Defining the Science Research Agenda

Practice to Research to Practice™

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Introduction
The members of AIHA and ACGIH are occupational and environmental health and safety (OEHS) professionals, including industrial hygienists, who protect workers by practicing the art and science of anticipating, recognizing, evaluating, controlling, and confirming protection from hazardous workplace conditions that may cause injury or illness. The members of AIHA and ACGIH have engaged in a process aiming to establish a research agenda that will benefit the organizations’ shared mission to protect worker health and safety. This research agenda reflects the needs of both organizations’ members and seeks to address science and practice gaps that hinder full worker protection. It is intended to stimulate ideas among academic, government, and private researchers. AIHA and ACGIH will use the agenda to advocate for occupational health research proposals that will present opportunities for the funding organizations to fulfill their research missions.

Defining the Science
The success of OEHS as a profession depends on cutting-edge research, training, and practical application—elements of a self-improving, evolving system. The mission of the Defining the Science Advisory Group (DTS-AG) is to develop and maintain a national OEHS research agenda endorsed by the AIHA and ACGIH boards of directors.

DTS-AG has been tasked to address such matters as:

- Identifying areas of practice that do not hold up to current scientific evidence so that AIHA, ACGIH, and other stakeholders may improve OEHS practice through focused outreach, promotion, and training.
- Identifying research initiatives that are needed to advance the state of OEHS science and address gaps in practical knowledge.
- Identifying opportunities to answer OEHS research questions through studies of at-risk workers.
- Defining a transparent, open process across volunteer groups, local sections, and allied stakeholders for creating and sustaining a living research agenda on behalf of the profession and prioritizing project ideas for future funding.
- Advising the AIHA and ACGIH boards and staff members on where they should focus their internal resources to advance the state of OEHS research.
- Defining the roles of AIHA and ACGIH as facilitators of OEHS scientific research—both for funded research opportunities that come to the organizations and as “bundlers” of partners, needs, and ideas to bring before funding organizations.
- Determining how AIHA and ACGIH may leverage their volunteer representatives who have been recently appointed to NIOSH National Occupational Research Agenda (NORA) councils. NORA is an important source of funding for research and training and helps inform NIOSH’s strategic plan.

Development of a Research Agenda
This research agenda follows the Practice to Research to Practice™ (P2R2P) model. The inaugural version of the research agenda is based on ideas suggested by AIHA and ACGIH members through the DTS submission process. More about the process of submitting and evaluating research ideas may be found in AIHA and ACGIH’s Defining the Science guide for members (PDF). Updated versions of the agenda will be issued periodically as new ideas are submitted, reviewed, and prioritized. Readers who wish to review the original submissions or provide comments on research ideas may access and comment via AIHA’s DTS webpage.

The research agenda is divided into two main sections. First, the Practice to Research section encompasses research required to address barriers to practice that...
exist due to lack of knowledge. Second, the Research to Practice section addresses the dissemination of new knowledge that has the potential to improve industrial hygiene (IH) practice or OEHS practice more generally.

Practice to Research
Research required to address barriers to practice due to a lack of knowledge.

Occupational Safety and Health Surveillance: The value of protecting occupational health lies in preventing the onset of new occupational disease and the exacerbation of existing disease following occupational exposures. The difficulty of measuring the human and financial costs associated with occupational diseases creates a barrier to supporting research focused on understanding and preventing these diseases. Illnesses and injuries that are not readily associated with single exposure events tend to go unrecognized. Since the causes of illnesses do not affect treatment decisions, medical care providers do not ascertain or report them.

The National Academies of Sciences, Engineering, and Medicine (NAS) published an authoritative report on this issue in 2018.\(^1\) The findings and recommendations of this report present opportunities to advocate for changes in public policy that will lead to wider recognition of the important role that protection of occupational health plays in improving the health and welfare of the American people. The NAS report counters the perceptions of the public and health practitioners by highlighting the large and growing burden of occupational illnesses on people’s overall health and the country’s economy.

According to the Centers for Disease Control and Prevention (CDC), public health surveillance is “the ongoing, systematic collection, analysis, and interpretation of health-related data essential to planning, implementation, and evaluation of public health practice.”\(^2\) Unexpected patterns or trends raise questions that trigger investigation and research. The U.S. Bureau of Labor Statistics (BLS) collects recordable injury and illness data from employers through workers’ compensation insurance claims and summarizes lost workday rates by industry; however, BLS’ methods miss data for health outcomes that are covered by health insurance or occur after a person’s separation from employment. Methods used in academic studies for estimating this lost data could be used to improve surveillance to manage health risks.

Quantifying the Health and Economic Burden of Occupational Disease: Occupational epidemiology and toxicology studies establish causation and dose-response relationships that provide technical bases for health and safety protection standards. For some time, workplaces have played a leading role in environmental health science research. Employers may support OEHS professionals who provide valuable insights into the contributions by work environments to unacceptable exposures that arise from production processes. OEHS professionals have a unique perspective on occupational health issues through the services they provide to protect workers, such as anticipating hazards, establishing administrative and engineering control measures, selecting personal protective clothing and equipment, collecting and interpreting exposure measurements, and investigating unexpected health outcomes.

Workers are an identifiable, genetically diverse group of people who are the first to be at risk of exposure to new materials entering commercial use. Toxicity testing, including the tests required by the 2016 Frank R. Launtenberg Chemical Safety for the

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21st Century Act, takes time and may not always identify relevant human health effects. As new materials and processes are introduced at an increasing pace, identifying workers who produce and use these materials opens up research opportunities that may provide technical bases for health protection programs. Because occupational health protection remains on alert for unexpected health effects and high exposure levels, the OEHS profession will continue to have an important role in generating hypotheses for testing and topics for study.

Estimates of the morbidity and mortality attributable to workplace exposures indicate a significant and growing problem. In a 2019 publication, the International Labor Organization (ILO) estimated that “diseases are the cause of the great majority of work-related deaths (2.4 million deaths or 86.3 percent), in comparison to fatal occupational accidents (which make up the remaining 13.7 per cent).” ILO concluded that work-related disease and accidents combined “account for 5 to 7 percent of deaths globally.”

Based on an in-depth literature review, the American Thoracic Society concluded that “workplace exposures contribute substantially to the burden of multiple chronic respiratory diseases,” such as asthma, chronic obstructive pulmonary disease, chronic bronchitis, idiopathic pulmonary fibrosis, hypersensitivity pneumonitis, and sarcoidosis. Furthermore, the COVID-19 pandemic has highlighted the role of occupational exposures in the spread of infectious diseases. Researchers at the University of Washington reported “approximately 10% (14.4 M) of United States workers are employed in occupations where exposure to disease or infection occurs at least once per week.” This study has also found about 18.4 percent of all U.S. workers to work in occupations where they may be exposed to disease or infection at least once per month.

Leading causes of death are increasingly the chronic diseases of old age. Occupational and environmental exposures increase people’s probability of developing these diseases, exacerbate disability, and decrease life expectancy. There are also hidden socioeconomic costs associated with uncontrolled occupational health risks. The trades and industries that put workers at risk are increasingly shunned by people unwilling to accept those risks, even for jobs that are among the highest paying in a given community. Those who are willing to take on these risky roles typically represent a more vulnerable segment of society with fewer resources to cope with the increased risks and adverse outcomes. Studying occupational health risks presents opportunities to reduce morbidity and mortality and reduce uncertainties about safe workplace conditions, thus providing individuals the freedom to pursue careers that reward their labor and ingenuity.

**Exposure Surveillance:** The existence of large, government-owned electronic databases of occupational exposure monitoring information creates possibilities to use the data in ways analogous to public health surveillance. Federal and state compliance requirements, small business consultations, and field studies have generated millions of exposure monitoring results. OEHS programs at government-owned research, development, testing, manufacturing, and medical care sites are other potential sources of information.

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3 International Labour Organization (2019): “Safety and Health at the Heart of the Future of Work: Building on 100 Years of Experience.”


However, there is no routine collection, analysis, interpretation, and dissemination of occupational exposure monitoring data in the way that BLS routinely publishes analyses of reportable injury and illness data. OEHS professionals must know this information for project planning. Summary data would provide technical bases for recommending controls and prioritizing organizations’ health protective efforts. In addition, exposure surveillance supports hypothesis-forming research that could identify areas to investigate or reduce uncertainties regarding exposure mitigation strategies.

Research on methods of collecting, analyzing, and interpreting existing government-owned exposure monitoring data has a high likelihood of success. There is a body of literature that employs government-owned data to support useful analyses. Most recently, the University of Michigan released a Noise JEM website that is populated with measurements from government databases, private industry, and the published literature and that supports queries for summary data by industry codes or occupation codes.6

Routinely publishing summary data would also promote standardized data reporting and recordkeeping. Organizations could use published summaries as baseline information to set occupational health goals. Progress in meeting their goals would require analyzing exposure monitoring results to create metrics comparable to published estimates. Over time, this would incentivize employers and organizations to create and follow standardized methods.

Improving Exposure and Risk Assessment: Preventing occupational illness requires using observations and exposure monitoring results to guide decisions on interventions needed to assure working conditions are protective. Current risk assessment and management practices and programs vary greatly across workplaces in their ability to recognize, evaluate, and control risks that are associated with exposure. Some workplaces take a comprehensive approach, such as the strategy advocated by AIHA, working to evaluate and control exposures for all workers, on all days, and for all environmental agents.7 Other workplaces focus only on regulatory compliance and incident or complaint follow-up. Many workplaces have no systematic practices or programs in place at all. These varying approaches could result in unacceptable health risks due to inadequate or nonexistent exposure assessment and management practices and programs. Workplaces are dynamic environments in which constantly evolving tasks, materials, and tools result in large variation in exposure levels. Exposure assessment programs of sufficient quality to account for the uncertainty in exposure levels support continuous improvement that will also compensate for the uncertainties in our understanding of the degree of health risk associated with exposure.

It is necessary to make a systematic and comprehensive survey of the prevalence and efficacy of exposure assessment and management practices and programs implemented in workplaces across various sectors (e.g., heavy and light manufacturing, resource extraction, chemical manufacturing and refining, healthcare, government entities, etc.). The results of this survey would inform OEHS practitioners and regulators on program and practice attributes that ensure adequate worker protection from occupational exposures.8

Using Monitoring Data to Improve Decision-Making:

- **Worker Self-Monitoring:** Typically, an OEHS professional observes exposure monitoring to prevent failed samples and capture job and task information.

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associated with monitoring results. The considerable
time and expertise required to collect monitoring
data severely constrains robust exposure evaluation
and results in health risks remaining uncharac-
terized and poorly managed. Research to develop
easy-to-use sensors, badges, and other monitoring
devices that workers can use to participate more
directly in the exposure assessment process would
provide a partial solution to the problem. Additional
research is also needed to determine straightforward and effective approaches that workers could
data during self-monitoring, either on their own or
with virtual support from an OEHS professional, to
document the sample, exposure, and concentration
information needed to complete a robust data set
that permits proper documentation and interpretation of exposure monitoring results.

- **Aerosol Mixtures**: Exposure monitoring results are
difficult to interpret for complex particulate aerosol mixtures such as welding fumes, concrete dust, and wildfire smoke, even when constituents have been fully characterized. Conservative rules for interpreting gravimetric or particle counting results would simplify monitoring and reduce the chance of misinterpretation.

- **Bioaerosol Monitoring**: Assessing exposures to spores, endotoxins, and infectious agents is often confounded by the diversity of bioaerosol agents in the environment. Methods for monitoring exposure to antigens and organisms that are hard to cultivate have been developed. Applied research focused on developing a measurement system to produce interpretable monitoring results for risk management decisions has a high likelihood of success.

- **Commercially Available High-Flow Inhalable Samplers**: Current personal sampling methods for high-hazard particulate aerosols (e.g., beryllium, manganese, etc.) have laboratory reporting limits near occupational exposure limits (OELs), which often results in non-detect values that can complicate evaluation of workplace compliance with these OELs. High-flow-rate, size-selective air samplers that provide actionable information related to the appropriate OELs must be developed to address this concern.

**Improving Decision-Making When Exposure Monitoring Data Are Not Available:**

- **Improve Qualitative Judgement Accuracy**: Decisions made without the benefit of formal modeling or exposure monitoring data, also referred to as “professional judgements” or “qualitative assessments,” are by far the most common approach to decision-making about health risks. Yet studies have shown that the accuracy of qualitative exposure assessments is often very poor, sometimes not statistically different from random chance, and tends to be biased towards low values.

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Various approaches have been suggested for improving the accuracy of qualitative exposure risk decisions, including accurate feedback loops, group discussion, practice, and models that provide structured characterization of determinants and decision rationale. However, little research has been conducted to determine the most efficient techniques for improving qualitative exposure risk judgements.

- **Exposure Predictor Model Development**: Properly validated mathematical models can efficiently estimate exposure with reasonable accuracy, even outperforming exposure monitoring when sample sizes are very small. They hold promise for integration into Bayesian exposure estimation approaches and, when monitoring is not possible, they may be the only option available aside from applying professional judgment. Research is needed to develop new modeling approaches and tools that are accurate and efficient.

- **Exposure Model Validation**: Mathematical models have potential to vastly improve the effectiveness and efficiency of risk decision-making but are currently limited. Validation of these models is essential to their use, but it is typically not done or performed inconsistently because there are no standard, scientifically vetted approaches to doing so. Research is needed to determine the most effective and efficient approaches to validating models’ abilities to accurately predict exposures in various types of operations and scenarios.

- **Define Appropriate Bayesian Priors**: Bayesian statistical approaches show promise in improving exposure judgments, and their use is becoming more widespread. One of the greatest advantages of Bayesian approaches is their ability to formally combine qualitative judgements or model results with measurement data to reach a decision based on the integrated information. For Bayesian approaches to reach their full potential, research is needed to determine the best means of incorporating qualitative judgments and modeling results into Bayesian priors without introducing undue inaccuracies and biases, which are known to exist in both qualitative judgments and modeling results.

**Control Validation**: Effective and efficient approaches to risk assessment and management rely on understanding control effectiveness for both characterizing risk and determining appropriate follow-up for

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19 DTS Submission List. Row 4. [https://app.smartsheet.com/b/publish?EQBCT=57736221c0db461a8bec3c7c264bb0b5](https://app.smartsheet.com/b/publish?EQBCT=57736221c0db461a8bec3c7c264bb0b5).
24 DTS Submission List. Row 16. [https://app.smartsheet.com/b/publish?EQBCT=57736221c0db461a8bec3c7c264bb0b5](https://app.smartsheet.com/b/publish?EQBCT=57736221c0db461a8bec3c7c264bb0b5).
27 DTS Submission List. Row 15. [https://app.smartsheet.com/b/publish?EQBCT=57736221c0db461a8bec3c7c264bb0b5](https://app.smartsheet.com/b/publish?EQBCT=57736221c0db461a8bec3c7c264bb0b5).
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exposure risk management. Research is needed to efficiently and consistently characterize the performance of specific types of controls used in various operations for the purposes of defining accurate control bands, improving qualitative judgments, and efficiently choosing exposure controls.28

• Validation of WELL Health-Safety Rating for Buildings: Unbiased assessment is needed of the International WELL Building Institute’s (IWBI) WELL Building Standard approach to rating a building’s ability to “deliver more thoughtful and intentional spaces that enhance human health and well-being” (https://v2.wellcertified.com/en/wellv2/overview). Research must ensure that the approach is grounded in robust science and determine its credibility and utility as a mechanism for improving indoor environments.29

• Developing Ventilation Systems for Welding and Cutting: Metal fabrication involving welding and cutting remains a major occupational health protection challenge. The effectiveness of general dilution or local exhaust ventilation systems is limited, especially for large work pieces. Capturing fumes at the point of generation can affect the quality of welds by removing shield gas or reducing the heat of the electrode. Studies to develop methods to reduce both near- and far-field exposures while maintaining weld quality are needed.30

• Validating the Efficacy and Safety of New Infection Control Technologies: New approaches for general indoor infection control are being developed and marketed with such as ultraviolet irradiation, ozone generation, ultra-filtration, bipolar ionization, and hydroxyls. Independent studies are needed to validate the effectiveness and safety of these new approaches.31

• PPE and Respiratory Protection: While control strategies at the top of the Hierarchy of Controls are preferred and every risk management program should have robust processes for continuously improving its controls, there are many instances when personal protective equipment (PPE) and respiratory protection are used as primary controls. However, according to NAS, “the science and research foundation for understanding the successful implementation of respiratory protection programs for all workers (implementation science) is relatively sparse.”32

Furthermore, both workers and members of the public heavily rely on respiratory protection against unexpected threats such as wildfire smoke or SARS-CoV-2. Because respiratory protection programs are primarily driven by known workplace exposure risks, most workers and members of the public are not covered by respiratory protection programs when those unexpected threats suddenly appear. Research is needed to better understand the strengths, limitations, and risk management performance of various respirator protection approaches for workers and the public from both known and unanticipated airborne hazards.

Effective Respiratory Protection for Bioaerosols During Pandemics: The COVID-19 pandemic highlighted the limitations of the OEHS field’s knowledge regarding the use of respirators and other face coverings as strategies for preventing disease trans-

mission, by both protecting uninfected workers and acting as effective source control for infected people. Research is needed in both areas, and the COVID-19 pandemic offers significant opportunities to conduct retrospective epidemiological studies to identify real-world factors influencing strategy effectiveness.33

**Need for Well-Trained OEHS Professionals:** The lack of well-trained OEHS practitioners presents an important ongoing barrier to the broad implementation of risk management practices needed to attain AIHA’s vision of “a world where all workers and their communities are healthy and safe.” While the current lack of up-to-date and comprehensive data prevents making definitive statements about imbalances between supply and demand for well-trained OEHS practitioners, AIHA’s public policy agenda states that the organization “can say with certainty that unmet OEHS needs do exist.”34

The last comprehensive analysis of professional OEHS staffing needs was commissioned by NIOSH in 2010 and concluded that the number of occupational health and safety professionals employers expected to hire in 2011–2016 was “substantially higher than the number estimated to be produced from [OEHS] training programs.” The study also found that there was an overall decline in OEHS program funding during the previous five years.35

A recent survey of OEHS professionals by the National Safety Council (NSC), published in April 2022, indicated at least anecdotal evidence of an increased need for well-trained OEHS professionals, with 55 percent of respondents saying they had personally observed a shortage of qualified OEHS professionals.36 In addition, 24 percent of respondents indicated their departments had increased staff in the past six months, and 37 percent of respondents anticipated their departments would add additional staff in the 12 months following the survey. Seventy percent of respondents believed that more employers would look within their organizations to fill OEHS roles, even if the person who filled the role had little or no safety experience.

Research is needed to update the OEHS field’s understanding of current and future needs for well-trained OEHS professionals so that plans and resources can be put in place to meet those needs.37

**Research to Practice:**

**The dissemination of new knowledge with the potential to improve OEHS practice.**

**Routine Use of Statistical Tools:** Without a basic understanding of lognormally distributed data and the use of traditional or Bayesian statistical tools to aid judgment, OEHS professionals frequently make inaccurate judgments about risks that are associated with exposure.13,17

**Accelerate Exposure Predictor Model Use:** Properly validated mathematical models can efficiently estimate exposures with reasonable accuracy and even outperform exposure monitoring for very small sample sizes.38 Modeling tools show promise for integra-

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tion into Bayesian exposure estimation approaches and, when monitoring is not possible, they may be the only option available to OEHS professionals beyond exercising professional judgment.17,21 Work is needed to accelerate the widespread adoption of existing modeling tools.

**Including Psychosocial Disorders and Mental Health in Total Worker Health:** Psychosocial health is impacted by issues ranging from social factors to hazardous tasks in the work environment. The Canadian Centre for Occupational Health and Safety (CCOHS), in conjunction with Simon Fraser University, has identified thirteen psychosocial risk factors that impact organizational health, the health of individual employees, and the financial bottom line. In recognition of the importance of psychological health, the International Organization for Standardization (ISO) has made two additions to the 45000 series of standards: ISO 45003, Occupational health and safety management—Psychological health and safety at work—Guidelines for managing psychosocial risks and ISO/PAS 45005, Occupational health and safety management—General guidelines for safe working during the COVID-19 pandemic.

It significantly impacts well-being in the workplace but is often an area in which many health and safety practitioners feel unqualified to take on leadership roles. Enhanced collaboration between AIHA, ACGIH, and professional societies representing industrial and organizational psychologists could promote collaboration at the organizational level to address the psychological stress created by occupational health risks and psychological barriers to behaviors that minimize those risks. In addition, research is needed to improve understanding of the complex interactions between environmental and psychosocial hazards experienced at and outside of work so that better guidance and tools can be developed to manage those hazards.

**Heat Stress Management:** According to OSHA, the effective management of heat exposures and resulting heat stress has come under increasing attention as “the danger of extreme heat increases each year due to continuing effects of climate change” and “workers suffer over 3,500 injuries and illnesses related to heat each year.”39

Although the factors influencing health impacts on individuals working in hot environments are relatively well understood, there is opportunity to better understand heat exposures and the relative effectiveness of various heat stress management programs across different industries and types of operations.40,41 Collaboration between AIHA, ACGIH, and professional societies representing exercise physiologists who do original research on thermal stress can help assure that authoritative guidelines continue to be informed by the latest research findings.42,43,44

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