria (e.g., regularity, predictability, and periodicity) Employee perceptions of schedules
Carr et al., 2015[54] Not reported	Musculoskeletal discomfort	Blood pressure, heart rate, weight, body composition, waist circumference, occupational time spent sedentary and physically active	Productivity, process evaluation to assess helpfulness to employee
Caspi et al., 2013[46] Health care	Musculoskeletal pain, work interference due to pain	Physical activity, multiple measures of safe (and unsafe) patient handling	Measures of unit safety practices, coworker support and supervisor support
Coffeng et al., 2014[51-53] Vitality in Practice (VIP) in Insurance Project Finance	NR	Need for recovery after work, multiple measures of physical activity at and outside of work (e.g., stair climbing, active commuting, leisure activities, sports, sedentary time at work), work-related stress, exhaustion	NR
Eriksen et al., 2002[42] Transportation and warehousing	Subjective health complaints, job stress	NR	Sick leave (self-reported), worker perception of intervention
Hammer et al., 2015[55] Safety and Health Improvement Program (SHIP) Construction	QOL (physical health composite score on the SF-12)	Blood pressure (reported as mean arterial blood pressure), safety compliance and safety-participation behaviors	Supervisor rating of various process measures (e.g., morale, work climate, team communication), measures of supervisor learning (via quizzes)
Hodges et al., 2004[37] City of North Little Rock Employee Health and Wellness Program Multiple industries	NR	NR	WC expenditures, utilization of heath care services, HP program participation, employee and employer satisfaction with intervention

Table 6. Outcomes evaluated in Total Worker Health interventions (continued)

Author(s), Year Study Name Industry	Final Health and Safety Outcomes	Intermediate Health Outcomes	Utilization and Other Outcomes
Maes et al., 1998[28] Brabantia Project Manufacturing	General stress, job stress	CVD risk score[a]	Quality of work (e.g., psychological demands, control, ergonomic conditions, social support), absenteeism
Maniscalco et al., 1999[47] Lafayette OBUWP Oil and gas extraction	NR	Cholesterol levels, level of fitness and nutrition (based on an HRA survey)	Work-related injuries based on an employer surveillance database, estimated cost savings related to medical and lost productivity costs associated with injuries, intervention participation
Nieuwenhuijse, 2004[36] Work Site Health Risk Project Health care	Pain, difficulty sitting	Composite measure of behavior change (reported as "positive, no change, or negative change") based on survey responses to multiple measures of health and safety behavior (e.g., taking mini posture breaks at work, engaging in regular exercise)	Multivariate analysis conducted to identify factors associated with positive behavioral change
Okechukwu et al., 2009[25] MassBUILT Construction	NR	Smoking cessation, other measures of cigarette use	NR
Olson et al., 2009;[44] Wipfli et al., 2013[45] SHIFT Pilot Study Transportation and warehousing	Overall health state (EQ-5D)	Multiple body measurements including weight, BMI, and waist-to-hip ratio; multiple dietary behaviors; physical activity level; work safety behaviors including number of hard breaks, percentage time over-speed and seat belt use; cholesterol levels; fasting blood glucose; blood pressure; multiple measures of fitness such as 6-minute walk test; measures of self-efficacy related to diet and exercise	Measures of organizational safety climate
Olson et al., 2015[43] Community of Practice and Safety Support Health care	Subjective well-being, depression symptoms, QOL (SF-12), psychosocial stress, physical pain	Multiple measures of dietary behavior, blood pressure, cholesterol levels, blood glucose, multiple body measurements (e.g., BMI, percentage body fat); multiple measures of fitness (e.g., grip strength, flexibility). counts of specific safety behaviors (e.g., use of new lift/transfer tool)	Intervention participation
Palumbo et al., 2012[29] Health care	QOL (SF-36), general stress, job stress, functional status	Multiple measures of flexibility (e.g., functional reach test, sit-and-reach test, and others)	Absenteeism
Porru et al., 1993[49] Manufacturing	NR	Blood lead levels, knowledge of lead toxicology and strategies for preventing lead-related diseases	Changes in worksite conditions associated with lead exposures
Sorensen et al., 1998;[9] Sorensen et al., 1996;[39] Sorensen et al., 1995[40] WellWorks Manufacturing	NR	Smoking cessation, multiple measures of dietary behavior, self-reported workplace hazardous exposures	NR

Table 6. Outcomes evaluated in Total Worker Health interventions (continued)

Author(s), Year Study Name Industry	Final Health Outcomes	Intermediate Health Outcome	Health Care Utilization and Other Outcomes
Sorensen et al., 2003;[10] LaMontagne et al., 2005;[26] Hunt et al., 2005[27] WellWorks-2 Manufacturing	NR	Smoking cessation, fruit and vegetable consumption	Measures of worksite participation and awareness of intervention, measures of worksite exposure prevention activity
Sorensen et al,, 2005;[33] Hunt et al., 2007;[34] Barbeau et al., 2004[35] Healthy Directions-Small Business Manufacturing	NR	Physical activity, multiple measures of dietary behavior, multivitamin use	NR
Sorensen et al., 2007[32] Tools for Health Construction	NR	Smoking cessation, other measures of tobacco use, fruit and vegetable consumption	NR
Tveito and Eriksen, 2009[31] Health care	Subjective health complaints. QOL (SF-36)	Coping	Sick leave, work quality (psychological demands, control/ decision latitude), employee perception of intervention
von Thiele Schwarz et al., 2015[50] Health care	Change in self-reported current health status[b]	NR	Absenteeism, workability, productivity, measures of integration developed by the investigators[c]

BMI = body mass index; CVD = cardiovascular disease; EQ-5D = EuroQOL five dimensions questionnaire; HRA = health risk appraisal; NR = not reported; OBUWP = Offshore Business Unit Wellness Program; QOL = quality of life; SF-12 = Medical Outcomes Study Short Form (12 items); SF-36 = Medical Outcomes Study Short Form (36 items); SHIP = Safety and Health Improvement Program; VIP = Vitality in Practice; WC = workers' compensation.

[a] The study investigators calculated the 8-year risk of CVD based on the Framingham risk score; variables included worker age, total cholesterol level, systolic blood pressure, and smoking status.

[b] The investigators assessed self-rated health using a single item; participants rated their current health status on a five-point scale ("very good" [1] to "very poor" [5]).

[c] Measures of integration were developed by the study investigators and focused on assessing the degree of integration associated with HP, OSH, and quality improvement processes; items included measures of employee involvement and exposure and assessment of the manager's attitude and actions related to the intervention.

Of the 24 included studies, 12 measured a final health or safety outcome; commonly evaluated outcomes included measures of quality of life, self-reported somatic complaints, and stress (including job stress). Eighteen studies measured an intermediate outcome; these included a diverse range of biomarkers associated with cardiovascular risk (cholesterol and glucose levels), measures of smoking cessation, and dietary habits, among others.

Outcomes directly related to OSH were less commonly measured compared with outcomes traditionally associated with HP. Across the 24 included studies, 10 measured changes in job stress, work safety practices, ergonomic behavior, or self-reported exposure to hazardous chemicals.[9,28,29,36,42-44,46,51,55] Two studies measured changes in occupational physical activity and sedentary behavior.[51,54]

One study evaluated rates of health care utilization[37] (e.g., primary care visits, use of occupational medicine services), and two studies reported rates of occupational injuries based on an employer database or incidence of workers' compensation claims.[38,47]

No study prespecified harms of the intervention as outcomes to be evaluated; two studies surveyed participants about potential adverse effects of the interventions (results are discussed in KQ 2).[41,43]

Studies also evaluated a range of other outcomes that we did not include for KQ 2; these outcomes included worker productivity and absenteeism, decision latitude (i.e., the ability to make work-related decisions), and employee satisfaction with the intervention. Studies assessing absenteeism defined or measured absenteeism using different metrics or over various lengths of time.[28,29,31,38,42,50] Three studies evaluated economic outcomes. One reported time lost costs,[29] one evaluated costs associated with treatment for occupational injuries and insurance rate increases,[37] and one calculated return on investment and net cost savings for all lost workday injuries and for only back injuries.[47]

Key Question 2. Effectiveness and Harms of Total Worker Health Interventions

Evidence for the effectiveness and harms of TWH interventions consisted of 12 RCTs, 2 NRCTs, and 1 prospective cohort study.[9,10,25,28,29,31-33,38,41,42,50,51,54,55] We rated 5 RCTs as medium risk of bias[32,33,51,54,55] and the other 10 studies as high risk of bias.

We rated studies as high risk of bias primarily because of a high risk of selection bias. Most studies had high overall attrition (ranging from 14 percent to 45 percent); many studies had differential attrition across study arms. In general, studies rated high risk of bias did not use any statistical methods to address missing data. Other common areas of bias included baseline differences between groups that the investigators did not address in their analyses.

The results of all studies synthesized for KQ 2 are described below by outcome category. We report results of studies rated medium risk of bias first (for each eligible outcome) and then results of studies rated high risk of bias. We also note the SOE grades (high, moderate, low, or insufficient) where relevant.

Key Points

- The 15 KQ 2 studies were heterogeneous; few studies of TWH interventions assessed the same outcomes among similar populations of workers.
- TWH interventions were effective for improving rates of self-reported 7-day smoking abstinence over 22 to 26 weeks compared with no intervention (low SOE).
- TWH interventions were effective for improving fruit and vegetable consumption over 26 to 104 weeks compared with no intervention (low SOE).
- TWH interventions were effective for reducing sedentary activity at work over 16 to 52 weeks compared with any comparator (low SOE).
- Evidence was insufficient to assess the effectiveness of integrated interventions for improving the following outcomes: quality of life, stress, blood pressure, weight, overall and work-specific levels of physical activity, consumption of red meat, safety behaviors, and safety compliance.

Health and Safety Outcomes

Quality of Life and Functional Status

Three studies reported on quality of life or functional status (Table 7). One RCT (N=116) rated medium risk of bias assessed improvement in quality of life among construction and utility workers using the SF-12.[55] Groups of workers were randomized to an intervention designed to improve work–life stress and safety behaviors (via supervisor behavior training and employee work groups) or no intervention. At 52 weeks, there was no difference between groups on the SF-12 physical health component composite scores.[55]

Two small RCTs (both high risk of bias) assessed improvements in quality of life among health care workers using the SF-36; both compared an integrated intervention with no intervention.[29,31] One (N=15) evaluated a single-component intervention (tai chi classes) aimed at improving stress and reducing risk of musculoskeletal injuries among older nurses (ages 49 years or older).[29] The other study (N=21) assessed a multicomponent intervention featuring employee participation in addressing work hazards and promoting physical exercise and stress management among nursing staff in a nursing home for the elderly.[31] Neither study found that the intervention significantly improved quality of life as measured by the SF-36 general health and mental health scores (Table 7).

The RCT evaluating tai chi among older nurses also assessed improvements in work-specific physical and psychological function measured by the Work Limitations Questionnaire (WLQ) (Table 7).[29] The WLQ measures the degree to which health problems interfere with the ability to perform job roles.[62] At 15 weeks, nurses receiving the intervention experienced an improvement in overall work limitations compared with nurses receiving no intervention.[29] The intervention was not associated with improvements in physical demands but was associated with improvements in mental demand, as measured by the two WLQ subscales.

Table 7. Results of quality of life and functional status outcomes

Author, Year, Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Quality of Life Outcomes Results	Functional Status Outcome Results
Hammer, et.al., 2015[55] RCT Medium	G1: Integrated intervention (NR) G2: No intervention (NR) Total N=264 52	SF-12 physical health component summary score Difference between groups on post-intervention score (SE): = -0.32 (0.82); p=0.69	NR

Table 7. Results of quality of life and functional status outcomes (continued)

Author, Year, Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Quality of Life Outcomes Results	Functional Status Outcome Results
Palumbo et al., 2012[29] RCT High	G1: Tai chi (7) G2: No intervention (7) 15	SF-36 General Health Score Mean change from baseline (SD) GI: +0.6 (7) G2: -4.0 (4.2) p=0.33 SF-36 Mental Health Score Mean change from baseline (SD) G1: +2.5 (9.3) G2: -7.0 (9.1) p=0.62	WLQ, Mean change from baseline (SD) Overall score: G1: -3.1 (1.2) G2: -0.8 (1.4) p=0.03 Physical demands Subscale: G1: -10.4 (11.7) G2: -2.5 (8.1) p=0.14 Mental demands Subscale: G1: -11.1 (10.1) G2: 0 (6.6) p=0.03
Tveito and Eriksen, 2009[31] RCT High	GI: Integrated intervention (19) G2: No intervention (21) 36	SF-36 General Health Score Mean score (95% CI) G1: Baseline: 42.3 (95% CI, 37.8 to 46.8) Post-test: 49.4 (95% CI, 43.5 to 55.3 G2: Baseline: 45.7 (95% CI, 41.7 to 49.7) Post-test: 44.7 (95% CI, 38.1 to 51.2) p=0.27 (difference between G1 and G2 post-tests) SF-36 Mental Health Score Mean score (95% CI) G1: Baseline: 47.3 (95% CI, 42.7 to 51.9) Post-test: 52.9 (95% CI, 48.4 to 57.3) G2: Baseline: 45.7 (95% CI, 41.7 to 49.7) Post-test: 49.8 (95% CI, 45.9 to 53.7) p=0.98 (difference between G1 and G2 post-tests)	NR

CI = confidence interval; G = group; N = number of participants analyzed; NR = not reported; RCT = randomized controlled trial; SD = standard deviation; SE = standard error; SF-12 = Medical Outcomes Study Short Form (12 items); SF-36 = Medical Outcomes Study Short Form (36 items); WLQ = Work Limitations Questionnaire.

Stress (General and Work Specific)

Three studies reported on a measure of stress (Table 8). One RCT (N=412) rated medium risk of bias enrolled office workers employed at a financial institution in the Netherlands; departments were randomized to one of the following four groups: (1) no intervention control group, (2) social environment intervention, (3) physical environment intervention, and (4) combined social and physical environment intervention.[51] At 52 weeks, workers in the combined intervention group experienced greater reduction in exhaustion measured by the Oldenburg Burnout Inventory than the control group[63] (Table 8). There was no difference between the

control group and any of the three active comparator arms on the following outcomes: need for recovery after work, detachment after work, and relaxation after work.

Two studies rated high risk of bias measured changes in levels of stress, one RCT[29] and one NRCT.[28] The tai chi intervention (described above) assessed general levels of psychological stress with the Perceived Stress Scale (PSS),[64] and work-specific stress was assessed with the Nursing Stress Scale (NSS).[65] At 15 weeks, the intervention group did not experience lower PSS scores or NSS scores compared with the control group (Table 8).[29]

The NRCT enrolled Dutch manufacturing worksites and assigned worksites to a multicomponent integrated intervention aimed at improving work conditions and promoting physical activity or no intervention.[28] General levels of stress were assessed with the Symptom Checklist-90 (SCL-90); at 3 years, levels of stress did not differ between workers employed at intervention sites and those at control sites (Table 8).[28]

Table 8. Results of general and work-specific stress outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Stress Outcome Results
Coffeng, et al., 2014[51] RCT Medium	G1: Combined social and physical environment intervention (92) G2: Social environment intervention (118) G3: Physical environment intervention (96) G4: No intervention (106) 52	Difference between active comparator and control group, beta coefficient (95% CI)[a]: Need for recovery[b]: G1 vs. G4: -6.8 (-14 to 0.4); p=0.07 G2 vs. G4: -2.3 (-8.7 to 4.2); p=0.49 G3 vs. G4: -4.2 (-11 to 2.7); p=0.23 Work-related stress Exhaustion[c]: G1 vs. G4: -0.2 (-0.3 to -0.1); p<0.01 G2 vs. G4: -0.1 (-0.1 to 0.0); p=0.13 G3 vs. G4: -0.1 (-0.2 to 0.0); p=0.23 Detachment after work[d]: G1 vs. G4: 0.0 (-0.3 to 0.3); p=0.85 G2 vs. G4: 0.1 (-0.1 to 0.4); p=0.35 G3 vs. G4: 0.2 (-0.1 to 0.5); p=0.16 Relaxation after work[d]: G1 vs. G4: 0.1 (-0.2 to 0.4); p=0.55 G2 vs. G4: 0.1 (-0.1 to 0.4); p=0.25 G3 vs. G4: 0.2 (-0.1 to 0.5); p=0.12
Maes et al., 1998[28] The Brabantia Project NRCT High	G1: Integrated intervention (113) G2: No intervention (113) 156	Symptom Checklist-90 Mean change from baseline: G1: -0.01 G2: 0 p-value: NS

Table 8. Results of general and work-specific stress outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Stress Outcome Results
Palumbo et al., 2012[29]	G1: Tai chi (7)	General stress: PSS, mean change from baseline (SD)
RCT	G2: No intervention (7)	G1: -2.8 (2.4)
High	15	G2: -1.4 (3.9) p=0.42
		Work-specific stress: NSS, mean change from baseline (SD) G1: -6.1 (14.2)
		G2: -1.6 (2.4) p=0.89

CI = confidence interval; G = group; N = number of workers; NRCT = nonrandomized controlled trial; NS = not significant; NSS = Nursing Stress Scale; PSS = Perceived Stress Scale; RAND-36 = 36-Item Short Form Survey from the RAND Medical Outcomes Study; RCT = randomized controlled trial; SD = standard deviation; vs. = versus.

[a] Outcomes are adjusted for age, gender, education, marital status, general health (measured with a single item, "In general, how would you rate your health?" on a 5-point scale (1 = poor to 5 = excellent) from the Dutch validated version of the RAND-36), job demands, supervisor support, and corresponding baseline measure of the outcome variable. A negative beta indicates a decrease in the outcome measure.[51]

[b] Assessed using the Need for Recovery after Work scale (score of 0 to 100 with higher scores reflecting greater need). Beta scores used as measures of intervention effect, with negative scores reflecting lower need for recovery compared with no intervention group.[51]

[c] Measured using the Oldenburg Burnout Inventory (score of 1 to 4 ranging from "totally agree" to "don't agree").[51]

[d] Measured using the Recovery Experience Questionnaire (score of 1 to 7 ranging from "never" to "always")[51]

Allergy Symptoms

No study rated as low or medium risk of bias assessed improvements in allergy symptoms.

One NRCT (high risk of bias) assessed a multicomponent intervention involving organizational integration between OSH and HP staff to promote appropriate use of allergy medications compared with no intervention.[38] At 28 weeks, self-reported allergy severity did not differ between workers employed at intervention worksites and those at control worksites (change from baseline, intervention: range -1.2 to 2.8; control=-0.09; p= not significant per authors).[38]

Subjective Health Complaints and Self-Rated Health Status

Four studies measured self-reported health complaints (including musculoskeletal complaints). One RCT (N=54) rated medium risk of bias assessed self-reported musculoskeletal discomfort in a population of sedentary office workers using the Standardized Nordic Musculoskeletal Symptom Questionnaire.[54,66] Enrolled workers were randomized to an ergonomic workstation optimization intervention or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation. At 16 weeks, there was no difference between groups on self-reported low back pain (p=0.94), neck pain (p=0.68), or shoulder pain (p=0.34) (data not presented by authors).[54]

Two RCTs (both high risk of bias) assessed subjective health complaints using the Subjective Health Complaints (SHC) Inventory.[31,42] The SHC Inventory assesses subjective health

complaints across five subscales: musculoskeletal pain, pseudoneurology, gastrointestinal problems, allergy, and influenza.[67] One RCT (N=40) enrolled staff at a nursing home in Norway;[31] the other RCT (N=860) enrolled Norwegian postal service workers.[42] Both evaluated a similar multicomponent integrated intervention that included worker participation in addressing potential work hazards, promoting physical exercise, and managing stress; one compared the intervention with no intervention[31] and the other compared the integrated intervention with three arms (an aerobic activity intervention, a stress management intervention, and a no-intervention control group).[42] At 52 weeks, SHC subscales did not improve among workers receiving the integrated intervention compared with workers in a control group in either study.[31,42] However, in the study enrolling postal workers, the intervention group reported fewer neck complaints than the control group (8 percent versus 48 percent, respectively; p=0.023) at 52 weeks; reports of complaints specific to the upper back or lower back did not differ between the intervention and control group.[31]

One RCT (N=312) (high risk of bias) compared organizational integration of OSH and HP functions with no integration. The study enrolled inpatient staff at a Swedish hospital; responsibility for OSH and HP activities was incorporated into ongoing quality improvement meetings.[50] The investigators assessed self-rated health using a single item; participants rated their current health status on a five-point scale ("very good" [1] to "very poor" [5]). Change from baseline in self-rated health did not differ between the integrated intervention and control groups at 52 or 104 weeks (p=0.72).[50]

Intermediate Outcomes

Smoking Cessation

Five studies assessed rates of smoking cessation (Table 9). One RCT rated medium risk of bias (N=188) enrolled unionized construction laborers and compared a multicomponent intervention designed in collaboration with union representatives with no intervention.[32] More workers at intervention worksites reported 7-day abstinence at 26 weeks (for any tobacco use and for smoking) and made more smoking quit attempts than workers at control sites (Table 9).

Table 9. Results of smoking-related outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N)[a] Outcome Timing (Weeks)[b]	Smoking Cessation Outcomes Results	Other Smoking Outcomes Results
Okechukwu et al., 2009[25] MassBUILT RCT High	G1: Integrated intervention (251) G2: No intervention (239) 22, 43	% of baseline smokers reporting 7-day abstinence at 22 weeks: G1: 26% G2: 17% p=0.014 % of baseline smokers reporting 6-month abstinence at 43 weeks: G1: 9% G2: 7% p=0.48	Cut down by at least ½ pack smoked daily at 43 weeks: OR, 3.13 (95% CI, 1.55 to 6.31) % of baseline smokers who made at least one quit attempt at 43 weeks: OR, 1.31 (95% CI, 0.88 to 1.96) % of workers reporting a decrease in the number of days smoked at 43 weeks: OR, 1.18 (95% CI, 0.62 to 2.25)

Table 9. Results of smoking-related outcomes (continued)

Author, Year, Study Name Study Design Risk of Bias	Arm (N)[a] Outcome Timing (Weeks)[b]	Smoking Cessation Outcomes Results	Other Smoking Outcomes Results
Sorensen et al., 1998[9,39,40] WellWorks RCT High	GI: Integrated Intervention (NR) G2: No intervention (NR) Overall N: 549[c] 104	% of baseline smokers reporting 6-month abstinence, overall sample: G1: 15% G2: 9% p=0.123 % of baseline smokers reporting 6-month abstinence, subgroup of skilled and unskilled laborers (N=NR): G1: 17.9% G2: 9.0% p=NS % of baseline smokers reporting 6-month abstinence, subgroup of office workers (N=NR): G1: 2.5% G2: 5.1% p=NS % of baseline smokers reporting 6-month abstinence, subgroup of professionals and managers (N=NR): G1: 14.2% G2: 18.6% p=NS	Not reported
Sorensen et al., 2003[10,26,27] WellWorks-2 RCT High	G1: Integrated intervention (436) G2: HP alone (389) 104	% of baseline smokers reporting 6-month abstinence, overall sample: G1: 11.3% G2: 7.5% p=0.17 % of baseline smokers reporting 6-month abstinence, subgroup of hourly workers (N=684): G1: 11.8% G2: 5.9% p=0.04 % of baseline smokers reporting 6-month abstinence, subgroup of salaried workers (N=141): G1: 9.9 % G2: 12.7% p=0.63	Not reported

Table 9. Results of smoking-related outcomes (continued)

Author, Year, Study Name Study Design Risk of Bias	Arm (N)[a] Outcome Timing (Weeks)[b]	Smoking Cessation Outcomes Results	Other Smoking Outcomes Results
Sorensen et al., 2007[32] Tools for Health RCT Medium	G1: Integrated intervention (any tobacco use, N=134; smokers, N=101) G2: No intervention (any tobacco use, N=113; smokers, N=87) 26	% of baseline smokers reporting 7-day abstinence: G1: 19% G2: 8% p=0.03 % of baseline tobacco users reporting 7-day abstinence (any tobacco use): G1: 19% G2: 7% p=0.005	% of baseline smokers who made at least one smoking quit attempt: G1: 53% G2: 35% p=0.03
Boggild and Jeppesen, 2001[41] Cohort study High	G1: Improvements in shift work (26) G2: No intervention (60) 24	% of workers who smoked at baseline: G1: 27% G2: 27% Median change from baseline (IQR): G1: 0 (0) G2: 0 (0) p=NS	Not reported

CI = confidence interval; G = group; IQR = interquartile range; N = number of participants analyzed; NR = not reported; NS = not significant (p-value not reported by authors); OR = odds ratio; RCT = randomized controlled trial.

[a] N here is for the subgroup of smokers (unless otherwise stated).

[b] Unless otherwise specified, this is the timing of outcome assessment in relationship to the baseline survey.

[c] This was the number of smokers who responded to baseline and followup assessments; the study reports that in the cohort of participants who responded to both baseline and followup assessments, 23% were smokers.[9]

Four RCTs rated high risk of bias assessed rates of smoking cessation. Three evaluated a multicomponent integrated intervention involving organizational integration and employee participation, two enrolled manufacturing workers,[9,10] and one enrolled building trade apprentice training program participants.[25] One RCT (N=825) compared an integrated intervention with an HP-only intervention; the 6-month abstinence rate did not differ between intervention and control groups at 2 years.[10] In a subgroup of hourly workers, more workers at intervention worksites reported 6-month abstinence than those employed at control worksites.[10] Two RCTs compared an integrated intervention with no intervention.[9,25] One found a reduced 7-day abstinence rate at intervention worksites compared with control worksites at 22 weeks.[25] Both RCTs also measured 6-month abstinence rates at longer outcome timings (43 to 104 weeks); there was no difference in 6-month abstinence rates between intervention and control groups in either study (Table 9).

The cohort study of Danish inpatient nurses found that improving shift-work scheduling was not associated with lower rates of smoking over 24 weeks (measured as the percentage of employees who reported smoking).[41]

Alcohol Consumption

No included studies rated medium or low risk of bias assessed changes in alcohol consumption.

The cohort study of Danish nurses (high risk of bias) described above assessed the effect of improving shift-work scheduling on alcohol intake. The median alcohol consumption per week did not differ between the intervention and control groups at 24 weeks (median change from baseline =0 in both groups; p=not significant per authors).[41]

Healthy Eating

Four RCTs (all from the same research team) measured outcomes related to healthy eating behaviors among U.S. manufacturing or construction workers (Table 10); two RCTs were rated medium risk of bias[32,33] and two high risk of bias.[9,10]

Table 10. Results of healthy eating outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Consumption of Fruit and Vegetable Outcomes Results	Other Healthy Eating Outcomes Results
Sorensen et al., 1998[9,39,40] WellWorks RCT High	GI: Integrated intervention (NR) G2: No intervention (NR) Overall N=2,386 104	Servings per day, mean change from baseline: G1: 0.22 G2: 0.09 p=0.04	Daily fiber intake (grams per 1,000 kcal), mean change from baseline, overall sample: G1: 0.58 G2: 3.39 p=0.08 Subgroup of skilled and unskilled laborers: G1: 0.89 G2: 0.36 p=0.012 Subgroup of office workers: G1: 0.11 G2: 0.29 p=NS Subgroup of professionals and managers: G1: 0.47 G2: 0.57 p=NS Number of kcal consumed as fat, % change from baseline, overall sample: G1: -3.36 G2: -1.55 p=0.01

Table 10. Results of healthy eating outcomes (continued)

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	Consumption of Fruit and Vegetable Outcomes Results	Other Healthy Eating Outcomes Results
Sorensen et al., 2003[10,26,27] WellWorks-2 RCT High	G1: Integrated intervention (2,413) G2: HP alone (2,214) 104	Servings per day, mean change from baseline: G1: - 0.10 G2: +0.05 p=0.24	NR
Sorensen et al., 2005[33-35] Healthy Directions-Small Business Study RCT Medium	G1: Integrated intervention (NR) G2: No intervention (NR) Overall N=3,092[a] 78[b]	% of participants consuming 5 or more servings of fruits and vegetables per day, mean change from baseline, overall sample: G1: +5.4% G2: +1.7% p=0.41 Subgroup of managers: G1: -5.5% G2: +3.6% p=0.048 Subgroup of workers: G1: +7.5% G2: +1.1% p=0.048	% of participants consuming 3 or fewer servings of red meat per week, mean change from baseline: G1: +4.1% G2: +3.0% p=0.72
Sorensen et al., 2007[32] Tools for Health RCT Medium	G1: Integrated intervention (298) G2: No intervention (280) 26	Servings per day, mean change from baseline: G1: +1.52 (SD=3.89) G2: -0.09 (SD=3.31) p<0.0001	NR

G = group; kcal = kilocalorie; N = number of participants analyzed; NR = not reported; NS = not significant; RCT = randomized controlled trial; SD = standard deviation.

[a] Per the authors, 974 workers responded to both the baseline and followup survey. This "embedded cohort" is included in the overall analysis but results are not reported separately for this group.[33]

[b] 18 months.[33]

Two RCTs rated medium risk of bias assessed a multicomponent intervention aimed at improving healthy eating by highlighting the potential adverse effect of work conditions (or exposures) and health behavior.[32,33] One (N=3,092) enrolled manufacturing worksites and randomized worksites to an integrated intervention or no intervention.[33] At 78 weeks, there was no difference between groups in fruit and vegetable consumption; however, in a subgroup analysis based on job type, hourly workers at intervention worksites increased consumption of fruit and vegetables more than workers at control sites (managers at intervention sites decreased consumption of fruit and vegetable from baseline to followup) (Table 10).[33] The other RCT (N=578) enrolled unionized construction workers and randomized workers to an integrated intervention (the intervention primarily delivered via phone calls and published educational materials) or no intervention;[32] at 26 weeks, there was no difference between groups in fruit and vegetable consumption.

Two RCTs rated high risk of bias enrolled manufacturing workers;[9,10] both assessed multicomponent interventions that included organizational integration and employee participation. One compared an integrated intervention with an HP-only intervention;[10] fruit and vegetable consumption did not differ between the intervention and HP-control groups at 104 weeks.[10] The other RCT compared an integrated intervention with no intervention; at 104 weeks, workers at intervention sites increased intake of fruit and vegetables and decreased intake of red meat compared with workers at control sites.[9] Workers at intervention and control sites did not differ in the change from baseline fiber intake. However, in a subgroup analysis based on job type, skilled and unskilled laborers at intervention sites increased fiber consumption more than laborers at control sites; there was no significant difference for other groups of workers (office workers, professionals, and managers).[9]

Physical Activity

Four studies measured changes in physical activity (Table 11); three were RCTs rated medium risk of bias.[33,51] One RCT (N=3,092) randomized manufacturing worksites to a multicomponent integrated intervention or no intervention.[33] The mean change from baseline in the percentage of employees who exercised 2.5 hours or more per week did not differ between intervention and control worksites in the overall sample; in a subgroup analysis based on job type, workers at intervention worksites increased levels of physical activity, while managers at intervention worksites decreased levels of physical activity (Table 11). The second RCT enrolled Dutch office workers employed at a financial institution; departments were randomized to one of the following four arms: (1) no intervention control group, (2) social environment intervention, (3) physical environment intervention, and (4) combined social and physical environment intervention.[51] At 52 weeks, there was no difference between any of the active comparators and the control group on any measure of overall physical activity (nonwork specific) (Table 11).[51] Workers in the physical environment intervention increased the frequency of stair climbing at work and decreased sedentary activity at work compared with the control group; there was no difference between the other two active comparators (social environmental intervention and combined social and physical environmental intervention) and the control group on any measure of work-specific physical activity or sedentary behavior outcome (Table 11). The third RCT (N=60) randomized sedentary office workers to a workstation optimization intervention (ergonomic assessment, education and prompts to promote breaks and posture variation) plus access to a seated activity permissive workstation or the workstation optimization intervention alone.[54] At 16 weeks, there was no difference between groups on the following outcome measures: total occupational physical activity, percentage of work time sedentary, and percentage of work time spent in moderate or vigorous physical activity (Table 11). Workers randomized to the integrated intervention increased the average percentage of the work day spent in light-intensity physical activity compared with the ergonomic intervention alone (difference between groups in mean change from baseline=1.1 percent; p=0.04); however, workers in the ergonomic intervention group experienced a decrease in time spent in light activity (-0.4 percent) compared with a small increase in the intervention group (0.7 percent).[55]

The cohort study of Danish nurses (high risk of bias) assessed the effect of improving shift-work scheduling (e.g., increased shift regularity) on outcomes associated with cardiovascular disease (CVD) risk over 24 weeks.[41] The mean change from baseline in the percentages of workers who reported not exercising did not differ between the intervention and control groups (Table 11).

Table 11. Results of physical activity outcomes

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	General Physical Activity Outcome Results	Work-Specific Physical Activity Outcome Results
Carr et al., 2015[54] RCT Medium	G1: Integrated intervention (30) G2: OSH-only intervention (30) 16	NR	Mean change from baseline (95% CI): Total occupational physical activity (average counts/work day)[a]: G1: 9752 (1, 067 to 18,436) G2: -142 (-10,623 to 10,339) Between group difference p=0.14 Work time sedentary (% of work day): G1: -2.0 (-4.4 to 0.3) G2: -0.4 (-1.1 to 0.2) Between group difference p=0.08 Work time in light intensity physical activity (% of work day): G1: 0.7 (-0.2 to 1.7) G2: -0.4 (-1.1 to 0.2) Between group difference p=0.04 Work time in moderate intensity physical activity (% of work day): G1: 1.1 (-1.1 to 3.2) G2: 0.07 (-0.7 to 0.8) Between group difference p=0.38 Work time in vigorous intensity physical activity (% of work day): G1: 0.3 (0.0 to 0.5) G2: 0.0 (-0.3 to 0.3) Between group difference p=0.44

Table 11. Results of physical activity outcomes (continued)

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	General Physical Activity Outcome Results	Work-Specific Physical Activity Outcome Results
Coffeng, et al., 2014[51] RCT Medium	G1: Integrated intervention (social and physical environment intervention) (92) G2: Social environment intervention (118) G3: Physical environment intervention (96) G4: No intervention (106) 52	Difference between active comparator and control group, beta coefficient (95% CI; p-value)[b]: Light physical activity: G1 vs. G4: -37.3 (-396.8 to 322.2), p=0.84 G2 vs. G4: -322.5 (-665.5 to 20.5), p=0.07 G3 vs. G4: -217.1 (-573.6 to 139.4); p=0.23 Moderate physical activity: G1 vs. G4: 54.8 (-58.1 to 171.8); p=0.36 G2 vs. G4: 63.1 (-48.9 to 175.2), p=0.27 G3 vs. G4: 6.8 (-108.1 to 121.7), p=0.90 Vigorous physical activity: G1 vs. G4: -38.5 (-88.0 to 11.0), p=0.13 G2 vs. G4: -11.6 (-59.3 to 36.2), p=0.64 G3 vs. G4: -4.6 (-53.2 to 44.0), p=0.86 Leisure activities [c]: G1 vs. G4: -41.5 (-155.9 to 72.8), p=0.48 G2 vs. G4: 33.5 (-76.9 to 144.0), p-0.55 G3 vs. G4: -28.0 (-141.1 to 85.2), p=0.63 Sport activities [c]: G1 vs. G4: -18.9 (-77.1 to 39.3), p=0.52 G2 vs. G4: 30.4 (-22.0 to 82.7), p=0.25 G3 vs. G4: 3.6 (-51.2 to 58.6), p=0.83	Difference between active comparator and control group, beta coefficient (95% CI), p-value): Stair climbing at work (number of times participants took the stairs during a usual workday): G1 vs. G4: 0.5 (-0.0 to 1.1), p=0.05 G2 vs. G4: -0.1 (-0.6 to 0.4), p=0.63 G3 vs. G4: 1.0 (0.5 to 1.5), p <0.01 Active commuting[c] (minutes per week): G1 vs. G4: 142.0 (-5.5 to 289.6), p=0.06 G2 vs. G4: -8.3 (-150.0 to 133.4), p=0.91 G3 vs. G4: 91.9 (-53.8 to 237.5), p=0.22 Sedentary behavior at work (minutes per day): G1 vs. G4: -33.8 (-90.3 to 22.7), p=0.24 G2 vs. G4: -29.8 (-80.3 to 20.8), p=0.28 G3 vs. G4: -57.9 (-111.7 to 4.2), p=0.03

Table 11. Results of physical activity outcomes (continued)

Author, Year, Study Name Study Design Risk of Bias	Arm (N) Outcome Timing (Weeks)	General Physical Activity Outcome Results	Work-Specific Physical Activity Outcome Results
Sorensen et al., 2005[33-35] Healthy Directions-Small Business Study RCT Medium	G1: Integrated intervention (NR) G2: No intervention (NR) Overall N=3,092[d] 78	Change from baseline in the percentage of participants who exercise ≥2.5 hours per week, overall sample: G1: +5.4% G2: -0.9 % p=0.23 Subgroup of managers: G1: -2.0 % G2: +3.7 % p=0.09 Subgroup of workers: G1: +7.1 % G2: -2.1 % p=0.09	NR
Boggild and Jeppesen, 2001[41] Cohort study High	G1: Improvements in shift work (26) G2: No intervention (60) 24	No exercise at baseline (%): G1: 12% G2: 7% Median change from baseline (IQR): G1: 0 (1) G2: 0 (0) p=NS	NR

CI = confidence interval; G = group; N = number of participants analyzed; NR = not reported; NS = nonsignificant; OSH = occupational safety and health; RAND-36 = 36-Item Short Form Survey from the RAND Medical Outcomes Study; RCT = randomized controlled trial.

[a] Measured via an ankle-worn accelerometer; this is the sum of all activity counts accumulated on valid accelerometer wear days. Days participants wore the monitor for <12 hours were excluded from the analysis.[54]

[b] All outcomes below are adjusted for age, gender, education, marital status, general health (measured with a single item, "In general, how would you rate your health?" on a 5-point scale [1 = poor to 5 = excellent] from the Dutch validated version of the RAND-36), job demands, supervisor support, and corresponding baseline measure of the outcome variable. A negative beta indicates a decrease in the outcome.[51]

[c] Physical activity levels were measured using the Short Questionnaire to Assess Health-enhancing Physical Activity Questionnaire. Active commuting refers to walking or cycling to and from work. Leisure activities include walking, cycling, gardening, chores, and sports. Employees were asked to report the frequency (times per week), duration of activities (in minutes), and self-reported intensity (light, moderate, or vigorous).

[d] Per the authors, 974 workers responded to both the baseline and followup survey. This "embedded cohort" is included in the overall analysis, but results are not reported separately for this group.[33]

Cholesterol

No included study rated low or medium risk of bias measured changes in cholesterol levels. The Danish nurses' cohort study assessed the effect of improving shift-work scheduling on cholesterol levels over 24 weeks.[41] Workers in the intervention group had significantly lower low density lipoprotein (median change from baseline, mmol/L=-0.2 versus 0.1; p=0.001) and total cholesterol levels (median change from baseline, mmol/L=-0.1 versus 0.0; p=0.003) than workers in the control group; the groups did not differ in high density lipoprotein levels (mean change from baseline, mmol/L=0.1 versus -0.1; p=0.18).[41]

Blood Pressure

Two RCTs rated medium risk of bias assessed changes in blood pressure.[54,55] One (N=116) enrolled construction and utility workers and randomized work groups to an integrated intervention aimed at improving work–life stress (via supervisor behavior training and employee work groups) or no intervention.[55] Blood pressure was measured via three consecutive readings during one visit; the authors report only the mean arterial blood pressure (MAP) (defined as 1/3 systolic blood pressure + 2/3 diastolic blood pressure) based on the average of the three readings. The baseline MAP was 95.45 mmHg; the number of workers who had hypertension or who were treated with blood pressure medication is not reported. At 52 weeks, there was a small statistically significant improvement in MAP in the intervention group compared with controls (change in MAP=-2.15 mm Hg; SE=1.03; p=0.038).[55] The second RCT (N=54) randomized sedentary office workers to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation.[54] At 16 weeks, there was no difference between groups in systolic blood pressure (p=0.90) or diastolic blood pressure (p=0.48).[54]

Cardiovascular Disease Risk Scores

No included study rated low or medium risk of bias assessed changes in a CVD risk score.

One NRCT (N=264) rated high risk of bias of Dutch manufacturing workers (described above) assigned worksites to a multicomponent integrated intervention or no intervention.[28] At 1 year, the intervention group experienced a small but statistically significant decrease in CVD risk score compared with the control group (change from baseline, intervention=-0.002 versus control: 0.007; p=0.01); the difference was not sustained at 2 years. At 2 years, both groups experienced a small overall increase in CVD risk from baseline (intervention=0.008 versus control=0.01); the between-group difference is small and the authors did not report a measure of variance for this observation.[28]

Hazardous Work Exposures

No included study rated low or medium risk of bias measured hazardous work exposures.

Two RCTs (high risk of bias) reported on outcomes related to hazardous work exposures.[9,10] Both studies enrolled manufacturing workers and evaluated multicomponent integrated interventions that included organizational integration and employee participation. One RCT (N=2,386) assessed self-reported exposures to carcinogenic substances after the intervention;[9] the intervention and control sites did not differ in the incidence of self-reported hazardous exposures (quantitative data were not provided). The other RCT (N=825) involved pre- and post-intervention worksite assessments conducted by an industrial hygienist;[10] potential exposure to hazardous processes was assessed with a nonvalidated rating scheme. The investigators reported no differential loss of higher hazard processes between intervention and control worksites and found no statistically significant differences for any specific work conditions between intervention and control sites.

Safety Compliance and Safety Behaviors

One RCT (N=116) rated medium risk of bias assessed changes in safety participation and safety compliance among construction and utility workers.[55] Participants were randomized to an intervention aimed at improving work–life stress (via supervisor behavior training and employee work groups) or no intervention. Safety compliance and safety participation were measured via

self-report on items such as "I use the correct safety procedures" and "I voluntarily carry out tasks or activities that help to improve workplace safety"; the full range of questions was not described by the authors.[55] Responses were rated on a 5-point scale and computed as a mean response (higher scores=higher levels of safety and compliance). There was no difference between groups in mean safety participation scores (0.14; SE=0.09; p=0.014) or mean safety compliance scores (-0.02; SE=0.08;p=0.83).[55]

Weight

One RCT (N=60) rated medium risk of bias randomized sedentary office workers to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation.[54] There was no difference between groups in the weight change from baseline to followup at 16 weeks (p=0.80).[54]

Utilization Outcomes and Occupational Injury and Illness Surveillance Outcomes

Workers' Compensation Claims and Short-Term Disability Claims

No included study rated low or medium risk of bias assessed rates of health care utilization or occupational injury and illness surveillance outcomes.

One NRCT (N= 519) rated high risk of bias enrolled workers at U.S. automotive manufacturing worksites.[38] Worksites were assigned to a multicomponent intervention developed through collaboration between OSH and HP programs to promote appropriate medical treatment for allergies, or to no intervention. The study measured rates of workers' compensation claims and short-term disability claims via the employer's disability database. The percentages of participants at who had one or more workers' compensation claims and short-term disability claims at 28 weeks did not differ between intervention and control sites (p-value not significant per authors for both outcomes).

Harms

No included study rated low or medium risk of bias reported on potential harms of interventions.

Two studies (both high risk of bias) reported potential harms; in both cases, harms were not prespecified. The Danish nurses cohort study of shift-work scheduling (N=172) surveyed participants in the intervention group about potential adverse effects of the intervention.[41] The intervention group judged the new schedule as having had a worse impact on family life (compared with the preintervention schedule) at 52 weeks.[41] The authors did not report quantitative results (e.g., measure of variance or p-value for the difference between groups); in addition, whether the effect of shift work on family life was measured in the comparison group was unclear. One RCT (N=860) enrolling Norwegian postal workers assessed potential harms in a four-arm study that compared an integrated intervention with aerobic exercise alone, stress management alone, and no intervention.[42] The authors asked participants whether the interventions had any influence on "health, work environment, work situation, physical fitness, muscle pain, ability to deal with stress, and knowledge of how to maintain good health," which they reported as a three-category scale (better, unchanged, worse). They reported no subjective

negative effects of the intervention at either 12 or 52 weeks after the intervention (but did not present any quantitative results).[42]

Key Question 3. Characteristics of Effective Integrated Interventions

KQ 3 describes characteristics of effective integrated interventions; it is intended to provide information about the interventions that show benefit for improving worker health for employers that may want to implement an evidence-based integrated intervention and for researchers who want to evaluate integrated interventions. We limited this question to those interventions effective for improving any outcome eligible for KQ 2 for which we found at least low SOE for benefit. Because of heterogeneity across included studies (in terms of populations, interventions, outcomes) and methodological limitations we were only able to make SOE conclusions for three outcomes: increased smoking cessation (measured by 7-day abstinence rates) over 22 to 26 weeks, increased fruit and vegetable consumption over 26 to 104 weeks, and decreased sedentary activity at work over 16 to 52 weeks. The applicability of these conclusions is very limited; conclusions for smoking cessation and fruit and vegetable consumption outcomes are based on four studies enrolling U.S. blue-collar manufacturing and construction workers.[9,25,32,33] Our conclusions related to sedentary activity at work are based on two studies enrolling office workers, one in the United Sates[54] and one in The Netherlands.[51] The results for these outcomes are discussed in KQ 2, and SOE assessments are shown in Appendix D.

To address this question, we focused on describing characteristics of interventions that relate to two main domains. The first addressed the *approach to integration*, or the way in which the intervention simultaneously addresses health protection and HP (e.g., strategic coordination across organizational departments or worker input into the design or implementation of the intervention). The second focused on the *specific content of the intervention*, that is, (1) OSH components (e.g., administrative controls to improve or remove work hazards or individual education related to work hazards) and (2) components related to HP (e.g., environmental changes or individual education to promote healthy behavior).

Key Points

- Effective interventions were heterogeneous. We were not able to separate out individual components from the overall type (or "bundles") of interventions that showed efficacy for outcomes eligible for KQ 2.
- Most effective interventions were informed by worker participation in the development, design, planning, or implementation of the intervention (or in more than one of these steps).
- All effective interventions included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior.
- Most interventions tailored intervention components or materials to cultural or social aspects of the worker population (e.g., to workers with low literacy skills or workers for whom English was not their first language).
- All effective interventions are multicomponent, complex interventions that reinforce messages about health and safety through multiple levels of influence or multiple modes of delivery (or both) over time.

Detailed Synthesis

Approach to Integration

In five of six studies contributing to our SOE grades, interventions were informed by worker participation in the development, design, planning, or implementation of the intervention. Two studies set in manufacturing worksites[9,33] involved the creation of a joint-worker-management employee advisory board (EAB) comprising workers, production managers, and representatives from health and safety and human resources departments who planned and implemented the intervention in partnership with the study investigators. EAB members gave input on specific components; for example, policies aimed at reducing hazardous occupational exposure were cowritten by the study investigators and workplace managers. Production managers included in planning activities helped to ensure that workers could alter their work schedules to participate in intervention activities.[33] In three studies, the intervention was designed based on input (or prior research) from members of the targeted occupational group (e.g., related to culture, potential occupational exposures, or work experience);[25,32,51] and in two of these studies, the intervention was also implemented in collaboration with union members or support from apprenticeship program leaders.[25,32]

In four studies, interventions were designed to simultaneously address OSH and HP concerns by highlighting the potential additive or synergistic risks of hazardous workplace exposures and health behavior, either through interventions delivered at the worksite (manufacturing worksites)[9,25,33] or via telephone-based interviewing and counseling combined with written educational materials provided to individual construction workers.[32] The two studies enrolling office workers focused on increasing physical activity at work to address hazards associated with sedentary work, one focused on ergonomic hazards[54] and the other focused mostly on decreasing work stress and burnout.[51]

All four studies set in a manufacturing worksite tailored intervention components to cultural or social aspects of the worker population (aside from the specific work-related hazards); for example, designing written materials so that they were accessible to workers with low literacy skills[33] and ensuring that surveys and other written materials were available in multiple languages for workers whose first language was not English,[32,33] or developing curricula that resonated with the workers' occupational culture.[25]

Given the limited number of studies contributing to our SOE grades (six studies) and the heterogeneity of interventions, we had insufficient evidence to determine whether certain strategies of integration directly contributed to the efficacy of an intervention or whether certain strategies are more or less effective for certain outcomes or subgroups of workers.

Complexity and Content of Interventions

All six interventions were multicomponent, complex interventions that delivered content through multiple levels of influence or multiple modes of delivery (or both) over time. For example, three studies conducted at a manufacturing worksite created multiple opportunities for workers to participate in worksite-based activities at the individual level (e.g., behavioral self-assessments with feedback, interaction with table-top displays and demonstrations).[9,25,33] One also included intervention components aimed at modifying the work environment to improve worker health and safety (e.g., adoption of new catering policies that promoted healthy eating and inclusion of an industrial hygiene assessment and feedback to worksites aimed at improving worker safety).[33] In one study focused on construction workers, one-to-one motivational

interviewing counseling sessions (via telephone) were conducted over time; a mailed report with individual feedback and written educational materials was provided at baseline and was periodically reinforced by sending "tip sheets" during the intervention.[32] Two studies included an individual health assessment (survey) with tailored feedback based on responses.[32,33]

All interventions included HP or OSH components (or both) that were new and not previously available to workers. Three studies primarily provided HP content that highlighted OSH concerns,[25,32,54] and three offered comprehensive HP and OSH components at the worksite.[9,33,51]

We did not find any direct evidence to determine whether specific components added benefit. That is, no study rated as medium or low risk of bias directly compared the delivery of an intervention having a specific component with the same intervention but lacking that specific component. Separating out individual components from the overall type (or "bundles") of interventions that showed efficacy for outcomes eligible for KQ 2 was not possible.

Key Question 4. Contextual Factors

KQ 4 asks "What contextual factors have been identified as potential modifiers of effectiveness in studies of integrated interventions?" Such factors can be quite diverse: (1) the legal-regulatory environment (e.g., state laws with respect to union representation); (2) employer characteristics, policies, or benefits (e.g., availability of health insurance coverage or paid sick leave); (3) work organization (e.g., shift work); and (4) social or economic factors (e.g., income or availability of community resources to support or promote health).

To address this question, we abstracted relevant data from all 24 included studies when investigators reported them. We included factors that were noted in the articles' results (e.g., whether the intervention was more or less effective at worksites that differed by a specific contextual factor) and issues that investigators may have discussed that could have potentially modified the effectiveness of interventions.

Key Points

- Few studies identified contextual factors that could have played a role in modifying the effectiveness of interventions.
- Work organization factors and union membership status were the two most commonly mentioned contextual factors. Other factors noted by at least one study included the following: presence of another (concurrent) intervention implemented during the study period, health insurance status (of the workers), availability of adequate resources to address employee concerns, support from higher management, and company downsizing.

Detailed Synthesis

Of the 24 included studies, 8 addressed contextual factors. Table 12 summarizes relevant contextual factors for specific occupational groups, settings, and key health and safety outcomes. These factors varied by study population and work setting. In general, they related to the following:

- health insurance status and access to primary care services
- work organization factors
- company downsizing
- availability of resources

- support from higher management
- union membership status, including ongoing union contract negotiations
- other ongoing OSH interventions

Table 12. Characteristics of studies describing contextual factors

Author(s), Year Study Name Study Design Unit of Intervention (N Worksites; N Workers)	Source Population Country	Outcomes	Contextual Factors
Allen et al., 2003[38] International's Allergy Project NRCT Worksite (7; 519)	Heavy manufacturer of medium- and heavy-duty trucks and diesel engines United States	Allergy symptoms, use of allergy medications, knowledge related to coping with severe allergy symptoms, productivity; absenteeism, rates of workers' compensation claims, and short-term disability claims	Health insurance status Union membership (including contract negotiations)
Barbeau et al., 2006[48] MassBUILT Pilot SG Pre/post Worker (1; 337)	Ironworker apprentices United States	Smoking cessation; other measures of cigarette use	Union membership
Boggild and Jeppesen, 2001[41] Cohort Worker (1; 101)	Nurses and nursing aides Denmark	Cholesterol levels, physical activity, prevalence of smoking, weekly alcohol intake, shift-work schedule changes, employee perceptions of schedules	Staffing levels, human resource policies related to overtime
Carr et al., 2015 [54] RCT Worker (1; 60)	Sedentary desk job workers at a private company United States	Musculoskeletal discomfort, blood pressure, heart rate, weight, body composition, waist circumference, occupational time spent sedentary and physically active, productivity, process evaluation to assess helpfulness to employee	Availability of resources to address employee concerns related to work–life stress
Coffeng et al., 2014[51] RCT Worksite and worker (NR; 412)	Officer workers with primarily desk jobs employed by a financial service provider The Netherlands	Need for recovery after work, multiple measures of physical activity at and outside of work (e.g., stair climbing, active commuting, leisure activities, sports, sedentary time at work), work-related stress, exhaustion	Support from higher management
Eriksen et al., 2002[42] RCT Worker (31; 860)	Post office or postal terminal workers Norway	Subjective health complaints, sick leave, job stress, worker perception of intervention	Company downsizing

Table 12. Characteristics of studies describing contextual factors (continued)

Author(s), Year Study Name Study Design Unit of Intervention (N Worksites; N Workers)	Source Population Country	Outcomes	Contextual Factors
Olson et al., 2009[44], Wipfli, 2013[45] SHIFT Pilot Study Pre/post Worker (4; 29)	Truck drivers United States	Measures of well-being, weight, BMI, waist-to-hip ratio, multiple dietary behaviors, physical activity level, safe driving behaviors, cholesterol levels, fasting blood glucose, blood pressure, multiple measures of fitness such as 6-minute walk test, measures of self-efficacy related to diet and exercise, workplace safety climate	Work organization factors, other concurrent worksite OSH interventions
Sorensen et al., 1998[9,39,40] WellWorks RCT Worksite (24; 2,386)	Manufacturers of industrial, chemical, and other products; textile dyeing; firefighting; and newspapers United States	Smoking cessation, multiple measures of dietary behavior, workplace hazard exposures	Union membership

BMI = body mass index; N = number; NRCT = nonrandomized controlled trial; OSH = occupational safety and health; RCT = randomized controlled trials.

Access to health care was identified as a potential modifier of an intervention aimed at improving the appropriate treatment of allergies among manufacturing workers (improving symptoms and reducing use of sedating medications).[38] The authors noted that 13 percent of participants were enrolled in a health maintenance organization, but did not document the health insurance status of other participants. According to the investigators, the overall low participation rate in the intervention was perhaps related to the fact that a change from a sedating to a nonsedating allergy medication required a physician's office visit and a prescription (and potentially a copayment for both); at the time of the study, nonsedating allergy medication had not become available over the counter.[38] Primary care physicians were not involved in the design or implementation of the intervention; the authors speculated that coordination with prescribing health care providers might have improved participation and modified the effectiveness of the intervention.[38]

Work organization factors were also noted as potential modifiers of intervention effectiveness in two studies.[41,44] In the study to improve shift-work schedules in a Danish hospital, staff shortages and changes in overtime policies during the intervention period were noted as factors that may have reduced study participation.[41] A new policy for handling of overtime work among nurses was put into effect during the intervention period; before the new agreement, overtime work was not paid, but the new policy paid overtime. The authors observed that this policy change reduced work hours for nurses (and meant extra work for the existing staff); it also led to more scheduling changes than expected (unrelated to the goals of the intervention).[41] A study of teams of truck drivers noted that work schedules may have limited participation and effectiveness of the intervention.[43] The authors noted that isolation among drivers and changes in driving routes during the intervention may have led to low levels of communication within teams, which then may have limited the effectiveness of the intervention.[43]

Company downsizing during the intervention was identified as a potential moderating factor in a multisite study of Norwegian postal workers.[42] The workers were told during the intervention that the number of post offices would be reduced considerably (from 2,300 to 1,400). One focus of the integrated intervention was on stress management and improving subjective health complaints; the authors speculated that company downsizing may have introduced turmoil and instability in the workplace.[42] In one study, the post-interview surveys were conducted among supervisors who completed training on work–life balance; supervisors found it difficult to provide resources to manage conflicts because of budget and staffing constraints.[55] The authors did not comment on whether this was felt to diminish the effectiveness of the intervention.

Support and commitment from higher management were noted as potential factors important to intervention success by authors of a study enrolling office workers employed by a Norwegian financial service provider.[51] The intervention focused on modifications to the work environment to reduce the need for work recovery and promote physical activity and relaxation. Post-intervention surveys found that employees and supervisors rated support by the financial service provider and their managers as relatively low. The authors commented that support and commitment from higher management are necessary for successful interventions.[51]

Union membership was considered to be a moderating factor in three studies enrolling U.S. manufacturing workers.[9,38,48] In one study, union concentration varied significantly by worksite; the authors noted that contract renewal negotiations were ongoing (at the time of the study) and may have reduced responses to surveys among people with chronic health conditions.[38] In another study, 5 of 12 worksites were unionized; union representatives served on EABs responsible for the intervention planning and implementation at worksites randomized to the integrated intervention.[9] This practice may have led to differences in participation and intervention effectiveness across worksites. Finally, support of the intervention by apprenticeship program leaders may have played a role in successful intervention implementation.[48] However, the authors noted that apprentice program leaders granted the study team 1 hour for the "toxics and tobacco" curriculum module instead of the requested 5 hours because of a concern that replacing instructions on other important health and safety issues with the tobacco-related curriculum would endanger the apprentices on the job. The authors did not comment on whether the shortened curriculum might have affected rates of smoking cessation at intervention sites.[48]

One study enrolling truck drivers identified another concurrent OSH policy change as a potential modifier of effectiveness.[57] One company implemented a mechanical speed-governing intervention for some trucks near the onset of the intervention; reduction in over-speed (driving over a preset speed criterion) may have been partially attributable to the effects of speed governing (and not the integrated intervention).[57]

Key Question 5. Evidence Gaps

In this KQ, we describe important research gaps identified in the conduct of this review. We consider "research gap" to mean a topic area for which missing or inadequate information limited our ability to reach a conclusion on the effectiveness of TWH interventions. We outline research gaps below by work settings and populations, interventions, comparators, and deficiencies in methods (including issues that related to the design and reporting of studies). We consider work settings and populations together since most studies recruit workers from specific worksites and who are at risk of similar work-related illnesses and injuries (and potentially similar in terms of demographics or risk factors for chronic diseases). The evidence gaps

outlined here are those we considered most relevant to work settings and populations in the United States.

Work Settings and Populations Studied

Geographic Setting

Included studies focused on worksites in select geographic areas. Our SOE grades primarily apply to blue-collar workers in the Northeast region of the United States (Massachusetts). No studies enrolled workers from states in the Southwest and only one study each was conducted in a Southeastern or Western state (Arkansas and Oregon, respectively). Only one study enrolled a population across different states (construction workers affiliated with the Laborers' International Union of North America (LIUNA).[32]

Industries and Occupational Groups

Our SOE grades primarily apply to U.S. blue-collar workers employed in the manufacturing and construction industries and sedentary office workers. In many cases, studies only reported on the characteristics of the industry or worksite from which populations were recruited, and did not always describe the range of occupations of enrolled workers. We noted the following gaps that relate to the industry or occupational groups included in studies of TWH interventions:

- No studies enrolled workers from these industry sectors: wholesale and retail trade; utilities (electricity, water, gas); information (publishing, broadcasting, telecommunications, etc.); real estate; professional, scientific, and technical services; educational services; arts, entertainment, and recreation; or accommodation and food services.
- The service sector as a whole (e.g., retail, transportation, communications industries, health care) is underrepresented in included studies when considering the prevalence of work-related injuries among workers in this sector. According to the U.S. Bureau of Labor Statistics (BLS), the service sector accounted for 65.5 percent of all private industry occupational illness cases in 2012 (the most recent data available).[68] However, a majority of included studies enrolled workers from goods-producing industries, which accounted for 34.3 percent of all private industry occupational illness cases in 2012.[68]
- Only two included studies enrolled workers from the transportation and warehousing industry.[42,44] No included study enrolled air, rail, water, or ground transit transportation workers. Health care was represented but studies primarily focused on select occupational groups (e.g., registered nurses).
- Few studies enrolled workers from the natural resources and mining sector (one studied workers in agriculture[30] and one in offshore oil drilling[47]). No studies enrolled workers in forestry and logging, fishing and hunting, or the onshore mining industries (coal, metal and nonmetal).
- In terms of specific occupational groups, only four studies enrolled office and administrative support workers (the occupational group with the largest employment in the United States). The following occupations were not represented in included studies: sales and related occupations (the second largest major occupation group in the United States);[69] food preparation and serving workers (the third largest major occupation group in the United States);[69] and workers in education and training, a large U.S. occupational sector.

Populations and Subgroups Studied

The demographics of workers enrolled in included studies were often not well described (aside from factors specific to the work setting or potential work hazards). We noted the following gaps that relate to major demographic features and baseline health of workers enrolled included trials:

- No study enrolled populations of workers who were very young or very old (the mean age of workers enrolled across included studies ranged from 30 to 50 years of age). According to the BLS, workers 45 to 54 years of age had the highest number of days-away-from-work cases in 2013 and workers 65 years of age or older had a greater number of median days away from work than younger workers.[70]
- Women were underrepresented in industries other than those typically conducted in a health care setting. According to the BLS, injuries and illnesses among men accounted for only 61 percent of all nonfatal injury and illness cases in 2013.[70]
- No study addressed differences in outcomes among subgroups of workers defined by age, sex, race, ethnicity, comorbidity, or income.
- People who work part time (regardless of their occupation) were often excluded from studies.

Interventions

Studies evaluated quite diverse interventions; the type and level of integration involved in interventions varied substantially. TWH is currently defined as "policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being."[71] Previous definitions have highlighted the integration of OSH and HP specifically.[11] Included studies did not use standard language regarding the nature or extent of integration; we found no direct evidence about whether certain policies or practices of integration are more or less effective than others. Sorensen and colleagues identified a core set of indicators of the implementation of integrated approaches to OSH and HP to help facilitate what is meant by "integrated strategies."[11,33] Often, these indicators were not well described across included studies. We identified the following gaps that relate to TWH interventions:

- Few studies assessed single-component interventions aimed at improving the work environment or work structure with the associated goals of improving OSH and promoting overall well-being.
- A minority of included studies (eight studies) evaluated an intervention that clearly involved organizational integration; that is, multiple departments within the work setting were involved with planning, implementing, and managing the intervention (e.g., OSH department, HP programs, and sometimes others).
- We found no studies that directly assessed whether specific combinations (or specific types) of program content were more or less effective than other combinations. Studies differed in terms of the degree to which program content focused on OSH concerns versus promotion of overall health and well-being.
- We could not assess whether strategies were more or less effective based on their complexity (single versus multicomponent) or level of influence (e.g., environmental or administrative controls, individual worker education, or both). Most studies assessed complex heterogeneous interventions that targeted both the worker and worksite.

Comparators

In general, studies were not designed to directly assess the effectiveness of integration alone (compared with no integration). Most studies compared an integrated intervention that included new OSH or HP components (or both) with no intervention. The effects of the added HP or OSH component (or both) offered to the intervention group could not be separated from the effects of integration.

Among studies that compared an intervention to no intervention (or usual workplace programs), studies often failed to describe the OSH or other health-related programs, policies, and benefits already in place and available to workers.

Outcomes

Although we considered a wide range of outcomes for this review, we were only able to rate the strength of evidence for three: smoking cessation, fruit and vegetable consumption and sedentary work behavior. We identified the following gaps in terms of the outcomes measured in included studies:

- We were not able to assess the strength of evidence related to any OSH outcome (e.g., rates of occupational injuries or illnesses). Few studies with a concurrent control group measured outcomes important to OSH. Whether integrated interventions improve workplace safety (compared evidence-based OSH programs or policies that are not considered integrated) is unclear.
- We did not find many of the outcomes listed in our inclusion criteria for KQ 2 (effectiveness and harms of interventions) reported in included studies, including the following: incidence of injuries or chronic diseases (e.g., diabetes, CVD); morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; changes in BMI; and measures of health care utilization (hospitalizations, emergency department visits, or outpatient clinic visits).
- Very few studies reported on the following outcomes: validated measures of quality of life or functional status; stress (job or general stress); rates of workers' compensation claims, short-term disability claims, and alcohol use.
- No included studies prespecified harms as an outcome of interest. We looked for evidence on the following potential harms of interventions but did not find any: increased barriers to reporting work-related injuries or illnesses, increased work stress, employee concerns about the privacy of health information, discrimination, and victim-blaming.

Deficiencies in Methods

Of the 24 included studies, 12 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 15 included studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations including the following:

- Among RCTs, we found inadequate reporting of randomization and allocation concealment. Most RCTs randomized at the worksite (or group) level; the number of worksites randomized was often small. In one case, two worksites were reported to be "randomized" and we called this a nonrandomized controlled trial.[28]
- Often, studies did not adequately describe the flow of participants, particularly those that randomized or assigned interventions at the worksite level. Most studies measured

outcomes based on survey responses before and after an intervention; response rates to the baseline surveys among eligible workers were sometimes low or not reported, and this practice contributed to selection bias.

- Overall attrition was high in several studies (14 percent to 54 percent in studies rated high risk of bias). Some studies did not provide sufficient data to calculate differential attrition between study arms. For the 10 studies that had very high overall attrition (>20 percent), high differential attrition (>15 percent), or both, only two employed methods to address missing data; one used last observation carried forward[42] and the other used software to impute missing data.[55] Most trials did nothing to address missing data (i.e., analyzed only completers).
- Statistical analyses did not often address important baseline differences between intervention and control groups; in some cases, important demographic information was not provided in order to assess whether there were baseline differences between groups.
- Several studies had small sample sizes, thus lacked power for determining intended effects.
- Investigators sometimes did not provide information on their statistical methods; also, authors did not always provide measures of variance (e.g., confidence intervals) for outcomes. This limited our ability to assess the precision of outcomes across studies.
- In several studies, contamination of the control arms compromised internal validity, for example, due to another worksite policy or program initiated during the intervention period that could have influenced outcomes measured in the study.
- In some cases, the length of followup may not have been adequate to assess the stability of findings over time. Only seven studies measured outcomes at or beyond 1 year. Our SOE grades (based on four studies) relate to outcome timings over 22 to 104 weeks.

Key Question 6. Future Research Needs

In this chapter, we make specific recommendations for future research focused on TWH interventions. These suggestions are based only on our evidence synthesis and are the research gaps outlined in KQ 5. These suggestions are intended to inform the Pathways to Prevention Workshop[19] on TWH; the workshop panel will consider these research needs in order to develop a summary of the current state of the science and future research needs related to TWH interventions.

Below, we make specific recommendations following the PICOTS framework laid out in KQ 5. We recommended specific research designs for the most important evidence gaps that relate to works setting and populations, interventions, comparators, outcomes, and study designs and deficiencies in methods.

Work Settings and Populations Studied

Geographic Setting

- Targeted regions of the country with a high burden of both occupational injuries and illnesses and chronic diseases should be a priority.
- Future research could target specific worksites in diverse regions of the United States that differ in terms of State government policy on economic development and labor, which can influence where employers locate and the attention they give to worker safety. There

is geographic variation across the United States in terms of fatal occupational injury rates (higher in the Western and Southern regions, in rural areas, and in less wealthy states).[72] States in the South and Midwest also have higher rates of risk factors for chronic disease, such as smoking, compared with other regions.[73]

Industries and Occupational Groups

- The applicability of interventions that were effective for reducing smoking and improving fruit and vegetable consumption is limited. Most included studies were published more than 10 years ago; current practice in terms of the availability of smoking cessation programs (at the worksite and via the health care setting) is likely to have improved over time. Future studies should consider similar interventions in other groups of workers (e.g., other blue-collar workers) or different settings to help clarify (1) the SOE for these interventions and (2) the applicability across various work settings and populations.
- Future studies should consider focusing on populations of workers in the service sector, such as retail, transportation, communications industries, and health care, given the high burden of occupational injuries in these populations.
- Occupational groups representing a large proportion of the U.S. workforce should also be a focus of future research (office and administrative support workers, sales and related occupations, and food preparation and serving workers). TWH interventions could have different outcomes depending on the industry setting and occupational groups enrolled.
- Future studies could enroll workers from a range of work settings (who receive a similar intervention, for example) in order to understand what factors related to the work setting modify the benefits (and potential harms) of TWH interventions. This approach might include recruiting worksites that differ by size, ownership of the enterprise (e.g., whether private or public sector), work organization (e.g., full- versus part-time job patterns), and unionization.

Populations and Subgroups Studied

- The National Institute for Occupational Safety and Health (NIOSH) lists changing workforce demographics (e.g., older workers, workers with disabilities, and others) as one of the issues relevant to advancing worker well-being through TWH;[7] future studies should consider targeting these populations to assess whether TWH interventions are effective in improving health outcomes that are unique to these groups of workers.
- Future studies could assess whether there are differences in outcomes among subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate). It is not clear whether certain categories of workers would benefit more than others from TWH. Workers with more resources (e.g., comprehensive health care insurance, access to wellness programs, sufficient income to afford gym memberships) may have less interest in TWH interventions. Identifying categories of workers for whom TWH is most effective, and under what conditions, should be a priority for future research.
- Future studies could enroll populations that are likely to have specific concerns related to work–life balance (e.g., single parents, caregivers of young children or elderly parents). Benefits, programs, and policies important to work–life balance (e.g., family and medical leave, paid time off, work–life programs) are noted by NIOSH as issues relevant to

advancing worker well-being through TWH but were not addressed in the included studies.[7]

Interventions

- Traditionally, OSH interventions focus on activities defined by a "hierarchy of control," in which identified hazards are controlled through elimination (physically removing the hazard), substitution (replacing the hazard), engineering controls (isolating people from the hazard), administrative controls (changing the way people work), or personal protection equipment.[74] Studies of TWH interventions should describe how the promotion of overall health and well-being fits into this framework and describe clearly where the synergy lies in terms of improvements in worker health.
- Future studies should clearly describe the specific approach used to integrate OSH and HP programs or policies. Investigators should lay out a framework for how the integrated intervention addressed *both* OSH and overall health.
- Authors of future studies might refer to research that has outlined indicators and metrics for "integration" and describe which of these integrated metrics were accomplished by the intervention under study.[11,12] Future research could build on this work and develop a taxonomy for TWH interventions that investigators could use to categorize and compare intervention types.
- The interventions we identified as effective suggest that employee participation is an important element in TWH interventions. Future studies should determine the most effective form of worker participation. It is unclear, for example, how the involvement of union representatives compares with "rank-and-file" worker participation in planning committees.
- Studies should evaluate interventions targeted at improvements in work organization. Work schedules and staffing (e.g., shift work, work hours), for example, have been highlighted as an issue relevant to TWH.[7] Few studies have assessed whether specific integrated strategies that modify the work organization improve worker health more than those focusing primarily on providing education, training, or behavioral counseling to individual workers.

Comparators

- An established body of literature supports the efficacy of worksite wellness interventions on smoking and other important outcomes;[75] similarly, evidence-based policies, programs, and practices focused on the prevention of occupational illness and injuries are available for specific industries and occupations.[76] Future studies should aim to directly assess the effectiveness of integration itself; in other words, this aspect of TWH interventions should be isolated from the effects of a new or improved OSH or HP program or policy. Studies should directly compare an integrated approach with a program that has similar OSH and HP elements available but does not deliberately coordinate them.
- In addition, investigators should clearly describe what OSH programs, HP programs, and health benefits (e.g., insurance, sick leave) are already in place and available to workers outside of the intervention being evaluated.

Outcomes

- Future studies should consider the feasibility of measuring a broader range of OSH outcomes. To understand whether a TWH approach prevents occupational illness and injury and promotes overall health, researchers need to examine indicators of improved safety.
- Future studies should also consider direct measures of worker health if possible; for example, they could use validated measures of health status, functional status, and wellness. Researchers should measure the incidence or morbidity associated with chronic diseases when feasible, particularly in populations of workers at higher risk of chronic conditions (e.g., older workers).
- Research teams should also choose intermediate outcomes carefully. These outcomes should be based on strong evidence for linkages to final health outcomes and for relevance to a particular population of workers. For example, rates of smoking might be prioritized in some populations because of (1) a high prevalence of smoking among a particular group of workers, (2) potential synergistic adverse effects related to a specific job hazard, and (3) a strong connection to CVD risk (regardless of factors related to OSH). Intermediate outcomes that have an unclear relationship to final health outcomes or OSH outcomes should receive less focus; these might include, for example, measures of cholesterol in otherwise healthy populations of workers who are young and have a low prevalence of other CVD risk factors.
- Future studies should consider assessing harms or potential unintended consequences of interventions at the individual worker and organizational levels. For example, studies could assess whether there was a concern about not giving adequate time or resources to OSH programs in studies of integrated interventions (among managers or OSH personnel). At the individual worker level, potential harms might vary by work setting or occupation; these might include increased barriers to reporting work-related injuries or illnesses, increased work stress, or concerns about the confidentiality of health information in the workplace.

Deficiencies in Methods

Future studies could address methodological limitations related to TWH interventions by considering the following:

- Worksite randomized trials should follow the recommendations for reporting outlined in the CONSORT statement extension to cluster randomized trials[77] or the Ottawa Statement on the ethical design and conduct of cluster randomized trials.[78] In particular, authors should provide a clear flow diagram to show the flow of participants from group assignments through the final analysis.
- Authors should consider whether the sample size (of worksites and workers) is likely to be sufficient to show a difference for the outcome being studied.
- RCTs are not always feasible due to barriers associated with studying populations of workers. Well-designed prospective cohort studies (or nonrandomized trials) with a concurrent control group would inform the strength of evidence related to TWH interventions. Studies without a control group are unlikely to contribute significantly to an understanding of the strength of evidence supporting TWH interventions (because of the inherent bias in the design); these designs should be avoided.

- For outcome measures by surveys, authors should describe the demographics (including occupational groups) of workers who respond and do not respond to surveys when feasible, so that this can be taken into consideration when assessing the potential risk of selection bias in studies.
- Authors should plan for high attrition (and differential attrition) and use methods to address missing data when necessary; approaches such as imputation of missing data should be considered, based on the potential reasons for missing data and the outcomes under study.
- Studies should address baseline differences between groups (when they are present) using appropriate statistical methods.
- Studies should report confidence intervals (or other measures of variance) for all outcomes they evaluate so that the precision around outcome measures is clear.
- Finally, in reporting their studies, authors should highlight whether other (concurrent) OSH programs, HP programs, or health benefits were in place or were implemented during the intervention in question; this will enable them to assess bias associated with contamination.

Discussion

Key Findings and Strength of Evidence

For this report, we conducted a systematic review to evaluate the evidence for Total Worker Health® (TWH) interventions. The purpose of this review is to provide an evidence report that the Pathways to Prevention Workshop Program of the Office of Disease Prevention at the National Institutes of Health can use to inform a workshop focused on TWH.[19] Below, we summarize the main findings by each Key Question (KQ), including giving the strength of evidence (SOE) for the bodies of evidence pertaining to the effectiveness and harms of interventions (KQ 2). We then discuss the findings in relation to what is already known, applicability of the findings, implications for decisionmaking, limitations of the review process or evidence base, and conclusions.

We had 24 studies described in 33 publications. We summarized the work settings and populations, interventions, and outcomes of all included trials in KQ 1. Of these 24 studies, 15 had a concurrent control group and were also eligible for KQ 2 (which assessed the effectiveness and harms of TWH interventions).[9,10,25,28,29,31-33,38,41,42,50,51,54,55] We rated the risk of bias as high for 10 of these studies; the remaining 2 studies were medium risk of bias.

We graded SOE only for outcomes reported in at least one study rated as medium risk of bias. When we graded evidence as insufficient, the evidence was unavailable, did not permit estimation of an effect, or did not permit us to draw a conclusion with at least a low level of confidence. An insufficient grade does not indicate that an intervention has been proven to lack effectiveness.

For KQ 3, we describe the characteristics of interventions for which we found at least low SOE for benefit. For KQ 4, we examined all 24 studies to determine whether authors noted important contextual factors that might have affected intervention effectiveness and to inform our assessment of the gaps in the literature (KQ 5) and future research needs (KQ 6) related to TWH interventions.

Key Question 1. Characteristics of Studies Evaluating Total Worker Health Interventions

Work Setting and Populations

Across all 24 studies, the heterogeneity was substantial with respect to the work settings, populations, intervention, and outcomes evaluated. The majority of studies enrolled workers from the manufacturing, construction, or health care and social assistance industries. Workers from the manufacturing and construction industry were more predominantly male and included a mix of blue-collar production workers and white-collar workers. Workers enrolled in studies set in the health care and social assistance industry were predominantly female nurses. Commonly targeted workers averaged between 30 and 50 years of age; only one study evaluated a younger workforce (mean <30 years of age), and only one study evaluated an older workforce (mean >50 years of age). Few studies described the baseline health status or medical comorbidity of included populations. The health promotion (HP) or occupational safety and health (OSH) services available at worksites in addition to the intervention under study were generally not described.

Interventions and Comparators

All studies assessed an intervention focused on an integrated objective (in terms of addressing both occupational hazards and promoting overall health). Eight studies assessed an intervention that involved strategic integration across organizational departments responsible for OSH and HP, and 17 involved worker participation in the development, design, planning, and implementation of the intervention. Six studies assessed an intervention with both strategic integration and worker participation. Most studies were multicomponent interventions; only 3 evaluated a single-component intervention. Only one included study assessed the effectiveness of integration alone (without added OSH or HP content). Twelve studies assessed interventions that included new, comprehensive HP and OSH components not previously available to workers; 6 included mostly HP content (tailored to the specific needs of workers); and 5 studies focused primarily on reducing occupational injuries, illnesses, or exposures (including work–life stress and job stress) and also included educational or other content related to promoting healthy behavior. Of the 24 studies, 15 included concurrent control groups, most of which received no intervention. Four studies included active control groups focused on HP or OSH alone.

Outcomes

Overall, included studies measured a wide variety of outcomes. Few studies assessed the same outcomes in similar populations of workers. Approximately half of studies measured a final health outcome (e.g., quality of life, functional status). Few studies evaluated work-related injuries or illness; work stress and changes in work safety behavior were commonly outcomes related to OSH. The most commonly reported intermediate health outcomes were body mass index, biomarkers associated with risk of cardiovascular disease (e.g., cholesterol), and health behaviors (primarily physical activity, smoking, and dietary behaviors). Several studies assessed outcomes that we did not include in KQ 2 (effectiveness and harms of TWH integrations); the two most common were measures of productivity and absenteeism.

Key Question 2. Effectiveness and Harms of Interventions

Evidence for the effectiveness and harms of TWH interventions for improving included outcomes eligible for KQ 2 consisted of 12 randomized controlled trials (RCTs), 2 nonrandomized controlled trial (NRCTs), and 1 prospective cohort study.[9,10,25,28,29,31-33,38,41,42,50,51,54,55]

We rated 5 RCTs as medium risk of bias[32,33] and the other 10 studies as high risk of bias. We rated studies as high risk of bias primarily because of a high risk of selection bias. Most studies had high overall attrition (ranging from 14 percent to 45 percent); many studies had differential attrition across study arms. In general, studies rated high risk of bias did not use any statistical methods to address missing data. Other common areas of bias included baseline differences between groups that the investigators did not address in their analyses.

The 15 KQ 2 studies were quite diverse; few studies of TWH interventions assessed the same outcomes among similar populations of workers. Table 13 summarizes our key findings by outcomes. We found low SOE to support the effectiveness of TWH interventions for improving rates of smoking and increasing the consumption of fruit and vegetable intake compared with no intervention; we also found low SOE to support the effectiveness of TWH interventions for reducing sedentary activity at work compared with any comparator. These results are summarized in Table 13. Evidence was insufficient to permit us to assess the effectiveness of

integrated interventions for improving quality of life, decreasing stress, blood pressure, weight, or consumption of red meat, overall physical activity, work-specific physical activity, or increasing safety compliance and safety behaviors; SOE grades for these outcomes are shown in Appendix D.

Table 13. Summary of key findings and strength of evidence for Total Worker Health interventions

Population; Intervention, Comparator; Time Point	N Studies; N Subjects Study Limitations	Outcome and Results	Strength of Evidence
Construction laborers[32] and manufacturing workers[25] Integrated intervention vs. no intervention 22–26 weeks	2; 737 Medium or high	**Self-reported 7-day smoking abstinence** One RCT (N = 188 smokers and recent quitters at baseline) rated medium ROB[32] found that more workers in the integrated intervention group than in the control group reported 7-day abstinence at 26 weeks: 19% vs. 8%; p = 0.03.[a] One RCT (N = 490 smokers at baseline) rated high ROB[25] found that more workers at intervention worksites than at control worksites reported 7-day abstinence at 22 weeks (26% versus 17%; p = 0.014).	Low for benefit
Manufacturing workers[9,33] and construction workers[32] Integrated intervention vs. no intervention 26–104 weeks	3; 6,056 Medium or high	**Self-reported fruit and vegetable consumption** Two RCTs rated medium ROB: One RCT (N = 578)[32] found that more workers in the intervention group than in the control group increased consumption of fruit and vegetables: mean increase in servings per day = +1.52 (SD = 3.39) vs. -0.09 (SD = 3.31); p = ≤0.0001. One RCT (N = 3,092)[33] found that more workers at intervention worksites than at control worksites reported consuming 5 or more servings of fruits and vegetables per day: [b] mean change from baseline = +7.5% vs. +1.1%; p = 0.048. One RCT (N = 2,386) rated high ROB[9] found that more workers at intervention worksites than at control worksitesincreased consumption of fruits and vegetables: mean change from baseline servings per day = 0.22 vs. 0.09; p = 0.04.	Low for benefit
Sedentary office workers,[51,54] Integrated intervention vs. any comparator 16–52 weeks	2; 262 Medium	**Sedentary activity at work** One RCT (N = 412)[51] found decreased sedentary activity in a physical environment intervention group compared with controls: difference between groups in minutes per day spent sedentary =-57.9; 95% CI, -111.7 to 4.2; p = 0.03.[c] One RCT (N = 60)[54] found a decreased percentage of worktime spent sedentary among the integrated intervention group[d] compared with an OSH-only group: -2.0 (95% CI, -4.4 to 0.3) vs. -0.4 (95% CI, -1.1 to 0.2); p = 0.08.	Low for benefit

CI = confidence interval; N = number; OSH = occupational safety and health; RCT = randomized controlled trial; ROB = risk of bias; SD = standard deviation.

[a] This RCT also found benefit for rates of 7-day abstinence of any tobacco use favoring the integrated intervention (19% versus 8%; p= 0.005).[32]

[b] In the overall sample of workers, there was no difference between intervention and control worksites (mean change from baseline percentage consuming 5 or more servings per day: +5.4% versus 1.7%; p=0.41); and managers at intervention worksites reported decreased consumption of fruit and vegetables compared with managers at control worksites (mean change from baseline consuming 5 or more servings per day: -5.5% vs. 3.6%; p=0.048).[33]

[c] There was no difference between the other two active comparators (social environmental intervention and combined social and physical environmental intervention) and the control group on any measure of work-specific physical activity or sedentary behavior outcome.[51]

[d] Workers were randomized to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation.[54]

Key Question 3. Components of Effective Interventions

We evaluated common characteristics of interventions that were effective for improving any outcome eligible for KQ 2 for which the SOE for benefit was at least low. We focused on characteristics of interventions that relate to the approach to integration and specific content of the intervention. Overall, we were able to make very few SOE conclusions because of the limitations of the evidence base. Effective interventions were heterogeneous and separating out individual components from the overall type (or "bundles") of interventions that showed efficacy for outcomes eligible for KQ 2 was not possible. Most effective interventions were informed by worker participation—in the development, design, planning, or implementation of the intervention (or in more than one of these steps). All effective interventions included comprehensive program content that addressed the potential additive or synergistic risks of hazardous workplace exposures and health behavior. Most effective interventions tailored intervention components or materials to cultural or social aspects of the worker population (e.g., to workers with low literacy skills or workers for whom English is not their first language). All effective interventions are multicomponent, complex interventions that reinforce messages about health and safety through multiple levels of influence or multiple modes of delivery (or both) over time.

Key Question 4. Contextual Factors

We abstracted data from included studies that related to contextual factors that the original authors had identified as potential modifiers of intervention effectiveness. We included factors that had been noted in the results (e.g., whether the intervention was more or less effective at worksites that differed by a specific contextual factor) and also those mentioned in the discussion that could have potentially modified the effectiveness of interventions.

Eight studies identified a contextual factor that could have played a role in modifying the effectiveness of interventions. Work organization factors and union membership status were the two commonly mentioned contextual factors. Other factors mentioned in at least one study included the following: presence of another (concurrent) OSH or HP policy implemented during the study period, health insurance status or access to primary care services, support from higher management; availability of resources, and employee stress or strain related to company downsizing during the intervention period.

Key Question 5. Research Gaps

We found numerous gaps in the literature base supporting TWH interventions in terms of work settings and populations, interventions, comparators, and deficiencies in methods.

Work Settings and Populations

No studies enrolled workers from states in the Southwest region of the United States; only one study each was conducted in a Southeastern or Western state (Arkansas and Oregon, respectively).

No studies enrolled workers from industries in these sectors: wholesale and retail trade; information (publishing, broadcasting, telecommunications); real estate; professional, scientific, and technical services; educational services; arts, entertainment, and recreation; or accommodation and food services. The service sector as a whole (e.g., retail, transportation, communications industries, health care) is underrepresented in included studies when considering the prevalence of work-related injuries among workers employed in this sector. In terms of specific occupational groups, few studies enrolled office and administrative support workers (the occupational group with the largest employment in the United States).[69] The following occupations were not represented in included studies: sales and related occupations (the second-largest major occupation group in the United States)[69] and food preparation and serving workers (the third-largest major occupation group in the United States).[69]

No study enrolled populations of workers who were very young or very old. No study addressed differences in outcomes among subgroups of workers defined by age, sex, race, ethnicity, comorbidity, or income. People who work part time (regardless of their occupation) were often excluded from studies.

Interventions

Studies evaluated quite diverse interventions; the type and level of integration involved in interventions varied substantially. We found no direct evidence on whether certain strategies of integration are more or less effective than others. A minority of included studies (eight studies) evaluated an intervention that clearly involved a systems-level approach to integration; that is, multiple departments within the worksite were involved with planning, implementing, and managing the intervention.

We found no studies that directly assessed whether specific combinations (or specific types) of program content were more or less effective than other combinations. Studies differed in terms of the degree to which program content focused on OSH concerns versus overall health and well-being.

We could not assess whether strategies were more or less effective based on their complexity (single versus multicomponent) or level of influence (e.g., engineering or administrative controls, individual worker education, or both).

Comparators

In general, studies were not designed to assess directly the effectiveness of integration alone (compared with no integration). Most studies compared an intervention that included new OSH and HP content (or components) with no intervention. The effects of the new HP or OSH component (or both) offered to the intervention group could not be separated from the effects of integration. Studies that compared an intervention with no intervention (or usual workplace programs) generally did not describe the HP or OSH programs already in place and available to workers.

Outcomes

Although we considered a wide range of outcomes for this review, we were able to rate the evidence for only three: smoking cessation, fruit and vegetable consumption, and sedentary activity at work. Very few studies with a concurrent control group measured outcomes important to OSH. Whether integrated interventions improve workplace safety (compared with OSH programs or policies that are not integrated with HP) is unclear.

We found no eligible studies eligible for KQ 2 (effectiveness and harms of interventions) reporting on the following outcomes: incidence of injuries, cardiovascular disease, or cancer; morbidity related to injuries, illnesses, or chronic disease (including work-related injuries and illnesses); depression or anxiety; body mass index; and measures of health care utilization (hospitalizations, emergency department visits, or outpatient clinic visits). A few studies reported on the following outcomes: validated measures of quality of life or functional status, stress (job or general stress), rates of workers' compensation claims, short-term disability claims, alcohol use, and illicit drug use.

No included studies prespecified harms as an outcome of interest. We looked for evidence on the following potential harms of interventions but did not find any: increased barriers to reporting work-related injuries or illnesses, work stress, adverse effects on personal health, discrimination, or victim blaming.

Deficiencies in Methods

Of the 24 included studies, 15 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 15 studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations. Among RCTs, we found inadequate reporting of randomization and allocation concealment. Most RCTs did their randomization at the worksite level; the number of worksites randomized was sometimes small. Studies often did not adequately describe the flow of participants; this was particularly true of those that randomized or assigned interventions at the worksite level.

Most studies measured outcomes based on survey responses before and after an intervention. Response rates to the baseline surveys among eligible workers were sometimes low or not reported, and this practice contributed to selection bias.

Overall attrition was high in several studies (14 percent to 54 percent in studies rated high risk of bias). Most studies did not conduct an intention-to-treat analysis (i.e., they analyzed only completers). We encountered baseline differences between groups in several studies; statistical analyses did not often address these differences. Several studies had small sample sizes and thus lacked power for determining intended effects.

Investigators sometimes did not provide information on their statistical methods; also, authors sometimes did not provide measures of variance (e.g., confidence intervals) for outcomes. In several studies, contamination of the control arms compromised internal validity; for example, another worksite policy or program initiated during the intervention period could have influenced outcomes measured in the study.

Finally, in some cases, the length of followup may not have been adequate to assess the stability of findings over time. Only seven studies measured outcomes at or beyond 1 year.

Key Question 6. Future Research Needs

Work Settings and Populations

Future research could target specific worksites in diverse regions of the United States that differ in terms of state government policy on economic development and labor; these factors can influence where employers locate and the attention they give to worker safety.

The applicability of interventions that were effective for reducing smoking, improving fruit and vegetable consumption, and reducing sedentary work activity is limited. Future studies should consider similar interventions in other groups of workers (e.g., other blue-collar workers) or different types of worksites to help clarify (1) the SOE for these interventions and (2) the applicability across various work settings and populations.

Consideration should be given to a broader set of populations of workers in the service sector, such as retail, transportation, and communications industries and health care in future TWH interventions. These populations have a high burden of occupational injuries. Occupational groups representing the largest number of U.S. workers should also be a focus of future research; these include (but might not be limited to) office and administrative support workers, sales and related occupations, and food preparation and serving workers. Future studies could enroll workers from diverse work settings (who receive a similar intervention, for example) to assess which factors related to the work setting modify the benefits (and potential harms) of TWH interventions.

Future studies could assess whether there are differences in outcomes among subgroups of workers defined by occupation, age, sex, race, ethnicity, comorbidity, or income (when appropriate). It is not clear whether certain categories of workers would benefit more from TWH compared with others. Future studies could enroll populations who are likely to have specific concerns related to work–life balance (e.g., caregivers of young children or elderly parents, single parents) or workers with unique health and safety concerns (older workers or workers with disabilities).

Interventions

Future studies should clearly describe the approach used to integrate OSH and HP programs, policies, or goals. Investigators should lay out a framework for how the integrated intervention addresses *both* OSH and overall health. Studies should focus on interventions targeted at the work environment or work structure. Work schedules (e.g., shift work, work hours), for example, have been highlighted as an issue relevant to TWH. Few studies have assessed whether specific integrated strategies that modify the work environment improve worker health more than those focusing primarily on providing education or behavioral counseling to individual workers.

Comparators

An established body of literature supports the efficacy of worksite wellness interventions on smoking and other important outcomes.[75] Future studies should try to assess directly the effectiveness of integration itself; in other words, this aspect of TWH interventions should be isolated from the effects of a new or improved OSH or HP component. Studies should directly compare an integrated approach with a program that has similar OSH and HP elements available but does not deliberately coordinate them. In addition, investigators should clearly describe what

programs related to health and safety are already in place and available to workers outside of the intervention being evaluated.

Outcomes

Future studies should consider the feasibility of measuring OSH outcomes. To understand whether "integration" improves both OSH and HP, researchers need to examine indicators of improved safety.

Future studies should also consider direct measures of worker health if possible; for example, using validated measures of health status, functional status, and wellness. Researchers should measure the incidence or morbidity associated with chronic diseases when feasible, particularly in populations of workers at higher risk of chronic conditions (e.g., older workers).

Research teams should also chose intermediate outcomes carefully. These outcomes should be based on strong evidence for linkages to final health outcomes and for relevance to a particular population of workers.

Finally, future studies should consider assessing harms or potential unintended consequences of the interventions. Measures of harms and unanticipated effects should be made at both the individual worker and organizational levels.

Deficiencies in Methods

Worksite randomized trials should follow the recommendations for reporting outlined in the Consolidated Standards of Reporting Trials (CONSORT) statement extension to cluster randomized trials[77] or the Ottawa Statement on the ethical design and conduct of cluster randomized trials.[78] In particular, authors should provide a clear flow diagram to show the flow of participants from group assignments through the final analysis. Of the 24 studies we included in this review, 9 had a pre-post design; because of the inherent risk of bias in pre-post studies, we did not include them in our assessment of the benefits and harms of TWH interventions. Among the 15 studies eligible for KQ 2 (i.e., those with a concurrent control group), many had methodological limitations.

Randomized trials are not always feasible because of barriers associated with studying populations of workers. Well-designed prospective cohort studies (or nonrandomized trials) with a concurrent control group could inform the SOE related to TWH interventions. Studies without a control group are unlikely to contribute significantly to an understanding of the SOE supporting TWH interventions (because of the inherent bias in the design); these designs should be avoided.

Investigators should plan for high attrition (and differential attrition between intervention and control groups). In addition, they should use methods to address missing data when necessary; approaches such as imputation of missing data or use of a baseline observation carried forward method (if appropriate to the outcome) should be considered.

Studies should address baseline differences between groups (when they are present) using appropriate statistically methods. Furthermore, investigators should report measures of variance (e.g., confidence intervals) for all outcomes they evaluate. Finally, in reporting their studies, authors should highlight whether other (concurrent) OSH and HP policies or programs had been in place or implemented during the intervention in question; this will enable them to assess bias associated with contamination.

Findings in Relation to What Is Already Known

This is an emerging body of literature; we did not find a previous systematic review that was similar in scope or that assessed the SOE related to common outcomes reported in studies of TWH interventions. We identified one prior systematic review[18] and one expert (or narrative) review[17] that provided a broad overview of TWH interventions.

The results of our current review are, in general, consistent with those in previous reviews with respect to conclusions about the limitations of the evidence base. For example Anger and colleagues noted that integrated interventions improved risk factors for chronic diseases. They concluded, however, that the evidence that integration itself confers a significant benefit is lacking and is "perhaps the most glaring gap in the TWH literature."[18]

Like previous reviews, we took a broad approach to defining "integration." Not surprisingly, our review and the two earlier reviews differ slightly in terms of included studies and whether we considered them integrated or not. For example, one study assessing a worksite wellness program designed for firefighters was included in the review by Anger and colleagues; we excluded this study because it had no explicit coordination between OSH and HP programs and no obvious OSH content or focus of the intervention.[79] We also excluded studies evaluating "sit-stand" workstations only (with no explicit coordination with HP activities or promotion of physical activity outside of work).[80]

Our review differs from others in terms of methods. Prior reviews have either not addressed potential bias associated with TWH interventions or used study design labels as a proxy for assessment of the risk of bias of included studies.[18] We used standard techniques for assessing risk of bias for individual trials or observational studies (documented in Appendix C) and grading the SOE for entire bodies of evidence (Appendix D).

Moreover, in terms of overall conclusions about the effectiveness of TWH interventions, our review differs in that we assessed the SOE for specific outcomes. Prior reviews have made generalized statements about the positive effects of TWH interventions or have summarized the benefits primarily by noting the number of statistically significant outcomes found across studies; they generally have not considered the consistency or precision associated with findings.[17,18] In general, the two prior reviews make stronger conclusions regarding the benefits of integrated integration than we reached.

Applicability

During our review process, we systematically abstracted key factors that may affect the applicability of the evidence base. We identified these key factors a priori. We defined applicability according to Agency for Healthcare Research and Quality guidance: "the extent to which the effects observed in published studies are likely to reflect the expected results when a specific intervention is applied to the population of interest under real-world conditions."[24] For this review, we focused on issues that relate to populations of workers and worksites in the United States.

Approximately one-half of the studies we included had been conducted in this country; the others were conducted in European or Scandinavian countries. Included studies focused primarily on populations employed either in the manufacturing or construction industries or in health care. Populations enrolled in included studies were generally between the ages of 30 and 50; the baseline comorbidity of workers was often not described. Results of included studies may not be applicable to workers who are very young or very old or who have a high burden of

comorbid medical conditions. The proportion of workers who had access to medical care or other, ongoing worksite health programs was often not well described. Whether the results of included studies would apply to worksites that have established HP and OSH programs in place (whether or not they are integrated) remains unclear.

Studies that contributed to our SOE grades for smoking and healthy eating outcomes had all been conducted among U.S. blue-collar workers (manufacturing worksites in the Massachusetts or unionized construction workers). The evidence for which we developed SOE grades is based on survey data collected before 2004 and comes from the same group of researchers.[9,10,32,33] Within the past decade (i.e., since the mid-2000s), workplace HP and OSH programs have very likely been improved; whether the results of these trials would be applicable to worksites that already have active HP programs (or policies) that promote smoking cessation and healthy eating is not clear.

More recent changes in health policy or practice (such as community health interventions and health care) may limit the applicability of studies published 10 or more years ago. After the implementation of the Affordable Care Act, national surveys show improvements in self-reported health care coverage, access to primary care and medications, greater affordability, and better health among younger populations of men (at least in states that expanded Medicaid coverage).[81] Access to smoking cessation services may be more widely available because of these changes; intervention components evaluated in older studies could now be considered "usual care" in some settings.

Limitations of the Review Process

We cast a broad net in terms of our inclusion criteria that relate to interventions. The studies that met our inclusion criteria used a range of strategies to address both OSH and overall health and well-being. Included studies were often published before the terms "integrated intervention" or "total worker health" were used to describe interventions. Because of a lack of consistent terminology related to "integration" and (potentially) inadequate reporting or description of intervention components in some studies, we may have overlooked some interventions that could be considered integrated. This was also a limitation in terms of synthesizing the evidence across complex interventions that use various approaches to addressing OSH and overall health. Our inclusion criteria for interventions are based on the definition of a TWH program from the National Institute of Occupational Safety and Health for "total worker health" and other, related guidance on integration.[11] The definition of TWH itself has shifted (in 2015) away from a more narrow focus on integrating OSH and HP to "an approach that advocates for a holistic understanding of the factors that contribute to worker well-being."[71] Our review scope did not include all studies that might fall under the larger umbrella of concerns relevant to TWH.

Our searches were based on studies generally considered to be focused on integration; however, these studies are not indexed by standard or consistent terms that are specific to integration or TWH. To address this deficiency, we solicited and received a database from NIOSH that listed studies deemed relevant to TWH. Our search strategies had identified the vast majority of these studies. Nevertheless, some studies that we excluded might still be considered related to TWH. All in all, therefore, whether certain types of interventions are considered integrated remains inconsistent. As noted previously, our review and two other prior reviews differed slightly in terms of included studies; for example, we excluded at least three studies found in those prior reviews as "wrong intervention" because they primarily addressed HP only or OSH only.[82,83]

Publication bias and selective reporting of outcomes are potential limitations. Although we searched for unpublished trials and unpublished outcomes, we did not find direct evidence of either of these biases. Many of the included trials were published before trial registries (e.g., clinicaltrials.gov) became available; had we been able to consult such registries, we would have had greater certainty about the potential for either type of bias.

Finally, for this review, we excluded non-English-language studies based largely on limitations of time and resources. However, we identified non-English-language studies in our searches and did not see any references that had the potential to be useful in this review. Searches of the NIOSH references did not uncover any non-English-language studies. Given this, and the fact that TWH is a relatively new strategy, we believe that limiting our review to English-language studies had little effect.

Limitations of the Evidence Base

The evidence base assessing TWH interventions was limited in scope and volume. It was inadequate to draw conclusions for some of our questions or subquestions of interest. Authors of different studies did not usually report the same outcomes or assess similar intervention types. Because of gaps in the trial evidence and because conducting trials in workplace settings is challenging, we included observational studies in this review.

For KQ 2, we limited our synthesis to studies with a concurrent control group. Studies with a pre-post comparison only generally do not provide valid and useful information to address questions of the benefits and harms of interventions. We did include pre-post studies to inform the assessment of gaps and future research needs, primarily in terms of describing gaps in the types of populations and interventions assessed in prior studies. Limiting by study design is unlikely to have had a major effect in terms of our assessment of the SOE.

Among studies eligible for KQ 2, many had methodological limitations introducing significant risk of bias. The major problems across studies relate to selection bias and attrition bias. These are described above under the section on research gaps (methodological limitations). Briefly, many studies relied on surveys to assess improvements in worker health; nonresponse bias is a concern. Overall attrition in studies was often high. For the 10 studies that had very high overall attrition (>20 percent), high differential attrition (>15 percent), or both, only 1 of these studies employed methods to address missing data[42] (e.g., last observation carried forward). Selection bias at the worksite level is also a potential concern; employers who agree to participate in studies assessing integrated interventions may differ in important ways from employers who decline to participate. Most trials analyzed only completers and did not use any methods to address missing data.

Among other problems seen (even in studies with medium risk of bias overall), we noted especially the following: no reporting of randomization and allocation concealment, difference in intervention and control groups at baseline, small sample sizes (and thus lack of power for determining intended effects), and lack of clarity in defining intervention components. Finally, studies often lacked of information on statistical methods (or data on confidence intervals or similar information on statistical tests).

Conclusions

Overall, we found the body of evidence to be small, heterogeneous in terms of populations; interventions; and measured outcomes; and, in some areas of interest, nonexistent. The small size of the body of evidence is not altogether surprising given that the concept of "integration" is

relatively new. The body of evidence may reasonably be expected to grow over the next few years. Evidence of low SOE supported the effectiveness of TWH interventions for improving the following: rates of smoking cessation over 22 to 26 weeks, increasing the consumption of fruit and vegetable intake over 26 to 104 weeks, and reducing sedentary work activity over 16 to 52 weeks. Evidence was insufficient to assess the effectiveness of integrated interventions for improving the following outcomes: quality of life, stress, blood pressure, weight, overall and work-specific levels of physical activity, consumption of red meat, safety behaviors, and safety compliance. Effective interventions were informed by worker participation and included comprehensive program content that highlighted the potential additive or synergistic risks of hazardous workplace exposures and health behavior. The applicability of these findings is limited; most trials enrolled blue-collar workers (from manufacturing worksites in Massachusetts or unionized construction workers) before 2004.

Additional adequately powered multisite RCTs or other prospective studies with a concurrent control are needed to replicate encouraging findings that have been observed to date in only a few trials. Investigators also need to design studies explicitly to assess the benefits of integration separate from new OSH or HP components. Including a broader range of workers in future studies could increase the applicability of TWH interventions and enable reviewers to assess the consistency of findings. It might also answer the question of whether integrated strategies are more effective (or not) in groups of workers who differ by demographic, social, or occupational characteristics that contribute to adverse health outcomes.

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Appendix A. Literature Search Strategies and Yields

Published Literature

Table A1. PubMed original search, 3/26/15

[Limited to date range of 1/1/1990 – present.]

Search	Query	Items found
#1	Search "total worker health"	22
#2	Search "Occupational Health"[Mesh] OR "Occupational Health Services"[Mesh] OR "Occupational Injuries"[Mesh] OR "Workplace"[Mesh] OR "worksite health"	45888
#3	Search (("Health Promotion"[Mesh]) OR "Accident Prevention"[Mesh]) OR "Wounds and Injuries/prevention and control"[Mesh]	160904
#4	Search (#2 AND #3)	7667
#5	Search (#1 OR #4)	7676
#6	Search (#1 OR #4) Filters: Humans	7116
#7	Search (#1 OR #4) Filters: Humans; English	6473
#8	Search (#1 OR #4) Filters: Publication date from 1990/01/01; Humans; English	6074
#9	Search ("Clinical Trial" [Publication Type] OR "Controlled Clinical Trial" [Publication Type] OR "Randomized Controlled Trial" [Publication Type]) OR "Evaluation Studies" [Publication Type] OR ("Cohort Studies"[Mesh]) OR "Longitudinal Studies"[Mesh]	2127524
#10	Search (#8 AND #9)	830
#11	Search (Occupational Diseases/prevention & control OR Accidents, Occupational/prevention & control)	22822
#12	Search "Workplace"[Mesh] OR Work[Mesh] OR worksite OR workplace OR protection OR "integrated intervention"	309706
#13	Search ((occupational health [mesh] OR occupational exposure [mesh]))	73332
#14	Search (#11 AND #12 AND #13)	1562
#15	Search study OR intervention OR program	7088040
#16	Search (#14 AND #15)	702
#17	Search (#14 AND #15) Filters: English	573
#18	Search (#14 AND #15) Filters: Humans; English	571
#19	Search (#14 AND #15) Filters: Publication date from 1990/01/01; Humans; English	563
#20	Search (#10 OR #19)	1359

Table A2. PubMed update search, 9/21/15

[Limited to date range of 8/1/2014 – present.]

Search	Query	Items found
#1	Search "total worker health"	26
#2	Search "Occupational Health"[Mesh] OR "Occupational Health Services"[Mesh] OR "Occupational Injuries"[Mesh] OR "Workplace"[Mesh] OR "worksite health"	47216
#3	Search (("Health Promotion"[Mesh]) OR "Accident Prevention"[Mesh]) OR "Wounds and Injuries/prevention and control"[Mesh]	166271
#4	Search (#2 AND #3)	7971
#5	Search (#1 OR #4)	7981
#8	Search (#1 OR #4) Filters: Publication date from 1990/01/01; Humans; English	253
#10	Search ("Clinical Trial" [Publication Type] OR "Controlled Clinical Trial" [Publication Type] OR "Randomized Controlled Trial" [Publication Type]) OR "Evaluation Studies" [Publication Type] OR	2199173

	("Cohort Studies"[Mesh]) OR "Longitudinal Studies"[Mesh]	
#11	Search (#8 AND #10)	29
#12	Search (Occupational Diseases/prevention & control OR Accidents, Occupational/prevention & control)	23088
#13	Search "Workplace"[Mesh] OR Work[Mesh] OR worksite OR workplace OR protection OR "integrated intervention"	321211
#14	Search ((occupational health [mesh] OR occupational exposure [mesh]))	75045
#15	Search (#12 AND #13 AND #14)	1610
#16	Search study OR intervention OR program	7337802
#17	Search (#15 AND #16)	720
#20	Search (#15 AND #16) Filters: Publication date from 2014/08/01; Humans; English	13
#21	Search (#20 OR #11) Filters: Publication date from 2014/08/01; Humans; English	41

Table A3. Cochrane Library original search for reviews, 3/26/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	16
#2	(occupational OR work) AND (health promotion OR prevention) AND (integrated OR "health education")	8

Table A4. Cochrane Library update search for reviews, 9/21/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	5
#2	(occupational OR work) AND (health promotion OR prevention) AND (integrated OR "health education")	1

Table A5. Cochrane Library original search for clinical trials, 3/26/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	21
#2	(occupational OR work) AND (health promotion OR prevention) AND (integrated OR "health education")	20

Table A6. Cochrane Library update search for clinical trials, 9/21/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	7
#2	(occupational OR work) AND (health promotion OR prevention) AND (integrated OR "health education")	0

Table A7. PsycINFO original search, 3/26/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	3
#2	(occupational OR work) AND (health promotion OR prevention) AND (integrated OR "health education")	23

Table A8. PsycINFO update search, 3/26/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	1
#2	(occupational OR work) AND (health promotion OR prevention) AND (integrated OR "health education")	8

Gray Literature

Table A9. Academic Search Premier, original search, 3/26/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	12

Table A10. Academic Search Premier, update search, 9/21/15

[No limits based on publication date.]

ID	Search	Hits
#1	“Total Worker Health”	9

Table A11. ClinicalTrials.gov, original search, 3/26/15

[No limits based on publication date.]

ID	Search	Hits
#1	"Total Worker Health"	12
#2	(occupational OR worksite) AND (health promotion OR prevention) AND (integrated)	8

Table A12. ClinicalTrials.gov, update search, 9/21/15

[No limits based on publication date.]

ID	Search	Hits
#1	"Total Worker Health"	0
#2	(occupational OR worksite) AND (health promotion OR prevention) AND (integrated)	0

Appendix B. Exclusions

X1: Not original research
X2: Ineligible population
X3: Wrong or no intervention
X4: Wrong or no comparator
X5: Wrong setting
X6: Wrong study design
X7: Non-English
X8: Ineligible publication type (used specifically for relevant ongoing studies' protocols)

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2. Abrams DB, Boutwell WB, Grizzle J, et al. Cancer control at the workplace: the Working Well Trial. Prev Med. 1994 Jan;23(1):15-27. PMID: 8016028. Exclusion Code: X3
3. Adera T, Amir C, Anderson L. Use of comparison populations for evaluating the effectiveness of hearing loss prevention programs. AIHAJ. 2000 Jan-Feb;61(1):11-5. PMID: 10772609. Exclusion Code: X3
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Appendix C. Risk of Bias Ratings

Table C1. Risk of bias assessments for TWH studies eligible for Key Question 2, part 1

Author, Year Trial Name (if applicable)	Study Design	Eligibility criteria clearly described?	RCTs ONLY: Method of randomization method adequate?	RCTs ONLY: Randomization at worksite or individual level?	RCTs ONLY: Allocation concealment adequate?	Obs Studies ONLY: Groups recruited from same source population?	Baseline Chx similar?	Intervention fidelity adequate?
Allen, 2003[1] International's Allergy Project	NRCT	Yes	NA	NA	NA	Yes	Yes	NR/CND
Boggild, 2001[2]	Prospective cohort study	No	NA	NA	NA	No	No	NR/CND
Carr, 2015[3]	RCT	Yes	Yes	Individual	Yes	NA	Yes	NR/CND
Coffeng, 2014[4] Be Active & Relax "Vitality in Practice"	RCT	Yes	Yes	Worksite	NR/CND	NA	Yes	NR/CND
Eriksen, 2002[5]	RCT	Yes	Yes	Worksite	Yes	NA	No	NR/CND
Hammer, 2015[6] Safety and Health Improvement Program (SHIP)	RCT	Yes	NR/CND	Other (see comments)	NR/CND	NA	Yes	NR/CND
Maes, 1998[7] The Brabantia Project	NRCT	No	NA	NA	NA	No	No	No
Okechukwu, 2009[8] MassBuilt	RCT	Yes	NR/CND	Worksite	NR/CND	NA	No	NR/CND
Palumbo, 2012[9]	RCT	Yes	NR/CND	Individual	NR/CND	NA	NR/CND	Yes
Sorensen, 1998[10-12] WellWorks	RCT	Yes	NR/CND	Worksite	NR/CND	NA	NR/CND	NR/CND
Sorensen, 2003[13-15] WellWorks-2	RCT	Yes	Yes	Worksite	Yes	NA	No	NR/CND
Sorensen, 2005[16-18] Healthy Directions-Small Business	RCT	Yes	NR/CND	Worksite	NR/CND	NA	No	NR/CND
Sorensen, 2007[19] Tools for Health	RCT	Yes	NR/CND	Individual	NR/CND	NA	Yes	NR/CND
Tveito, 2009[20] Integrated Health Programme	RCT	Yes	Yes	Individual	NR/CND	NA	NR/CND	NR/CND

Table C1. Risk of bias assessments for TWH studies eligible for Key Question 2, part 1 (continued)

Author, Year Trial Name (if applicable)	Study Design	Eligibility criteria clearly described?	RCTs ONLY: Method of randomization method adequate?	RCTs ONLY: Randomization at worksite or individual level?	RCTs ONLY: Allocation concealment adequate?	Obs Studies ONLY: Groups recruited from same source population?	Baseline Chx similar?	Intervention fidelity adequate?
von Thiele Schwarz, 2015[21]	RCT	Yes	NR/CND	Hospital Ward	NR/CND	NA	No	Yes

Chx, Characteristics; CND, cannot determine; Obs, observational; NA, not applicable; NR, not reported; NRCT, non-randomized controlled trial; RCT, randomized controlled trial; ROB, risk of bias

Table C2. Risk of bias assessments for TWH studies eligible for Key Question 2, part 2

Author, Year	Reported adherence to the intervention?	Overall attrition?	Differential attrition?	Differential (≥15%) or overall high attrition (generally ≥20%) raising concern for bias?	Analysis conducted on an ITT basis?
Allen, 2003[1] International's Allergy Project	NR	NR	NR	NR/CND	No
Boggild, 2001[2]	Variable [a]	Workplace: None; Workers: baseline survey response 68%; 24 weeks (101 baseline respondents - 75 completed post-test)/101 = 26%	Unclear [b]	Yes	No
Carr, 2015[3]	Activity monitor: 92%; Active workstation: 70%	Overall: 10%; Lost to Followup: 8%; Discontinued: 2%	0%	No	No
Coffeng, 2014[4] Be Active & Relax "Vitality in Practice"	See comments	6 months: 15%; 12 months: 20%	Attrition (% sample) by study arm for the control/social/physical/combo groups: 6 months: 8/11/15/29; 12 months: 9/20/21/32	Yes	Yes
Eriksen, 2002[5]	NR	Workers, 52 weeks: (860 randomized/completed pre-survey - 472 completed follow-up)/860 randomized=45%; Workers, 12 weeks: (860 randomized/completed pre-survey - 628 completed post-test)/860 randomized = 27%	Workers, 52 weeks: 40-52% across groups; Workers, 12 weeks: 20-33% across groups	Yes	Yes
Hammer, 2015[6] Safety and Health Improvement Program (SHIP)	See comments	10% (see comments)	4% (see comments)	No	Yes
Maes, 1998[7] The Brabantia Project	Variable [c]	Workers: baseline survey response (52%); Workers, 156 weeks: (346 baseline respondents - 264 follow-up survey respondents)/346 = 24%	0%	Yes	No
Okechukwu, 2009[8] MassBuilt	NR	Workers: baseline survey response 94%; at 6 months: (1817 initial responders - 1213 completers)/1817=33%	NR/CND	Yes	Yes
Palumbo, 2012[9]	Average attendance of 13 classes= 82%	Workers: 21%	14%	Yes	Yes

Table C2. Risk of bias assessments for TWH studies eligible for Key Question 2, part 2 (continued)

Author, Year	Reported adherence to the intervention?	Overall attrition?	Differential attrition?	Differential (≥15%) or overall high attrition (generally ≥20%) raising concern for bias?	Analysis conducted on an ITT basis?
Sorensen, 1998[10-12] WellWorks	See comments	Worksites: NR; Workers, mean baseline survey response across sites 61% (range 36-99%); Workers, post-intervention: (5914 baseline respondents – 2658 follow-up survey respondents)/5914 = 60%	NR	Yes	No
Sorensen, 2003[13-15] WellWorks-2	NR	Worksite: 2/17 (11.8%); Workplace processes (for safety outcomes): 24/131 (18.3%); Workers, baseline survey response rate: 57%; baseline respondents to final survey: (9019-5156)/9019 = 43%	Worksite: unclear; Workplace processes: unclear, differential N provided for only 16 of 24 missing workplace processes; Workers: unclear [d]	Yes	No
Sorensen, 2005[16-18] Healthy Directions-Small Business	Variable [e]	Worksites: 8%; Workers: baseline respondents to final survey: (1740 baseline respondents - 974 who completed baseline and follow-up survey)/1740 = 44%	Worksites: 0%; Workers: NR	Yes	Yes
Sorensen, 2007[19] Tools for Health	NR	14%	3%	No	Yes
Tveito, 2009[20] Integrated Health Programme	NR	28%	18%	Yes	Yes
von Thiele Schwarz, 2015[21]	NR	Workers: (312 workers with baseline survey - 202 workers completed all surveys)/312 workers = 35% Workers, baseline survey response rate: 87.5%	NR/CND	Yes	NA

[a] The authors state that some wards did not consistently adhere to schedule due to "staff shortage, sickness and maternity leave, new rules for handling overtime work, and the like."[2]

[b] Authors state initial participation did not differ between wards. "Dropout rate" between baseline and 6 months was significantly higher in "intervention control wards and lower in the day-working control wards."[2]

[c] The authors note that participation for health promotion activities varied: 10-20% participation rate for health education sessions and 60-70% for health fair and exhibition.

[d] The authors only provide sufficient data to calculate differential attrition for the cross-sectional sample of workers who completed a baseline and following-up survey (7%); for the embedded sample who completed a baseline survey, the non-response rate to the follow-up survey by group (intervention versus control) is NR.

[e] Varied by intervention component and worksite: 74% of final survey respondents reported participating in ≥1 of 17 health promotion and/or safety programs at intervention sites vs. 29% at control sites. Mean worksite participation was 47% per event per site (range: 17-56%)[17]

CND, cannot determine; ITT, intent-to-treat; N, number; NA, not applicable; NR, not reported

Table C3. Risk of bias assessments for TWH studies eligible for Key Question 2, part 3

Author, Year	Cross-overs or contam-ination raising concern for bias?	Eligible outcome measures valid and reliable?	Outcome assessors masked?	Duration of follow-up adequate to assess outcome?	Appropriate method used to handle missing data?	Analysis adjusted for potential confounders?	ROB	Comments on Risk of Bias Rating
Allen, 2003[1] International's Allergy Project	No	Yes	NR/CND	No	No	No	High	Experimental and control sites differed at baseline (age, job type, union concentration and allergy medicine regimens). Participation varied substantially by worksite and intervention component. Outcome measures were poorly described and evaluated after only one education cycle; authors note several cycles may be required to produce desired changes. Multiple elements of study design were NR. Attrition was NR; analyses focus on completers (pre-post surveys).
Boggild, 2001[2]	No	Yes	No	Yes	No	NR/CND	High	High overall attrition and differential attrition contributed to high risk of selection bias. Groups differed at baseline (satisfaction with works schedule, exercise frequency and smoking status); there was no adjustment for differences or other confounding variables in the analysis. Some wards chose to implement a partial rather than full set of intervention components. Authors compared three groups based on participation (full, partial, none); reasons for choosing or not choosing the full intervention may relate to work conditions or baseline differences across wards.
Carr, 2015[3]	NR/CND	Yes	Yes	Yes	No	Yes	Medium	In total 57% of employees (N=167) completed both baseline and follow-up surveys.

Table C3. Risk of bias assessments for TWH studies eligible for Key Question 2, part 3 (continued)

Author, Year	Cross-overs or contam-ination raising concern for bias?	Eligible outcome measures valid and reliable?	Outcome assessors masked?	Duration of follow-up adequate to assess outcome?	Appropriate method used to handle missing data?	Analysis adjusted for potential confounders?	ROB	Comments on Risk of Bias Rating
Coffeng, 2014[4] Be Active & Relax "Vitality in Practice"	NR/CND	Yes	No	Yes	Yes	Yes	Medium	Selection bias is a concern; of 1182 eligible workers, 412 enrolled in the study (35% response rate). Participation may have been very low at some sites; the percent of participants that used any of the intervention components at least once ranged from 45-76% across sites. Authors report that cross-over/contamination is unlikely since randomization was at the department level, but did note that the control group may have used some environmental modifications. There was substantial overall and differential attrition; authors reported that there was no difference in baseline characteristics between completers and non-completers. Authors performed a linear mixed model analysis for each outcome measure assuming data was missing at random.
Eriksen, 2002[5]	No	Yes	NR/CND	Yes	Partially	No	High	High overall and differential attrition contributed to selection bias. Groups differed at baseline (number of working hours per week and years in current occupation). Authors conducted a modified ITT analysis and handled missing data using a LOCF approach for some outcomes

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Table C3. Risk of bias assessments for TWH studies eligible for Key Question 2, part 3 (continued)

Author, Year	Cross-overs or contam-ination raising concern for bias?	Eligible outcome measures valid and reliable?	Outcome assessors masked?	Duration of follow-up adequate to assess outcome?	Appropriate method used to handle missing data?	Analysis adjusted for potential confounders?	ROB	Comments on Risk of Bias Rating
Hammer, 2015[6] Safety and Health Improvement Program (SHIP)	NR/CND	NR/CND	No	Yes	Yes	Yes	Medium	Randomization and allocation concealment were not described. All supervisors and workgroups completed sessions; adherence (or participation) by individual workers is unclear. There was an e evaluation of the extent and effect of missing data on results; missing data patterns were described, imputation was utilized, and additional analytic approaches were used to accommodate the missing data. In total, 57% of employees (N=167) completed both baseline and follow-up surveys. Of 90% of randomized employees who completed either a baseline or 12 month survey included in the analysis; overall attrition based on the N analyzed was 10%.
Maes, 1998[7] The Brabantia Project	NR/CND	No	No	Yes	No	Yes	High	At baseline: intervention group had more women (26% vs. 12%) and less education (61% vs. 49% with only an elementary education) than control group. Groups also differed in variables associated with working conditions. Only gender and educational level were entered as covariates in analyses. Adherence to some intervention components was very low. Important outcomes were mostly reported as composite scales or scores. Overall attrition was high (24%).
Okechukwu, 2009[8] MassBuilt	NR/CND	Yes	NR/CND	Yes	No	Yes	High	Groups differed in race, gender, and income at baseline. There is high overall attrition (33%) and no methods used to handle missing data. Differential attrition NR.
Palumbo, 2012[9]	NR/CND	Yes	NR/CND	Yes	No	No	High	Baseline characteristics are noted in text but not provided in a table. Study is small (N=14) with overall high attrition (21%) and differential attrition (14%), and no methods were used to address missing data. Numerous risk of bias elements NR.

Table C3. Risk of bias assessments for TWH studies eligible for Key Question 2, part 3 (continued)

Author, Year	Cross-overs or contam-ination raising concern for bias?	Eligible outcome measures valid and reliable?	Outcome assessors masked?	Duration of follow-up adequate to assess outcome?	Appropriate method used to handle missing data?	Analysis adjusted for potential confounders?	ROB	Comments on Risk of Bias Rating
Sorensen, 1998[10-12] WellWorks	NR/CND	Yes	No	Yes	No	Yes	High	High risk of selection bias. There was substantial attrition for the primary outcome measure; differential attrition is unclear. Participation varied across intervention activities and by job status; overall participation in ≥1 activity during two year intervention was 34-40%. Self-reported quit rate measure has risk of recall bias. Numerous risk of bias elements NR.
Sorensen, 2003[13-15] WellWorks-2	NR/CND	Yes	No	Yes	No	NR/CND	High	Groups differed at baseline in terms of age, education and job type. There is high attrition (54%) not accounted for in the analysis; differential attrition is not clearly reported. Self-reported quit rate measure has risk of recall bias. Safety measures not validated. Authors report adjusting for baseline differences between arms, but covariates are unclear. Numerous risk of bias elements NR.
Sorensen, 2005[16-18] Healthy Directions-Small Business	No	Yes	NR/CND	Yes	No	Yes	Medium	Groups differed at baseline; intervention sites had more women than control sites. “Minimal intervention" control group not well described. Fidelity to intervention is unclear; participation varied by worksite. Attrition is high; authors report conducting ITT analysis using LOCF for missing data for two worksites that dropped out (results not reported separately, do not address missing data for non-responders from other worksites). Analyses adjusted for potential confounding by worksites, occupation, and race/ethnicity.

Table C3. Risk of bias assessments for TWH studies eligible for Key Question 2, part 3 (continued)

Author, Year	Cross-overs or contam-ination raising concern for bias?	Eligible outcome measures valid and reliable?	Outcome assessors masked?	Duration of follow-up adequate to assess outcome?	Appropriate method used to handle missing data?	Analysis adjusted for potential confounders?	ROB	Comments on Risk of Bias Rating
Sorensen, 2007[19] Tools for Health	NR/CND	Yes	NR/CND	Yes	Yes	NA	Medium	Groups differed slightly at baseline; intervention group had more participants with post-high school training and higher salary compared with control group. Multiple study design elements (e.g., fidelity, randomization methods, allocation concealment) not well described. Eligible outcomes assessed by self-report (smoking, dietary changes) and subject to recall bias.
Tveito, 2009[20] Integrated Health Programme	NR/CND	Yes	Yes	Yes	No	NA	High	High attrition (overall and differential) contribute to risk of selection bias. Dropouts were younger and had more sick leave than completers. Baseline groups are not well described (e.g., age, comorbidities, job type). Adherence, intervention fidelity are not reported.
von Thiele Schwarz, 2015[21]	Yes	NR/CND	NR/CND	Yes	No	No	High	High attrition (>30%), potentially confounding differences between groups not fully addressed or adjusted for in the analysis contributed to bias. Baseline intervention and control groups differed by job type and length of employment onwards. Contamination is also concern; control units had OSH functions integrated into continuous improvement processes during intervention period. Self-rated health outcome does not appear to be externally validated.

CND, cannot determine; ITT, intent-to-treat; LOCF, last observation carried forward; N, number; NA, not applicable; NR, not reported; OSH, occupational safety and health

References for Appendix C

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Appendix D. Strength of Evidence Tables

Table D1. Strength of evidence: Smoking cessation

Population; Intervention, Comparator; Outcome measure; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Construction laborers[1] and manufacturing workers[2] Integrated Intervention versus no intervention; Self-reported 7-day abstinence 22-26 weeks	2; 737 RCTs	Medium or High	Consistent	Indirect	Precise	One RCT (N = 188 smokers and recent quitters at baseline) rated medium ROB[1] found more workers in the integrated intervention group reported 7-day abstinence at 26 weeks than workers in the control group: 19% vs. 8%; p= 0.03[a] One RCT (N = 490 smokers at baseline) rated high ROB [2] found more workers at intervention worksites reported 7-day abstinence at 22 weeks compared with workers at control worksites (26% versus 17%; p=0.014)	Low for benefit

[a] This RCT found also found benefit for rates of 7-day abstinence of any tobacco use favoring the integrated intervention (19% versus 7%; p= 0.005).[1]

RCT = randomized controlled trial; ROB= risk of bias.

Table D2. Strength of evidence: Healthy eating behavior (increased consumption of fruit and vegetables)

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Manufacturing workers[3,4] and construction workers[1] Integrated Intervention versus no intervention; 26-104 weeks	3; 6056 RCTs	Medium or High	Consistent	Indirect	Precise	**Two RCTs rated medium ROB:** One RCT (N=578)[1] found that more workers in the intervention group increased consumption of fruit and vegetables than workers in the control group: mean increase in servings per day= +1.52 (SD=3.39) vs. -0.09 (SD=3.31); p= <0.0001 One RCT (N=3,092)[3] found more workers at intervention worksites reported consuming 5 or more servings of fruits and vegetables per day than workers at control worksites[a]: mean change from baseline= +7.5% vs. +1.1%; p=0.048 One RCT (N= 2,386) rated high ROB[4] found more workers at intervention worksites increased consumption of fruit and vegetables than workers at control worksites: mean change from baseline servings per day= 0.22 vs. 0.09; p=0.04	Low for benefit

[a] In the overall sample of workers, there was no difference between intervention and control worksites (mean change from baseline % consuming 5 or more servings per day: +5.4% versus 1.7%; p=0.41); and managers at intervention worksites reported decreased consumption of fruit and vegetables compared with managers at control worksites (mean change from baseline consuming 5 or more servings per day: -5.5% vs. 3.6%; p=0.048).[3]

RCT = randomized controlled trial; ROB= risk of bias; SD = standard deviation.

Table D3. Strength of evidence: Healthy eating behavior (decreased consumption of red meat)

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Manufacturing workers;[3] Integrated Intervention versus no intervention; 78 weeks	1; 3092 RCT	Medium	Unknown	Indirect	Imprecise	Percent of workers who reported consuming 3 or fewer servings of red meat per week: mean change from baseline= +4.1% in the intervention group vs. +3.0% in the control group; p=0.72	Insufficient

RCT = randomized controlled trial.

Table D4. Strength of evidence: Increased levels of physical activity

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Type of Physical Activity Measure Direction and Magnitude of effect	Strength of Evidence
Manufacturing workers,[3] and office workers employed at a financial institution[5] Integrated Intervention versus no intervention; 16-78 weeks	2; 3504 RCTs	Medium	Unknown	Indirect	Precise for outcome in manufacturing workers); imprecise for outcomes in sedentary office workers	**Overall physical activity:** One RCT (N= 3,092; manufacturing workers)[3] found increased self-reported physical activity levels at intervention worksites compared with control worksites[a]: change from baseline % reporting ≥ 2.5 hours of physical activity per week= +7.1 vs. -2.1; p=0.09 One RCT (N= 412; sedentary office workers)[5] found no difference between three integrated intervention groups and a control group on any measure of overall physical activity (weekly levels of light, moderate and vigorous physical activity; leisure time activity, active commuting and sports activity)	Insufficient
Sedentary office workers,[5,6] Integrated Intervention versus any comparator 16-52 weeks	2; 262 RCTs	Medium	Unknown (different outcome measures)	Indirect	Precise for stair climbing at work; Imprecise for occupational physical activity level	**Work-specific physical activity:** One RCT (N=412)[5] found increased stair climbing at work in a physical environment intervention compared with controls: difference between groups in number of times workers reported using stairs per day= 1.0; 95% CI, 0.5 to 1.5; p <0.01. One RCT (N=60)[6] found no difference between groups in total occupational physical activity, or work time spent in moderate or vigorous physical activity; workers in the integrated intervention increased the percent of work time spent in light physical activity more than a OSH-only group: 0.7% (95% CI,-0.2 to 1.7) vs. -0.4% (95% CI, -1.1 to 0.2); p=0.04	Insufficient

Table D4. Strength of evidence: Increased levels of physical activity (continued)

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Type of Physical Activity Measure Direction and Magnitude of effect	Strength of Evidence
Sedentary office workers,[5,6] Integrated Intervention versus any comparator 16-52 weeks	2; 262 RCTs	Medium	Consistent	Indirect	Precise	**Sedentary activity at work:** One RCT (N=412)[5] found decreased sedentary activity in a physical environment intervention group compared with controls: difference between groups in minutes per day spent sedentary= -57.9; 95% CI, -111.7 to 4.2; p=0.03.[b] One RCT (N= 60) [6] found decreased percent of work time spent sedentary among the integrated intervention group [c] compared with a OSH-only group: -2.0 (95% CI, -4.4 to 0.3) vs. -0.4 (95% CI, -1.1 to 0.2); p=0.08	Low for benefit

[a] In the overall sample of workers, there was no difference between intervention and control worksites (mean change from baseline % reporting ≥ 2.5 hours of physical activity per week= +5.4% versus -0.9%; p=0.23); and managers at intervention worksites reported decreased levels of physical activity compared with managers at control worksites (mean change from baseline % reporting ≥ 2.5 hours of physical activity per week= -2.0% vs. +3.7%; p=0.009).[3]

[b] There was no difference between the other two active comparators (social environment intervention and combined social and physical environment intervention) and the control group on any measure of work-specific physical activity or sedentary behavior outcome.[5]

[c] Workers were randomized to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation.[6]

RCT= randomized controlled trial.

Table D5. Strength of evidence: Work stress

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Office workers employed at a financial institution;[5] Integrated Intervention versus no intervention; 52 weeks	1; 412 RCT	Medium	Unknown	Direct	Imprecise	Workers in the combined intervention group [a] experienced greater reduction in exhaustion measured by the Oldenburg Burnout Inventory than the control group. There was no difference between the control group and any of the three active comparator arms on the following outcomes: need for recovery after work, detachment after work and relaxation after work.	Insufficient

[a] The study randomized workers to one of four arms, including: (1) no intervention control group, (2) social environment intervention, (3) physical environment intervention, and (4) combined social and physical environment intervention.[5]

RCT= randomized controlled trial.

Table D6. Strength of evidence: Quality of life (SF-12)

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Construction and utility workers;[7] Integrated Intervention versus no intervention; 52 weeks	1; 264 RCT	Medium	Unknown	Direct	Imprecise	No difference between groups [a] on the SF-12 physical health component summary score: difference between groups on post-intervention score (SE): = -0.32 (0.82); p=0.69	Insufficient

[a] Workers were randomized to an intervention aimed at improving work-life stress, (via supervisor behavior training and employee work groups) or no intervention.

RCT= randomized controlled trial; SE= standard error; SF-12 = Medical Outcomes Study Short Form (12 items)

Table D7. Strength of evidence: Safety Compliance and Safety Behaviors

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Construction and utility workers;[7] Integrated Intervention versus no intervention; 52 weeks	1; 264 RCT	Medium	Unknown	Direct	Imprecise	No difference between groups[a] in mean safety participation scores (0.14; SE=0.09; p=0.014) or mean safety compliance scores (-0.02; SE=0.08;p=0.83).[7]	Insufficient

[a] Workers were randomized to an intervention aimed at improving work-life stress, (via supervisor behavior training and employee work groups) or no intervention. Safety compliance and safety participation were measured via self-report on items such as "I use the correct safety procedures" and "I voluntarily carry out tasks or activities that help to improve workplace safety"; responses were rated on a 5-point scale and computed as a mean response (higher scores = higher levels of safety and compliance).

RCT= randomized controlled trial; SE= standard error; SF-12 = Medical Outcomes Study Short Form (12 items)

Table D8. Strength of evidence: Blood pressure

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Sedentary desk job workers;[6] Construction and utility workers;[7] Integrated Intervention versus any comparator 16 to 52 weeks	2; 324 RCTs	Medium	Unknown	Indirect	Imprecise	One RCT (N= 264; construction and utility workers) found a small statistically significant improvement in MAP in the integrated intervention group[a] compared with controls at 52 weeks (change in MAP= -2.15 mm Hg; SE= 1.03; p=0.038).[7] One RCT (N= 60; sedentary office workers) found no difference between groups[b] at 16 weeks; only p-values reported for systolic blood pressure (p=0.90) and diastolic blood pressure (p=0.48).[6]	Insufficient

[a] Workers were randomized to an intervention aimed at improving work-life stress, (via supervisor behavior training and employee work groups) or no intervention.

[b] Workers were randomized to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation.[6]

MAP = mean arterial blood pressure; OSH= Occupational Safety and Health; RCT= randomized controlled trial; SE= standard error

Table D9. Strength of evidence: Weight

Population; Intervention Category; Time-point	Number of Studies; Subjects Study Design	Study Limitations	Consistency	Directness	Precision	Direction and Magnitude of effect	Strength of Evidence
Sedentary desk job workers;[6] Integrated Intervention versus OSH-only intervention; 16 weeks	1; 60 RCT	Medium	Unknown	Indirect	Imprecise	No difference between groups[a] in the weight change from baseline to follow-up at 16 weeks (p=0.80; data not reported)	Insufficient

OSH = Occupational Safety and Health; RCT= randomized controlled trial.

[a] Workers were randomized to an ergonomic workstation optimization intervention alone or an integrated intervention that included the same ergonomic intervention plus access to a seated activity permissive workstation.[6]

References for Appendix D

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